5.0 ENVIRONMENTAL RESOURCES AND CONSEQUENCES FOR THE APPLICANT'S PROPOSED ALTERNATIVE

The following section describes the existing environmental conditions for the Applicant's proposed action at Horseshoe Shoal, and examines the potential impacts resulting from the construction, operation/maintenance and decommissioning of the proposed wind park (130 WTGs, the ESP, scour control mats, and the associated electric transmission cable systems). This section addresses both the MEPA Certificate of the Secretary of Environmental Affairs on the ENF (April 22, 2002) and the USACE Scope of Work for this DEIS (June 21, 2002), and has been developed in response to extensive public scoping comments including input from cooperating agencies.

In response to the MEPA scope and the need for State and Federal agencies to clearly distinguish between existing conditions and impacts for areas that are, and are not, within their jurisdiction this section has been structured to separately discuss the conditions and impacts within and outside the 3-mile State Territorial Limit between Massachusetts' waters and Federal waters (as defined by the Submerged Lands Act (43 U.S.C. §§ 1301 *et seq.*)). Although this format at times results in repetition of information, it is necessary in order to facilitate the coordinated review of one document as a Federal DEIS, State DEIR and regional Cape Cod Commission DRI.

Each of the following sub-sections addresses a specific environmental resource by describing the existing conditions and discussing the impacts to that resource which can be expected to occur as the result of the proposed Project. The types, extent and duration of data collection and field studies, and the methodologies used to present the information contained in this section have been developed by the USACE through consultation with the appropriate cooperating agencies.

5.1 Geology and Sediment Conditions

5.1.1 Introduction

This section describes existing geology and sediment conditions in the marine and onshore portions of the Project area, and provides a discussion of regulatory requirements applicable to the Project that are related to geology and sediments. The information contained in this section was obtained from literature review, agency consultations, site investigations, and review of existing site investigation data. Several specific issues addressed per scoping and agency request include the potential for shoreline erosion (addressed in Sections 5.1.3 and 5.1.4); surficial marine geologic conditions that influence benthic habitats and fisheries conditions at depths pertaining to construction suitability; specific identification of areas where land alteration is proposed; and interpretation of historic geologic data for Nantucket Sound as input to a predictive model regarding submerged archaeological sites on Horseshoe Shoal (Section 5.10).

Section 5.1.2 provides a description of sampling programs and studies completed for this Project. In Section 5.1.3, information from those studies and secondary data review are utilized to provide a description of existing conditions for the Project area. This section separately addresses characteristics seaward and landward of the State Territorial Limit (3 nautical miles (5.6 kilometers) from shore). Section 5.1.4 provides an analysis of anticipated Project impacts, with mitigation discussed in Section 5.1.5, and references provided in Section 5.1.6.

5.1.2 Field Studies Completed

Integrated marine geophysical/hydrographic surveys and geotechnical/sediment sampling programs were conducted by Cape Wind for the Project in 2001, 2002 and 2003 over Horseshoe Shoal and along the proposed submarine cable route between the Horseshoe Shoal and the proposed landfall location in Yarmouth. Surveys were also conducted along alternative marine cable routes landing at Cotuit and Popponesset. Deep geologic borings (penetrating up to approximately 150 feet (46 meters) of subsurface sediment) were advanced on Horseshoe Shoal in April 2002 and August and October 2003.

The investigations were designed to provide data to assess and characterize existing seafloor and sub-seafloor conditions in order to appropriately select design, construction and installation techniques for the proposed wind turbine array and associated submarine transmission lines. The primary objectives of these studies were to identify water depths, seafloor morphology and structural features, sub-seafloor stratigraphy, and natural or man-

made obstructions on or below the seafloor. Data collected during marine field investigations for the Project are summarized below and described in the following sections:

- Marine geophysical/hydrographic surveys of the Wind Park, alternative interconnects, and Cape Wind's Scientific Measurement Devices Station (SMDS);
- Collection and characterization of sediment vibracores in 2001 and 2003;
- Geotechnical and geochemical analysis of sediment composites from selected vibracores;
- Collection of marine benthic grab samples in 2001 and 2002;
- Advancement of 3 borings to a maximum drilled depth of 98.5 feet (30 meters) below sea bottom in 2002; 10 borings to a maximum depth of 150.3 feet (45.81 meters) below sea bottom in August 2003; and 9 borings to a maximum depth of 102 feet (31.09 meters) below sea bottom in October 2003; and
- Sediment transport modeling of a range of current and wave conditions (see Section 5.2 and Appendices 5.2-A and 5.2-B).

Review of background information, including available published and unpublished sources of information and previous studies (referenced in Section 5.1.6), was also conducted to characterize existing conditions in Nantucket Sound and along the onshore cable route. Subsurface field information collected by others, as referenced, was integrated with subsurface information collected during Project studies, to clarify geologic conditions in and near the Project area. The studies are described below. Results of the studies are presented in Sections 5.1.3.2 and 5.1.3.3.

Note that, prior to construction, onshore field investigations would be conducted in specific locations within the onshore Project area (such as at roadway intersections) in order to identify geotechnical conditions pertinent to detailed Project design and construction.

5.1.2.1 Marine Geophysical/Hydrographic Surveys

The marine geophysical/hydrographic surveys were designed to collect remote sensing data over Horseshoe Shoal and the proposed and alternative submarine cable routes. The purpose of this information was to evaluate WTG installation feasibility, assist in selection of appropriate foundation system design, and determine the geologic variability of subsurface sediments on Horseshoe Shoal and along proposed submarine cable routes.

June to August 2001 Geophysical/Hydrographic Survey

From June to August 2001, a marine geophysical/hydrographic survey was conducted by OSI within the Proposed Horseshoe Shoal Alternative site in Nantucket Sound and along alternative submarine cable routes. Survey tracklines are shown in green on Figure 5.1-1. The survey included use of side-scan sonar to evaluate surface sediments, seafloor morphology and potential surface obstructions; high frequency transducer receiver ("chirp") and low frequency transducer receiver ("boomer") sub-bottom profilers to evaluate subsurface sediment conditions; magnetometer to identify ferrous objects at the surface or shallow subsurface areas; and a precision fathometer to measure water depths. Locations of survey anomalies were precisely identified using a Differential Global Positioning System (DGPS) accurate to +/- 3.3 feet (1 meter). Specifications of the instrumentation used during the survey are listed in Table 5.1-1.

The turbine array and SMDS areas were encompassed by a total of 14 tracklines oriented north-south and spaced 2,743 feet (836 meters) apart; five east-west oriented lines spaced 5,236 feet (1,596 meters) apart; and two additional east-west lines spaced 2,000 feet (610 meters) apart. Three tracklines, spaced 500 feet (152.4 meters) apart, provided subsurface data between the ESP and the proposed landfall location in Yarmouth. Additional tracklines were run to enable avoidance of areas where review of the data suggested hard bottom conditions existed. OSI survey coverage of the bottom during this survey is described below (Nowak, 2002):

- **Side-Scan Sonar:** Sweep range was up to 328 feet (100 meters) on either side of the underwater transducer (towfish), depending on water depth. The normal convention is to tow the side scan instrument 26 feet (8 meters) to 66 feet (20 meters) above the bottom for optimum coverage at this sweep range. In shallow water, where tow height is limited by water depth, the effective sweep coverage is approximately 12.5 times the towed transducer height above the seafloor. In shallow water, the transducer is generally towed within 5 feet (1.5 meters) of the water surface, so the towed transducer height is equal to the water

depth minus 5 feet (1.5 meters). The main beam coverage of each channel of the side scan sonar is between 20 and 70 degrees below the horizontal plane.

- **Cesium Magnetometer:** This magnetometer senses the ambient magnetic field and localized anomalies. Each individual run of the magnetometer used in the survey can be considered to have coverage of approximately 50 to 75 feet (15.2 to 22.9 meters) in width. An anomaly peripherally detected by a single magnetometer run would not provide an accurate indication of size or location of that magnetic anomaly off the trackline. Additional magnetometer information was collected at anomalies as necessary, based upon field interpretation of the data.

- **Sub-Bottom Profiler:** The coverage of the instrumentation is generally narrow, and considered to be the area directly below the instrument.

August 2002 Supplemental Geophysical Survey of SMDS Area

A supplemental August 2002 marine geophysical survey of the SMDS site was conducted in a 630-foot x 810-foot (192-meter x 246.9-meter) area centered on the SMDS site, approximately 11 nautical miles (20.4 kilometers) south-southwest of Hyannis Harbor. A total of 25 transects, generally at 50-foot (15.2-meter) intervals, were surveyed to identify potentially significant submerged prehistoric archaeological resources (see Section 5.10). The equipment listed on Table 5.1-1 was used for this survey as well, with the exception of the deep "boomer" sub-bottom profiler.

June to July 2003 Supplemental Geophysical Survey of Horseshoe Shoal and Proposed Submarine Cable Route

Because the planned array was reduced from 170 to 130 turbines and the layout reconfigured following the 2001 survey, a geophysical program was conducted in June-July 2003 to help evaluate seafloor and subsurface conditions directly over the new turbine and inner-array cable locations proposed. The geophysical survey was followed by a geotechnical boring program (see August and October 2003 field program descriptions in Section 5.1.2.2) in order to correlate seismic data with geologic conditions. This geophysical program was also planned to support a marine archaeological reconnaissance survey within the Project area, as described in Section 5.10.2.3. The subsequent October 2003 vibracore program provided both shallow sediment samples for geotechnical analysis for foundation design and information used in the archaeological survey (see Sections 5.10.3.1.1 and 5.10.3.2.1).

Field operations for this supplemental geophysical program in deeper waters were conducted in June and July 2003, with shallow waters near the Lewis Bay landfall area surveyed in September 2003. Survey vessels were equipped similarly to the 2001 Geophysical Program, with remote sensing and vessel positioning equipment, as listed on Table 5.1-1.

Survey tracklines were chosen prior to commencement of survey operations, and are shown in blue on Figure 5.10-1. In the area of the proposed WTG array on Horseshoe Shoal, survey lines were run northwest-southeast and east-west to connect proposed WTG locations. Northwest-southeast survey lines consisted of a centerline crossing proposed WTG locations and two survey lines each offset 50 feet (15.2 meters) east and west of the centerline.

The centerline was run with a full instrument suite (FIS), including "boomer" and "chirp" subbottom profilers, side-scan sonar, magnetometer, and fathometer. The offset lines were run with a reduced instrument suite (RIS), including "chirp" subbottom profiler, side-scan sonar, magnetometer, and fathometer. East-west lines connecting WTGs and portions of proposed inner-array cable routes were surveyed as two RIS survey lines offset from the cable centerline by 25 feet (7.6 meters) on each side.

In the ESP area, survey lines were run with the RIS generally northwest-southeast at a 50-foot (15.2 meter) line spacing. Hydrographic, magnetometer and "chirp" subbottom data were collected on all lines. Side-scan sonar data were collected on nearly every line. The submarine cable route between the proposed ESP and landfall was surveyed as two RIS survey lines offset from the proposed submarine cable route centerline by 25 feet (7.6 meters) on each side.

5.1.2.2 Geologic and Geotechnical Program

Summer 2001 Vibracore and Benthic Grab Program

The Summer 2001 sediment sampling and geotechnical program was performed after the 2001 geophysical survey results were reviewed. The program was conducted in accordance with procedures outlined in ESS, Inc.'s *Geotechnical Sampling and Analysis Protocol* (2001), which was provided to the MADEP and USACE for review and comment prior to the fieldwork. No modifications to the protocol were requested by MADEP (MADEP, 2001).

The program consisted of the following activities:

- Advancement of a total of 46 vibracores at selected locations in the Wind Park and along alternative submarine cable routes to confirm geophysical survey interpretations of subsurface sedimentary conditions;
- Visual characterization and photography of the cores, to identify sediment types; and
- Selection of representative sediment samples from similar and varied acoustic/geologic types for subsequent laboratory analysis of bulk physical properties and chemical parameters.

Benthic grab samples (BG series) were also collected from surface sediments at the vibracore locations, prior to coring for benthic species analysis. Locations of the vibracores (VC01 series) are shown on Figure 5.1-1; a summary of vibracore information is presented on Table 5.1-2.

Composite sediment samples from representative vibracores were submitted for analysis of physical properties (Geotesting Express, Inc., 2001 and 2003) and chemical constituents (Woods Hole Group Environmental Laboratories, 2001a, 2001b and 2003). Results of these analyses are presented in Sections 5.1.3.2 and 5.1.3.3, and on Tables 5.1-3 through 5.1-6.

Sediments from a total of 60 vibracores within the turbine array area and along alternative cable routes were submitted for bulk physical analysis (46 locations in 2001, and 14 in 2003). A total of 120 composited samples were analyzed for various bulk physical parameters, including sieve analysis; moisture content; ash content; organic content; combined gradation analysis; and Atterberg Limits.

