Chapter 3

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Tip of Nantucket National Wildlife Refuge featuring the rip at Great Point

Refuge Resource Descriptions

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Introduction

This chapter describes the physical, biological, and sociological environment of Nantucket NWR. We begin with a description of the physical landscape, and then follow with descriptions of the land use history in the area, current refuge administration, natural resources, visitor services, and archeological and cultural resources.

The Physical Landscape

Setting

Nantucket NWR is primarily a barrier beach system at the northern-most point of the Coskata-Coatue Peninsula on the eastern side of Nantucket Island (map 1-1). It is at this point that two longshore currents meet, running north, creating a riptide that extends offshore. Nantucket Island, "the land far at sea," is located about 25 miles south of Cape Cod in Nantucket Sound (map 1-2). Bounded by Nantucket Sound to the north and the Atlantic Ocean to the south, Nantucket Island is heavily influenced by maritime processes. Wind and wave energy and storms can alter the size and shape of the land due to sand movements. The location of the refuge on Great Point creates ever-changing coastlines and habitats through erosion and deposition of sand.

Nantucket Island, together with the small islands of Tuckernuck and Muskeget, constitutes the town of Nantucket, Massachusetts, and the coterminous Nantucket County, which are consolidated. Part of a larger sand spit known as Great Point, Nantucket NWR is at the tip of the long, narrow Coskata-Coatue Peninsula containing the approximately 1,100-acre wildlife refuge owned by TTOR. Nantucket NWR is situated on this terminal beach spit where the currents of the Atlantic Ocean and Nantucket Sound meet, providing important coastal habitat for migrating birds, as well as a long tradition of wildlife-dependent recreation at the northeastern-most point on Nantucket Island.

Watershed

A watershed is a terrestrial concept that describes an area where all the water (subsurface and surface) converges in the same place. This is a hierarchical system that derives from the smallest stream outward to regional watercourses. Because it is an island, Nantucket is hydrologically isolated and receives its fresh water from precipitation. According to the Nantucket Land Council, 10 watersheds were identified and delineated for Nantucket Island in 1990 (*http://www.nantucketlandcouncil.org/WaterProt.html*; accessed March 2011). This map delineates a watershed that includes the refuge, with much of the outermost portions of the Coskata-Coatue Peninsula, and portions of the eastern and northern shores of the island. Island groundwater flow is generally from the center of the island outwards towards ponds and harbors.

Nantucket Island was formed from glacial activity and is characterized by a combination of hills on the north side and flat outwash plains to the south. Elevation ranges from sea level to 108 feet above sea level (NCSS 1979). The island also consists of about 28 miles of shoreline which is constantly changing due to wind and tidal influences (*http://www.umb.edu/nantucket/nantucket/index.html*; accessed March 2011). There are 28 ponds and lakes on the island, the sole repositories of fresh water.

The Massachusetts Office of Energy and Environmental Affairs designated the Nantucket Island watershed which includes Nantucket Island, Muskeget Island, and Tuckernuck Island. Watershed priorities set forth by the State of Massachusetts for the Nantucket Island watershed are:

- Improve the quality of marine waters and fisheries habitat by reducing nutrients entering waterways from point and nonpoint source pollution.

- Support a comprehensive water resources management plan to address pollution from wastewater.
- Work to develop a comprehensive wastewater management plan for the island, including sewer for Monomoy and a wastewater facility in Siasconset, Massachusetts.
- Identify key parcels of open space for acquisition and/or restriction to protect future water quality.
- Ensure that the watershed has the necessary resources to gain measurable improvements in water quality.

You may view this information at: *http://www.mass.gov/eea/air-water-climate-change/preserving-water-resources/mass-watersheds/* (accessed March 2012).

Extrapolating outward, the refuge does not fit into the traditional watershed concept at a more regional scale because it is a maritime island and is therefore isolated and subject to oceanic processes. However, Nantucket and associated islands are included in the Cape Cod and Islands watershed (U.S. Geological Survey (USGS) HUC 01090002), which includes Nantucket (including Muskeget and Tuckernuck Islands), Martha's Vineyard (including Nomans Land Island), and the Elizabeth Islands (U.S. Environmental Protection Agency (EPA), *http://cfpub.epa.gov/surf/huc.cfm?huc_code=01090002*; accessed March 2011). Nantucket Island is 49 square miles, out of a total of 159 square miles in total land area for the watershed.

Geographical Setting

Biophysical Ecoregion

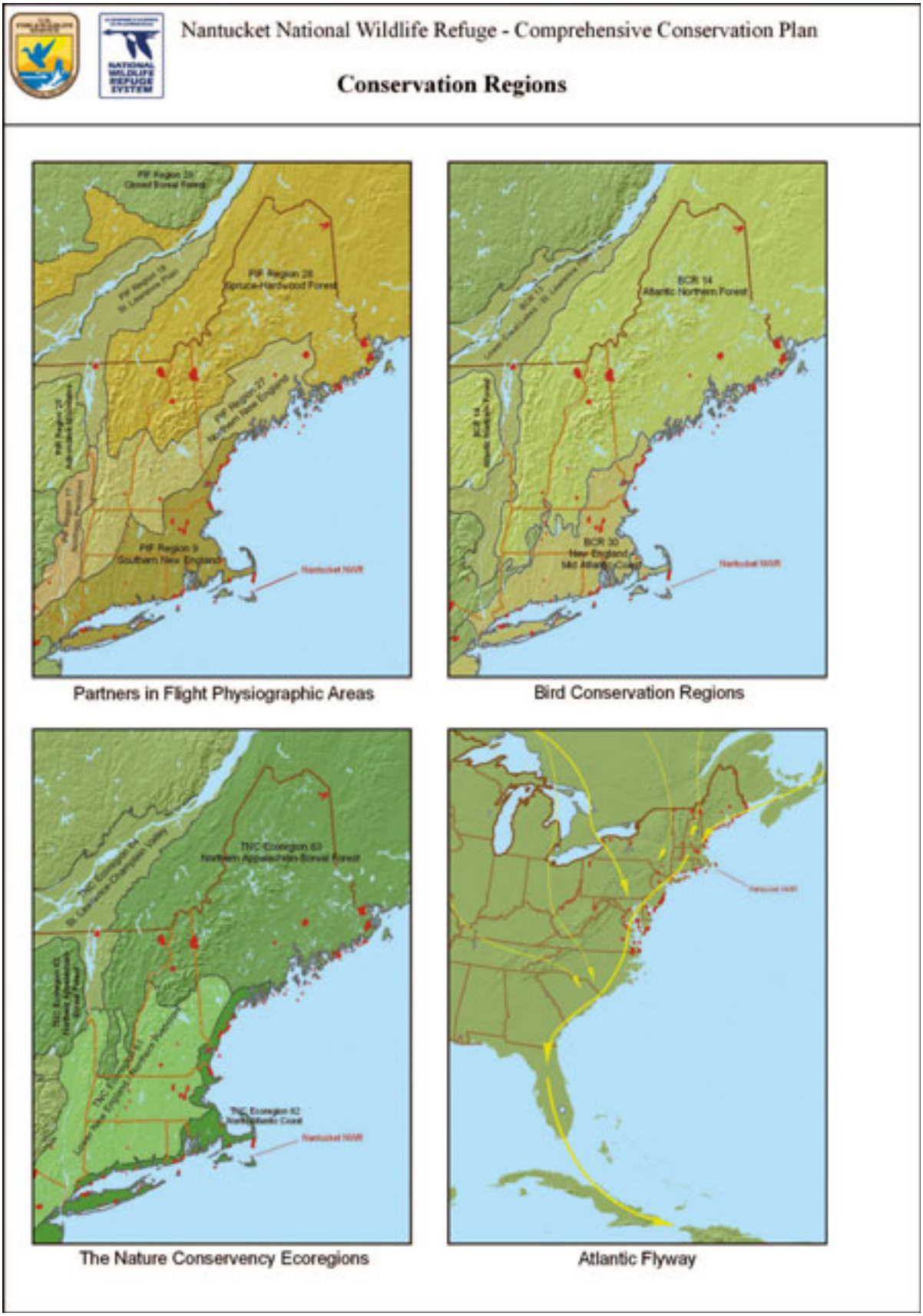
The Nature Conservancy (TNC) has divided the continental United States into 63 ecoregions which are large geographic areas that share similar geologic, topographic, ecological, and climatic characteristics. These ecoregions are modified from the U.S.D.A. Forest Service "Bailey System" (Bailey 1995). TNC has developed Ecoregional Conservation Plans that identify conservation targets and prioritize conservation actions for each ecoregion.

Nantucket NWR is in the North Atlantic Coast (NAC) ecoregion as described by TNC (see map 3-1). This ecoregion extends from Pemaquid Point in Maine south to Delaware Bay. Flat topography, low elevations (less than 600 feet), scattered moraines, large rivers draining into estuaries and bays, and a mild, humid climate characterize this region. Rocky coasts dominate the shorelands in the north, grading into salt marsh communities to the south. The once extensive forest graded from white pine-oak-hemlock forest in the north, to dry oak-heath forests, to mesic coastal oak forests in the south. Wetlands, beaver meadows, pine barrens, and heathlands were embedded in this forested landscape. Hundreds of years of land clearing, agriculture, and widespread development has fragmented the landscape and eliminated large areas of forest. Still, smaller ecological systems remain, including barrier beaches and dunes, salt marshes, and freshwater wetlands (TNC 2006). Current action sites for TNC exist on Martha's Vineyard and Cape Cod, where land protection and management activities are already occurring.

Atlantic Coast Flyway

Nantucket NWR is within the Atlantic Flyway (see map 3-1). Flyways have been used for many years in North America as the unit for managing waterfowl populations, because they allow land managers to link efforts to conserve migratory bird species and their habitats on breeding, migration, and wintering grounds. The ACJV area includes the entire U.S. Atlantic Coast lying completely within the Atlantic Flyway. In this large area, the ACJV partners work together to assess the status, trends, and needs of bird populations and their habitats. The

Map 3-1. Conservation Regions



partners then use this information to help guide the distribution of resources to the needs and issues of highest priority.

Landscape Conservation Cooperatives
In cooperation with the USGS, the Service is initiating a new approach to landscape conservation through a national geographic network that will create a spatial frame of reference to build partnerships and connect projects to larger-scale biological priorities. These 21 geographic areas are aggregates of BCRs (see chapter 1), and provide a basis for forming LCCs with other Federal agencies, non-governmental organizations, States, Tribes, universities, and other stakeholders to accomplish conservation goals. Nantucket NWR is located in the North Atlantic Landscape Conservation Cooperative (LCC) which combines BCRs 14 (Northern Atlantic Forest) and 30 (New England/Mid-Atlantic Coast), and contains 12 out of 13 Northeast States as well as the District of Columbia (map 3-2). Near Nantucket NWR, there exist many conserved lands with which the refuge can partner along Cape Cod and associated islands (map 3-3).

Consisting of a diverse array of ecosystems, from high elevation spruce-fir forests to coastal islands, there will be many different conservation priorities to be addressed in the North Atlantic LCC. The U.S. Fish and Wildlife Service recently completed a year-long effort to identify representative species "for designing conservation and management strategies that will most effectively sustain fish and wildlife populations at desired levels in the face of land use change, climate change, and other stressors occurring within the North Atlantic LCC". Many partnerships for watershed, fish, and migratory bird conservation already exist within this geographic region and will provide a basis from which to initiate the LCC, which will also incorporate Canadian partners. Eighty-seven terrestial species were selected as representative species for this LCC, 34 of which are in the southern New England Region (which encompasses Nantucket NWR). A different selection process was used for selection of aquatic species, but they are not relevant to this CCP. For more information, go to, *http://www.fws.gov/science/SHC/lcc.html* (accessed March 2011).

Notable Physiographic and Landform Features

Geomorphic regions or "physiographic provinces" are broad-scale subdivisions based on terrain texture, rock type, and geologic structure and history. Our project area lies in the Sea Island Section of the Atlantic Coastal Plain delineated by the USGS (*http://tapestry.usgs.gov/physiogr/physio.html*; accessed March 2011). Many of these islands off the coast of Massachusetts mark the southern limit of the last glacial maximum (21,000-18,000 years before present (BP)), and are where terminal moraines of clay-rich, poorly sorted glacial materials were deposited. This had an influence on the subsequent development of beaches, offshore islands, and other landforms (*http://tapestry.usgs.gov/features/features.html*; accessed March 2011).

The island of Nantucket, along with Martha's Vineyard, marks the southern extent at the last glacial maximum. As a result, the surface of Nantucket Island is a combination of terminal moraines which are marked by hills, finely textured soils, and outwash plains which are flatter areas with coarse materials and dry soils (Foster and Motzkin 2003).

According to the NCF, the glacier's retreat has left Nantucket Island with many unusual landforms. Extending west to east, just south of the town of Nantucket, a line of low, rolling hills is final evidence of the terminal moraine. The weight of huge, melting blocks of ice left imbedded in the till and outwash formed depressions called kettleholes, which are scattered throughout the island. West of town, the sea has cut into the exposed northern edge of the moraine, creating the Nantucket Cliffs. The movement of glacial meltwaters down the slope of the

Map 3-2. USFWS Land Conservation Cooperatives

Map 3-3. Conserved Lands in the Vicinity of Nantucket National Wildlife Refuge

outwash plain to the sea formed numerous north-south oriented depressions, or glacial river valleys. Today, some of these depressions are dry valleys and others are fresh water ponds. (*http://nantucketconservation.org;* accessed March 2011*).*

Coastal Geomorphology
Coastal geomorphology is the study of the processes that influence coastal landforms. These natural coastal processes include accretion and erosion, or the deposition and removal, of sand along shorelines. Sand that is eroded from one beach will be transported downdrift and will accrete on another. These processes are influenced by many factors, some of which include ocean currents, tides, winds, sea floor bathymetry, and human modifications. The dynamic nature of these systems means that the same beach can both accrete and erode seasonally within a given year, and can fluctuate between accretion and erosion over long periods of time (MA CZM 2002). These processes provide continually changing coastlines and habitats for many species of wildlife.

Great Point at one time was an island north of Coskata, made of Pleistocene material that extended farther to the east than at present. Today, Point Rip marks the location of that deposit, a gravelly shoal just offshore at the point. Eventually, a sandbar formed connecting this island to Coskata, now known as The Galls, and Holocene deposits now characterize the substrate on Great Point (Rosen 1972). Two longshore currents run north parallel to the shore; these occur on both the east and west beaches of Great Point and The Galls. At the tip of Great Point, these two longshore currents meet, creating a riptide that extends offshore over the gravel shoal at Point Rip. The action of these currents causes beach drift to occur. Sand is slowly being transported from the east side of the point and is deposited on the west side, resulting in the gradual westward movement of Great Point over time.

Great Point provides an example of the dynamic nature of coastlines. The changing coastline is something that coastal States have monitored over the last century, and these data assist shoreline planning efforts. In Massachusetts, there have been four shoreline analyses conducted, dating back to the mid-1800s. The most recent analysis, based on data from 1994, was finalized in 2001. It evaluated over 800 miles of Massachusetts coast at 40-meter intervals, and compared the most current shoreline with the historic shorelines to determine rates of shoreline change (WHOI 2003).

According to this most recent shoreline analysis, 68 percent of the Massachusetts shoreline is in a long-term erosional trend, 30 percent is in a long-term accretional trend, and 2 percent shows no net change. Overall, results indicate that the Massachusetts shore is eroding at a long-term average annual rate of 0.58 to 0.75 feet (mid-1800s to 1994). This coincides with the 75 percent of U.S. coastline that is eroding (WHOI 2003).

For Nantucket Island, the long-term average shoreline change rate over the same time period is a loss of 2.1 feet per year, but the short-term trend rates will vary by and within communities. These long-term annual averages take into account long-term erosion or accretion periods, potentially resulting in deceptively low change rates, when in fact the short-term trend change rates for a particular location can be much higher (WHOI 2003). Great Point has shifted southwest since the mid-1800s, with a long-term change rate of -4.59 feet per year (eroding) on the northeast shore (close to the tip), and -0.79 feet per year (eroding) on the western shore, near the point (*http://www.mass.gov/czm/hazards/shoreline_change/shorelinechangeproject.htm*; accessed March 2011). This not only affects the overall size of the refuge, but also the available habitat for species that rely on

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Changing refuge beaches

shoreline habitat. Accretion and erosion are very important components of these coastal ecosystems, because they are one of the major influences on the amount and quality of habitat for beach-nesting species (MA DFG 2006).