A total of 33 marine sediment samples were submitted for bulk chemical analysis (25 in 2001, and eight in 2003). All samples submitted for chemical analysis were composited from the 0- to 5-foot (0- to 1.5-meter) depth range because shallow sediments are more likely to be affected by potential modern contamination than the deeper sediments. Sample locations were selected in 2001 to assess the chemical conditions of shallow marine sediments throughout the Project area, as well as shallow sediments that were observed to contain greater than 50 percent fines during field classification. Sample locations in 2003 were selected to provide additional data coverage and from site-specific locations (such as within a nearshore bathymetric low, and in Lewis Bay). Samples were selected based upon depth and location within the Project area, using the following locational categories and parameters:

- **Cable route cores:** Sediments were composited from the 0- to 5-foot (0 to 1.5 meter) and 5- to 10-foot (1.5 to 3 meter) depth intervals, with a minimum of one physical sample submitted for bulk analysis from each depth interval in this category. If the sample from these depths contained more than 50 percent fines based on visual observations, then a sample of that interval was also collected and submitted for chemical analysis.
- **Nearshore and select cable route cores:** Sediments were composited from the 0- to 5-foot (0 to 1.5 meter) and 5- to 10-foot (1.5 to 3 meter) depth intervals. A minimum of one sample was collected and submitted for bulk physical analysis from each interval, and a minimum of one sample from the 0- to 5-foot (0 to 1.5 meter) depth range was collected and submitted for chemical analysis in this category.
- **Cable route cores within the WTG array:** Sediments were composited from the 0- to 5-, 5- to 10- and 10- to 30-foot (0- to 1.5-, 1.5- to 3-, and 3- to 9.1-meter) depth intervals, with a minimum of one sample submitted for bulk physical analysis from each interval within this category. If the composite sample for the 0- to 5- or 5- to 10-foot (0 to 1.5 or 1.5 to 3 meter) interval contained more than 50 percent fines based upon visual observations, then a sample of that interval was also submitted for chemical analysis.
- **WTG Cores:** Sediments were composited from the 0- to 10- and the 10- to 20-foot (the 0- to 3- and the 3- to 6.1 meter) depth intervals. A minimum of one sample was submitted from each interval for bulk physical

analysis. If the composite of the 0- to 10-foot (0- to 3-meter) depth interval contained more than 50 percent fines based on visual observation, then a sample from that depth interval was also submitted for chemical analysis.

- **Select WTG cores**: Sediments were composited from the 0- to 10-foot (0- to 3-meter) and 10- to 20-foot (3- to 6.1-meter) depth intervals. A minimum of one sample from each interval was submitted for bulk physical analysis; a minimum of one sample from the 0- to 10-foot (0- to 3-meter) interval was submitted for chemical analysis.

The results of chemical analyses were compared to marine sediment guidelines published by Long et al., 1995, which are used to assess effects to the benthic community. Results are presented on Tables 5.1-4 though 5.1-6 and discussed in Sections 5.1.3.2 and 5.1.3.3.

April 2002 Deep Borings

Three deep borings (GZA-SB-01 through GZA-SB-03) were advanced on Horseshoe Shoal in April 2002 at locations shown on Figure 5.1-1. The borings were advanced to a maximum-drilled depth of 98.5 feet (30 meters) below the seafloor (127.5 feet (38.9 meters) below MLLW) to characterize geologic conditions to the maximum expected depths of the WTG foundations. Split-spoon sediment samples were obtained at approximately 5-foot (1.5 meter) intervals, and visually classified.

Summer 2002 A-series Benthic Grab Samples

A total of 33 grab sediment samples were collected from the seabottom for benthic analysis in three areas of Nantucket Sound. Sediments were visually characterized for sediment type and benthic species; benthic analyses are presented in Section 5.3.

October 2003 Vibracore Program

A total of 25 vibracores were collected along the proposed submarine cable route and in the eastern portion of Horseshoe Shoal during this field program. Vibracore locations were selected after review of the 2003 geophysical data.

During this program, nine vibracores were advanced in areas of possible archaeological sensitivity throughout the WTG array, as part of the marine cultural resources investigation (see Section 5.10). These cores were located to determine the presence/absence of organic sediments intermittently encountered in previous studies in order to assess the origin (terrestrial or marine) of the organic material, if found.

An additional 14 vibracores were advanced for geotechnical and chemical analysis along the proposed submarine cable route to characterize the sediment at and above the proposed cable burial depth. Samples from Cores VC03-10 through VC03-24 were analyzed for bulk physical parameters. Samples from Cores VC03-13, VC03-16, VC03-19 and VC03-20 were analyzed for bulk physical and chemical parameters. The results of these analyses are discussed in Sections 5.1.3.2 and 5.1.3.3, and are shown on Tables 5.1-2 through 5.1-6.

Because an area of fine-grained material was encountered along the proposed submarine cable route in Lewis Bay, a series of test cores were advanced to identify the horizontal and vertical extent of this fine material. This process included advancing vibracores and immediately splitting them on the deck to photograph and visually describe the sediment. The Lewis Bay cable route was delineated to avoid these fine sediments, to the extent feasible. Sediments from cores along the selected Lewis Bay route were then submitted for bulk physical analyses.

August 2003 Deep Borings

In August 2003, 10 borings were advanced across Horseshoe Shoal for geotechnical purposes. These borings were designated SB-01 to SB-07 and SB-11 to SB-13, and were advanced to depths between 98.4 and 150.3 feet (30 and 45.81 meters) below the seafloor. Locations are shown on Figure 5.1-1. Sediment field tests were performed including pocket penetrometer and torvane tests to estimate the undrained shear strength of the cohesive soils. Grain size and Atterberg Limits analyses were performed on sediment samples collected via split-spoon. Pressuremeter tests were performed at select depths in Borings SB-05 and SB-13.

October 2003 Deep Borings

Also for geotechnical purposes, nine borings were advanced in October 2003 to depths between 100 and 102 feet (30.5 to 31.09 meters) below the seafloor at proposed wind turbine locations on Horseshoe Shoal. These borings were designated according to their WTG grid number: SB-A10, SB-B12, SB-C9, SB-D4, SB-D11, SB-G2, SB-G11, SB-J5, and SB-J13. Locations are shown on Figure 5.1-1. In Boring SB-B12, where organic silt was encountered, an undisturbed sample was obtained by pushing a Shelby Tube mechanically into the soft sediments. Field tests included pocket penetrometer and torvane tests, to estimate the undrained shear strength of cohesive soils (GZA, 2003).

Data obtained from these field studies was integrated with published reports and information on Nantucket Sound to characterize existing conditions in the vicinity of the Project area, as described in Section 5.1.3.

5.1.3 Existing Conditions

Cape Cod extends from southeastern Massachusetts approximately 40 miles (64.4 kilometers) east and then north into the Atlantic Ocean. Martha's Vineyard is located about 5 miles (8 kilometers) south of the Cape, with Nantucket about 25 miles (40 kilometers) south of the Cape and 15 miles (24 kilometers) east of Martha's Vineyard. These sand-rich landforms partially surround and shelter Nantucket Sound, a broad passage of relatively shallow water, from the open Atlantic Ocean. Horseshoe Shoal is located roughly in the middle of Nantucket Sound, between Cape Cod and the Islands. As its name suggests, Horseshoe Shoal is shaped like a horseshoe opening to the east, with a northern leg and a southern leg surrounded by deeper water, as shown on the bathymetric map presented as Figure 4.1. Information regarding bathymetry in this area is provided in Section 5.2. The geologic framework of Nantucket Sound, including Horseshoe Shoal, and onshore in the vicinity of the cable system, is discussed below.

5.1.3.1 Geologic Framework

The Project area is within the Atlantic Coastal Plain physiographic province, an area of low-lying generally seaward thickening sediments between the New England uplands and the seaward edge of the continental shelf.

From a geologic perspective, the Cape and Islands are relatively young lands, created largely by glacial and post glacial processes (Oldale, 2001). Advances and retreats of sediment-laden ice toward the end of the Wisconsinian-age glacial stage originally molded the present landscape in the late Pleistocene Epoch about 23,000 to 18,000 years ago. The movements of localized glacial ice lobes may have been influenced by the shape of the underlying lands, with major lobes occupying pre-existing topographic depressions, such as Buzzards Bay, Nantucket Sound, and Cape Cod Bay. Following glaciation, the landscape was further reworked by water-borne sediments during the gradual climatic warming that occurred during the Holocene Epoch.

Bedrock Geology

Bedrock is deep beneath the Cape and Islands, and is not exposed, as it is on the mainland to the west and north of Cape Cod. Bedrock is not mapped beneath Nantucket Sound on the Bedrock Geologic Map of Massachusetts (Zen, 1983). The map indicates that lithified (hard) bedrock beneath Cape Cod is metamorphic feldspathic gneiss and amphibolite of Proterozoic age. In Woods Hole, granite was penetrated at a depth of about 270 feet (82.3 meters); in Harwich, metamorphic rock described as schist was found at a depth of 435 feet (132.6 meters) (Oldale, 2001). A deep boring on Nantucket encountered igneous basalt, which may have been related to Triassic rifting of the early Atlantic Ocean (Oldale, 2001). A schematic showing estimated depths to bedrock across Nantucket Sound is provided in Figure 5.1-2 (from Oldale, 2001).

Younger non-lithified Cretaceous and overlying Tertiary-age coastal plain sediments are mapped as bedrock beneath Martha's Vineyard and Nantucket (Zen, 1983). Some of these seaward thickening unconsolidated pre-glacial deposits are exposed at Gay Head on Martha's Vineyard, and may have been locally incised beneath Nantucket Sound by ancient pre-glacial drainage patterns.

During 2001 and 2003 geophysical surveys, acoustic subbottom penetration was restricted below seismic reflectors referred to as Acoustic Basement (AB), shown on Figure 5.1-3. AB reflectors can indicate the top of hard rock or may reflect the presence of other dense or consolidated material. In the Project area, however, the

AB reflector was penetrated by deep borings, including Boring GZA-SB-02, which penetrated the location of the reflector at approximately 60 feet (18.3 meters) below sea bottom (see Figure 5.1-3). This depth corresponded to the top of a gray varved (thinly bedded) unit of fine sand, silt and clay in that boring. Only unconsolidated sediments were encountered below the AB reflector (to the boring's drilled depth of 98.5 feet (30 meters) below the sea floor).

Within the Project area, the deepest boring advanced as part of the Project (Boring SB-01, advanced by GZA in August 2003) penetrated 150.3 feet (45.81 meters) of unconsolidated sediments, also well below the AB reflector. No lithified bedrock was encountered in any of the deep borings. The absence of hard bedrock and thickness of soft sediments within the Project area indicates that it is unlikely that rock blasting would be required to build the Project.

The geophysical data indicates that an underlying topographic high is present below the depth of glacial and post-glacial sediments beneath Horseshoe Shoal itself. This suggests that the Shoal is a relatively stable structural feature, possibly a pre-glacial coastal plain topographic high, and would be expected to provide a stable underpinning for the Project structures during the life of the Wind Park.

Faults and Historic Seismic Activity

No faults have been identified within the Project area, based upon a review of field data and available technical literature. Ancient faults at depths well below glacial and post-glacial sediments are likely associated with a reported buried Triassic-Jurassic rift basin southeast and outside of the Project area. This basin was probably formed during rifting associated with the early formation of the Atlantic Ocean (Oldale, 2001). The basalt bedrock encountered in the deep boring on Nantucket (see above) may have been related to this ancient rifting.

A USGS compilation of known earthquakes over a 300-year period indicates that no earthquake epicenters with estimated magnitudes 3.0 or greater have occurred within 10 miles (16 kilometers) of the Horseshoe Shoal site (USGS, 2001). The Project area is located within Seismic Zone 2A, which encompasses all of southern New England and eastern New York (Uniform Building Code, 1997).

Glacial and Post-Glacial Geology

During the Wisconsinian glaciation in the Pleistocene, ice blanketed New England reaching as far south as the Cape and Islands (Uchupi et al., 1996; Oldale, 2001). As the glaciers advanced and grew to the south, ice movement pushed a variety of sediments and rocks in front of and beneath the ice. The roughly east-west oriented topographic highs of present-day Nantucket and Martha's Vineyard mark the terminal moraines, or southernmost extent, of two lobes of glacial ice, which began to retreat approximately 18,000 years before present (BP). The topographic highs along the mid-Cape, along which much of Route 6 extends, are recessional moraines that mark the location where the receding ice sheet stalled temporarily.

As the climate gradually warmed during the Holocene Epoch of the last 12,000 years, the glaciers once covering the Cape and Islands continued to melt and retreat. Meltwaters rushed off the ice, transporting and sorting the sediments they carried into the topographic lows south of the moraines, creating generally level outwash plains of stratified drift, and temporary glacial lakes.

A 10-foot (3-meter) thick thinly-bedded stratigraphic unit of fine sand, silt and clay was encountered at approximately 60 feet (18.3 meters) below the sea floor in Boring GZA-SB-02, as shown on Figure 5.1-3. These types of sediments are described as "varved," and are often associated with glacial lake deposits. This unit, which coincides with the geophysical AB reflector, may indicate deposits from a former glacial lake that temporarily occupied low portions of what is now Nantucket Sound. Boring GZA-SB-02 is located on the inside edge of the northern leg of Horseshoe Shoal, near its inner embayment. Varved sediments were also encountered in several other borings located around the eastern perimeters of the shoal, at depths between approximately 48.5 to 60 feet (14.98 to 18.3 meters) below the seafloor (GZA, 2003). The sediments were not age-dated.

As sea level continued its overall rise during the Holocene Epoch, these unconsolidated glacial sediments continued to be transported, eroded, deposited and reworked by marine, tidal, and wind-driven (aeolian) forces.

The sediments provide the raw material for the beaches of the Cape and Islands, which continue to be shaped by currents, storms and tidal marine processes today.

In conjunction with marine cultural resources studies conducted for the Project, as presented in Section 5.10 and Appendix 5.10-C, the potential that Horseshoe Shoal was a previously exposed landform and therefore available for past human occupation and use was assessed. Worldwide and regional studies of sea level rise since the end of the last glaciation indicate different rates of rise in different geographic areas, even within New England. The variability suggests that other factors besides ice melt (such as localized geologic conditions that may include crustal subsidence or rebound) appear to influence sea-level rise. Comparison of the localized sea level curves to others suggest that sea level rose more quickly in southeastern Massachusetts than in other areas, a factor that has been attributed to concurrent crustal block subsidence in this area (Redfield and Rubin, 1962; Oldale and O'Hara, 1980). Other geologic and hydraulic processes, such as intricate meltwater systems and possible impoundment of meltwater behind ice dams, forming glacial lakes, could have also affected post-glacial water levels in Nantucket Sound.

Application of published sea level rise rates for the southeastern Massachusetts offshore Project area (Uchupi et al., 1996; Oldale, 2001; Redfield and Rubin, 1962) were applied to present day bathymetry across Horseshoe Shoals. Figures 4-3 through 4-7 in the report by PAL in Appendix 5.10-C entitled *Marine Archaeological Reconnaissance Survey for the Cape Wind Energy Project* shows estimated positions of paleo-shorelines at approximate times BP in Nantucket Sound. The data indicate that large portions of Horseshoe Shoals would have been exposed and potentially available for human occupation up until approximately 6,000 years BP, although much, if not all, of the ancient soil surfaces (paleosols) were likely destroyed by storm and wave action during the Holocene marine transgression. Organic materials, including wood, were encountered in several vibracores in limited areas within the eastern portion of the Horseshoe Shoal embayment, as described in Section 5.1.3.2. The implications of the paleo bathymetric reconstructions and these organic materials with respect to the potential for now submerged potential archaeological deposits are evaluated in Section 5.10, Cultural and Recreational Resources and Visual Studies and the report in Appendix 5.10-C.

Existing geologic conditions within the entire Project area, including the Wind Park, the submarine cable route including Lewis Bay, and the onshore cable route, are described below.

5.1.3.2 Conditions Outside of Massachusetts Waters

The Minerals Management Service (MMS), a bureau with the U.S. Department of Interior (USDOI), has jurisdiction over the mineral resources of the federal Outer Continental Shelf (OCS). Under Public Law 103-426, the MMS is allowed to convey rights to OCS sand, gravel or shell resources for use in shore protection, beach or wetlands restoration, or construction projects funded or authorized by the federal government. According to MMS mapping (Status of federal OCS Leasing Program 2003 http://www.mms.gov/ld/PDFs/status.pdf) all Federal waters off the New England coastline (including all of Nantucket Sound), although eligible for mineral extraction, have been withdrawn from leasing through June 30, 2012.

Surface Conditions

Review of the surficial geophysical data across Horseshoe Shoal indicates a generally sandy seafloor with several areas of sandwaves. Two representative side-scan sonar images of the seafloor are shown on Figure 5.1-4. The top image shows the smooth sandy bottom present along much of the northern leg of Horseshoe Shoal, and the western and eastern ends of the southern leg. The bottom side scan image on Figure 5.1-4 shows both long period and short period sand waves, which are present in the areas of greater sand wave height shown on Figure 5.1-6.

Shallow sediments obtained from vibracores to maximum depths of 20 feet (6.1 meters) across Horseshoe Shoal were comprised of predominantly medium-grained poorly sorted sands, winnowed of finer material by wave and tidal action. The distribution of surficial marine sediments is mapped on Figure 5.1-5. Fine sands and silty sands surround the shoal in deeper waters. Localized fractions of silt, gravel and/or cobbles, consistent with glacial drift, have also been identified in surficial and subsurface sediments in the survey area.

A large field of sandwaves extends across the southern half of the Shoal, with several smaller fields located to the north within the Project area. The areal extents and observed heights of the sandwaves are mapped on Figure 5.1-6. The sandwave crests are oriented generally in a north-south direction, with long period sand wave (LPSW) wavelengths ranging between 100 to 600 feet (30.5 to 182.9 meters). Short period sandwaves (SPSW) are located between the larger crests (see Figure 5.1-4, bottom). The average sandwave height was 4 to 5 feet (1.2 to 1.5 meters), but waves as high as 15 feet (4.6 meters) were found. Smaller wave heights of 1 to 2 feet (0.3 to 0.61 meters) often occur between the larger wave crests. The size of the sandwaves attest to the dynamic shallow water environment on Horseshoe Shoal, as described in the Physical Oceanographic Conditions section (see Section 5.2).

The symmetry of the sandwaves indicates migration to the east or west, depending on where they formed on the shoal. Sandwaves forming on the west flank of the shoal tend to migrate easterly. Sandwaves forming on the east flanks of the shoal tend to migrate to the west. Sandwaves across the crest of the shoal have a symmetrical profile, suggesting an equal force in both the ebb and flood tidal phases.

An area of scattered boulders was identified during the 2003 geophysical survey in an area west and north of the ESP, as shown on Figure 5.1-5 (OSI, 2003). Other intermittent glacially transported boulders may also be present within the Project area. Other side-scan anomalies, or targets, encountered during the geophysical survey in the Wind Park area may represent features such as gravel, cobble patches, submerged aquatic vegetation (see Section 5.8.3.1.1) or possible cultural resources (see Section 5.10.3.1.2).

An analytical sediment transport model was used to conduct 26 simulations addressing a range of current and wave conditions across the Project Site. The model and results are described in Section 5.2 and Appendices 5.2-A and 5.2-B. Results indicated that the highest potential for sediment transport is along the shallow portions of the shoal on the northwest corner, with little potential for sediment transport along the deeper portions of the shoal, especially on the east side. Bedload transport (sediment movement along the sea bottom) is higher than suspended transport, due to the relatively coarse surface sediments.

Subsurface Conditions

Geophysical subbottom reflectors are often related to specific stratigraphic units, as the acoustic properties of different types of sediment or rock affect the travel times of the sound waves emitted during remote sensing surveying. Numerous continuous and semi-continuous seismic reflectors were observed in the geophysical data throughout the Project area in both surface and subsurface sediments, suggesting minor horizontal and vertical variations in sediment type and depositional environment. Appendix 5.1-A contains sections of "boomer" subbottom profile records run over representative WTG locations, correlated with deep borings advanced at the WTG locations. The acoustical subbottom data and stratigraphy identified in the boring logs are consistent with the glacial history of the area. The data indicate that most of the subsurface material contains predominantly fine- to coarse-grained sand interbedded with deposits of clay, silt, shell-hash, gravel and/or cobbles, all derived from glacial outwash. Limited areas of Horseshoe Shoal contained near-surface gaseous sediments derived from organic material, which restrict seismic penetration (i.e., underlying strata are masked). Deeper water areas appear to contain fine-grained marine deposits. Although the vibracores and borings did not encounter evidence of subsurface boulders, the presence of occasional large boulders on the seafloor is an indication that there may be isolated boulders in the subsurface (OSI, 2002; OSI, 2003).

Near-surface flat-lying subbottom reflectors indicate layers of recently deposited or reworked bottom-sediments at the near surface. These correspond to the poorly-sorted predominantly fine- to medium-grained sands often encountered in the borings in the upper 20 to 30 feet (6.1 to 9.1 meters) of stratigraphic sections, and may represent marine bar deposits atop Horseshoe Shoal. The relatively high-energy sand-rich deposits reflect the reworking and winnowing of sediments that continues to occur, as tides and wave action form the sand waves and swept surfaces of the shoal (see Section 5.2).

Within the embayment between the legs of the shoal, several vibracores encountered what appears to be a correlative (i.e., possibly related) organic layer at depths between 5 and 12 feet (1.5 and 3.6 meters) below the seafloor. This layer was encountered in USGS Vibracore 4939 (O'Hara and Oldale, 1987), 2001 vibracores VC01-G4 and VC01-G7, and 2003 vibracores VC03-04 and VC03-05. The organic material recovered in USGS Vibracore 4939 was age-dated at approximately 6,470 +/- 200 years BP (O'Hara and Oldale, 1987). Calibration of this date

using OxCal Version 3.5 computer software provided a date range of 7,513 to 7,233 years Cal-BP with an 88 percent probability (see Appendix 5.10-C).

Reconstruction of paleo bathymetry indicates that, as of approximately 7,250 BP (the approximate time of the calibrated age date of the organic material in USGS Vibracore 4939), the easternmost area within the embayment may have contained a possible fresh water kettle pond (see Figure 4.3 in Appendix 5.10-C). Microscopic analysis of the organic material recovered in three vibracores within or near to this low area found plant assemblages indicative of deposition in or adjacent to a quiet shallow freshwater pond (in VC03-04 and VC01-G4) and a forest floor (in VC03-05) (King, 2003). The associated strata may represent now-submerged paleosols in proximity to freshwater, which are types of environmental settings sensitive for potential archaeological resources, as further discussed in Section 5.10.

The discontinuous nature of these organic strata is reflected in the absence of organic material found in VC03-01, which was advanced several hundred feet from VC01-G4. The presence of the organic strata appear to correlate to shallow, highly discontinuous seismic reflectors observed in the "chirp" subbottom data in limited areas in the eastern embayment. The discontinuous nature of now-submerged ancient paleosols is consistent with the extensive disturbance and erosion expected during the high energy conditions that occurred during the Holocene Epoch marine transgression. The presence of these zones in several vibracores in the embayment may reflect greater preservation potential in that more protected area. Additional information is presented in Section 5.10 and Appendix 5.10-C.

Bulk Physical Analyses of Sediment Samples

Twenty-five samples were collected from the proposed Horseshoe Shoal WTG array area during 2001 and 2003 vibracore programs. These cores were advanced to depths ranging from approximately 3.3 to 22 feet (1.0 to 6.7 meters) below the present seabed. Fifteen of the vibracores were collected from relatively shallow water locations on Horseshoe Shoal. The remaining vibracores were collected within the basin-like feature between the northern and southern legs of the shoal, in deeper water areas.

The sediment samples were submitted for bulk physical analyses. The following geotechnical analyses were performed: sieve analysis (ASTM Method D 422); moisture, ash and organic matter (ASTM Method D 2974); moisture content (ASTM Method D 2216); combined gradation analysis (ASTM Method D 422c); and Atterberg Limits (ASTM Method D 4318). A summary of the bulk physical analysis results is presented in Table 5.1-3.

In brief, sediment collected across Horseshoe Shoal was found to be relatively homogeneous horizontally and at depth, and can be characterized as poorly graded, fine to coarse-grained sand with minimal percentages of silt and gravel. The moisture content of the analyzed samples ranged from a minimum of 8.6% at VC01-G9 to a maximum of 27.1% at VC01-G4. VC01-G4 and VC01-G11 were the only samples with organic contents above 1%. VC01-G11 was the only sample determined to be plastic in character. Cores collected in the embayment between the northern and southern legs of the shoal contained higher percentages of fine materials. Vibracore VC01-G4 encountered a layer of peat from 8 to 11 feet (2.4 to 3.4 meters) below the seafloor. Vibracores VC03-04 and VC03-05 encountered significant layers of clay and silt containing some organic material and shell-hash interbedded between layers of sand.

Sediment collected along the proposed submarine cable route in Nantucket Sound was similar to the sediment collected across Horseshoe Shoal, and consisted of poorly graded, fine to coarse-grained sand with varying percentages of silt and gravel. Table 5.1-3 provides a complete listing of the bulk physical analytical results.

Analytical results indicate the shallow sediments within the Project area are non-plastic and contain predominantly poorly graded sand (well sorted, with little variation in grain size) and silty sand. These sediment types are generally consistent with the visual classifications of surface sediment types from the vibracores (see Figure 5.1-5). The bulk physical analysis would be utilized as a basis for design and construction specifications for the Project.

Bulk Chemical Analyses of Sediment Samples

Bulk chemical analyses were performed on seven selected cores collected from the WTG array area during the 2001 vibracore program to determine whether disturbed sediments could pose an environmental concern. Four

of the seven cores (VC01-G3, G5, G13, and MT1) were selected prior to collecting the2001 vibracores to characterize surface sediment types located within the WTG array. The other three cores (VC01-G1, G4, and G11) were selected due to the visual observation of greater than 50% fine material at the time of sample collection. In general, fine-grained silts and clays tend to accumulate environmental contaminants more readily than coarser-grained sediments.