Major Historical Influences Shaping Landscape Vegetation

Estimating the historic natural vegetation types, how they were distributed, and what ecological processes influenced them prior to major, human-induced disturbance, can help us evaluate future management options. However, many ecologists caution against selecting one point in time and instead recommend evaluating the "historical range of variation" for each habitat type.

According to noted ecologist Robert Askins of Connecticut College, "This approach recognizes that the proportions of grassland, shrub land, young forests, and old-growth forests have shifted constantly over the past few thousand years as the climate changed and people have modified the land by hunting, burning, and farming. Preserving the biological diversity of any region requires a range of habitat types, including those created by natural disturbances. If there are no natural or artificial disturbances generating grassland, shrub land, and young forest, then not only will early succession obligates be in trouble, but so will mature forest specialists that use early succession habitats at key points in their life cycles. Only large public lands like refuges, parks, preserves can sustain the full range of early succession and forest habitats, so in most regions land managers will need to cooperate to ensure that these habitats are adequately represented across the regional landscape" (Askins 2000).

A brief summary of influences on natural vegetation patterns across the landscape follows.

Glaciation

Massachusetts, like all of New England, was covered by the Laurentide ice sheet during the last glacial maximum, approximately 21,000 to 18,000 BP. The glacier reached its southernmost extent at the islands of Martha's Vineyard, Nantucket, and Nomans Land, marked by the deposition of terminal moraines on these islands (*http://pubs.usgs.gov/gip/capecod/glacial.html*; accessed March 2011). Terminal moraines are formed when the glacier becomes static, having reached the southernmost point where its rate of advancement is roughly equal to that of its rate of melt, resulting in essentially zero net advancement. These terminal moraines are a build-up of the rock debris, or glacial till, embedded in the glacier that gets sloughed off and deposited along the leading edge of the glacier. The

sedimentation on these islands is consistent with this process (Motzkin and Foster 2002).

At the last glacial maximum, much of what is now the submerged continental shelf along the Massachusetts coast was exposed dry land because much of the world's water was locked up in continental ice sheets. It is estimated that worldwide sea levels were lower than today by 279 to 427 feet (Pielou 1991). By approximately 18,000 BP, the ice sheet began to retreat in response to the warming climate and by about 14,000 to 15,000 BP it had at least reached what is now the northern border of Massachusetts. As the ice sheets retreated, sea levels gradually rose. In addition, the earth's crust was slowly rebounding from the heavy weight of ice, but not as fast as sea levels were rising. This caused coastal flooding along the northern New England coast as far south as Boston (Jorgensen 1971). By about 12,000 BP the coastline between the Bay of Fundy and Cape Cod was much as it is now (Pielou 1991).

The advance and subsequent retreat of the glacier, and changing climate had a profound impact on the local biota. With the advance of the glacier, many northern species were locally displaced and subsisted in southern areas of refugia. The retreating glacier marked a period of time when much of the physical environment was in a constant state of flux. Climatic factors such as temperature, precipitation, humidity, and atmospheric carbon dioxide were fluctuating. The earth's crust was rebounding at the same time that sea levels were rising, and the local hydrology was still in a dynamic state. The glacier itself was directly altering the landscape as it retreated by depositing till, boulders, isolated slabs of ice that melted to form kettle hole ponds, and by forming proglacial lakes as a result of the voluminous meltwater pouring off the retreating glacial front (Williams 2002, Jackson et al. 2000, Prentice et al. 1991). Combined, these factors made for ever-changing conditions as plant and wildlife species recolonized the area.

As the climate warmed and the ice retreated farther north, continual weathering and erosion of rock over time released nutrients and created new soils for plants to grow. Just south of the glacier, it is thought that tundra-like vegetation was dominant on the landscape, though there may have been places where the ice abutted spruce (*Picea* spp.) forests (Pielou 1991, Jackson et al. 2000). The tundra-like landscape was dominated by sedges and dwarf shrubs for several thousand years. As the climate warmed, these plants and associated animals followed the glacier as it receded north. The tundra continued to retreat, eventually restricted to the highest mountaintops (Davis 1983, Marchand 1987).

It has been shown that climatic temperature alone does not adequately explain the post-glaciation vegetation history, but regional temperature and moisture levels working in concert may explain the variability in the post-glacial phytogeography in southern New England. By 14,600 BP spruce populations were prevalent in New England and they persisted until 11,600 BP when white pine (*Pinus strobus*) became the dominant species, replacing spruce during a drier, warmer climatic period. Hemlock (*Tsuga canadensis*), beech (*Fagus grandifolia*) and birch (*Betula* spp.) increased by about 8,200 BP, replacing the white pine after a concurrent rise in moisture availability. Hemlock, a more mesic species, experienced a population crash around 5,400 BP, originally thought to have been due to the first-ever recorded occurrence of a pathogen. However, recent evidence indicates that its decline took place during a drier microclimate which may also have been a factor. Deciduous species such as hickory (*Carya* spp.) and chestnut (*Castanea dentata*) were much slower to reach New England, 6,000 BP and 3,000 BP respectively. This was likely due to regionally cooler temperatures and lower moisture levels than today (Shuman et al. 2004, Shuman et al. 2005).

Large mammals, including mastodons, wandered the spruce parkland and grassy savanna, but disappeared quickly at the same time as the glacier receded and humans advanced across the region. Thirty-five to forty large mammals became extinct 9,000 to 12,000 years ago, while other mammals that lived at that time, such as white-tailed deer (*Odocoileus virginianus*), are still present today (Pielou 1991, Askins 2000).

More Contemporary Influences on Vegetation Patterns

Natural disturbances vary across New England, depending on geographic location, forest type, and local conditions. In pre-settlement times coastal regions experienced the highest rates of disturbance because of the prevalence of sandy pine-oak barrens, high densities of Native Americans, higher frequencies of hurricanes, and longer snow-free periods. These disturbance regimes may have maintained about 1 to 3 percent of the inland northern hardwood forests, greater than 10 percent of the coastal pine-oak barrens, and perhaps 7 percent of spruce swamp and spruce flat habitats in early successional habitat (Lorimer and White 2003).

Native insects and disease, ice storms, droughts, floods, landslides, and avalanches have caused minor and major disturbances. Lorimer and White (2003) depict hurricane frequencies as varying from 85 years in southeastern New England, 150 years through central Massachusetts and the southeast corner of New Hampshire, to 380 years or more in northern New England. Lorimer (1977) estimated catastrophic disturbances from fire and windthrow at intervals of 800 and 1,150 years, respectively.

Agriculture, logging, fire, windthrow, exotic pests and diseases, and development have significantly altered the New England landscape. Agriculture had the greatest effect on New England's forests, causing major changes in cover types and soils over a wide area. Although most of the region's forests were cut at least once, most logging did not affect succession or impact soils. Intense fires fueled by logging slash did have a lasting impact on forest vegetation patterns (DeGraaf and Yamasaki 2001).

Sheep Grazing

Grazing was common throughout the New England coast during the eighteenth and nineteenth centuries. As European settlement increased, coastal islands were cleared of forests, and though fire was used to some extent, it was the chronic, intensive disturbance created by plowing, harrowing, and grazing by sheep and cattle that had a more lasting impact on modern vegetation (Motzkin and Foster 2002). As a result, the landscape changed from a primarily forested one with small-scale disturbances that created a shifting mosaic of openings, to one in which grasslands were ubiquitous by the 1800s. On Nantucket, extensive areas of forest were cut for building materials, firewood, and to create pasture land. Estimates for Nantucket Island indicate approximately 15,000 sheep were present by the late 1700s (Foster and Motzkin 2003).

The impacts this had on local vegetation was rapid and long-lasting. Grazing controlled the growth of woody species while increasing grass, herb, shrub, and weed species. Overgrazing, on the other hand, created areas that were nutrient deficient and led to a loss of vegetation cover, wind erosion, and in some cases, dune development (Foster and Motzkin 2003). Extensive sheep grazing continued to alter the soil and habitat resulting in a landscape dominated by low shrubs and grasses (*http://nantucketconservation.org;* accessed March 2011).

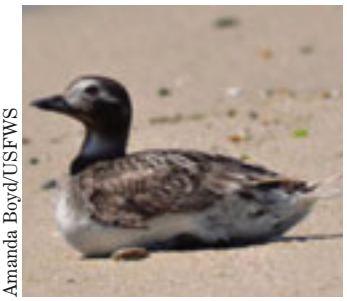
Modern shrub, grass, and heathland communities are primarily the result of the intensive agricultural land use practices by European settlers, and likely do not represent ecological communities or species associations found prior to European

settlement (Foster et al. 2002). However, these modern open land communities do support many species of conservation concern and therefore have high conservation value. They provide much-needed habitat for present-day indigenous species that have lost habitat throughout their ranges as a result of human development and other anthropogenic factors.

Fire

The history of fire on Nantucket Island prior to the twentieth century is largely unknown. If the fire history of Nantucket is similar to the fire history on Martha's Vineyard, then there are likely to have been many fires on the island with varying frequency, intensity, and geographic scope caused by differences in physiographic, biotic, and cultural factors (Foster et al. 2002).

There is agreement in the literature that Native Americans did use fire as a tool to clear the forest understory for ease of travel, to manage deer populations, and possibly to create small openings around their seasonal camps (Motzkin and Foster 2002, DeGraaf and Yamasaki 2001). The results of these land use practices have been described as creating a shifting mosaic of localized early successional habitat, but likely did not result in broad-scale alterations to the landscape (Foster and Motzkin 2003). At the time of European settlement, Cape Cod and the islands of Martha's Vineyard and Nantucket were wooded with no large-scale occurrences of grasslands or other openings (Foster et al. 2002).



Amanda Boyd/USFWS

Long-tailed duck

In the Cape Cod region, charcoal evidence from paleoecological studies indicates that the use of fire increased concurrently with the clearance of forests in the time of European settlement. Fire, in combination with other European practices such as logging, plowing, and grazing transformed the landscape from one dominated by forests into one where grasslands and coppice woods were prevalent. In a comparison between pre- and post-European settlement, fossil pollen values on Martha's Vineyard, which has a very similar land use history to Nantucket, show large increases in species such as ragweed, sorrel, and grasses indicating the presence and prevalence of open lands on the island after European settlement (Foster et al. 2002). On Nantucket, the island was virtually treeless by the early to mid-1800s (*http://nantucketconservation.org;* accessed March 2011). Vegetation on the island changed; species composition shifted to those well-adapted to repeated disturbances. Site fertility decreased under the combined pressures of these uses, and thus smaller heath plants gained a foothold, resulting in the sandplain grasslands and coastal heathlands present today (Foster and Motzkin 2003).

Land Use History

Early Native American Influences

There is some indication in the archaeological record of paleo-Indian people populating New England, likely including the Cape Cod region, shortly after the post-glacial recolonization of many plant species in the region (12,000 to 9,000 BP). However, given the paucity of data available from this time period, it is not possible to provide much insight into their relationship to the landscape or their subsistence strategies beyond the now-disabused notion that they were specialized in hunting megafauna. It appears more likely that while seasonal big game movements and hunting were important factors, they also incorporated a more generalist strategy that utilized all the technology and resources available to them (MHC 1987).

The Early Archaic Period (9,000 to 7,000 BP) is represented from archaeological sites found on Cape Cod and Nantucket. These indicate a regional movement pattern around a centralized area, though there were some differences in subsistence patterns noted between those sites found interior, and sites found

associated with hydrological features. The Middle Archaic (7,000 to 5,000 BP) period shows a marked increase in the number of sites found, and thus indicates an increase in the population or at least occupation of the Cape Cod region. Sites representing this time period are found on Cape Cod (34), Nantucket (12), and Martha's Vineyard (25). These sites were associated with headwaters of streams and other areas with access to anadromous fish runs. There is also indication from sites on Martha's Vineyard of hunting and fishing activities. By the Late Archaic Period (5,000 to 2,700 BP), there were several traditions, or tool forms, in use (Laurentian, Susquehanna, Small-stemmed, and Orient) that indicate an adaptability and utilization of a wide range of resources and a more fixed presence on the landscape (MHC 1987).

In the Cape Cod region, Early Woodland (2,700 to 2,000 BP) sites are not well represented, in part due to overlap in traditions (Small-stemmed in particular) from the Late Archaic Period and in part due to problems with ceramic analysis and dating techniques. However, there are sites that represent the Early Woodland Period in conjunction with Middle (2,000 to 1,200 BP) and/or Late Woodland Periods (1,200 to 400 BP) as well. The Early Woodland Period ushers in an era of ceramic use, as well as the use of materials from other geographic locations indicating contacts with other regions which were important, but not pervasive. It was primarily a regionally insular way of life. Quartz, quartzite, and felsite were the primary materials used, and these were easily found along local beaches and river channels. The Late Woodland Period is the time when the prehistoric Cape Cod regional population was at its peak, and sites indicate the use of every habitat type. The remains of sea mammals, terrestrial mammals, shellfish, and great auk (*Alca impennis*) have been associated with these sites (MHC 1987).

Though some archaeological sites on Nantucket indicate earlier occupation, there are indications in the archaeological record that Nantucket became a more intensively used area at least as early as the Middle Woodland Period. A preponderance of these sites is in coastal and estuarine areas, including near Squam Pond, Henecater Swamp, and Hummock pond (MHC 1987). This is not uncommon, as throughout southern New England, there were higher Native American population densities near the coasts, presumably because of a greater diversity of subsistence items including seasonal fish and shellfish. Data suggest that Native Americans during the Woodland Period predominantly utilized a hunter-gatherer strategy throughout the region, using a combination of fishing, shellfishing, and hunting with a moderate use of horticulture (Motzkin and Foster 2002, Foster et al. 2002).

There is some question in the literature as to the extent that Native Americans modified their environments in New England prior to European settlement. New paleoecological evidence and a re-evaluation of ethno-historical data indicate that previous assertions of the widespread occurrence of open land across the pre-European landscape as a result of Native American modifications were overstated. It is clear that agriculture in the form of corn, beans, and squash were being used on the Cape and islands prior to European arrival, and the use of fire was an important tool to clear land for agriculture and to clear forest understories for ease of travel and hunting (MHC 1987, DeGraaf and Yamasaki 2001).

Paleoecological data suggest that islands such as Nantucket were dominated by oak (*Quercus* spp.), pine (*Pinus* spp.), and other hardwoods for thousands of years prior to European influence. Even on islands such as Nantucket and Block Island, that were more densely populated by Native Americans than other nearby islands at that time, fossil pollen for grassland species and charcoal values were very low

right up to European settlement. This indicates that open lands on Nantucket were uncommon if existent at all. Regional charcoal values (Cape Cod) do not seem to correspond to Native American settlement patterns. Any open lands on Nantucket, including heath and grass, were primarily confined to the coastal fringes, and overall vegetation patterns had more to do with physiography than human intervention (Foster et al. 2002, Foster and Motzkin 2003).

Some islands, including Nantucket and Martha's Vineyard, were more densely populated than others. By the time of the Contact Period (around the 17th century), there was an estimated 2,000 to 3,000 Native Americans living on Nantucket. Though no evidence has been found thus far to identify village centers, they may have been associated with quality shellfishing sites and near anadromous fish runs. Subsistence was through a mix of agriculture, fishing, hunting, and shellfishing, though fishing appeared to have been more important than hunting or agriculture on Nantucket. There were no European settlements during this period, but there were occasional European explorers, traders, or fishermen that made brief contact (MHC 1987). By the late 1600s, deeds indicate the presence of five main sachemships on Nantucket; Seiknout, Pattacohonet, Attapeat, Wanachmamack, and Nickanoose. The island was divided among them, with some shared areas (Little 1996).