Bulk chemical analysis of representative composite samples was conducted by Woods Hole Group of Raynham, Massachusetts. Testing was performed for the following parameters using the following EPA analytical methods: Metals – arsenic, cadmium, chromium, copper, lead, mercury, nickel, vanadium, zinc (EPA Method Series 6000 and 7000); PCBs congeners (EPA Method 8082); pesticides (EPA Method 8081); PAHs (EPA Method 8270C); TPH (EPA Method 8100M); and TOC (EPA Method 9060).

To assess the relative environmental quality of these sediments, the analytical laboratory results for targeted chemical constituents were compared to established guidelines for marine and estuarine sediments (Long et al., 1995). Tables 5.1-4, 5.1-5 and 5.1-6 summarize the chemical analytical results and compare detected constituents to the Effects Range-Low (ER-L) and Effects Range-Median (ER-M) values. None of the targeted chemical analytes were detected in the samples above ER-L or ER-M guidelines, where established, for marine sediments.

5.1.3.3 Conditions Inside of Massachusetts Waters and Onshore

Nantucket Sound and Lewis Bay

Surface Conditions

The sea bottom along the proposed submarine transmission line route undulates gently from the Wind Park up to the southern Cape Cod shoreline and contains few significant geologic features. Along the proposed submarine cable route within the state territorial limit, two zones of sand waves were encountered during the 2003 geophysical survey, with wave heights less than 3 feet (0.91 meters). Bottom sediments are similar to those encountered in the Wind Park area, including fine- to coarse-grained sands with localized fractions of clay, silt, gravel and/or cobbles. A coarse bottom area was identified on the sonar records just southeast of the cable corridor, near Gardiners Rock and Great Rock. An area of possible submerged aquatic vegetation (SAV) growth was identified near Egg Island (the extent of which was mapped by Woods Hole Group in July 2003, as discussed in Section 5.8.3.1.2). A rock pile was identified just northwest of the proposed cable landfall. Cape Wind has determined that each of these areas can be easily avoided.

During the 2001 geophysical survey of an alternative route east of the proposed route, an area of intermittent boulders and possible glacial till outcropping at the sea floor was encountered southwest of Point Gammon. The proposed route, located to the west of the earlier alternative (shown in green on Figure 5.1-1 just east of the proposed route), avoids these areas.

Review of sub-bottom profiling data revealed evidence of many continuous, semi-continuous, and discontinuous subsurface acoustic reflectors, suggesting slight horizontal and vertical changes in sediment type and depositional history. Subsurface sediment conditions along the proposed submarine cable route were found to be consistent with previous surveys and studies, and generally indicate a consistent sandy-type bottom with thin depositional layering.

Interpretation of geophysical information about Lewis Bay indicates that sediments there are predominantly sands and silts of variable grain size, with traces of interbedded gravel, clay and shell-hash. Near the landfall, sediments contain a mixture of sand and silt. Near the mouth of Lewis Bay are scattered glacial erratics (boulders) on and just below the sandy surface, as shown on the nautical charts and as observed during the 2003 geophysical survey.

Bulk Physical Analyses of Sediment Samples

A total of 11 vibracores in the 2003 vibracore program were collected from the proposed submarine cable route within state territorial limits, at depths ranging from approximately 7.8 to 9.9 feet (2.4 to 3. meters) below the present seabed. Six of these vibracores were collected in Nantucket Sound (VC03-13 through VC03-18). The

remaining five vibracores were collected inside Lewis Bay (VC03-19 through VC03-24). Locations are shown on Figure 5.1-1. One to two samples from each vibracore were submitted for bulk physical analysis. Results of analyses of samples along the submarine cable route are presented in Table 5.1-3.

Sediments analyzed for bulk physical characteristics of subsurface sediments along the proposed submarine cable route in Nantucket Sound exhibited almost identical physical characteristics to those found in the WTG array area. The majority of sediment consisted of poorly graded, fine to medium-grained sands. Within Lewis Bay, higher percentages of silt and clay were identified. Thin layers of organic material were also found within the sands. Vibracores VC03-18 and VC03-24 encountered peat deposits approximately one-half foot (0.15 meters) thick at 8 feet (2.4 meters) and 5 feet (1.5 meters) below the seafloor, respectively. As would be expected in an embayed environment, organic content was consistently higher as compared to organic contents in vibracores collected within Nantucket Sound.

At vibracore location VC03-19, sandy clay was encountered from 0 to 9.8 feet (2.99 meters) below the seafloor. Vibracores VC03-22, VC03-23 and VC03-24 were then advanced from 400 to 700 feet (122 to 213.4 meters) north of the proposed submarine cable route in Lewis Bay to identify sediment types, which were found to be sandier at those locations and similar to sediment types along the cable route in Nantucket Sound. Results indicate that clay percentages are higher in the southern portion of Lewis Bay; this area can be avoided with minor rerouting to the north. Table 5.1-3 provides a complete listing of the bulk physical analytical results.

Bulk Chemical Analyses of Sediment Samples

Bulk chemical analyses were performed on samples from four of the vibracores collected along the proposed submarine cable route within the state territorial limit during the 2003 vibracore program. All constituents detected in the samples (primarily metals) were at concentrations below the ER-L and ER-M guidelines for marine sediment. Tables 5.1-4, 5.1-5 and 5.1-6 provide a complete listing of the chemical analytical results for the 2001 and 2003 vibracore programs along the submarine cable route.

Onshore Surficial Geology

The Geologic Map of Cape Cod and the Islands, Massachusetts (Oldale and Barlow, 1986) maps the onshore area where the submarine cable system comes ashore, and north to the vicinity of the Route 6 interchange at Exit 7, as containing Harwich outwash plain deposits. These unconsolidated glacial deposits are composed primarily of gravelly sand, with localized fractions of silt and clay. From the Route 6 interchange northerly then westerly to the Barnstable Switching Station, the onshore cable route would be within Sandwich Moraine Deposits. These poorly sorted glacial deposits contain mostly sand and gravel, with abundant fine sand, silt and clay. Dense till and some boulders are expected in these moraine deposits.

Soils developed from the exposed portions of surficial geologic strata were identified and mapped by the National Conservation Service, and published in the Soil Survey of Barnstable County, Massachusetts (USDA, 1993). Soils developed from the Harwich outwash plain deposits include the Carver coarse sand series (varying slopes). However, because the first 4 miles of the onshore transmission line route would be installed below existing roadways (New Hampshire Avenue, Berry Avenue, Higgins Crowell Road and Willow Street), undisturbed native soils would not be affected, with the exception of a small area of Carver coarse sands (0 to 3% slope) at the Lewis Bay landfall. The roads are generally constructed on fill placed over sandy soils termed Udipsamments, which contain a surface layer of yellowish brown loamy sand underlain by loose coarse sand.

Within the ROW to the Barnstable Switching Station, the onshore cable would be installed through soils in the Plymouth-Barnstable complex, which developed from moraine deposits. These are well drained to excessively drained (dry) soils on slopes, which contain stones and boulders (USDA, 1993).

5.1.4 Analysis of Impacts

The Project has been designed to minimize seabed, sediment, and soil disturbance in both marine and onshore work areas during construction, operation, and maintenance. Construction activities that may pose short-term effects on geology and seafloor sediments include:

- Installation of the WTG monopile foundations systems to a depth of approximately 85 feet (26 meters) below the sea floor;
- Jet plow embedment of the inner-array submarine cables linking the WTGs to the ESP and the 115 kV submarine cable system from the ESP to the landfall in Yarmouth, with up to 6 feet (1.8 meters) of sediment coverage after installation;
- Anchoring and positioning of construction vessels;
- Subsurface HDD to connect the submarine cable system to the onshore transition vault at the proposed landfall at New Hampshire Avenue in Yarmouth;
- Below ground installation of the onshore cable system beneath existing previously disturbed roadways and ROWs, from the transition vault at the landfall to the NSTAR electric transmission line ROW at Willow Street in Yarmouth; and
- Below ground installation of the onshore cable system along the existing NSTAR electric transmission line ROW to the tie-in at the Barnstable Switching Station.

Additional information regarding the Project activities identified above, and the potential impacts to geology, including marine sediments and onshore soils and sediments, are discussed in the sections that follow. The discussion of Project impacts, associated with both construction and operation, is addressed separately for activities proposed seaward and landward of the state territorial limit (3 nautical miles (5.6 kilometers) from land).

The proposed location of the Wind Park on the OCS would affect MMS management of the mineral resources located within the Project area after June 30, 2012. The presence of the WTGs and the connecting inner-array cabling would, at that time, prohibit the extraction of minerals from the seabed within the boundary of the Wind Park for the balance of the life of the Project. Thus, other areas under MMS jurisdiction would have to be considered for mineral extraction projects from June 30, 2012 until the decommissioning of the Wind Park. Following decommissioning, the seafloor within the Wind Park boundary would again be available to MMS for the conveyance of mineral extraction rights.

It should be noted that, for the operating life of the Project, any environmental impacts inherent to the extraction of minerals from the sea floor would be precluded within the Wind Park boundary.

5.1.4.1 Potential Impacts to Marine Geology Outside of Massachusetts Waters

As discussed in Section 4.0, the WTG array would be located outside of the Massachusetts 3-nautical mile (5.6 km) state jurisdictional limit and exclusively within the waters of Nantucket Sound subject to federal oversight and control. The installation of the inner-array and submarine cable system, the WTG foundations, pilings for the ESP, placement of scour control mats, and vessel anchoring and anchor line sweep would cause temporary and localized marine sediment disturbance, as noted above. Maximum anticipated temporary and permanent impacts to surface marine sediments as a result of construction, operation, and decommissioning of the Project are presented in Table 5.3-3, and are discussed below.

Potential Impacts of WTG and ESP Installation and Decommissioning

A monopile-type foundation system is proposed in order to minimize direct impact compared to a lattice or multi-pile foundation. Pre-construction seabed preparation for the monopile foundation installation is not currently contemplated. Preliminary geotechnical and structural engineering evaluations for the Project indicate that, for each WTG, a pile diameter of approximately 16.75 feet (5.1 meters) or 18 feet (5.5 meters) would be driven approximately 85 feet (26 meters) into the unconsolidated sediments beneath Horseshoe Shoal. Results of subsurface field investigations for the Project have indicated no bedrock within the maximum depth anticipated for the Project. Therefore, no rock drilling or blasting is expected.

Geophysical and geotechnical surveys indicate that subsurface sediment conditions within the WTG array on Horseshoe Shoal consist primarily of sands, glacial deposits, and other unconsolidated sediments up to 150 feet (46 meters) below the present sea bottom (OSI, 2002; OSI, 2003; GZA 2003). The pile foundation system would likely be installed by mechanical hammer driving techniques, thereby minimizing seabed disturbance and turbidity associated with other types of foundation installation, such as gravity base or drilled foundation installations.

Chemical analysis of marine sediments within the Project area indicate that trace levels of potential constituents of concern present in sediment samples from Lewis Bay and Nantucket Sound were found however they were determined to be at concentrations below levels that would cause either chronic or long-term biological impacts and should pose little or no risk to water quality or biota, as discussed in Sections 5.1.3.2 and 5.1.3.3, and shown on Tables 5.1-4 through 5.1-6.

The majority of sediments suspended during foundation installation are conservatively expected to settle within the immediate vicinity of the foundations within one to two tidal cycles because the volume of sediment that would be suspended during the pile driving is expected to be minimal. This expectation is based on the predominance of sand sized sediments in the Wind Park area and the fact that the volume of sediment suspended by pile driving would be much less than the sediment volume suspended by jet plow embedment of the submarine cables (refer to Section 5.2 and Appendix 5.2-C for information on expected settlement rates associated with jet plow embedment). In addition, because the monopiles are hollow and open-ended, subsurface sediments would be encased within the monopile, providing additional structural support and minimizing disturbance of sediment from installation activities. Installation of the monopile foundations would not require excavation or backfill of bottom sediments.

Scour mats would be installed around the WTGs and ESP following monopile foundation installation, and would remain in place during inner array cable installation and throughout the life of the project. As discussed in Section 4.0 and the scour analysis in Appendix 4.0-A, the artificial fronds on the scour mats are designed to slow water velocity at the seabed, allowing suspended sediments to settle on the mats, thus reducing the potential for local scour around each structure. The effectiveness of the scour control measures would be monitored by periodic diver inspection during construction and during maintenance inspections.

Sediment suspension related to anchoring, winching, and the use of jack-up barges associated with construction of the WTGs is anticipated to be short-term and localized, due to the predominance of sands in this area, which settle more readily to the bottom than do finer-grained sediments. As discussed above, suspended sediments are expected to settle back to the sea floor within one to two tidal cycles because the amount of sediment suspended by the anchoring, winching, and use of barges is expected to be small and predominantly sands, which settle quickly (see Appendix 5.2-C). Given the existing dynamic environment, natural processes are anticipated to rapidly restore seabed topography following completion of construction.

Intermittent cobbles and boulders may be present on the seafloor, which may be movable with conventional offshore construction equipment. Subsurface cobbles and boulders that may be encountered during installation would either be captured within the monopile or deflected during pile driving (depending upon size). If an obstruction is encountered, the monopile would be offset to an adjacent location within the immediate vicinity which would not significantly affect the overall grid spacing.

Total temporary impacts to surface sediments due to installation of the WTGs and ESP from the jack-up barges and anchoring and anchor line sweep, is 479 acres/20,861,856 square feet (1,938,130 square meters) (Table 5.3-3).

Project decommissioning is expected to result in temporary and localized impacts to sediments similar to or less than those described for construction. Decommissioning for the WTGs and the associated cables is essentially the reverse of the installation process with the exception that no pile driving would occur. The monopile, with the transition piece, would be cut off at the seabed followed by the removal of the sediment within it to a suitable depth (approximately 6.5 feet (2 meters) below the level of the seabed). Once the sediments have been removed, the remaining monopile would be cut off at a depth of approximately 6.5 feet (2.0 meters) below the surface. The temporary void left in the seabed would infill as a result of the sandy side slopes and natural processes.

Potential Impacts of WTG Operation

After installation of the pile foundations and during Project operation, some localized scour around the monopile foundations could occur at the seabed-monopile interface around each WTG, depending on local sediment transport conditions. A scour analysis was conducted to predict sediment scour that may occur in seabed

sediments around the WTG structures (see Section 4.0 and Appendix 4.0-A). Scour processes are driven by the influences of wave action (wind-driven and ocean swell) and currents (tidal and wind-driven), which can cause flow vortices around a piling-type structure at the seabed. The vortices can cause an area of scour to develop around a pile.

In brief, results of the studies indicated that localized effects to sediment transport patterns are anticipated immediately around WTG foundation bases, due to localized turbulence adjacent to the structures. In the absence of mitigation measures, the maximum scour depth predicted under the two likeliest scenarios for Nantucket Sound conditions was up to approximately 4 feet (1.2 meters) below the seabed, with at least some scour effects extending a maximum of 33 feet (10 meters) horizontally from the WTG (see Appendix 5.2-A). Under the third scenario (100-year storm in open ocean conditions, without the sheltering effects of Nantucket and Martha's Vineyard), scour was predicted to a maximum depth of 8 feet (2.4 meters) around the WTGs. However, this scenario is unlikely, as the hydrographic conditions in Nantucket Sound are not within an open ocean setting (see Appendix 4.0-A). The results of the scour analysis indicated that, with scour control mitigation in place, there would be no long-term effects on the sediment composition of Horseshoe Shoal due to construction or operation of the Project (see Appendix 4.0-A).

Scour protection would be installed as described in Appendix 4.0-A (Scour Analysis), to mitigate these potential impacts. The proposed system of anchored scour mats, with artificial fronds to slow water velocity at the seabed, around each WTG would mitigate potential scour effects. The effectiveness of the scour control would be periodically monitored by diver inspection. In the event that scour mats are found to be less effective than anticipated, more traditional scour protection methods (such as rip-rap) are available as an alternative.

The Project's foundation design would result in a maximum permanent area of seabed occupation from the 130 WTG monopiles and ESP pilings of approximately 0.68 acre/29,637 square feet (2,753 square meters). Additional seabed area would be occupied by six scour control mats – at 16.5 by 8.2 feet each (5 by 2.5 meters each) – to be placed around each of the monopile foundations. Adding in the six scour mats associated with each of the six 42-inch (106.7-cm) diameter ESP pilings results in permanent seabed occupation of 2.53 acres/110,160 square feet (10,234 square meters) for all the scour mats encircling the WTGs and ESP structures. A total of approximately 3.21 acres/139,797 square feet (12,987 square meters) of seabed would be permanently occupied by Project structures, including the WTG monopiles, ESP foundations and associated scour mats. Please refer to Table 5.3-3 for a full presentation of seafloor impact areas.

Natural wave and tidal processes over the generally sandy seabed across the shoals at the Proposed Site create a dynamic geologic environment, as evidenced by the presence of sand waves. As a result, natural processes are anticipated to rapidly restore seabed topography following completion of construction. Migration of sand waves across Horseshoe Shoal should have no impact on the integrity of Project structures, since they are set deep into the sediments (50 to 90 feet (15.2 to 27.4 meters), depending on water depth). Migration of sand waves across the shoals should not be substantially affected by the presence of the WTGs, which would be widely spaced (minimum of 2,066 feet (629 meters) between WTG edges) and have highly localized connections to the seabed. No adverse impacts to sediment and marine geology are anticipated due to operation of the WTGs.

Potential Impacts of Installation of Inner-array Cables

As described in detail in Section 4.3.3, the inner-array cables would be installed using jet plow embedment. The 78-mile (125.5-km) inner-array cable system linking the WTGs to the ESP would be buried to depths of 6 feet (1.8 meters) below sea bottom, in order to eliminate potential impacts to navigation, as well as potential conflicts with anchors and fishing gear.

Temporary direct impacts to surface sediments would result from installation of the inner-array cables and anchoring activities associated with construction. The expected maximum width of surface disturbance is 6 feet (1.8 meters) from the jet plow, plus an additional 6 feet (1.8 meters) of surface disturbance related to the jet plow pontoons. Temporary impacts to surface sediments would also result from anchoring of construction vessels and anchor sweep. These activities result in an estimated total temporary direct area of surface sediment disturbance from inner-array cable installation and anchor activities calculated to be 684.87 acres/29,832,660 square feet (2,771,545 square meters) (Table 5.3-3). The layout of the inner array cables is shown on Figure 4-8.

Trenching technology is described in Section 4.0. In brief, a skid/pontoon-mounted jet plow would be towed by the cable-laying barge. It is anticipated that, to install the inner-array cabling to the required depth providing a minimum of six feet of cover in the sediments that are generally found in the Project area, the jet plow blade is lowered onto the seabed, pump systems are initiated to fluidize sediments as the jet plow progresses along the pre-selected marine cable route, creating a trench approximately 4 to 6 feet (1.2 to 1.8 meters) wide (top width) to a depth of 8 feet (2.4 meters) below present bottom. The cable system then settles into the trench via its own weight. One pass of the jet plow is expected to be required to install each segment of the inner array cables. As the jet plow progresses along the route the water pressure at the jet plow nozzles will be adjusted as sediment types and/or densities change to achieve the required minimum burial depth of 6 feet of cover. In the unlikely event that the minimum burial depth of 6 feet below present bottom is not met during jet plow embedment, additional passes with the jet plow device or the use of diver-assisted water jet probes will be utilized to achieve the required depth.

In sandy sediments, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (generally minutes to less than one hour at any fixed location), based upon modeling described in Section 5.2 and Appendix 5.2-C. Therefore, sediment suspension associated with construction activities is expected to be temporary and localized due to the predominance of sands in this area.

Impacts to marine sediments due to anchoring, winching, and spudding activities associated with construction activities of the inner-array cables are expected to be short-term and localized. Given the dynamic sedimentary environment across the shoals, natural processes are anticipated to rapidly restore seabed topography following completion of construction.

Potential Impacts of Inner-array Cables Operation

Because the inner-array cables would be buried to depths of 6 feet (1.8 meters) below sea bottom, the potential for conflicts with anchoring or fishing activities would be minimized. Scour is not anticipated to affect the sediment cover over the buried inner array cables, as the scour is caused by the interaction of waves and currents around a structural object at the sediment surface. Nonetheless, the inner array cables would be inspected periodically to ensure adequate coverage is maintained. If problem areas are discovered, the submarine cables will be reburied.

No adverse impacts to marine geology or sediments are anticipated due to this element of the Project's operation.

Potential Impacts Due to Installation of 115 kV Submarine Cable System

The 115 kV submarine cable system, from the ESP to the seaward HDD terminus, would also be installed using jet plow embedment, as described in Section 4.3.4. The submarine cable system linking the ESP to the Lewis Bay terminus would be embedded in two trenches, one for each circuit, with approximately 20 feet (6.1 meters) of horizontal separation between the trenches. The distance from the ESP to the landfall is 12.2 miles (19.6 km). It is anticipated that, to install each submarine transmission line circuit to the required depth providing a minimum of six feet (1.8 meters) of cover in the sediments that are generally found along the proposed submarine transmission line route into Lewis Bay, the jet plow tool will fluidize a pathway approximately four to six feet (1.2 to 1.8 meters) wide at the seabed and eight feet deep. As the jet plow progresses along the route the water pressure at the jet plow nozzles will be adjusted as sediment types and/or densities change to achieve the required minimum burial depth of 6 feet. In the unlikely event that the minimum burial depth of 6 feet below present bottom is not met during jet plow embedment, additional passes with the jet plow device or the use of diver-assisted water jet probes will be utilized to achieve the required depth. The installation of the submarine cable system beyond the 3-nautical mile limit would result in a total temporary direct area of surface sediment disturbance of 98.35 acres/4,283,664 square feet (397,965 square meters) from 5.6 miles of cable installation (Table 5.3-3).

In order to achieve the 6-foot (1.8-meter) design burial depth, the jet plow is anticipated to disturb a pathway approximately 4 to 6 feet (1.2 to 1.8 meter) wide. The subsurface program conducted to date indicates geologic conditions appear suitable to achieve the 6-foot (1.8-meter) burial depth. Intermittent glacially deposited boulders may require minor route alteration during cable installation.

In sandy sediments, such as the Project setting, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (generally minutes to less than one hour at any fixed location) (see Appendix 5.2-C). Therefore, sediment suspension associated with construction activities is expected to be temporary and localized due to the predominance of sands in this area.

Sediment suspension related to anchoring and winching activities associated with cable installation are expected to be short-term and localized. Therefore, no adverse impacts to geology and sediments are anticipated as a result of this element of Project construction.

Potential Impacts Due to Operation of 115 kV Submarine Cable System

No adverse impacts to marine geology and sediments are anticipated as result of Project operation. The cable system would be inspected periodically to ensure adequate coverage is maintained. If problem areas are discovered, the submarine cables will be reburied.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to geology or sediments would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable, has been proposed by National Grid that involves the installation of a second electric transmission cable between Cape Cod and Nantucket. Its proposed route would only cross the Project's submarine cable route in the vicinity of Hyannis Harbor, well within the Massachusetts 3-mile limit (as discussed below in Section 5.1.4.2). Therefore no significant cumulative impacts to geology and sediments are expected to result from the installation of both projects outside of Massachusetts waters.

The submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance dredging. Therefore, no significant cumulative effects to geology and sediments are expected in the area of the North Channel crossing.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts to geology and sediment are expected since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

Secondary Impacts

There are no potential onshore secondary impacts to geology and sediments associated with construction staging/laydown activities at Quonset. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy, and no significant land alteration would be necessary to accommodate the Project's staging activities.

Impact Summary

For the Proposed Site, the combined total temporary impacts to seafloor sediments from anchoring associated with the installation of the turbine towers, equipment, blades, the ESP platform, inner-array cable connection, and the scour protection mats, and 115 kV submarine cable transmission system outside of the 3-nautical mile (5.6 km) state territorial limit is expected to be approximately 1,262.13 acres/54,978,180 square feet (5,107,640 square meters). A total of approximately 3.21 acres/139,797 square feet (12,987 square meters) of surface

seabed would be permanently occupied by Project structures, including the WTG monopiles, ESP foundations and associated scour mats (Table 5.3-3).

5.1.4.2 Potential Impacts to Marine Geology Inside Massachusetts Waters and Onshore Geology

As described in Section 4.3, two 115 kV submarine transmission circuits would bring electric energy from the ESP in federal waters to the mainland. This submarine cable system would make landfall at the proposed transition vault in Yarmouth, then run underground in existing public ways and ROWs to the NSTAR Electric ROW at Willow Street in Yarmouth. The ductbank would then run underground along the NSTAR Electric ROW to the Barnstable Switching Station. The installation and operation of the marine and onshore cables, and the associated onshore transition vault and manholes, would be the only Project activities conducted within the 3-nautical mile (5.6 km) state territorial limit. Potential impacts to geology and the seabed would be limited to temporary localized sediment disturbance along proposed cable corridors during cable installation.

5.1.4.2.1 Nantucket Sound and Lewis Bay Landfall

Maximum anticipated temporary and permanent impacts to surface marine sediments as a result of construction, operation, and decommissioning of the Project are presented in Table 5.3-3, and are discussed below.

Potential Impacts Due to Installation of the 115 kV Submarine Cable System
As discussed above, the 115 kV submarine cable system from the ESP to the seaward HDD terminus would also be installed using jet plow embedment, as described in Section 4.3.4. Transmission lines linking the ESP to the Lewis Bay terminus would be embedded in two trenches, one for each circuit, with approximately 20 feet (6.1 meters) of horizontal separation between trenches. The distance from the ESP to the landfall is 12.2 miles (19.6 km), of which 6.6 miles (10.6 km) is within state territorial waters. Cables would be buried to a depth of approximately 6 feet (1.8 meters) below the seafloor.