European Influences

While it is likely that European explorers, traders, and fishermen may have had contact with the Native Americans on Nantucket as early as the 15th century, it wasn't until Bartholomew Gosnold's voyage in 1602 that the island was explored or described by a European. As European interests in Nantucket and the New World grew, the island was originally deeded to be a part of New York, before being turned over to Massachusetts in 1692. In 1635, King Charles I granted lands including what is present day New York and Nantucket Island to the Earl of Sterling, and then in 1639 granted the island of Nantucket to Sir Ferdinand Gorges, resulting in a conflict of ownership. During the 1640s, a man named Thomas Mayhew and his son, who were merchants and missionaries, were interested in converting the island's Native Americans to Christianity, and in creating European settlements. In 1641, the Mayhews secured Nantucket, Tuckernuck, and Muskeget from both Stirling and Gorges. In 1659, the Mayhew's bought the rights to the land on Nantucket from the two leading sachems on the island, Wanackmamack and Nickanoose (Jacobson 2000, MHC 1987).

Mayhew then sold Nantucket to a partnership of 10 individuals, known as the First Purchasers, who moved to and settled on the island by 1660, and kept a section for himself. These purchasers not only secured the rights to the western half of the island from the Wampanoag sachems Wanackmamack and Nickanoose, but also the timber and grazing rights throughout the island, except during the planting season (MHC 1987, Little 1996). These first 10 purchasers brought family and others with them, and Nantucket began to attract those not satisfied with life on the mainland (Jacobson 2000).

During this period, the European settlers were establishing a community in the area near Capaum Pond, and were engaged in agriculture (corn and possibly rye, wheat, oats, and barley) and animal husbandry. Cattle, horses, domestic fowl, pigs, and sheep were brought to the island, and sheep were fast becoming prominent. In 1669, these European settlers had to limit grazing rights for each shareholder due to evident overgrazing of common grazing lands. These restrictions were for each shareholder to limit themselves to "no more than forty sheep, three cows, and one horse" (Little 1996). This began a period of time when the island's Wampanoags and Europeans made a number of land transactions to try to ensure there was enough room and resources on the island for both communities and ways of life.

While agriculture was an important component of life on Nantucket, it was evident that it was not as productive compared to the mainland. European settlers also hunted, fished, shellfished, and gathered wild plants as part of their subsistence, and by the late 1600s there was a noticeable shift from agriculture to fishing as a way of life (MHC 1987). Codfishing and whaling stations were established around the island by 1672, and road networks were built to connect them for easy access. These areas included Siasconset, Polpis Harbor, Quidnet, and Great Point. Codfishing crews were made up of the island's Wampanoag residents, as were the codfishing camps that contained the fish houses. The island's Wampanoag residents also taught the European settlers whaling technology and made up the majority of the whaling crews. The whalers established lookout stations which were manned by whalemen during the season. When a whale was sighted from the observation tower, a crew would chase and harpoon it. The whale was then dragged ashore, and the blubber was removed to process oil. Huts, and later houses, were built near the shore and two villages grew out of this development, one of them being Sconset, which is still a viable town and the other eventually grew into the town of Nantucket (Jacobson 2000). By 1775, there were a reported 150 boats in Nantucket's whaling fleet, more than any other whaling community during colonial times (MHC 1987).

The European population on Nantucket blossomed throughout the 18th century. The fisheries were growing in prominence throughout the region, and transportation and trade ships were regularly running from the mainland to Nantucket. A Quaker community was established on the island by 1711, and by the end of the 18th century, half of the island population belonged to the Quaker community (Jacobson 2000). Even though the fisheries were becoming the main trade, the Wampanoag Tribe continued to hunt, fish, shellfish. and produce corn. The European settlers, too, continued agriculture and husbandry, but sheep became the prominent farm product (MHC 1987). Land was cleared to accommodate the settlements, farms, grazing practices, and whaling stations that arose out of European habitation on Nantucket, and to build houses, ships, and to provide fuel. By the late 1700s, Nantucket was essentially devoid of trees; fuelwood was imported from the mainland, and peat was harvested from bogs as a source of fuel (*http://nantucketconservation.org;* accessed March 2011).

Likely due to the influx of so many European settlers, a plague seriously impacted the Native American population on the island in 1763. It is estimated that only several hundred individuals were left, from an original estimated Nantucket Wampanoag population of about 2,400 at the time of the island's first European settlement. The first census in 1765 of the entire island, Native Americans and Europeans combined, reported 3,320 inhabitants (MHC 1987). The Native American population continued to decline due to disease and economic hardship. In 1822, the last full-blooded Nantucket Native American died (Jacobson 2000).

Things changed with the onset of the Revolutionary War and Nantucket's economy was decimated. The whaling fleet was lost, the land was void of timber, and agricultural fields were no longer as productive. The whaling industry had relied heavily upon the Native community for operation and the island's declining Wampanoag population caused a labor deficit. To make up for this, formerly enslaved Africans who had escaped or been freed became a vital component of the whaling crews. An African settlement grew on the southern half of the island. The whaling industry was slowly rebuilt and became a dominant economic force. However, due to the Embargo Act imposed by Thomas Jefferson and silt building up in Nantucket harbor, the industry slowed down again. The industry grew after the War of 1812, but then subsided again when whale populations decreased

(Jacobson 2000). A few vessels still attempted to procure whale oil, but the sperm whale (*Physeter macrocephalus*) population was depleted and it became too expensive to continue. People of Nantucket began to try other economic ventures to support the exhausted whaling economy. By 1865, the population had decreased by almost half, from 9,012 in the 1840s, down to 4,800 persons. In 1869, the last whaler left Nantucket, and much of the population was leaving as well, due to the declining economy. There were 111 farms still productive in 1865, producing barley, corn, potatoes, and cranberries (MHC 1987).

After the Civil War, Nantucket began to be marketed as a vacation resort (Jacobson 2000). In the 1870s, the tourist industry began to take hold on the island, with hotels being established in the main towns of Nantucket, Siasconset, and Head of the Harbor. A railroad was built on the island to transport tourists from Nantucket Town to Sconset in the 1880s, and a steamboat ran twice daily between Woods Hole and Nantucket Town (MHC 1987). The economy has focused on the tourist industry since then. Land use and the division of land parcels have been centered on accommodating the new industry (Jacobson 2000).

Though sheep-grazing was gradually reduced from a peak of approximately 15,000 sheep in the late 1700s, dairy and vegetables became valuable farm products in the late 1800s and early 1900s. Cranberry production continued during this time, though not at high levels, and commercial scallop fishing was initiated in the late 1880s, giving Nantucket an excellent reputation for fine scallop fishing throughout New England (MHC 1987).

Human Influences over the past 100 Years

During the 20th century, land use and the economy remained focused on the tourist industry. Inns, cottages, and summer houses were built to attract summer visitors, and community residents took in boarders (*www.nantucketchamber.org/visitor/history.html*; accessed March 2011). These activities tapered off during World War I, but began again in the 1920s with a new focus on the island's whaling history (MHC 1987). The 1900s also marked the end of sheep grazing, thus a reestablishment of shrubs throughout the island has occurred. Today, woodlands do occur on Nantucket, but in much less quantity than before European settlement.

Amanda Boyd/USFWS

Aerial view of Nantucket National Wildlife Refuge from Great Point Lighthouse

The last 100 years has also marked an era of land conservation on the island. The NCF owns and manages almost 8,900 acres of conservation lands, and TTOR owns and manages 1,117 acres of conservation lands. Many other conservation organizations exist on Nantucket and contribute to raising awareness and protecting declining coastal habitats and wildlife. These organizations include; Nantucket Land Bank Commission, Massachusetts Audubon Society, Nantucket Land Council, Maria Mitchell Association, and others. Together, these conserved lands protect (although not in perpetuity) a significant portion of Nantucket's coastal habitats and natural communities (see appendix G).

Current Conditions

General Climate Description

Nantucket Island is bound by Nantucket Sound to the north and the Atlantic Ocean to the south, resulting in a maritime-influenced climate which is characterized by warmer temperatures in the winter and cooler temperatures in the summer compared to mainland Massachusetts locations. On Nantucket Island, approximately 44 inches of precipitation fall annually, with almost half of the precipitation occurring from April through September (NCSS 1979). Average low temperatures range from 26 degrees Fahrenheit in January to 63 degrees Fahrenheit in July. Average high temperatures range from 40 degrees Fahrenheit in January to 78 degrees Fahrenheit in July (U.S. Weather Bureau). Average monthly water temperatures range from 32 degrees Fahrenheit in January to 75 degrees Fahrenheit in August (*http://www.nantucket.net/links/weather.php*; accessed May 2012). Prevailing winds are from the southeast, and are usually greatest in February (NCSS 1979).

Climate Change

Climate change is a significant concern to the Service and to our partners in the conservation community. Scientists are predicting changes in temperature, precipitation, soil moisture, and sea level, all of which could adversely affect vegetation and ecological systems. We expect that species ranges will shift northward or toward higher elevations as temperatures rise, but responses likely will be highly variable and species-specific. Under those rapidly changing conditions, migration, not evolution, will determine which species are able to survive (USFWS 2006). Species that cannot migrate will suffer the most. For example, plants, mussels, and amphibians are more vulnerable to shifts in temperature that may affect their ability to survive, grow, and reproduce.

Climate change impacts in coastal regions include a higher frequency of intense hurricanes and storms, more severe impacts of lesser-intensity storms, including nor'easters, warming ocean waters, and rising sea levels (Frumhoff et al. 2007). Sea level rise is one of the most potentially serious consequences of climate change for coastal ecosystems like Nantucket NWR. According to the USGS, sea levels have been steadily rising 1-2 millimeters (0.04 to 0.08 inches) per year since the 19th century (*http://geochange.er.usgs.gov/poster/sealevel.html*; accessed March 2011). This is a result of a reduction of ice caps, ice fields, and mountain glaciers, in combination with the thermal expansion of ocean waters. If sea level continues to rise, this could have serious impacts on coastal islands including Nantucket NWR.

The Intergovernmental Panel on Climate Change's (IPCC) most recent climate change report offers a range of estimates of sea level rise over the next century based on model projections under different emissions scenarios. With no likelihood attributed to any of these scenarios, the lowest estimate is 0.18 to 0.38 meters (7 to 15 inches) under the B1 scenario, and the highest estimate is 0.26 to 0.59 meters (10 to 23 inches) under the A1FI scenario (IPCC 2007). It is important to note, however, that these upper bounds do not represent the upper limit of potential sea level rise, because of limitations in knowledge for all of the drivers of sea level change.

Local impacts would be determined by whether the land is subsiding (lowering in elevation due to underground changes, e.g., ground water pumping) or uplifting, topography, and the presence of sea walls and other anthropogenic factors (Galbraith et al. 2002). In the Northeast, sea level rise is higher than the global average because of land subsidence, and parts of both Nantucket and Martha's Vineyard have been classified as areas of high vulnerability to sea level rise by the USGS. Coastal communities in Massachusetts such as Gloucester and Marshfield are predicted to lose more than 5 percent of their land area due to rising ocean waters by 2100 (TNC 2006). By the mid-1990s, Boston had already

seen an increase in mean sea level since 1950 by 5 to 6 inches, and was predicted to see another increase of 22 inches by 2100 (TNC 2006, EPA 1997).

These losses in coastal land area include intertidal, salt marsh, and drier coastal upland habitat, resulting in a decrease in feeding, resting, and breeding habitat for many coastal fish and wildlife species. These include many marine and coastal bird species, lobsters, and clams, commercial fish including menhaden (*Brevoortia tyrannus*), alewife (*Alosa pseudoharengus*), and herring (*Clupea harengus*), among other species (Frumhoff et al. 2007).

In recognition of this, Nantucket NWR was one of several coastal refuges in the northeast which underwent a SLAMM (Sea Level Affecting Marshes Model) analysis. SLAMM incorporates existing information (such as elevation data) and five processes that affect wetland fate (inundation, erosion, overwash, saturation, and accretion). The models then project potential coastal habitat changes correlated with sea level rise by 2025, 2050, and 2100. They included the IPCC A1B Mean and Maximum scenarios, as well as 1.0 and 1.5 meter sea level rise projections. In particular, the analysis highlighted significant findings for Nantucket NWR, and will enable the refuge manager to take steps to mitigate for any of the potential outcomes.

SLAMM analysis results were completed in February 2009, and indicate that the refuge will lose at least one-fifth of its dry land, and half of its land designated as ocean beach by the end of this century as a result of sea level rise associated with climate change (see table 3.1). The most extreme scenario presented a loss of 70 percent of the refuge's dry lands and almost 90 percent of its ocean beaches.

Table 3.1. Losses in Refuge Lands Characterized as Dry Land or Ocean Beach Under the Four Different Sea Level Rise Scenarios by 2100. Taken from Application of the Sea Level Affecting Marshes Model (SLAMM 5.0) to Nantucket NWR Report (Clough and Larson 2009).

Sea level rise by 2100 (meters)	A1B Mean Scenario 0.39	A1B Max Scenario 0.69	1 Meter Scenario 1.0	1.5 Meter Scenario 1.5
Dry Land (percent loss)	20	33	51	71
Ocean Beach (percent loss)	49	57	77	89

All scenarios predicted losses in land area by 2100. The tip of Great Point was the first to disappear in all of the scenarios, followed by intrusions to the east and west beaches by ocean water, until in all scenarios there was no more land designated as Ocean Beach on the western side of the refuge, and only a very small portion left on the eastern side by 2100. The lands designated as Ocean Beach that did remain became much more scattered and redistributed throughout what remained of the refuge in the model scenarios.

When using models, there can always be uncertainties in the results due to limitations in input data and knowledge of all of the components of an ecosystem. However, this does not mean that the use of models is uninformative, nor does it undercut their importance as tools to help with management decisions. It simply highlights the need to place the results in the appropriate context for decision-making. For Nantucket NWR, there was some known uncertainty because of poor resolution from a lack of accurate elevation data. Since no light detection and ranging (LiDAR) elevation data was available for the refuge, National Elevation Data (NED) was used instead which was based on a survey conducted in 1972. NED indicated that none of the refuge was over the 10-foot contour line, causing poor resolution of what was considered dry land on the refuge. For the model results, this means that the predictions in the losses of dry land could be refined with more accurate elevational input data. See appendix H for the report.

Nevertheless, this analysis provides us with some picture of what to expect in the next century, and provides an opportunity to begin to consider our options for management and mitigation of these potential outcomes. Ocean beaches are particularly vulnerable to sea level rise, and Nantucket NWR was considered even more so because of its low elevation (less than 10 feet above sea level). These results indicate that in the absence of any mitigation, much of the refuge habitat for beach-nesting birds will be lost.

Originally designed for coastal marshes, the SLAMM model does not adequately incorporate other oceanic processes, such as erosion and accretion (see the section on Coastal Geomorphology). Therefore, predicted shoreline changes are compounded by these additional factors and may not be fully comprehensive. However, given that the refuge is approximately 21 acres at the tip of a barrier beach system, these erosion and accretion patterns will likely affect the overall acreage and orientation of the refuge over time; it is likely that with a moderate increase in sea level, the refuge will be subject to heavy losses in acreage as predicted. As climate change becomes better understood, our ability to model climate change impacts increases; therefore the refuge will continue to look for opportunities to take advantage of the latest scientific advancements to aid in refuge management.

Air Quality

The Massachusetts Department of Environmental Protection (MA DEP) monitors levels of ozone and particle pollution from several stations in Massachusetts for attainment or exceedance of the National Ambient Air Quality Standards (NAAQS) set by the EPA. These standards are reviewed every 5 years by the EPA and may be changed due to new scientific information. It is incumbent upon each State to ensure these standards are met and maintained. In the case of an exceedance of these standards, pollution control strategies are implemented, and once the standards are attained, a plan is developed to maintain that standard in such a way that incorporates future economic and emissions growth.