In order to achieve the 6-foot (1.8-meter) design burial depth, the jet plow is anticipated to disturb a pathway approximately 4 to 6 feet (1.2 to 1.8 meters) wide. The subsurface program conducted to date indicates geologic conditions appear suitable to achieve the 6-foot (1.8-meter) burial depth. Intermittent glacially deposited boulders may require minor route alteration during cable installation.

Sediment suspension associated with cable installation would be localized and temporary. It is estimated that within the 3-nautical mile (5.6-km) state territorial limit, 115.97 acres/5,051,529 square feet (469,302 square meters) of seafloor would be temporarily impacted by submarine cable installation (Table 5.3-3). In sandy sediments, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (generally minutes to less than one hour at any fixed location) (see Appendix 5.2-C). Therefore, sediment suspension associated with construction activities is expected to be temporary and localized due to the predominance of sands in this area.

Sediment suspension related to anchoring and winching activities associated with cable installation are expected to be short-term and localized. Therefore, no adverse impacts to geology and sediments are anticipated as a result of this element of Project construction.

Potential Impacts Due to Operation of the 115 kV Submarine Cable System
Because the 115 kV submarine cable system would be buried to nominal depths of 6 feet (1.8 meters) below sea bottom, the potential for conflict with anchoring or fishing activities would be minimized to the greatest extent feasible. No adverse impacts to marine geology and sediments are anticipated as result of Project operation.

Potential Impacts Due to HDD Conduit Installation
As described in detail in Section 4.3.5, the 115 kV submarine cable system would be transitioned to the onshore cable transmission line via HDD, to avoid impacts to existing shore protection structures and the intertidal zone at the landfall. The conduit that would encase the 115 kV submarine cable system beneath the shoreline would be installed from the onshore HDD staging area. HDD operations would be staged from a designated temporary onshore location at the landfall (see Section 4.0 for details and location). A submarine area beyond the intertidal zone in Lewis Bay has been selected as the proposed exit location for the boreholes. The HDD boreholes would

be approximately 200 feet (61 meters) long. Each circuit would be split just offshore of the HDD exit into two separate cable bundles such that four conduits would need to be installed by HDD.

At the seaward end of the conduit, a temporary cofferdam would be constructed to contain suspended sediments and minimize sediment disturbance during material removal activities. Excavated material would be placed on a barge, appropriately contained, and removed to an appropriate onshore disposal location. Potential permanent impacts to the shoreline and intertidal zone would be avoided through use of HDD. Impacts to the seabed and surface sediments would also be minimized; temporary surface sediment impacts related to construction of the HDD are estimated to be approximately 0.067 acre/2,925 square feet (272 square meters) (Table 5.3-3).

Potential Impacts Due to Operation of HDD Conduit

No adverse impacts to marine geology and sediments are anticipated as result of this element of Project operation.

Cumulative Impacts

As stated above, other activities in the past, present, or future which may contribute to cumulative impacts to geology or sediments would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent, cumulative sediment suspension and deposition. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on recent experience it could be needed in the next 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. Future USACE maintenance dredging in Hyannis Harbor would be the subject of an additional NEPA document. In any event, as discussed in Appendix 5.2-C, sediment deposition resulting from the cable installation would be minimal and localized, and would not substantially contribute to any significant cumulative impact to geology and sediments.

A new submarine transmission cable has been proposed by National Grid between Cape Cod and Nantucket. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. In locations where the two projects may be proximate, the impacts of each project may be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment associated with the Project are minimal and of short duration, these temporary impacts are not likely to occur at the same time. Thus, it is likely that Project impact would have ceased, and would not be coincident with other potential project impacts. Therefore, no significant cumulative impacts to geology and sediments are expected to result from the installation of both projects.

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the Project area. However, such marina dredging projects, if they were to occur, are very localized and would not be likely to result in sediment suspension and deposition that would be coincident with the cable installation (the closest point of which would be a minimum of 0.5 miles (805 meters) from the closest marina). Thus, no significant cumulative impacts to geology and sediments are anticipated from these activities.

5.1.4.2.2 Onshore Cable

The proposed installation process for the onshore cable system is described in detail in Section 4.3.6. This section describes potential onshore impacts associated with the Project. The onshore portion of the Project is designed to avoid impacts to undisturbed native soils and other geologic resources by utilizing previously disturbed ROWs and roadways.

Potential Impacts Due to Installation of the Onshore Transmission Line

The onshore transmission cable system would be installed within existing paved roadways in Yarmouth from the landfall location to the NSTAR Electric ROW, as described in Section 4.0. Storm water erosion and sedimentation controls would be in place prior to the initiation of construction activities. Excavated soil from the trench and vaults would be temporarily stored adjacent to the worksite or transported off-site, if on-site storage is not possible. Where soil is stored at the site, it would be stabilized with erosion and sedimentation controls. Once the transmission line is installed, the excavation would be backfilled and repaved as necessary. Following completion of construction, all equipment and construction debris would be removed from the site and the area would be returned to its original condition. The total estimated area to be temporarily disturbed along the proposed onshore transmission line route from the landfall location to the NSTAR Electric ROW is approximately 4.9 acres/213,444 square feet (19,830 square meters).

Within the NSTAR Electric ROW from Willow Street to the Barnstable Switching Station, cables would be installed using the same general methods used for the road route described above. After the installation of the transmission line is complete, the excavation would be backfilled to the original grade, and the area would be seeded with an erosion control seed mixture for stabilization. Trenchless technologies would be utilized where the transmission line intersects with an existing railroad ROW near Willow Street, and where the ROW crosses Route 6 to the Barnstable Switching Station. The total width of workspace disturbance would be approximately 25 feet (7.6 meters), including construction access, laydown areas, and the 8-foot (2.4-meter) wide trench. This work would require the temporary disturbance of approximately 5.8 acres/252,648 square feet (23,472 square meters) of vegetation within the maintained ROW as well as minor permanent alteration as a result of the manhole covers.

Potential Impacts Due to Operation of the Onshore Transmission Line

No permanent impacts to geology would occur due to operation of the onshore cable along the roadways, as the cable is sited within previously disturbed roads and ROWs. Permanent impacts within the NSTAR ROW result from native soils being replaced by the 9 underground vaults and 36 manhole covers (4 associated with each vault), as described in Section 4.2.3 and shown on Figure 4.15. No adverse impacts to soils and other geologic resources are anticipated as result of Project operation.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to geology or soils would include other upland cable or pipeline installations, excavation activities, and other wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative). The cumulative impact from one potential activity that may occur within the location and timeframe of the proposed Project is discussed below.

There are no significant cumulative impacts expected to result from the onshore portion of National Grid's Nantucket Cable should it be installed at the same time as the onshore portion of the Project's cable system. The proposed Nantucket Cable's onshore route is more than a mile (1.6 km) distant from the Project's proposed route, and would pass through the central portion of Hyannis, while the Project's onshore route bypasses the center of town to the east.

5.1.5 Mitigation

Results of geophysical and geotechnical studies indicate geologic conditions are suitable for construction and operation of the Project. The Project was designed based in part on results of physical analyses of sediments and hydrographic studies. Project construction methodologies have been selected to minimize direct, indirect, and cumulative environmental impacts on marine and onshore geology and sediments, to the extent practicable. These measures include using state-of-the-art hydraulic jet plow installation, HDD beneath the intertidal zone and shoreline, monopile foundations for WTG towers, scour protection mats to reduce scour potential, and post-construction monitoring to document habitat disturbance and recovery (see Section 6.0). Operation of the Wind Park and cable system is not anticipated to adversely impact geologic resources or sediments in the Project area. A Spill Prevention Control and Countermeasure (SPCC) Plan would be in place during Project construction/decommissioning and operation to prevent/control potential impacts to seabed, wetlands, and water

quality that could result from spills of fuel, lubricating oils, or other substances associated with the use of marine vessels and machinery (see Section 5.9).

The Project would be designed, constructed, operated and maintained in accordance with appropriate earthquake-related provisions, as contained in building codes and standards applicable to the Project. All Project work would be performed in accordance with applicable local, state, and/or federal safety standards.

The proposed method of installation for the submarine and inner-array cables is hydraulic jet plow embedment. This method of simultaneously laying and burying the cables ensures the placement of the submarine cable system at the target burial depth with minimal bottom disturbance. In sandy sediments, such as those in the Project area, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Appendix 5.2-C).

HDD would be used to avoid impacts to the shoreline and intertidal zone. A temporary cofferdam would be used during construction to minimize sediment resuspension at the interface between the HDD conduit and submarine cable system. The HDD operation would be staged at the onshore landfall area and involve the drilling of the borehole from land toward the offshore exit point, further avoiding impacts to the shoreline and intertidal zone. The transition of the cables from the conduits to subsurface sediments would involve construction of a temporary cofferdam at the end of the conduit boreholes. Approximately 840 cubic yards (642.2 cubic meters) of sediment would be excavated from the cofferdam. All of the excavated sediment would be removed, so no discharge is proposed. From the pit to the ESP, cables would be installed using the hydraulic jet plow. After the submarine cable system has been installed, the cofferdam would be removed and natural tidal processes would resettle sediment into the pit normalizing the seafloor. A small depression may remain over the pit area after installation, depending on localized sediment depositional processes.

To minimize the release of bentonite drilling fluid into Lewis Bay during HDD, freshwater would be used as a drilling fluid to the extent practicable prior to the drill bit or the reamer emerging in the pre-excavated pit. This would be accomplished by pumping the bentonite slurry out of the hole, and replacing it with freshwater as the drill bit nears the pre-excavated pit. It is likely that some residual volume of bentonite slurry would be released into the pre-excavated pit. The depth of the pit and the temporary cofferdam perimeter are expected to be of an adequate volume to contain any bentonite slurry that may be released. Prior to drill exit, and while the potential for bentonite release exists, diver teams would install a water-filled temporary dam around the exit point to act as an underwater "silt fence." This dam would contain the bentonite fluid as it escapes and sinks to the bottom of the pre-excavated pit, thus allowing for easy clean-up using high-capacity vacuum systems.

Potential impacts to seabed geology and marine sediment would be minimized to the greatest extent practicable through the use of monopile foundations for WTG structures, scour mats with artificial fronds around WTG monopiles and ESP pilings, and low-impact hydraulic jet plow cable installation techniques, and by limiting the area of seabed and ground disturbance to within specified work areas. Seabed impacts related to sediment disturbance from anchoring and/or the resting of work vessels on the seabed within designated work areas would be comparable to disturbance already occurring within Nantucket Sound from natural events (e.g., storms) and use of commercial fishing gear.

For the above-mentioned reasons, no long-term adverse impacts to marine geology and sediments are anticipated from Project construction, operation, and maintenance. In the onshore portion of the Project, in order to minimize impacts to previously undisturbed and more environmentally sensitive areas, the route has been sited entirely within existing roadways and ROW.

In addition to the measures described above, several preventative/contingency plans would be in place during Project construction/decommissioning and operation to prevent erosion and sedimentation, respond if a release to the environment occurs, and ensure proper operation and maintenance of equipment. These plans are likely to include:

- **Spill Prevention Control and Countermeasure (SPCC) Plan** – The Applicant would prepare a SPCC Plan that would detail the means to prevent, control, and mitigate releases to the environment. The SPCC Plan would be implemented during Project construction/decommissioning and operation to prevent potential

impacts to water quality that could result from spills of fuel, lubricating oils, or other substances associated with the use of construction vehicles/vessels and other equipment and machinery. In the event of a release, clean up measures would be employed to minimize impacts to the environment and assure the protection of any people and wildlife in the immediate area.

- **Storm Water Pollution Prevention Plan (SWPPP) –** The Applicant would prepare a SWPPP which describes erosion and sedimentation controls to be used during Project construction/decommissioning and incorporates applicable best management practices (BMPs) for erosion control and stormwater management during construction.
- **Operation and Maintenance (O&M) Plan** – The Applicant would prepare an O&M Plan that would detail standard operating and maintenance protocols to ensure proper operation of Wind Park facilities. The O&M Plan would specify operating guidelines, maintenance schedules, and materials approved for maintenance activities. The maintenance program would include preventive and emergency maintenance functions including shore-based predictive maintenance analysis of the WTGs and ESP.

5.2 Physical Oceanographic Conditions

5.2.1 Introduction

This section provides a characterization of water depths, currents, waves, and the sediment transport regime of the Proposed Project site in Nantucket Sound. Similar information is provided for Lewis Bay. Information included in this section was developed based on compilation and analysis of existing data, field investigations, agency consultation, and analytical modeling.

Oceanographic studies completed to date are described in Section 5.2.2. Existing oceanographic conditions, based upon literature review and the results of the studies undertaken, are discussed in Section 5.2.3. Potential impacts and mitigation measures related to construction/decommissioning and operation/maintenance of the Project are discussed in Sections 5.2.4 and 5.2.5, respectively.

5.2.2 Studies Completed

5.2.2.1 Review of Existing Data

Existing sources of data reviewed include:

- Bathymetry – Bottom depth measurements throughout Nantucket Sound from NOAA navigation charts;
- Tidal Currents – Tidal current information and observations within Nantucket Sound from a variety of sources dating back to the 1840's;
- Ocean Waves – Hindcast (historical predictions) wave information for a 40-year period offshore of Nantucket Island and Martha's Vineyard within the Atlantic Ocean;
- Winds (used to model local waves and currents) - Hourly measurements from Otis Airport between the late 1940s to present, Hyannis Airport (1973-2001), and Nantucket Airport (1986-2001); and
- Grain Size (used to assess sediment transport) – Sediment grain size data from USGS.

These data sources were used to plan field survey and analytical modeling efforts, as input parameters to analytical modeling, and to assess existing conditions in and around the Project Area for this document.

5.2.2.2 Field Surveys

Integrated marine geophysical/hydrographic surveys and geologic/sediment sampling programs were conducted by Cape Wind in 2001 and 2002 over Horseshoe Shoal and along the submarine cable system corridor between Horseshoe Shoal and the proposed landfall location in Yarmouth. The investigations were designed to provide data to assess and characterize existing oceanographic conditions, including water depths, seafloor morphology and structural features, and sub-seafloor stratigraphy, and to provide information to assist in characterizing wave, current (tidal and wind-driven), and sediment transport processes. Data collected during marine field investigations for the Project are summarized below and described in the following sections. Data that was collected during field investigations include the following.

- Geophysical Survey – Bathymetric measurements and side-scan sonar data were collected within the Project area, including the interconnection route into Lewis Bay, as described in Section 5.1.
- Current Measurements – Detailed current measurements were taken using a vessel-mounted Acoustic Doppler Current Profiler (ADCP) at various locations throughout Nantucket Sound, in the vicinity of the Proposed Site. Measurements included current speed and direction at half-meter water depth increments throughout a tidal cycle.
- Sediment Samples – Vibracore and grab samples were obtained for bulk physical characterization of Project area sediments in Nantucket Sound and Lewis Bay.
- Additional site-specific field data would continue to be collected on Horseshoe Shoal through the use of continuously recording instrumentation that would be placed on the SMDS, installed on the southern edge of the Project area. Data collected would include wind direction and speed, wave height and frequency, and current speed and direction.

5.2.2.3 Existing Conditions Modeling

Analytical models were applied to characterize wave, current (tidal and wind-driven), and sediment transport processes at the Proposed Site. The modeling and results are described in detail in Appendix 5.2-A and Appendix 5.2-B. The modeling methods applied by Woods Hole Group are summarized below.

Waves
An analytical model developed by the USACE (*Wind Speed Adjustment and Wave Growth*) (USACE, 1992) was used to determine wind-generated wave characteristics in Nantucket Sound based on wind information obtained from Nantucket Airport. Wave model simulations were conducted corresponding to various wind directions and speeds. A shoaling coefficient and wave breaking criteria was applied to the highest wind-generated wave condition modeled for Nantucket Sound to characterize the spatial distribution of wave height over the Proposed Site. In addition, one average ocean swell wave condition was modeled for the Proposed Site, and analysis was performed to estimate extreme wave heights and periods for 2-year, 10-year, 50-year, and 100-year return periods.

Currents
An empirical analysis based on current ADCP data and historical data was used to determine tidal current speeds and direction for the Proposed Site; and modeling by Woods Hole Group (Trowbridge 2002, Appendix B of Appendix 5.2-A) was used to determine wind-driven currents on Horseshoe Shoal.

Sediment Transport
A comprehensive analytical two-dimensional sediment transport model developed by Woods Hole Group based on theory Madsen and Grant 1976 (Appendix C of Appendix 5.2-A) was used to conduct 26 simulations, addressing a range of current and wave conditions for the Proposed Site. For each condition, the model calculated wave-induced bottom current velocities, near-bottom tidal current velocities, a qualitative representation of where and whether sediment transport would be likely to occur, and quantitative estimates of potential bed load, suspended load, and total sediment transport rates.

5.2.2.4 Model Simulations of Jet Plow Embedment of Cable System

A simplified model (using SSFATE modeling techniques) was performed by Applied Science Associates, Inc. (ASA) to simulate water column sediment concentration and sediment deposition thickness and extent resulting from jet plow embedment of the submarine cable system. SSFATE model simulations were completed along a representative straight-line segment 4,200 feet (1,280 meters) in length, presuming sand-sized sediment based on information from Vibracore VC01-L2, near the inlet to Lewis Bay. The results presented from the simulation can be considered typical and generally representative of the subsurface sediment types expected to be encountered along the submarine cable system route, as those are also primarily sand-sized sediments (see Section 5.1). The methodology and results of sediment modeling are described in Appendix 5.2-C. The modeling and results are considered to be representative of sediment conditions throughout the project area.

5.2.3 Existing Conditions

The in-water area within which the Project is proposed is Nantucket Sound, with electric cable installation proposed in waters within Lewis Bay as well. Nantucket Sound is a broad passage of water that separates the south shore of the Cape Cod mainland and the islands of Nantucket and Martha's Vineyard. It is approximately 23 miles (37 km) long (east-west direction), and between 6 and 22 miles (9.7 and 35.4 km) wide. Lewis Bay is a coastal embayment along the south coastline of Cape Cod. It is northeast of Hyannis Harbor, and is separated from Nantucket Sound by Point Gammon and Great Island (see Figure 4-1)). Oceanographic conditions for each area are discussed below.

5.2.3.1 Water Depths/Bathymetry

In general, the bathymetry in Nantucket Sound is irregular, with a large number of shoals present in various locations throughout this glacially formed basin. Charted water depths in the Sound range between one and 70 feet (0.3 and 21.3 meters) at MLLW (Figure 4-1). A combination of NOAA nautical charts and project-specific hydrographic surveys (see Section 5.1_for survey details) were used to assess existing bathymetric conditions.

The Proposed Site is located on Horseshoe Shoal, a prominent geological feature in the center of the Sound (Figure 4-1). Depths on Horseshoe Shoal are as shallow as 0.5-foot (0.15 meters) at MLLW. Measured depths of 60 feet (18.3 meters) at MLLW occur between the northern and southern legs of the shoal. An east-west trending natural channel feature exists on the southern leg of the shoal, with measured water depths approaching 50 feet (15.2 meters) at MLLW.

Water depths between Horseshoe Shoal and the Cape Cod shoreline are variable, with an average depth of approximately 15 to 20 feet (4.6 to 6.1 meters) at MLLW. Along the transmission line interconnection corridor, depths vary from about 16 to 40 feet (4.9 to 12.2 meters) at MLLW, with an average depth of approximately 30 feet (9.1 meters) at MLLW.

Water depths in Lewis Bay and Hyannis Harbor are variable, ranging from approximately 8 to 16 feet (2.4 to 4.9 meters) at MLLW in the center of the bay to less than five feet (1.5 meters) at MLLW along the perimeter and between Dunbar Point and Great Island. There are three navigation channels in Lewis Bay: the Federal Navigation Channel providing access to Hyannis Inner Harbor (authorized depth –13 feet (-4.0 meters) MLW); one privately maintained channel into Mill Creek (reported depth of –2 feet (-0.6 meters) MLLW in 1983); and one privately maintained channel northeast of Great and Pine Islands (approximately seven feet deep (2.1 meters) at MLLW).

The submarine cable system route would extend outside the eastern edge of the federal channel into Lewis Bay, and would then turn east north of Egg Island to make landfall between Mill Creek and the privately maintained channel northeast of Great and Pine Islands. Water depths along this route in Lewis Bay range from 2 to 16 feet (0.6 to 4.9 meters), with an average of approximately 8 feet (2.4 meters). The shallowest portions of Lewis Bay/Hyannis Harbor along this route exist between Great Island and Dunbar Point and at the landfall, with depths of one to four feet (0.3 to 1.2 meters) at MLLW.

5.2.3.2 Currents

Currents in Nantucket Sound are driven by strong, reversing, semidiurnal tidal flows. Wind-driven currents are only moderate because of the sheltering effect of Nantucket and Martha's Vineyard. The tidal range and diurnal timing are variable because of the semi-enclosed nature of the Sound and the regional variations in bathymetry. Typical tidal heights are in the range of one to four feet (0.3 to 1.2 meters), with tidal surges of up to approximately 10 feet (3 meters) having been recorded during hurricanes (Bumpus et al., 1973; Gordon and Spaulding, 1979). Times of high and low tides vary across the Sound by up to two hours.

Tidal flow and circulation within the Sound generate complex currents, the directions of which form an ellipse during the two tidal cycles each day. The complex bathymetry of Nantucket Sound forces the tidal ellipses to take different shapes in different regions of the Sound. Just off the coast of the south shore of Cape Cod, there is a strong rectilinear, semi-diurnal tidal flow approximately parallel to the coast (Goud and Aubrey, 1985). The

tidal current flows to the east during the flood tide (incoming) and to the west during the ebb tide (outgoing). Peak tidal currents often exceed two knots (Bumpus et al., 1973). The intensity of tidal flow, in general, decreases from west to east. There is a slow net drift of the water mass toward the east in the Sound. The net drift is about 2,153 square feet (200 square meters) per tidal cycle, roughly five percent of the total easterly and westerly tidal flows (Bumpus et al., 1971).

To characterize site-specific tidal and wind-driven currents at the Proposed Site in Nantucket Sound, analytical models were applied (Appendix 5.2-A), with the results summarized as follows.

- Flood currents on the shoals are generally directed easterly, with ebb currents generally directed westerly.
- Local changes in tidal current direction occur on Horseshoe Shoal due to its bathymetric features, with currents diverted slightly around the shallowest portion of the shoal.
- Flood currents are generally stronger than ebb currents, and spring tidal currents are approximately 15 to 20% stronger than mean tidal currents.
- Tidal current velocities were calculated to be approximately two feet/second (0.61 m/second) at Horseshoe Shoal.
- Wind-driven current velocities modeled at Horseshoe Shoal were found to be much lower than tidal velocities, and were found to be concentrated over the crest of the shoal.

Current speed and direction were found to vary more with location than water depth. Vector representations of tidal currents at three locations on Horseshoe Shoal are found in Appendix 5.2-A, Figure 3-8. The estimated tidal currents at Horseshoe Shoal from the analytical models are illustrated in Appendix 5.2-A, Figure 3-13.

5.2.3.3 Waves

There is no extensive source of wave data within Nantucket Sound, so available wind data and analytical models were used to characterize wind-generated waves at the Proposed Site (see Appendix 5.2-A and Appendix 5.2-B). The major factors affecting the magnitude and period of wind-generated waves in this area are: the fetch length (the distance over which wind acts on the water surface), average water depth, and wind speed. The wave model applied used these factors to estimate wave height and period under different conditions. Fundamentally, larger waves are generated as wind speed, water depth, and fetch length increase. Fetch is restricted within Nantucket Sound due to surrounding landforms including Cape Cod, Monomoy Island, Nantucket Island, and Martha's Vineyard.

Wave model simulations were performed using the USACE's *Wind Speed Adjustment and Wave Growth* model (USACE,1992) to estimate significant wave height (i.e., the average height of the highest 1/3 of waves in a sea state); peak period (i.e., the period that characterizes the majority of the waves in the sea state); and peak direction. The results represent wave conditions at the center of the Proposed Site at Horseshoe Shoal. Generally, the model indicates that Horseshoe Shoal is exposed to the largest waves from the easterly directions. Wind-generated significant wave heights generally range from less than one foot to nearly four feet (0.3 to 1.2 meters), with relatively short spectral peak wave periods (between two and four seconds). Individual wave heights can be higher, and substantially higher waves would be present during storms. The wave data being collected at the SMDS would provide valuable data for ground-truthing wave modeling results at the Horseshoe Shoal site.

Using the model results, a shoaling coefficient and wave breaking criteria were applied to obtain a distribution of the wave heights over the shoals, as described in Appendix 5.2-A. Generally, wave height changes in the shallow portions of the shoal due to wave shoaling and breaking, while wave period remains constant. Figures 3-5a and 3-5b of Appendix 5.2-A show the significant wave height distribution for the largest calculated significant wave height at the Proposed Site.

It is also possible that longer period waves enter Nantucket Sound from the Atlantic Ocean. Therefore, a conservative estimate of long period swell conditions was developed for the Proposed Site. The average wave height of offshore waves approaching from easterly through southeasterly directions east of Monomoy within the Atlantic Ocean was used for this analysis. The average height for these offshore waves is 4.5 feet (1.4 meters),

and the average wave period is eight seconds. Average ocean waves were selected for this analysis to capture potential effects for longer period waves. Although significantly higher and longer period waves occur in the ocean (e.g., heights greater than 20 feet with periods exceeding 12 seconds), it was not judged appropriate to assume such large waves occur in Nantucket Sound given the presence of the numerous relatively shallow shoals. A shoaling coefficient was used to modify the ocean swell and provide an estimate of resulting wave heights and distribution at Horseshoe Shoal. Offshore waves are also likely to be modified substantially by the complex and shallow shoal structure separating Nantucket Sound from the Atlantic Ocean, as well as by the relatively narrow gaps between Monomoy Island and Nantucket Island to the east and between Nantucket Island and Martha's Vineyard to the south. These factors were not included in the analysis because these features would typically serve to dissipate ocean swell effects. Therefore, the analysis is relatively conservative, reflecting higher wave levels than would likely occur. The results are shown in Figures 3-5a and 3-5b of Appendix 5.2-A.