Great Point Lighthouse

Elizabeth Wunker/USFWS

In 2008, Massachusetts was in attainment of the air quality standards for all pollutants except ozone. Ozone at ground level is a respiratory irritant that can reduce the overall function of the lungs, cause asthma attacks, and aggravate chronic lung diseases. It also inhibits vegetation growth, and is often found in higher concentrations far downwind from the origination of the precursors that react to form it (MA DEP 2009). Over the last decade, the State of Massachusetts has made progress in reducing the number and severity of ozone exceedances, and in January 2008 submitted a State Implementation Plan to the EPA that describes strategies to attain the 8-hour ozone standard by 2010 (MA DEP 2008a).

There are a total of 14 air quality monitoring stations across Massachusetts. Based on information collected from these sites, there were a total of 49 exceedances of NAAQS for ozone over 15 days in 2008. The closest two monitoring stations to the refuge are included in those that registered exceedances: Fairhaven, Massachusetts (4 days) and Truro, Massachusetts (3 days). Exceedances at a station averaged over 3 years can lead to a violation of NAAQS. Based on data from 2006 to 2008, both of these stations were in violation of the 8-hour ozone standard (MA DEP 2009).

Water Quality

Summary of the General Condition of Nantucket
Nantucket Island contains freshwater and saltwater wetland habitats including saltmarsh, intertidal flats, and ponds. The only source of fresh water is from precipitation and infiltration. Nantucket Sustainable Development Corporation recently examined ground water sustainability in a report "Sustainable Nantucket—A Compass for the Future." The report summarized three items necessary to maintain groundwater supply: the amount of water pumped out of the ground to use, the amount of rainfall, and groundwater level. In the past 10 years, only the amount of water being used has dramatically changed.

The EPA has designated Nantucket as a Sole Source Aquifer because there is no other alternative for drinking water if this aquifer should fail (*http://www.epa.gov/region01//eco/drinkwater/solenan.html*; accessed March 2011). This designation means that Federal funding will not be available for any project the EPA determines poses a threat to the water quality of the aquifer through recharge. The benefit of such a designation is an increased public awareness that there is only one source of drinking water for the entire community, and therefore the community may be more willing to protect it locally. Groundwater recharge is through precipitation events; Nantucket receives approximately 44 inches of water each year, 25 inches of which are recycled back to the atmosphere through evaporation and transpiration, 1 inch migrates overland becoming surface runoff, and the remaining 18 inches infiltrates into the soil, recharging the groundwater (*http://www.nantucketlandcouncil.org/WaterProt.html*; accessed March 2011).

The refuge consists of approximately 21 acres of barrier beach and dune habitat at the tip of the Coskata-Coatue Peninsula. It does not contain any fresh water, nor is it affiliated with any public wellfields on the island. It is surrounded on three sides by ocean waters.

Long-Term Trends and Status of Water Quality for Nantucket
In 2001, the Massachusetts Department of Public Health received Federal funding to begin monitoring marine beaches throughout the State. Any public or semi-public beaches are tested daily or weekly for Enterococci as an indicator organism for water quality throughout the bathing season. In the 2004 bathing season, 17 beaches in Nantucket were part of the marine beaches testing program. Six of these beaches recorded single sample exceedances of the standard (MA DPH 2005).

Biological assessments of water quality in 2000 had only one coastal embayment in the Nantucket Islands Watershed, Madaket Harbor, which was listed as supporting aquatic life. The other three salt pond/coastal embayments (Polpis Harbor, Hither Creek, and Long Pond) were reported as impaired for aquatic life. Fish consumption advisories were placed in effect for Tom Nevers Pond, Gibbs Pond, and Miacomet Pond. Great Point Pond, the closest inland waterbody to the refuge, was tested for shellfishing and primary and secondary contact recreation use (prolonged and accidental contact with the water, including swimming, wading, and boating) and was found supportive of all three. It was not assessed for aquatic life, fish consumption, or aesthetics (MA DEP 2003).

All surface waters subject to tidal influence within the Nantucket drainage area were classified as SA, or excellent habitat for fish, aquatic life, wildlife, and primary and secondary contact recreation (MA DEP 2003).

The waters immediately north of Nantucket, in Nantucket Sound, are designated as a No Discharge Area (NDA). This means that no boats may discharge any sewage, treated or otherwise, in these waters immediately adjacent to Nantucket Island. This designation is applied when a community or the State determines that an area is ecologically or recreationally important enough to warrant additional protection. These influxes of sewage from boats, even when treated, can discharge nutrients, chemicals, and pathogens into the water, increasing public health concerns as well as overall concern for water quality. Increased levels of nitrogen, a component of sewage, can have wide-ranging effects on waterbodies, including encouraging algal blooms, decreasing dissolved oxygen content, and increasing turbidity (or poor water clarity), which can all have impacts on the species reliant upon these coastal waters.

Water quality measures from 2006 and 2007 from 19 sampling sites throughout Nantucket Sound indicate a generally good condition for nitrogen (0.28 to 0.32 milligrams Nitrogen/liter), water clarity (using Secchi disk, 2.9 to 4.8 meters), and chlorophyll-a (2.4 to 4.9 micrograms/liter), though there was a gradient present with poorer results in the vicinity of the south shore of Cape Cod, particularly from Yarmouth to Chatham from land-based discharge. While these three water quality measures were within the range that supports high nitrogen-related water quality, there has been a yearly trend of increasing nitrogen input into Nantucket Sound, which is cause for concern (*http://www.nantucketsoundkeeper.org/water-quality-results.asp*; accessed March 2009).

State-reported Impaired Waters

In 2008, the DEP released the 305(b)/303(d) Integrated List of Waters (report; MA DEP 2008b). It combines both the 305(b) Water Quality Assessment and the 303(d) Report on Impaired Waters for each river basin. The DEP compiled those reports and submitted them to the EPA and Congress to satisfy the Federal reporting requirements under section (b) 305 of the Clean Water Act.

Much of the data in this report comes from a number of different third-party sources including Federal, State, and non-governmental agencies, as well as projects with State, local, or Federal funding that submit individual watershed reports. Though the sources of data are varied, they must all have a Quality Assurance Project Plan, use of a State certified lab, QA/QC for data management, and documentation in a citable report. This ensures they are all subject to the same documentation and validation procedures.

The report on impaired waters in the State describes segments of streams, lakes, and estuaries that exhibit violations of water quality standards, details the pollutant responsible for the violation(s), and the cause and source of the pollutant, if known. There were 174 impaired waters in the USGS HUC 0109002 watershed (including the Nantucket Islands Watershed). Of these, pathogens were the most-reported cause (122). In the Nantucket Islands Watershed (Martha's Vineyard, the Elizabeth Islands, and Nantucket), there were 18 waterbodies listed as impaired. Pathogens were the primary cause for impairment, but other impairments included nutrients, organic enrichment/low dissolved oxygen, other habitat alterations, turbidity, and noxious aquatic plants. There are no impaired water bodies on the Nantucket NWR. Nantucket waters that were listed as impaired were: Nantucket Harbor (pathogens, nutrients, noxious aquatic plants), Polpis Harbor (pathogens, nutrients, other habitat alterations), Sesachacha Pond (pathogens), and Gibbs, Miacomet, and Tom

Nevers Ponds (metals other than mercury) (*http://iaspub.epa.gov/tmdl_waters10/huc_rept.control?p_huc=01090002&p_huc_desc=CAPE%20COD*; accessed March 2011). There is a draft pathogen total maximum daily load (TMDL) for the Nantucket Islands Watershed and a nitrogen TMDL for the Nantucket Harbor Embayment System (*http://www.mass.gov/dep/water/resources/wqassess.htm*; accessed March 2011).

Submerged Aquatic Vegetation (SAV) as an Indicator of Water Quality
SAV is a critically important component of the aquatic environment in shallow coastal ecosystems, and its presence and robustness are indicators of good water quality. SAV can only thrive in shallow depths where light reaches the benthic zone. The rooted aquatic beds provide shelter and food for numerous aquatic invertebrates. SAV also recycles nutrients, helps to stabilize sediment, and oxygenates the water (*http://www.mass.gov/dep/water/resources/eelgrass.htm*; accessed March 2011).

SAV composition varies with salinity. In Massachusetts, the most common species is eelgrass (*Zostera marina*) along the coastline. The MA DEP began a program in 1995 to track and monitor changes in existing eelgrass beds to provide an indicator of water quality. Eelgrass is an ideal species because it is sensitive to nitrogen loading and to physical disturbance, and can be documented using aerial photos.

Head of the Harbor, located just a few miles southwest of Nantucket NWR is one of the sites used by the MA DEP Eelgrass Mapping Project. Measurements taken in 1995 and again in 2001 at Head of the Harbor showed a 38.1 percent decrease in acreage of eelgrass, from 408.9 acres down to 252.9 acres (*http://www.mass.gov/dep/water/resources/eelgrass.htm*; accessed March 2011).

The Regional Socioeconomic Setting

Socio-economic Factors: Regional

Nantucket County has the lowest population of any county in Massachusetts. At the time of the 2000 census, the population of Nantucket County was 9,520 (51.3 percent male and 48.7 percent female), which is about 0.15 percent of the entire population in Massachusetts. The median age was 36.7 years with 7,692 people over the age of 18 years and 1,000 people over the age of 65 years. The population has been steadily increasing since then. In 2009, the population estimate was 11,322, an increase of 18.9 percent since 2000 (*http://quickfacts.census.gov/qfd/states/25/25019.html*; accessed March 2011).

Nantucket Sustainable Development Corporation examined the stability of the local population on Nantucket Island in a report "Sustainable Nantucket—A Compass for the Future." It stated, "… most full-time residents of Nantucket have lived here for more than 10 years, and 28 percent of us have lived here for 20 years or more. Among full-time residents, 19 percent have lived here less than 5 years, and 18 percent have lived here 5 to 10 years. (*http://www.sustainablenantucket.org/wp-content/uploads/2010/06/Indicators_Final_Report.pdf*; accessed February 2011).

The peak season population on the island has increased 33 percent since 1990. Estimates of Nantucket's summer population range from approximately 50,000 to 60,000 people, not including shorter visits of one week or less (*www.nantucket-ma.gov/Pages/NantucketMA_Visitor/nantucketfacts.pdf*; accessed March 2011).

Table 3.2 illustrates the population changes over the last century.

Table 3.2. Population Change on Nantucket Island.

Year	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	2010
Population	3,006	2,962	2,797	3,678	3,401	3,484	3,559	3,774	5,087	6,012	9,520	10,172
Percent Change	–	-1	-6	+31	-8	+2	+2	+6	+35	+18	+58	+7

Economic Base

The median household income for Nantucket County in 2008 was $69,993. This was the fourth highest income in the State, exceeded only by Norfolk County ($80,944), Middlesex County ($78,040), and Plymouth County ($72,931) and is higher than the State average ($65,304). In 2000, the median household income was $55,522. A large portion of the income in Nantucket County is generated by tourism and construction of second homes.

The economy of Nantucket has evolved over time from the riches and ultimate economic crash associated with the harvesting of whales into an economy that is very dependent on tourism. The State of Massachusetts reports that in 2010 there were on average 5,704 jobs on the island. Over one-third of these jobs were in the tourism-related sectors of retail trade (14.6 percent) and Accommodations and Food Service (21.8 percent). Another ten percent of the jobs on the Island were in Construction, as a large percentage of the island's housing consists of secondary vacation homes. Employment on the Island is highly seasonal. The State reports that employment roughly doubled between January 2011 (5,077) and July 2011 (10,305), which reflects the increasing demand for goods and services from summer residents. The annual average unemployment rate has increased over the past several years to 7.8 percent in 2010, which is consistent with national trends. In 2011 unemployment on the Island ranged from a high of 15.3 percent in February 2011 to a low of 3.5 percent in August 2011. These statistics are reflected in Tables 3.3 and 3.4.

Table 3.3. 2010 Nantucket Average Employment and Wages.

Industry	Establishments	Total Wages	Average Employment	Average Weekly Wage
Total, All Industries	1,032	$259,842,085	5,704	$876
Construction	284	$32,367,978	566	$1,100
Manufacturing	16	$2,219,760	63	$678
Wholesale Trade	13	$2,599,050	51	$980
Retail Trade	164	$30,498,003	831	$706
Transportation and Warehousing	24	$10,508,447	215	$940
Information	11	$5,314,727	86	$1,188
Finance and Insurance	11	$5,553,851	59	$1,810
Real Estate and Rental and Leasing	62	$6,916,747	136	$978
Professional and Technical Services	60	$8,897,155	156	$1,097
Administrative and Waste Services	102	$19,818,840	428	$890
Health Care and Social Assistance	27	$26,671,207	472	$1,087

Industry	Establishments	Total Wages	Average Employment	Average Weekly Wage
Arts, Entertainment, and Recreation	26	$14,323,545	383	$719
Accommodation and Food Services	121	$37,400,288	1,244	$578
Other Services, Ex. Public Admin	81	$10,788,275	272	$763
Public Administration	15	$17,026,205	260	$1,259

Source: Executive Office of Labor and Workforce Development, State of Massachusetts. http://www.mass.gov/lwd/economic-data/. Accessed March 2012.

Table 3.4. Nantucket Laborforce, Employment, and Unemployment (not seasonally adjusted).

Month	Year	Labor Force	Employed	Unemployed	Unemployment Rate
12	2011	6,364	5,781	583	9.2
11	2011	6,522	6,030	492	7.5
10	2011	7,789	7,382	407	5.2
9	2011	9,138	8,730	408	4.5
8	2011	10,677	10,303	374	3.5
7	2011	10,717	10,305	412	3.8
6	2011	9,600	9,170	430	4.5
5	2011	7,651	7,189	462	6.0
4	2011	6,465	5,928	537	8.3
3	2011	5,942	5,134	808	13.6
2	2011	5,809	4,921	888	15.3
1	2011	5,986	5,077	909	15.2
Annual	**Year**	**Labor Force**	**Employed**	**Unemployed**	**Unemployment Rate**
Average	2010	7,876	7,260	616	7.8
Average	2009	7,820	7,284	536	6.9
Average	2008	8,441	8,166	275	3.3
Average	2007	8,551	8,354	197	2.3
Average	2006	8,412	8,218	194	2.3
Average	2005	8,138	7,940	198	2.4
Average	2004	7,840	7,643	197	2.5
Average	2003	7,691	7,496	195	2.5
Average	2002	7,469	7,324	145	1.9
Average	2001	7,118	7,002	116	1.6
Average	2000	7,289	7,181	108	1.5

Source: Executive Office of Labor and Workforce Development, State of Massachusetts. http://www.mass.gov/lwd/economic-data/. Accessed March 2012.

Land Type and Ownership Pattern
Over 40 percent of Nantucket Island (over 12,000 acres) is owned by conservation organizations (*http://www.umb.edu/nantucket/nantucket/*; accessed March 2011). The NCF is the largest landowner on Nantucket Island and owns almost 8,900 acres (*http://nantucketconservation.org*; accessed March 2011).

Refuge Revenue Sharing Payments

The Refuge Revenue Sharing Act of 1935, as amended, provides annual payments to taxing authorities, based on acreage and value of refuge lands. We have contributed refuge revenue sharing payments to the town of Nantucket since the refuge was established. Money for these payments comes from the sale of oil and gas leases, timber sales, grazing fees, the sale of other refuge system resources and from Congressional appropriations. The actual Refuge Revenue Sharing Payment does vary from year to year because Congress may or may not appropriate sufficient funds to make full payment, which it has not done since at least 1997. Payments are based on one of several different formulas, whichever results in the highest payment to the local taxing authority. In Massachusetts, the payments are based on three-quarters of one percent of the appraised market value. The purchase price of a property is considered its market value until the property is reappraised. The Service reappraises their properties every 5 years.

Table 3.5. Refuge Revenue Sharing Payments for Nantucket NWR from 1997-2010.

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Payment	$2,163	$1,910	$1,798	$1,683	$1,468	$1,499	$553	$531	$470	$531	$491	$475	$346	$244

Amanda Boyd/USFWS

Female common eider

Refuge Administration

Refuge Establishment and Land Acquisition

In 1973, we acquired what was then approximately 40 acres of land at the tip of the Coskata-Coatue Peninsula through the Act Authorizing the Transfer of Certain Real Property for Wildlife from the Coast Guard. Today, the refuge is approximately 21 acres (see Coastal Geomorphology section). The Coast Guard continues to maintain control of a less than one-acre inholding on the refuge that contains the Great Point Lighthouse.

The Eastern Massachusetts NWR Complex and Staffing

When the refuge was established, it was administered as a satellite of Parker River NWR in northeastern Massachusetts. In 1980, management was transferred to Great Meadows NWR, which is now part of the Eastern Massachusetts NWR Complex located in Sudbury, Massachusetts. We use the term "refuge complex" to describe two or more individual refuges, typically in the same region of a State or adjoining States, administratively combined under a single refuge manager's responsibility. Present staffing for the complex include 16 permanent positions, 12 located at the complex headquarters in Sudbury, 1 located at Assabet River NWR and 3 located on Monomoy NWR, 2 full time term biologists, 2 part time park ranger, and several seasonal biological technicians and interns. There is no permanent staff stationed on Nantucket NWR, however, complex biologists conduct site visits several times a year and a seasonal technician was present onsite in 2010 and 2011. The refuge manager is responsible for determining how to distribute staff time to accomplish priority work.

Funding

The funding for the Nantucket NWR is embedded in the budget for the entire refuge complex. Operational funding includes salaries, supplies, travel, and all other operational activities (wildlife and habitat surveys and management) that are not funded by special projects. Our annual funding fluctuates according to the number and size of the projects funded that year (e.g., vehicle or equipment replacement, visitor service enhancements, and facility improvements). Revenue sharing with TTOR and NCF from permits to access Coskata-Coatue Refuge and the refuge must be explored. This source of funds could support management through interpretive signs, a Service vehicle, law enforcement presence, seasonal staff, overhead costs for a visitor center, and/or assistance in maintaining facilities. The table below summarizes the levels of funding for the entire Eastern Massachusetts NWR Complex, including Nantucket NWR, in fiscal years 2007 through 2010.

Table 3.6. Fiscal Year Funding for the Eastern Massachusetts NWR Complex for 2007-2011.

	2007	2008	2009	2010	2011
Operations	$2,070,809	$2,181,898	$1,919,276	$2,124,250	$2,109,679
Construction	$2,898,619	$497,465	$4,560,000*	$2,022,800*	$227,302
Total Fiscal Year Budget	$4,969,428	$2,679,363	$6,479,276*	$4,147,050*	$2,336,981

**Includes ARRA funded projects, road work and construction of a new visitor center at the Assabet River NWR.*

Refuge Facilities and Maintenance

The facilities on the refuge are sand access "roads" and interpretive signs. Several portable restrooms are provided and maintained by TTOR. Under this CCP the Service will explore the establishment of additional facilities on the island to provide refuge staff with the resources needed to conduct business while on the refuge, as well as increase visitor awareness of the refuge and refuge staff.

Findings of Appropriateness and Compatibility Determinations

The following list represents the compatibility determinations that have been approved by the refuge manager and Regional Refuge Chief for Nantucket NWR:

- Environmental Education and Interpretation
- Wildlife Observation and Photography
- Recreational Fishing
- Research Conducted by Non-Service Personnel
- Commercial Guides, Tours, and Outfitting
- Outdoor Events and Ceremonies
- Non-Motorized Boat Landing and Launching

- Beachcombing
- Sunbathing and Swimming

See appendix B for the full compatibility determinations and associated findings of appropriateness for refuge activities. Appendix B also provides the analysis which finds several other activities, such as organized picknicking, camping, fires, and pets as inappropriate uses of the refuge. Chapter 1 describes these two processes. See also the discussion below on special use permits.

Partnerships

Since Nantucket NWR was established, we have combined our resources with others to form several outstanding partnerships. These partners have conducted research, and have played a critical role in monitoring wildlife and protecting wildlife habitat, and in engaging visitors through interpretation and educational programs. Some of these partners include MassWildlife and the Massachusetts Audubon Society. The Maria Mitchell Association is a relatively new local partner to the refuge. With a mission of promoting astronomy, science, and education on Nantucket Island, they offer unique collaborative research and public engagement opportunities.

Our most enduring partnerships involve TTOR and NCF, two non-profit organizations that have worked with the Service to provide access to the refuge and to manage and protect all of the Coskata-Coatue peninsula, particularly for the federally listed piping plover and State-listed least tern *(Sterna antillarum),* and their associated wildlife habitat. Both organizations are highly regarded on Nantucket and provide leadership in species conservation and habitat management.

All overland access to the Nantucket NWR is through the Wauwinet Gatehouse, which is approximately five over sand miles from Great Point. TTOR requires all vehicles to have an oversand permit to access their property and by default the refuge. The NCF owns the gatehouse through which access is granted for the entire Coskata-Coatue Peninsula, and partners with TTOR to staff the gatehouse. TTOR shares revenues collected from the sale of oversand vehicle permits with NCF. TTOR also monitor vehicular access to both properties by establishing driving routes and enacting closures when necessary due to the presence of nesting plovers and terns, and/or erosion.

Under a now-expired MOU with the Service, TTOR has monitored and protected wildlife and habitat on the refuge for many years. TTOR has and will to some degree continue to act as a liaison with the community by being an onsite point of contact, and by providing interpretive opportunities and educational programs to the public.

Community Outreach

Reaching out to the Nantucket community is a key aspect to informing the public about refuge management. Due to the lack of on-site staff, Service-based outreach is conducted primarily through the media. Newspaper articles inform the public about upcoming events, meetings, or CCP-related information. We maintain a refuge Web site and established a Facebook page in 2011. We are able to communicate through e-newsletters for refuge updates in the future.

Special Use Permits, Including Research

Special use permits are issued to individuals, organizations, and agencies that request the use of refuge facilities or resources beyond what is available to the general public through the visitor services program. In order to ensure that wildlife disturbance is minimized, each activity authorized by a special use permit must be an appropriate and compatible use of the refuge. Special conditions and restrictions are often imposed by the refuge manager in the

Amanda Boyd/USFWS

Visitors enjoying the refuge on a summer's day

issuance of a special use permit. Further details on special use permits are available from the refuge headquarters.

Refuge Natural Resources

Nantucket NWR is located at the very tip of the Coskata-Coatue Peninsula, in an area known as Great Point (map 3-4). This area encompasses both the refuge and parts of the adjacent TTOR land above the area known as The Galls. The refuge constitutes approximately 21 acres on the northernmost tip of the peninsula. A third conservation organization, the NCF, owns both the Coatue Wildlife Refuge and The Haulover, found south of TTOR's Coskata Refuge. Within the landholdings of these three organizations on Coskata-Coatue, there lies an extremely diverse assemblage of habitats, and though we focus on Nantucket NWR, we must incorporate discussion of these lands as well to provide the appropriate landscape context. Many species may be seen on or near the refuge, but in fact breed in habitats provided on these adjacent lands, and vice versa.

Soils—General Description

Two soil types were identified for the refuge, and 10 soil types were identified for the rest of the Coskata-Coatue Peninsula using the most recent data available according to the Web Soil Survey (NRCS, *http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm*; accessed March 2011). Of the two identified for the refuge, beaches are found along the perimeter of the refuge at the ocean's edge, while udipsamments are found in the interior. See tables 3.7 and 3.8 for descriptions of each.

Table 3.7. Nantucket NWR Soils.

Soil Type	Percent Slope	Drainage Class	Parent Material	Landform
Udipsamments, rolling	4 to 16	Not Available	Loose sandy eolian sands	Barrier beaches
Beaches	Not Available	Not Available	Reworked sandy beach sand derived from igneous and metamorphic rock	Not Available

Map 3-4. Coskata-Coatue Peninsula, Great Point and Nantucket NWR

Table 3.8. Coskata-Coatue Soils.

Soil Type	Percent Slope	Drainage Class	Parent Material	Landform
Udipsamments, rolling	4 to 16	Not Available	Loose sandy eolian sands	Barrier beaches
Beaches	Not Available	Not Available	Reworked sandy beach sand derived from igneous and metamorphic rock	Not Available
Pawcatuck mucky peat	0 to 1	Very poorly drained (non-saline to moderately saline)	Partly decomposed herbaceous organic material over loose sandy glaciomarine deposits	Marshes (marine)
Riverhead-Nantucket Complex	3 to 8	Well drained	Friable coarse-loamy eolian deposits over loose sandy glaciofluvial deposits derived from granite and gneiss	Outwash plains
Ridgebury variant silty clay loam	0 to 3	Poorly drained	Dense clayey lodgment till	Depressions
Plymouth-Evesboro complex	3 to 8	Excessively drained	Loose sandy ablation till	Moraines
Woodbridge variant loam	0 to 3	Moderately well drained	Friable coarse-loamy eolian deposits over dense fine-loamy lodgment till derived from granite and gneiss	Moraines
Berryland variant loamy sand	0 to 3	Very poorly drained	Loose sandy glaciofluvial deposits derived from igneous and metamorphic rock	Terraces
Medisaprists	0 to 1	Very poorly drained	Organic deposits	Bogs
Klej and Pompton soils	0 to 3	Poorly drained	Loose sandy glaciofluvial deposits derived from granite and gneiss and/or firm fine-loamy lacustrine deposits and/or firm fine-loamy marine deposits	Outwash plains

Refuge Habitat Types and Vegetation

Barrier Beach Dunes

Most of the refuge is characterized as barrier beach dunes, which includes the beach, berm, and dune system. Barrier beach dunes generally begin at the high water line and extend inland and upland. Dune systems vary in topography, elevation, and relative amounts and types of vegetation, and are greatly influenced by wind and wave energy. Barrier beach dunes are also found throughout the Coskata-Coatue Peninsula, and comprise a large portion of the edges of Nantucket Island. In 2010, a comprehensive vegetation survey was started (table 3.9). Many plants are still being identified to species and cross-referenced with the newest checklist of Massashusetts plants (Cullina et al. 2011). Efforts to correctly identify plants on the refuge will continue in future years, but a list of identified plants to date is below.

Table 3.9. Nantucket NWR Plant List.

Common Name	Scientific Name
Bayberry	*Morella pensylvanica*
Beach Heather	*Hudsonia tomentosa*
Beach Pea	*Lathyrus japonicus*
Dunegrass	*Ammophila breviligulata*
Japanese Rose**	*Rosa rugosa*
Poison Ivy	*Toxicodendron radicans*
Reindeer Moss	*Cladonia rangiferina*
Sea Rocket	*Cakile edentula*
Seabeach Knotweed	*Polygonum glaucum*
Seaside Goldenrod	*Solidago sempervirens*
Seaside Spurge	*Euphorbia polygonifolia*

Common Name	Scientific Name
Cyperus (genus unidentified)	*Cyperus*
Orach*	*Atriplex patula*
Tall Wormwood	*Artemisia campestris*
Jointweed	*Polygonum articulatum*
Poor-man's Pepper	*Lepidium virginicum*
Eastern Red Cedar	*Juniperus virginiana*
Sweet Everlasting	*Pseusdogaphalium obtusifolium*
Saltwort (Prickly or Carolina)	*Salsola kali*
Oenothera (genus unidentified)	*Oenothera*
Fireweed	*Erechtites hieracifolia*
Sea Chickweed	*Honckenya peploides*

** species introduced*
*** species introduced and invasive*

The barrier beach dune systems on coastal islands support a variety of birds. Beach berm habitat in general, between the high tide water line and the toe of the dunes, support nesting piping plovers, common terns *(Sterna hirundo)*, least terns, and American oystercatchers (*Haematopus palliates)*. Unfortunately, these species nest in beach habitat that is also desirable to summer tourists (on foot and OSVs), making them vulnerable to disturbance and reproductive failure. Conservation organizations on Nantucket Island work to protect nesting habitat according to Federal guidelines by seasonally closing nesting areas and minimizing disturbance.

Bill Thompson

Ruddy turnstone

Intertidal

Intertidal areas are found along the perimeter of the refuge, interfacing with the ocean, and encompass virtually all of the Coskata-Coatue Peninsula and Nantucket Island. Nantucket Island has approximately 28 miles of changing coastline, all of which is tidally influenced to some degree. The width of the intertidal area varies depending on the slope of the sand flats adjacent to the shoreline. Although little vegetation grows in most of the intertidal areas, this habitat is very rich as a result of daily tidal influence and renourishment. These intertidal habitats generally support a variety of invertebrates (e.g., soft shell clams and horseshoe crabs (*Limulus polyphemus*)), foraging birds (American oystercatchers and piping plovers), and marine mammals (gray (*Halichoerus grypus)* and harbor *(Phoca vitulina)* seals). Other species that benefit from these habitats that are found on adjacent lands include greater yellowlegs (*Tringa melanoleuca*), lesser yellowlegs (*Tringa flavipes*), sanderlings (*Calidris alba*), semipalmated sandpipers (*Calidris pusilla*), ruddy turnstones (*Arenaria interpres*), and short-billed dowitchers (*Limnodromus griseus*).

Invasive Plants

Non-native invasive species often out-compete native plants, reducing available food and habitat required by other native avian and mammalian species. No comprehensive survey of invasive plants has been conducted on the refuge due to a lack of staff time and availability of funds. The only documented invasive species to date are Japanese rose and sea poppy.

Coskata-Coatue and Nantucket's Contextual Landscape: Habitat Types and Vegetation

Wetlands

Wetlands on the Coskata-Coatue Peninsula include both freshwater and saltwater ponds, marshes, and swales. Each site has a unique species assemblage; therefore it is difficult to categorize them. However, there are some commonalities described below.

Saltmarsh

Saltmarshes generally occur in calm intertidal areas, but are some of the most productive ecosystems because of the amount of biomass associated with them. Salt and brackish marshes are located in the swales east of Coskata Woods at The Glades, and on the Coatue points. These habitats support a variety of salt-tolerant vegetation including: saltmarsh cordgrass (*Spartina alterniflora*), salt meadow grass (*Spartina patens*), spike grass (*Distichlis spicata*), black grass (*Juncus gerardi*), sea lavender (*Limonium latifolium*), saltmarsh aster (*Symphyotrichum subulatum*), seaside goldenrod (*Solidago sempervirens*), seabeach knotweed (*Polygonum glaucum*), and ladies' tresses, a native orchid (*Spiranthes*). Saltmarshes also serve as sources of algae, plankton, and small crustaceans as a result of daily tidal influence and renourishment, which in turn support a number of shorebirds and waterbirds. Many species use saltmarshes in the early stages of their life cycles before becoming large enough to leave for deeper waters. These species include mollusks, crustaceans, striped bass, and flounder. Saltmarsh habitat also provides rich feeding habitat for foraging shorebirds such as least sandpiper (*Calidris minutilla*). Wading birds such as great egrets (*Ardea alba)* will also feed in this habitat. In addition, species such as American oystercatcher, willet (*Tringa semipalmata),* and common terns will nest in slightly elevated patches of saltmarsh. There is no saltmarsh on Nantucket NWR. There are some freshwater marshes associated with the swales, and these habitats potentially support species including snapping turtles (*Chelydra serpentina*), painted turtles (*Chrysemys picta*), spring peepers (*Pseudacris crucifer*), and green frogs (*Rana clamitans*) (*http://nantucketconservation.org;* accessed March 2011*).*

Ponds and Wetlands

There are several ponds on the Coskata-Coatue Peninsula, although there are none on Nantucket NWR. The Great Point Lagoon and Coskata Pond are two of the largest. Great Point Lagoon is approximately 40 acres, and the Coskata Pond and associated wetlands (The Glades) total approximately 300 acres. These habitats support a variety of flora including many of the saltmarsh species listed previously, as well as sea-blite (*Suaeda calceoliformis*), lady's thumb (*Polygonum persicaria* L.), fall panic-grass (*Panicum dichotomiflorum*), and saltmarsh fleabane (*Pluchra odorata*). Great Point Lagoon undergoes fluctuations in salinity, and therefore species composition is subject to change, and it has reduced in size in recent years. This area also supports peatlands. Various fauna rely on these wetlands including terns, gulls, herons, egrets, and osprey (*Pandion haliaetus*).

Freshwater ponds and wetlands support feeding, resting, and nesting birds such as American black duck, belted kingfisher (*Ceryle alcyon*), mallard (*Anas platyrhynchos*), and red-breasted merganser (*Mergus serrator*). They also provide fresh water for drinking and preening and are utilized by species such as terns and gulls. Amphibians and reptiles potentially found in these habitats include snapping turtles, painted turtles, green frogs, and spring peepers (TTOR 2001, *http://nantucketconservation.org;* accessed March 2011).

Maritime Hardwood Forests

Hardwood forests are limited on Nantucket Island, with the largest concentrations occurring on the northeastern portion of the island. Maritime forests grow on dry, upland soils, and are surrounded by salt water influences (marsh, pond, harbor, ocean) and sand dunes. Coskata Woods represents one of the only woodlands on the Coskata-Coatue Peninsula, and one of the only

woodlands left intact through European settlement on Nantucket. Having survived the land clearing during Nantucket's initial period of settlement starting in 1659 and beyond, a local law was passed in 1711 that prevents its cutting.

Today, it is a mature stand of white (*Quercus alba*) and black (*Quercus velutina*) oak, with occasional eastern red cedar (*Juniperus virginianus*), and tupelo (*Nyssa*), spanning approximately 60 acres. Subject to salt spray, these trees are twisted and stunted in growth and appearance. The understory varies due to moisture and substrate, but is primarily characterized by beaked hazelnut (*Corylus cornuta*), sweet pepperbush (*Clethra alnifolia*), arrow-wood (*Viburnum dentatum*), poison ivy, and swamp azalea (*Rhododendron viscosum*). Other species found in these woods include a diverse invertebrate community. Leaf beetles and caterpillars, lynx spiders, lace wings, ladybird beetles, ground beetles, and saltmarsh mosquito are common. Birds seen associated with these woodlands include barn swallow (*Hirundo rustica*), tree swallow (*Tachycineta bicolor*), red-tailed hawk (*Buteo jamaicensis*), American crow (*Corvus brachyrhynchos*), kestrel (*Falco sparverius*), osprey, northern harrier (*Circus cyaneus*), and summer tanager (*Piranga rubra*). White-tailed deer and a variety of small mammals are also found in these woods (TTOR 2001). There is no forest on Nantucket NWR.

Eastern Red Cedar Savanna
TTOR's Coskata-Coatue Wildlife Refuge contains the largest stand of Eastern Red Cedar Savannah in New England, at over 400 acres, which is known locally as "The Cedars." The stand grows on a Holocene deposit and has been shaped by past land uses, including fire and grazing. Species associated with TTOR's Red Cedar Savanna include common hairgrass (*Deschampsia flexuosa*), red fescue (*Festuca rubra*), and prickly pear cactus (*Opuntia humifusa*). In addition, species like black oak, black cherry (*Prunus serotina*), and beach plum (*Prunus maritima*) also grow within this stand. These woods also support many of the species listed under Coskata Woods (TTOR 2001).

Special Status Plants

Though no comprehensive surveys have been conducted, Seabeach knotweed (*Polygonum glaucum*) was identified on the refuge in 2009. Seabeach knotweed is listed as a species of special concern in Massachusetts.

On the Coskata-Coatue Peninsula, there are several additional species of rare plants. These include the eastern prickly pear cactus (State-listed endangered), oysterleaf (*Mertensia maritima*, State-listed endangered), and American sea-blite (*Suaeda calceoliformis*, State-listed special concern).

Unique and Significant Natural Plant Community Types on the Surrounding Nantucket Landscape

According to the Massachusetts BioMap program, the Coskata-Coatue Peninsula and other Nantucket Island coastal beaches contain a Maritime Dune Community, listed as Imperiled, and a Maritime Juniper Woodland/Shrubland which is listed as Critically Imperiled. The Maritime Dune Community supports all three Massachusetts' populations of prickly pear cactus, two of the best populations of American sea-blite, and the globally rare Seabeach knotweed. This habitat is important for beach-nesting birds such as American oystercatcher, common terns, the federally protected piping plover, and State-listed least tern. The Maritime Juniper Woodland/Shrubland is a small but high quality evergreen community within the salt spray zone. This means that the trees are typically short, not exceeding 15 feet, and scattered, creating openings for a variety of herbaceous and shrubby species (MA NHESP 2004). There are no unique or significant natural plant communities on the refuge itself.

Nantucket has several key conservation organizations with significant land holdings on the island and surrounding coastal areas. These parcels conserve large acreages representative of Nantucket's habitats and rare communities listed above. These key parcels are listed in detail in appendix G.

Refuge Biological Resources

Federally Listed Endangered or Threatened Species

Piping plovers (federally listed as threatened) occasionally use the refuge to nest during the breeding season, though in small numbers. Roseate terns *(Sterna dougalii;* federally listed as endangered) use the refuge for staging before and after the breeding season.

Birds

Coastal islands are particularly important for nesting shorebirds and seabirds, and migrating songbirds, seabirds, and shorebirds during north- and southward migrations. Though Nantucket NWR is small and is comprised mainly of dune and beach habitat, it is part of a larger context of conserved lands within the Atlantic Flyway. The Service alone has refuges associated with Cape Cod (Monomoy and Mashpee NWRs), and coastal islands south and southwest of Cape Cod including Nantucket NWR, Nomans Land Island NWR, Faulkner Island (Steward B. McKinney NWR), and Block Island NWR. In past years, bird monitoring on Nantucket NWR has focused on beach-nesting species including piping plovers and terns. Annual surveys and monitoring of nesting attempts have been conducted by TTOR. In 2010 and 2011, a biological science technician staffed the refuge (late May to mid-September in 2010, late April to early November in 2011) and conducted comprehensive wildlife surveys of all birds using the refuge.

The refuge is located at the tip of the Coskata-Coatue Peninsula, on what is known as Great Point, the area north of the narrow sand bar called The Galls. Because Great Point includes both the refuge and TTOR land, it can be difficult at times to distinguish between the two when referring to reports. For the purposes of the discussion below, reference to Great Point will be inclusive of both the refuge and TTOR property.

Shorebirds

Piping plover and American oystercatcher are two species of shorebirds of conservation concern which occasionally use the refuge. Though numbers are consistently low on the refuge, piping plovers and American oystercatchers have regularly nested on Great Point (off of the refuge) and the rest of the Coskata-Coatue Peninsula for decades. TTOR has been managing piping plover habitat on the refuge since 1982. In 2001, a Section 7 evaluation was completed to initiate management of piping plover according to the 1994 piping plover Federal guidelines. Since then, TTOR in conjunction with the Service has established symbolic fencing in early April, and initiated beach closures for piping plover.

Amanda Boyd/USFWS

American oystercatcher with band

Since record keeping began (in 1983) for piping plovers on Great Point, numbers of nesting pairs have ranged from zero (1999) to a high of 12 (1996). In the years 1996 and 2006, there have been nesting pairs on the refuge. In 2007, there was a pair on the refuge displaying territorial behavior by May 28, however, no nest was ever found and the birds were no longer seen after June 12. In 2008, no piping plovers nested on Great Point for the first time since piping plover management began. Of the entire Coskata-Coatue Peninsula, there were a total

of eight piping plover nests monitored that fledged five chicks in 2007. In 2008, a total of four chicks fledged from the three piping plover nests monitored (Melvin 2006, Melvin 2007, USFWS undated, TTOR 2007, TTOR 2008). In 2010 and 2011, no piping plovers nested on Nantucket NWR, but a pair was scraping and exhibiting territorial behavior through the end of May in 2011. Only a few piping plovers were seen foraging in September (USFWS unpublished data).

American oystercatchers have also been regular nesters along the beaches of Coskata-Coatue. Since 2005, TTOR has collaborated with The City University of New York to band individuals each year. This is contributing to a better understanding of American oystercatcher dispersal, migration, survival, and recruitment in the Northeast. In 2007, there were 16 breeding pairs on TTOR property, with two re-nests and five chicks fledged. In 2008, there were 13 breeding pairs on TTOR and private property, with one fledged chick (TTOR 2007, 2008). In 2010 and 2011, no American oystercatchers nested on the refuge but one pair exhibited courtship and territorial behavior for multiple days in June (USFWS unpublished data).

The consistently low numbers of nesting pairs and variable nest success and fledging rates of these shorebird species are cause for some concern. This may be due to any number of factors, but habitat, human disturbance including OSV use, and predation are three that need further investigation. While TTOR has managed beach vehicle access and has erected symbolic fencing to prevent human nest disturbance, they did note the failure of two American oystercatcher nests within a day following the unauthorized presence of dogs in close proximity to the nests. They have also noted nest failures due to predation. An active great black-backed gull (*Larus marinus*) colony on Great Point in 2008 was estimated to have had 200 nesting birds, and similar estimates were posited for the herring gull colony as well. One confirmed rat den on The Galls was located, with an additional two locations suspected (TTOR 2008). These dens represent additional sources of potential nest predation, and continuing threats to shorebird nest success in the future.

The refuge and other areas of the Coskata-Coatue Peninsula provide resting and staging habitat for shorebirds during migration as well. Casual observations of larger numbers of American oystercatcher in late summer seem to indicate that the Coatue property owned by NCF may provide important staging habitat for them prior to fall migration (S. Koch, personal communication, 2010). Other shorebirds including sanderlings (*Calidris alba*), semipalmated sandpipers (*Calidris pusilla*), black bellied plovers (*Pluvialis squatarola*), semipalmated plovers (*Charadrius semipalmatus*), and ruddy turnstones (*Arenaria interpres)*, have all been observed using the refuge during migration. Sanderlings are the most common shorebird species during fall migration and a high count of approximately 300 was recorded at one time on the refuge in early October, 2011 (USFWS unpublished data).

Seabirds

The BCR 30 plan identifies several species of seabirds of conservation concern found on the refuge. Common and least terns, two State-listed species, are regular breeders along the refuge and adjacent beaches, and use the refuge as a staging site prior to migration. Historically, Great Point has been the site of one third of Massachusetts' breeding least terns (TTOR 2001). Since 1978, numbers of least tern pairs have fluctuated on Great Point, ranging from zero in 1991, to over 1,000 in 2 consecutive years (1996 and 1997; USFWS undated).

Stephanie Koch/USFWS

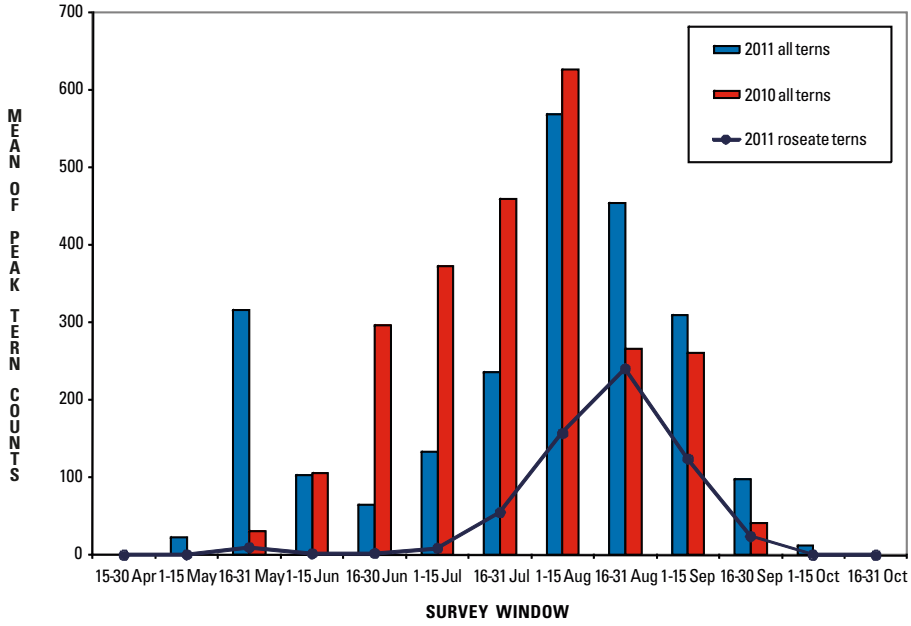
Common tern

In 2005 and 2006, least terns nested on the refuge, hatching 4 and 2 hatchlings, respectively. In 2007, least terns attempted to nest at 4 locations in total; 3 on Great Point and 1 at The Galls. The third nesting attempt consisted of 60 nests at the tip on the refuge. The fourth attempt was initiated in the last week of July with a total of four nests, and was in association with common and roseate tern adults with young. Both the third attempt at the tip of Great Point and the final attempt during the 2007 season on The Galls were destroyed by gulls (TTOR 2007). In 2008, 73 nests were counted in a colony located at The Galls. Eventually, this colony was depredated, and another nesting attempt was initiated on Great Point with 13 nests. This second attempt resulted in three fledged chicks (TTOR 2008). In 2010 and 2011, no least terns nested on the refuge but a small number of birds were observed scraping on multiple days in late May in 2011 (USFWS unpublished data).

Common terns are often found on Great Point in lower numbers, ranging from 1 nesting pair in the early 1980s and again in the early 1990s up to 35 nesting pairs in 1996. In 2007, 1 common tern pair nested in The Glades, and in 2008, 1 nesting pair was located at Great Point, but was depredated. They also use the refuge as a staging area prior to fall migration, along with many other species of terns that congregate in the months of July, August, and September. Daily counts of staging terns frequenty are in the hundreds, and include common, least, roseate, and black terns *(Childonias niger)*. In 2008, informal counts of 280 to 500 staging terns were documented on Great Point daily through the end of August (TTOR 2008). In 2010 and 2011, the very northern tip of the refuge was used extensively as a staging area for common and roseate terns. Tern use was recorded through standardized surveys consisting of systematic counts refugewide, as well as high counts. Standardized surveys are still being analyzed, but daily high counts were averaged over 2-week periods to display seasonality of use in 2010 and 2011 on Nantucket NWR. In 2010, roseate terns were not often identified to species, thus this information is not displayed for 2011.

In general, Nantucket NWR is utilized more during the post-breeding staging period than the pre-breeding staging period, although several hundred birds were using the refuge during the last two weeks of May in 2011. In 2010, regular counts weren't initiated until the last week of May, and this may account for the lower averages that year. We would expect numbers to be lowest during June and the first half of July when most terns are nesting at other sites, but in 2010, we did have large numbers of terns copulating (and some scraping) during the breeding season. During the post-breeding period in both years, numbers of staging terns (all species combined) peaked during the first half of August, but numbers of roseate terns appear to have peaked during the second half of August in 2011 (USFWS unpublished data).

Figure 3.1. Tern Numbers on Nantucket NWR in 2010-2011.



Arctic terns (*Sterna paradisaea*) and roseate terns are two species that are much rarer on Great Point. Roseate terns were historically common breeders along the Massachusetts coast, typically found among common tern colonies on Nantucket Island and Muskeget Island. Originally reduced in number by the plume industry of the late 1800s, the species recovered slightly during the 1900s, but are today in decline due to displacement by gull colonies (MA DFG 2006). As a result, roseate terns are both federally listed and State-listed. Arctic terns, another State-listed species, are at the southernmost extent of their distribution in Massachusetts, and therefore do not occur in large numbers in the State. They have occasionally bred on Great Point; records show 1 nesting pair in 1982, 1993, and again in 1995 (USFWS undated). In 2010, no roseate terns nested on the refuge, but the very northern tip of the refuge was used extensively as a staging area (see above numbers for total terns).

A colloborative study led by USGS involves color-banding and resighting birds to learn more about regional survival and movement throughout the Gulf of Maine. Over 1000 color-banded roseate terns have been resighted at Nantucket NWR in 2010 and 2011, and analyses are still ongoing to determine the relative importance of Nantucket NWR amongst other staging sites. In the 10-year comparison of annual colonial bird surveys for Coskata-Coatue, herring gull (*Larus argentatus*) counts were 278 in 1994-95, and 374 in 2006-07. Great black-backed gull counts were 814 in 1994-95, and 654 in 2006-07 for the same location (S. Melvin, personal communication, 2010). According to TTOR (2007, 2008), Great Point serves as a prime nesting area for great black-backed and herring gull colonies. These gull numbers are increasing and they may be attempting to expand into new nesting areas. Coskata-Coatue is the site of the largest great black-backed and herring gull colonies on Nantucket (*http://nantucketconservation.org;* accessed March 2011*)*. Laughing gulls (*Leucophaeus atricilla*) were also seen on Coskata-Coatue beaches prior to migration (TTOR 2007).

Waterfowl

While the refuge does not support habitat for waterfowl, many waterfowl species can be found in the diverse habitats on adjacent lands, and in the nearshore waters of the refuge. Open ocean habitats and nearshore waters provide rich foraging habitat for seaducks. Bays and inlets provide shelter during high winds and seas. Five of these waterfowl species are of conservation concern and are

listed below in table 3.8 with their conservation tiers based on the 2007 BCR 30 plan. The MA CWCS lists the American black duck as an at-risk breeding species and a species of management concern.

American black ducks, the waterfowl species of greatest concern, may be nesting in areas adjacent to the refuge. They are fairly common in the Great Point Lagoon and at Coskata Pond in the Glades on TTOR property. The limited surveys available from which to obtain count or abundance data make it difficult to estimate how many individuals use the refuge or surrounding habitat during the breeding season.

During the winter, on the other hand, large rafts of waterfowl can be seen in the lakes and ponds on the island, or just offshore. Working collaboratively, the Service and MassWildlife conduct aerial mid-winter inventories in January that have resulted in overwinter counts for mallard (*Anas platyrhynchos*), American black duck, scaup species (*Aythya* spp.), common goldeneye (*Bucephala clangula*), bufflehead (*Bucephala albeola*), canvasback (*Aythya valisineria*), long-tailed duck (*Clangula hyemalis*), scoter species (*Melanitta* spp.), Atlantic brant (*Branta bernicla*), common eider (*Somateria mollissima*), merganser species, Canada goose (*Branta canadensis*), and mute swan (*Cygnus olor*). For most of these species, these counts seem to be highly variable from year to year (see table 3.10), and may represent fluctuations in statewide populations, or simply shifting population centers around the Cape Cod area. These counts provide information on regional waterfowl abundance and can indicate regional population changes over time.

Common eiders, in particular, are extremely abundant in the ocean waters off Massachusetts. They are a species that typically breed farther north, in Labrador south to Maine, but have recently been found nesting on islands off the coast of Massachusetts. During the winter, they congregate in the bays, estuaries, and open ocean environments along the Massachusetts coast; the largest grouping is centered in Nantucket Sound (MA DFG 2006). They feed in waters 6 to 25 feet deep, and their most important food item during the winter (and throughout year) is the blue mussel (*Mytilus edulis*), which is a boreo-temperate species common in North- and Mid-Atlantic waters (MA DFG 2006, USFWS 1989). Common eiders also frequently loaf on the shores of Nantucket NWR and adjacent beaches.

Table 3.10. BCR 30 Priority Waterfowl Species and Survey Results from the Mid-winter Waterfowl Surveys Conducted Annually by the Service and MassWildlife. These results reflect counts from Nantucket Island and surrounding waters.

	BCR 30 Rank	2005	2006	2007	2008	2009
Mallard	High	10	127	318	98	12
American Black Duck	Highest	422	326	896	596	391
Scaup spp.	High	315	265	120	6	0
Common Goldeneye		430	882	50	680	17
Bufflehead		612	260	273	400	94
Long-tailed Duck		931	536	15		7
Scoter spp.		126	677	4,377	1,358	485
Common Eider	High	11,893	4,624	2,765	57,210	125
Merganser		152	591	742	569	14
Canada Goose		181	312	47	89	26
Atlantic Brant	Highest	106	35	211	30	148
Swan spp.		9	27	13	8	0
Misc.					31	

Occasionally, seaduck carcasses will wash up on the refuge, sometimes in large numbers, and these occurrences can be indicative of a large mortality event, or localized die-off. Common eiders especially seem vulnerable to epizootic diseases, perhaps due to their densely populated breeding colonies and large offshore overwinter populations (MA DFG 2006). When possible, refuge biologists record these mortality events when they are observed during site visits and report them to SEANET (Seabird Ecological Assessment Network). This is a collaborative program reliant upon volunteers that endeavors to track mortality events in seaducks and other coastal and marine birds to investigate causes of mortality and threats to these species. The program also endeavors to establish a baseline of normal mortality, based on wash-ups, so that when there are mortality events a comparison can be made.

Songbirds
There have been no comprehensive avian surveys on the refuge. The savannah sparrow (*Passerculus sandwichensis*) is listed as a moderate priority species of conservation concern in BCR 30 and they are a common grassland generalist species that can also be found in coastal openlands. They are one of several species that feed in the dune habitats along Coskata-Coatue (*http://nantucketconservation.org;* accessed March 2011*).* In mid-September 2010, a large group of tree swallows (*Tachycineta bicolor*) was recorded on the refuge. During one of the wildlife surveys, approximately 1,700 tree swallows were recorded in the dunes of the refuge.

Raptors
No comprehensive raptor surveys have been conducted on the refuge and no nesting raptors have been documented. Adjacent TTOR lands do provide raptor nesting habitat, particularly for northern harrier and osprey, and occasionally some individuals will be seen foraging on the refuge.

During migration, however, raptors are a little more common on the refuge, and species including peregrine falcon (falco peregrinus)and merlin (falco columbarius) are observed. Also, short-eared owls (*Asio flammeus*) and bald eagles (*Haliaeetus luecocephalus*) are reportedly seen on the refuge for brief periods during the winter.

Fish and Other Aquatic Species

Numerous saltwater fish species have been identified in Nantucket Sound and the Atlantic Ocean in New England. This information was derived from the Division of Marine Fisheries Trawl Surveys, 1978-1999 (Arnold Howe, Senior Marine Fisheries Biologist, 50A Portside Drive, Pocasset, MA 02559).

Mollusks and Crustaceans
While no surveys have been conducted on the refuge, a variety of aquatic invertebrates are found in the intertidal and deep waters on and around the islands of Nantucket County.

Mammals
Though no comprehensive terrestrial mammal surveys have been conducted, there are not many mammal species other than seals that are likely on the refuge. Evidence of feral cats and rats have both been documented widely on adjacent lands, as well as ocassionaly on refuge lands. These species are not native to the island, but are species that are typically associated with humans. They can have a serious impact on wildlife, and are documented nest predators of some of the beach-nesting species that use the refuge, including terns and the piping plover.

In recent years, Great Point has become a haul-out site for gray seals. Gray seals were found along the northwestern Atlantic coast until the 17th century, and were considered locally extinct until the 1980s (see Wood 2009 for detailed

Tom Eagle/USFWS

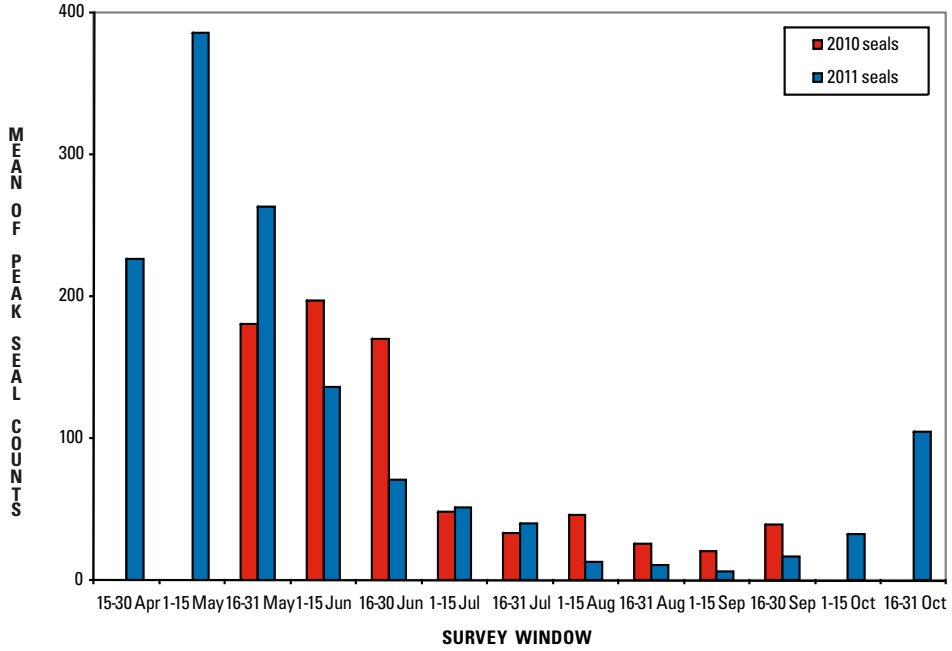
Gray seal pup

accounts of seal numbers). While their pupping grounds are historically further north on Sable Island and in the Gulf of St. Lawrence in Canada, there has been a year-round breeding population around Cape Cod and associated islands since the late 1990s. In fact, Muskeget Island and the associated shoals supports the largest breeding population of gray seals in the U.S. and represents one of only two sites in Massachusetts where gray seals pup. The other site is Monomoy NWR. Though there is currently no estimate for the U.S. population, surveys conducted since their arrival in the 1980s indicate a steady increase in abundance in both Maine and Massachusetts, though it is unclear if this is due to population expansion or immigration (Waring et al. 2009). Even if the US population is truly increasing, the increase in seal numbers on the refuge may not reflect the degree of increase in the entire seal population; seals are using many other sites throughout the northeast and surveys need to encompass all these areas to accurately reflect changes in the US population.

A dynamic small closure that was established in 2008 to protect visitors from the seals and the seals from visitors has been maintained by TTOR and the Service generally year-round, when seals are present. The closed area expands and contracts as seal use changes. Seal use was recorded through standardized surveys consisting of systematic counts refugewide, as well as high counts, in 2010 (May–September) and 2011 (April–October). Standardized surveys are still being analyzed, but daily high counts were averaged over 2-week periods to display seasonality of use in 2010 and 2011 on Nantucket NWR. Generally seal numbers are lowest in July and August, and begin building in the early fall through the winter. Service staff are not onsite regularly in the winter time, but TTOR does conduct period counts and seal numbers are generally variable from day to day. Numbers of seals are generally consistently high again in the spring.

A small numbers of gray seals also give birth to pups on Nantucket NWR and adjacent property. Nantucket NWR has also recently been added to the flight path for regionwide aerial seal surveys conducted by NOAA, and this information will be helpful in tracking importance of this site to pupping.

Figure 3.2. Seal Numbers on Nantucket NWR in 2010-2011.



Seals are food generalists and will consume a wide variety of prey items, focusing on abundant species. Ampela (2009) conducted a long-term diet study of seals in the northeast and found that sand lance (*Ammodytes*) was the most dominant prey item by weight (53 percent). Sand lance combined with winter flounder *(Pseudopleuronectes americanus)*, hake (*Urophycis* spp.), and Atlantic cod *(Gadus morhua)* accounted for 82 percent of seal diet by weight. Smooth skate *(Malacoraja senta)* and alewife *(Alosa pseudoharengus)* were also important diet items. There is no specific diet information for seals that are using Nantucket NWR as a haul-out site. Instances have occurred in which a seal will take, or attempt to take, fish off the line of an angler. However, there is no conclusive information regarding the prey items Nantucket seals are feeding on. USFWS staff collected seal scat on Nantucket NWR in 2011, but they have not yet been analyzed.

Reptiles and Amphibians

There are no known reptiles or amphibians associated with the refuge. The reptiles and amphibians that occur in the freshwater ponds and bogs throughout Nantucket include: snapping turtles, painted turtles, spotted turtles, spring peepers, green frogs, and northern water snakes (*Nerodia sipedon*) (*http://nantucketconservation.org;* accessed March 2011*)*. A preliminary snake cover board study completed in 2007 throughout Nantucket Island and Tuckernuck Island identified the presence of eastern garter snake (*Thamnophis s. sirtalis*), northern ring-necked snake (*Diadophis punctatus edwardsii*), eastern milk snake (*Lampropeltis t. triangulum*), ribbon snake (*Thamnophis s. sauritus*), and smooth green snake (*Opheodrys vernalis*). Out of five study sites on the island of Nantucket, the closest two to the refuge were located at Coskata Woods and Wyers Point, and these sites yielded eastern garter snake and smooth green snake, respectively (Smyers 2008).

Invertebrates

Mosquitoes, greenheads, and horseflies can all be found on the Coskata-Coatue Peninsula (TTOR 2001), as can butterflies and dragonflies (species unknown; E. Wunker, personal communication, 2010).

Refuge Visitor Services Program

Priority Wildlife-Dependent Recreational Uses

Nantucket NWR is a common destination for recreation on Nantucket Island. Of the six priority wildlife-dependent, recreational uses on NWRs, five—fishing, wildlife observation and photography, and environmental education and interpretation—all occur on the refuge. Only hunting does not occur on the refuge. The refuge is open year-round to pedestrians and oversand vehicles (OSV). There are generally seasonal closures on parts of the refuge to either pedestrians or vehicles to protect nesting piping plover habitat, least tern nesting sites, staging terns, and/or seal haul-out sites.

Because of the distance from the Wauwinet Gatehouse to the point, OSV use is permitted on portions of the refuge when public access is allowed. The refuge is most often accessed through the Coskata-Coatue Wildlife Refuge, although occasionally visitors arrive by boat or by foot. Vehicular access to Coskata-Coatue is limited to those who have purchased TTOR over sand permits, which are required year round and are valid from April 1 to March 31. Pedestrians can walk to the refuge without purchasing an over sand permit, but it is about a 5 mile walk to the tip from the Wauwinet Gatehouse, which is beyond most people's abilities or interest to undertake. Vehicular access to the refuge is not available when TTOR closes the Galls to protect unfledged piping plovers.

Located within the refuge is a half-acre inholding owned by the Coast Guard that contains the Great Point Lighthouse. At the lighthouse is a small parking area. Portable restroom facilities are provided by TTOR, which also maintains the lighthouse through a management agreement with the Coast Guard.

There is a permanent "entrance" sign south of the lighthouse on the southern boundary of the refuge, and several official boundary signs are located along the western and southern boundary; otherwise there is no discernable demarcation between TTOR and Service properties. Other signs on the refuge are temporary and signify beach closures due to seals or shorebirds.

The refuge is particularly attractive to anglers and has been considered a premier destination on the island for its bluefish and striped bass. Ardent anglers surfcast for bluefish and striped bass in May and June. In the summer, bluefish are a great attraction to tourists. Striped bass come by the refuge beginning in August during their fall migration and are a major attraction. Fishing for stripers as well as the occasional false albacore and bonita continues into the fall. Albacore and also Spanish mackerel are more commonly fished on the sound side of the Coskata-Coatue peninsula. (S. Nicolle, personal communication, 2012) The Nantucket Anglers Club hosts the annual "Cranny" Cranston Beach Bluefish Tournament each October; Great Point is a major destination for this tournament. For decades, anglers had been able to access "the rip" which is located at the tip of Great Point, on the eastern side of the refuge. The rip currents that extend right off the Point make it very easy for shore-based anglers to target striped bass and blue fish during their seasonal runs. This section of the refuge has long been considered by anglers as the primary destination for surf-fishing, although considerable numbers of anglers fish on the refuge's western beach as well as along the Atlantic Ocean and on the sound side on TTOR's both sides of the Coskata-Coatue peninsula. Since 2008, however, symbolic fencing has been erected at the seal haul-out site on the tip to ensure visitor protection and to comply with the Marine Mammal Protect Act. Currently, seals are utilizing the closed area much of the year. This closed area has also served as a seasonal staging area for common and roseate terns. Because our primary mission is to protect wildlife and its habitat, Service staff are obligated to maintain seasonal adaptive closures, even if and when this makes some areas unavailable to anglers. We recognize the challenges and frustration this represents to the angling community. Although unrestricted access to the refuge has not been authorized

in recent years due to wildlife management priorities, we are committed to providing as many angling opportunities on the refuge as possible when and where appropriate.

Although fishing has historically been the primary recreational use of the refuge, in recent years there has been a shift in visitor use. Some visitors come to the refuge just to be at the very tip of Nantucket Island. The beach itself attracts many visitors, as does the Coast Guard lighthouse. Many visitors now come to the refuge to look at the seals and birds. They also participate in interpretive programs which are primarily conducted by TTOR or the Maria Mitchell Association. TTOR provides several programs and activities on Coskata-Coatue including a Natural History Tour, Fishing Discovery and Fishing for Kids, Science Discovery Thursdays, Shipwreck and Lifesaving Museum and Great Point Tour, and the Sunset and Lighthouse tours that engage members of the public and promote understanding of these unique barrier beach ecosystems and the resources they provide. Some of these tours also include the refuge, and help to provide onsite interpretive programming. When possible, refuge staff and partners offer on-the-spot interpretation and structured educational programming to help visitors understand not only the history of the refuge, but the importance of managing willdife and habitat.

Over a decade ago, the Service commissioned a study to estimate the regional economic contribution of recreational and commercial activities on the Monomoy and Nantucket National Wildlife Refuges to provide information to assist land managers and the public in evaluating the economic implications of changes in management practice.[1] That report estimated annual visits to be 35,000 in 1998 and 70,000 in 1999. This is published information but it is impossible to indicate the accuracy of this data, as these estimates were not based on empirical data counts but rather reflected "best guesses" by TTOR and Service staff. Consequently, it is difficult to make any long-term, historical statements about visitation trends to the refuge without being overly speculative. Because we do not maintain any permanent staff presence at the refuge we are very dependent on the general estimates provided to us by TTOR to calculate both the number of visitors and types of activities undertaken at the Point.

Historically, information about the number of refuge visitors has been obtained from TTOR. This is based in part on the number of vehicles that go through the Wauwinet gatehouse. TTOR installed a car counter at the Wauwinet Gatehouse in 2009 in order to better track visits and estimate visitor numbers.[2] In 2009 the Service used this data to estimate that there were 41,300 visitors to the refuge.[3] 2010 visitation data was estimated to decline by about four percent to 39,700 visitors. 2011 visitation data was not estimated by the Trustees because of a broken vehicle counter. Anecdotally, however, visitation was likely down In 2011 as the Trustees restricted vehicle access from June 5th through August 20th because of nesting, federally protected piping plovers on their property. Restricted vehicle access is a common occurrence during the summer months but in 2011 the restrictions lasted longer than usual due to anomalies in the plover's nesting period.

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[1] Economic Assessment of the Nantucket and Monomoy National Wildlife Refuges. Industrial Economics, Incorporated, Cambridge, MA. May 2000.

[2] The Trustees estimate the total number of visitors by dividing in half the total number of vehicle "clicks" (because one visiting vehicle clicks the counter upon entry and again upon exiting the gatehouse) and then multiplying the total number of vehicle visits by an average of 2.3 occupants per vehicle.

[3] The Service did not attempt to adjust Wauwinet Gatehouse data for vehicle trips not extending all the way to the Nantucket NWR (e.g., Trustees service vehicles, patrols, and trips to private property). TTOR has estimated that 80 percent of visitors travelled all the way up to Great Point on the NWR.

The average number of OSV permits sold by TTOR in the past few years has averaged slightly less than 2,250 permits a year; the number has been decreasing each year since at least 2007 (S. Nicolle, personal communication). The decline in total sales is attributed to the closing of the Galls for plover protection along with overall declining economic conditions on the island. Some anglers may no longer be fishing at all on the refuge because the rip is closed due to seals or migratory birds, however it is not known whether they are purchasing an OSV permit anyway to access fishing opportunities on TTOR land. Anecdotally, while the Woods Hole, Martha's Vineyard, and Nantucket Steamship Authority report that passengers carried from the mainland to Nantucket during the months of July and August declined from 207,490 passengers in 2009 to 205,467 passengers in 2011,[4] the Nantucket Anglers' Club reported a slight increase in the number of anglers participating in the 2011 Nantucket Inshore Fishing Classic Fishing Tournament compared to the previous year. Specifically, the Club reported that a total of 232 anglers participated in the event in 2011 compared to 211 anglers in 2010.[5] Anglers entering the event can fish from shore or boat throughout the waters of the Island, including Great Point.

In 2010 and 2011, a Service biological science technician was stationed on the refuge for most of the summer. The technician was present on the refuge 4-5 days a week from late May to mid-September in 2010 and late April to early November in 2011. In addition to collecting biological information, the technicians provided informal interpretation through regular patrols and recorded numbers of visitors and their primary activity on the refuge through standardized surveys. The number of visitors recorded on these surveys can't be reliably extrapolated to a total count of visitors because surveys were unequally distributed through time. A high count of 346 visitors was recorded on one day in August 2011, however. Comparisons of relative amount of visitation between years is also confounded by unequal sampling effort and different levels of access to refuge properties (due to closures on and off refuge property). These detailed analyses are still ongoing. However, counts of visitors do provide useful information about the most common recreational activities, and these are presented here. In 2010, 1876 visitors were recorded on surveys and in 2011, 2143 visitors were recorded on surveys (USFWS unpublished data). This information is presented in Table 3.11.

Table 3.11. Observed Public Use by Category in 2010 and 2011.

User Group Description	2010 number, percentage of total	2011 number, percentage of total
general beach enthusiast (activity not covered by other descriptions)	1056, 56%	833, 39%
passenger in vehicle	188, 10%	443, 21%
angler	323, 17%	291, 14%
wildlife watcher (includes birds and seals)	94, 5%	266, 12%
photographer	27, 2%	33, 1%
lighthouse visitor	88, 5%	226, 11%
tour group participant	100, 5%	51, 2%

This data is interesting when compared to information we received as part of an informal public use evaluation conducted in 1999 at Nantucket NWR. The evaluation was focused on filling knowledge gaps regarding the following:

[4] *http://www.steamshipauthority.com/ssa/traffic.cfm* (Accessed on 1/4/2012).

[5] Memo from Ms. Carol Crowell, 2011 Committee Chairperson Nantucket Anglers' Club Inc. to Mr. Steve Nicole, Trustees of the Reservation, December 6, 2011.

types of recreational use/activities, time intervals and locations of recreational activities, where cars are parked, the condition of facilities, if wildlife is present, activity in grass/dune areas, presence of dogs and if on/off leash, and TTOR presence. Offsite information included if any Nantucket NWR information was disseminated at the entrance gate, and what information was provided regarding the Nantucket NWR and/or beach regulations at rental car facilities.

Originally intended to be an observation-based evaluation at the refuge by volunteers representing the Service (though not in uniform), the actual evaluation period also included direct feedback from refuge visitors through informational interviews and survey questionnaires. The evaluation took place between August 26-28, 1999, a consecutive Thursday, Friday, and Saturday to be representative of the kind of use on both week and weekend days. Service volunteers spent the three days in shifts spanning the daylight hours on the refuge conducting observations and interacting with refuge visitors.

Visitors to the beach were also asked to fill out evaluation forms. Evaluation forms were filled out by 68 people on the refuge over the course of the evaluation period. These 68 evaluations included 39 tourists, 21 summer residents, and 8 year-round residents. It should be noted that the summaries below may only be relevant within the context of the evaluation period, and provide only a sampling of perspectives of the various visitor-type groups as this was not intended to be a statistically representative study.

Most tourists came to Great Point for reasons other than fishing, were with family groups, and came primarily during the middle of the day. Many of these visitors found out about Great Point through friends, and 31 percent were return visitors from previous years. They perceived visitation at Great Point (number of cars and people) to be "higher than normal," but did not provide a definition of what normal was.

Summer residents, on the other hand, were there primarily to fish (all but one) and almost all of them were returning lifetime visitors. This group visited Great Point more regularly than the other two groups evaluated, and perceived visitation to Great Point to be lower than average.

Year-round residents noted that fishing at Great Point was the best on the island, and almost all of them were there to fish. This group was more aware that the tip of Great Point was a refuge, and had been visiting Great Point throughout their lives. This group felt that visitation was average or lower than normal, but over half suggested that visitation had been steadily increasing over the last 5 years.

In the economic analysis report conducted back in 2000, the Service estimated that the total economic contribution associated with visitor expenditures to Nantucket NWR ranged between $5.4 to $10.8 million (1999 dollars). In current dollars, these estimates would range between $7.34 to $14.7 million (2011$).[6] This was estimated to be nearly one percent of the baseline output to lodging, grocers, restaurants, and sporting and outdoor stores in the region. These expenditures helped support between 86 to 171 jobs in the region. The wide range in expenditures reflects the discrepancy between the number of estimated visitors in 1998 and 1999. It was estimated that back at the time of the study, recreational fishermen spent nearly $91.00 (1999$) per day on transportation, food, lodging, and supplies, while other visitors to the refuge spent approximately $99.00 per day (1999$). Expenditures were partly based on data obtained from the 1996 National Survey of Fishing, Hunting, and Wildlife Associated Recreation and do not specifically reflect expenditures associated with visitation to the refuge.

[6] $1.00 in 1999 has the same purchasing power as $1.36 in 2011. *http://www.bls.gov/data/inflation_calculator.htm*

Unfortunately, USFWS has limited data to estimate how both expenditures and visits have changed over time. The Service is not aware of any other studies that have estimated the economic contribution of visitors fishing or viewing wildlife at the refuge.

Fees collected by TTOR for OSV permits have generated over $300,000 a year. This represents a significant revenue source for TTOR, with much of these revenues staying on Nantucket Island. TTOR provides a portion of these funds to NCF for gatehouse staff, to provide restrooms at the Great Point lighthouse, and to hire rangers and staff and conduct oversight and interpretative programs which benefit Nantucket NWR. TTOR staff help keep Service staff informed of refuge conditions. They make beach access recommendations, explain refuge regulations to the public in an effort to increase compliance, and provide onsite interpretation. TTOR has been our primary liaison to the public by providing information about Service policies, management actions, and natural resource value. It is estimated that 80 percent of the individuals who purchase OSV permits do so to visit the refuge, and while none of those permit fees come to the Service, we do obtain benefit from TTOR's stewardship of their lands as well as Nantucket NWR. Historically, the Service has not collected or used funds from permit fees. Should the Service wish to collect fees in the future, we will conduct additional outreach and obtain public comment before making a decision to implement access fees.

Other Public Use Activities

Other Activities Allowed

In general, for a public activity to be allowed on a refuge, it must first be found appropriate and compatible, in compliance with Service policies (see chapter 1). Activities that have been found both appropriate and compatible for Nantucket NWR are: environmental education and interpretation, wildlife observation and photography, recreational fishing, research conducted by non-Service personnel, commercial guides, tours, and outfitting, many outdoor events and ceremonies, non-motorized boat landing and launching, beachcombing, and sunbathing and swimming. Not all these are wildlife-dependent activities, but they are enhanced by the presence of a natural environment. All other activities are not allowed or can only be allowed under a Special Use Permit, assuming they are appropriate and compatible. See appendix B for an updated list of compatibility determinations and findings of appropriateness.

Law Enforcement Concerns and Activities Not Allowed

Most visitors respect the refuge rules and regulations on public uses and activities. TTOR rangers and the Massachusetts Environmental Police officer stationed on Nantucket Island regularly patrol TTOR's Coskata-Coatue Refuge as well as Nantucket NWR and they, as well as Service law enforcement officers, have observed the recurrence of several unauthorized public uses at the refuge. Some activities, such as pets and kite flying, have been determined to never be appropriate or compatible.

Many visitors bring their pets, primarily dogs, onto the refuge. While there are visible and legible signs posted around the refuge stating the refuge's no dog policy and information on TTOR and Service websites, many visitors may be confused because TTOR allows dogs on their adjacent property from September 15 through March 31. Visitors who do understand the differing regulations but bring their dogs onto the refuge despite this do so intentionally, though perhaps with little knowledge of the impacts. The presence of dogs, whether on- or off-leash, is not allowed on the refuge at any time because they are extremely disruptive to wildlife. Beach-nesting bird species perceive dogs as predators, and their presence can lead to the abandonment of nests. Dogs off-leash can also directly impact nests and individual birds by entering fenced-off areas where

nests are located, and they can be disruptive to other beachgoers. Even during the September 15 through March 31 period, there is wildlife on the refuge, such as loafing common eiders and seals, that are disturbed by dogs and people engaged in non-wildlife-dependent activities with their dogs.

Kite-flying or any activity associated with kites have similar effects; beach-nesting species respond to kites as they would to aerial predators, and again this can lead to nest abandonment or undue stress to the birds.

The other two major violations of refuge policy are those who choose not to respect seasonal beach closures and those who walk through sensitive dune and vegetation. These areas are closed to public use to both protect habitat and wildlife from thousands of beachgoers who may be well-intentioned, but who collectively can have a large, deleterious impact. Beach closures are not only intended to protect wildlife from human impacts, in compliance with Federal guidelines, but also are intended to protect beachgoers from wildlife such as seals which can be aggressive. In addition, these species are all federally protected under the Endangered Species Act, Migratory Bird Treaty Act, and/or the Marine Mammal Protection Act.

Though not within the jurisdiction of the refuge, it has also been reported that boats will attempt to get close to marine mammals in the water in order to "get a better look" or "a longer look," possibly to please clientele in the case of chartered boats. These actions are in fact a violation of the 150-foot buffer zone delineated in the MMPA (16 U.S.C. § 1371-1372). In some cases, refuge staff have observed that violations of this act from boats speeding around the point that resulted in propeller injuries to seals (E. Wunker, personal communication, 2010). Other violations of this act include attempting to feed marine mammals. These actions also disrupt anglers casting from shore who are acting within the law.

Other refuge activities not allowed are camping, trespassing in areas closed to the public, and setting campfires. Since the refuge was established, we have not allowed those activities for the following reasons:

- First, those activities are not wildlife-dependent, recreational uses, nor are they necessary for the safe, practical, or effective conduct of a priority public use.

- Second, they are likely to cause the disturbance of wildlife in critical habitats. Specifically, due to the predominant choice of shoreline locations for those activities, they may lead to nest abandonment or failure for federally listed nesting shorebirds.

- Finally, they are likely to interfere with the visitors engaging in priority public uses.

Through our partnership with TTOR, and their efforts to educate the public about these rules, we are attempting to eliminate these unauthorized activities on the refuge. The efforts of the Massachusetts Environmental Police are also invaluable in monitoring and enforcing State and Federal laws and refuge policies on the property. However, despite refuge regulations against them, some of those activities persist, and remain significant law enforcement issues. Through consistent monitoring with the help of TTOR and the Massachusetts Environmental Police, increasing public awareness of refuge boundaries and any difference in policies between TTOR and Service properties, and increasing our efforts to educate and inform the public, we expect these activities to decrease.

Refuge Archaeological, Historical, and National Resources

All of Nantucket Island is listed as a National Historic District under the National Historic Landmarks program administered by the National Park Service. This designation includes two concentrations, and these are Nantucket Town, which provides an excellent example of an early New England seaport, and Siasconset, where some of the island's earliest houses still remain. Historic landmarks are designated by the Secretary of the Interior for their significant value in interpreting or representing the heritage of the United States. This was granted to Nantucket because of its history as a world-renowned whaling port (*http://tps.cr.nps.gov/nhl/detail.cfm?ResourceId=581&ResourceType=District*; accessed March 2011).

National Natural Landmarks is another program administered by the National Park Service that recognizes nationally significant natural areas throughout the U.S. in order to encourage their preservation. Muskeget Island has been designated as a National Natural Landmark since April of 1980. Recently, TTOR has proposed the designation of the Coskata-Coatue Peninsula as such, and we are currently endeavoring to include the refuge in that designation.

Archaeological resources have been found throughout Nantucket Island. While there have been no formal surveys done of the refuge itself, there have been cultural surveys conducted throughout the island of Nantucket. These surveys have yielded six native village sites, with the potential for additional sites of archaeological importance (MHC 1987). One of these confirmed sites is located on Great Point, though not on the refuge property. Its close proximity to the refuge implies that similar land uses and histories are present on the refuge, and suggests the potential that similar items of archaeological importance could be found on the refuge. This adds another layer of importance to the protection of refuge resources. This potential will be considered should any refuge management activities take place in the future that could have a potential impact on these resources, in compliance with Federal mandates.