Extremal analysis was performed to estimate wave height and period characteristics for the 2-, 10-, 50-, and 100-year return periods. These were estimated for both locally generated and offshore waves using a computer model entitled "Extrm2: Extremes Program" (Appendix 5.2-B). The extreme storm wave for this Project is defined as the average height of the highest 1 percent of all waves in the spectrum (for the 50-year return the extreme storm wave at Horseshoe Shoal was estimated to be 17.3 feet). The wave characteristics estimated from this analysis are detailed in Appendix 5.2-B.

5.2.3.4 Salinity

Salinities in Nantucket Sound are near oceanic, and salinity gradients are small due to strong lateral and vertical mixing. River runoff into Nantucket Sound is low, so there is little dilution of ocean waters with fresh water. Surface and bottom water salinities vary seasonally and spatially from about 30 ppt to 32.5 ppt (Bumpus et al., 1973). Surface water salinities throughout the Sound are just over 31 ppt during the summer, and are uniformly about 32 ppt in the winter (Limeburner et al., 1980).

5.2.3.5 Temperature

The annual cycle of surface and bottom water temperatures in Nantucket Sound encompasses a range of about 45°F, from nearly 30° F (-1°C) in the winter to as high as 75°F (24°C) in the late summer (Bumpus et al., 1973). Temperature extremes are greatest in coastal ponds and estuaries, and the seasonal temperature cycle is smallest in the deeper parts of the Sound. However, because the Sound is shallow and well mixed, there is little lateral temperature variation and vertical temperature stratification. There is a tendency in the summer for surface water temperature to increase from east to west in Nantucket Sound. In the winter, the gradient is in the opposite direction (Limeburner et al., 1980). This change is caused by the intrusion of warmer continental shelf water into the Sound from the east during the summer months.

Bottom water temperature varies less and changes more slowly on a seasonal basis than surface water temperature. The highest bottom water temperature in Nantucket Sound during summer is in the range of 61°F to 66°F (16 to 19°C) (Theroux and Wigley, 1998). Warmest bottom water temperatures are near the coast of the south shore of Cape Cod, and temperature decreases with distance offshore. Coolest bottom water temperatures in Nantucket Sound (during winter) are in the range of 32°F to 35.6°F (0 to 2°C), and become warmer with distance from the Cape Cod and Nantucket shorelines.

5.2.3.6 Sediment Transport Regimes

Analytical sediment transport modeling was performed to determine the extent to which existing wave and current conditions are likely to lift and move sand at the Proposed Site (see Appendix 5.2-A).

Generally, the analysis found that active sediment transport occurs at all of the shoals, even under typical wave and tidal current conditions, and there is a net transport of sediment to the east as a result of flood dominated tidal currents. The greatest impact on sediment transport initiation is due to waves. The largest wind-generated waves in the wave distribution within Nantucket Sound can cause a significant increase in sediment transport. The highest sediment transport rates are focused locally on the shallowest portions of the shoal, and there is relatively little sediment transport in the deeper regions for typical conditions.

Bed load transport (sediment movement along the sea bottom) on Horseshoe Shoal is typically an order of magnitude greater than suspended load transport. This is expected at the Horseshoe Shoal Site, where sediments are relatively coarse (see Section 5.1 for more detail on sediment types and characteristics). In addition, the level of wave and current energy under typical conditions is not sufficient to lift and suspend large volumes of sediment within the water column, further supporting this expectation.

5.2.3.7 Ambient Near-Bottom Suspended Sediment Concentrations

A simplified analysis of ambient near-bottom suspended sediment conditions was performed by Woods Hole Group to estimate naturally occurring suspended sediment conditions along the proposed cable route in Nantucket Sound. For this simplified analysis, a reference concentration of suspended sediment was estimated that represents the near-bottom concentration of suspended sediment generated in response to the local wave and tide conditions forcing on the seabed.

The technical approach was based upon the original work by Madsen and Grant (1976), since updated by several authors including Madsen (1993), and is outlined in Appendix 5.2-A. The grain size distribution and water depths were specified based upon sediment analysis information at vibracore location VC01-L4, which is located between Point Gammon and Bishop and Clerks in Nantucket Sound.

Since tidal currents affect large areas, it is appropriate to estimate near-bottom suspended sediment concentrations resulting from tidal action rather than a volume of suspended sediment. The concentration depends on both the wave characteristics (period and height) and the direction at which the waves approach relative to the tidal currents. When the approach of average waves[71] (2.6 second period, 1.6-foot (0.49 meter) height) is aligned with running tidal currents, near-bottom suspended sediment concentrations in Nantucket Sound are estimated to be approximately 71 mg/l. When average waves (2.2 second period, 1.3-foot (0.40 meter) height) approach perpendicular to running tidal currents, near-bottom suspended sediment concentrations in Nantucket Sound are estimated to be approximately 45 mg/l.

In addition to the ambient suspended sediment concentration resulting from wave and tidal actions, other routine and accepted human activities (such as trawling) result in the creation of increased near-bottom suspended sediment concentrations. The volume of sediment that is injected into the water column by fishing gear, such as an otter trawl, is dependent upon the type of sea floor being disturbed, the nature of the currents in the area disturbed, the rate at which the trawl is towed, and the rate of sediment settling. Churchill (1998) reports that modeling of these parameters show that "the overall impact of trawling on sediment suspension is a strong function of bottom depth." Churchill (1998) has measured near-bottom total TSS to be up to 1,500 mg/l as a result of trawling operations. With the seafloor conditions found in Nantucket Sound, it is estimated that approximately 1.32 cubic yards (1.01 cubic meters) of suspended sediment is injected into the water column for every foot of commercial trawling.

5.2.4 Analysis of Impacts

Anticipated impacts on the physical oceanographic environment from installation of the WTGs, the inner-array cables, and the submarine cable system between the ESP and the landfall would be minimal and localized. The nature and extent of these impacts and proposed mitigation measures are summarized below. Impacts from decommissioning are assumed to be the same or less than those associated with installation of the Project.

- **Water Depths/Bathymetry:** Seabed elevations in the vicinity of the WTGs and cables would be modified slightly as a result of sediment displacement. Changes in seabed elevation around each WTG would be limited to localized scour around each WTG. The maximum estimated scour distance from a WTG is approximately 60 feet (18.3 meters) (2.9% of the minimum distance between WTGs), with an associated estimated scour depth of approximately 8 feet (2.4 meters). A slight depression, estimated to be between 0.5 to 2 feet (0.15 to 0.61 meters) deep, is anticipated to result from installation of the inner-array cables

[71] Modeled waves in Nantucket Sound near Horseshoe Shoal generated by average wind speed from a direction in-line with running tidal currents.

and the submarine cable. This slight depression is expected to fill in over time through natural sediment resuspension, deposition, and consolidation. Even though the scour around each WTG would be minimal and localized, scour mitigation measures, described in Section 5.2.5, would be implemented.

Construction of the temporary cofferdam at the exit hole of the HDDs to be used for cable installation under the Cape Cod Shoreline would include the dredging of sediments to a elevation of approximately -10 feet (-3 meters) MLLW. When the temporary cofferdam sheeting is removed, the sediment on the outside of the sheeting would shift into the cofferdam excavation as a result of gravity. This would result in a depression in the sediment surface that could be several feet deep. This depression would be allowed to naturally fill in over time through natural sediment resuspension, deposition, movement and consolidation.

- **Currents:** The Project is not expected to have large-scale impacts on tidal or wind-driven currents in Nantucket Sound because of the small cross sectional area of the WTGs and the wide spacing between them. Small eddies may develop in the immediate vicinity of the WTGs but are expected to dissipate a short distance from the WTG.

- **Waves:** Due to the proposed spacing of the WTGs (0.34 nautical mile (629 meters) from north to south, and 0.54 nautical mile (1,000 meters) from east to west, the Project would not be expected to have significant large-scale impacts to wave conditions. At the smaller scale, a pile's influence on wave propagation in the immediate vicinity of each WTG would depend on the ratio between the diameter of the pile and the wavelength of the incident wave. Piles with diameters less than one-tenth of the incident wavelength do not have an impact on waves, since the waves pass the pile without reflection or diffraction. Piles with diameters greater than one-tenth of the incident wavelength do have an impact on incident waves in that the waves are reflected by the pile and diffracted around the pile. So, as wavelength increases, the effect the pile has on wave propagation decreases (USACE, 2003).

  Nantucket Sound has relatively sheltered waters, in which the majority of waves are locally generated. Modeling of locally wind-generated waves (Appendices 5.2-A and 5.2-B) indicated that these waves typically have wave periods between 2 and 4 seconds and thus have relatively short wave lengths (approximately 20 to 70 feet (6.1 to 21.3 meters)).

  The proposed diameter of monopiles that would be used for WTGs is either 16.75 or 18 feet (5.1 or 5.5 meters), depending on the water depth at the WTG location. Each of these pile diameters is greater than one-tenth the average locally-generated and ocean wavelengths. Thus, only small-scale reflection and diffraction of locally-generated and ocean waves would be expected to occur in the immediate vicinity of each WTG location.

  Therefore, the Project is not expected to have significant impacts to wave conditions in Nantucket Sound. The Project would not significantly interfere with the propagation of non-breaking waves. Waves that are near breaking or actively breaking would impact the WTG, and break on the structure.

- **Salinity:** The Project is anticipated to have no impacts to salinity in Nantucket Sound because there would be no intake or discharge of seawater associated with the Project, no new sources of freshwater due to the project, nor any other mechanism by which salinity would be altered.

- **Temperature:** The Project is anticipated to have no measurable impacts to water temperature in Nantucket Sound because the cables would be buried a minimum of 6 feet (1.8 meters) below present bottom.

- **Sediment Transport Regimes:** Localized effects to sediment transport patterns may occur immediately around the WTG foundation base. However, it is expected that a localized sediment transport equilibrium condition would be reached shortly after construction of the Wind Park given the cyclical nature of both the tidal regime and scour. Considering the spacing between adjacent structures, the cyclical nature of marine scour, the predicted range of scour depths and aerial extents of scour, and the determination by the Woods Hole Group reports (Appendix 5.2- A and 5.2-B) that there is relatively little sediment transport in the vicinity of Horseshoe Shoal, the presence of the array is anticipated to have no long-term, far-field effects on the composition of Horseshoe Shoal.

- **Water Column Sediment Concentration and Sediment Deposition Thickness Resulting from Jet Plow Embedment of the Submarine Cable System:** Modeling predicted the areal extent and thickness of sediment deposition with distance from the centerline of the proposed cable route and the resultant water column concentrations of suspended sediment resulting from jet plow embedment of the cable system along a representative straight-line segment 4,200 feet (1,280 meters) in length in sand-sized sediment. As stated previously, the model simulation predictions can be considered typical and generally representative of the sediment types (primarily sand-sized sediments) expected to be encountered along the submarine cable system route. Background or ambient concentrations were not included in these results, and simplifying assumptions used in this analysis include constant water depth and typical tidal currents within this water body (see Appendix 5.2-C).

  The results of the model simulation indicate that sediment deposition ranges from zero to approximately 0.9 inches (23 mm) adjacent to the jet plow trench in sandy sediments. As depicted in Figure 2 of Appendix 5.2-C, the majority of the sediment deposition is expected to remain within or immediately adjacent to the cable trench. The model simulation indicates that sediment deposition quickly tapers off to below 0.2 inches (5 mm) at approximately 100 feet (30.5 meters) on either side of the cable trench in sandy sediments. These deposited sediments are anticipated to dissipate over time through natural tidal and storm-related sediment processes.

  The model also predicts that, in sandy sediments, suspended sediment concentrations from the jet plow are estimated to occur in a limited area in close proximity to the cable trench and exist for short durations of minutes to less than one hour at any fixed location. As shown in Figure 3 of Appendix 5.2-C, the model simulation indicates that suspended sediment concentration from the jet plow ranges from less than 5 mg/L to approximately 120 mg/L in sandy sediments. Maximum suspended sediment concentrations are predicted by the model to drop off to approximately 70 mg/L within approximately 250 feet (76.2 meters) on either side of the cable trench in sandy sediments, which is in the same range as the estimated near-bottom suspended sediment concentrations that occur during a tidal cycle (see Section 5.2.3.7).

  In addition, the amount of suspended sediment injected into the water column from jet plow embedment is estimated to be approximately 0.36 cubic yards (0.28 cubic meters) for every linear foot of cable installed, which is much less than that introduced into the water column from commercial trawling operations (see Section 5.2.3.7).

  In conclusion, the near-bottom suspended sediment impacts associated with the jet plow are similar to ambient conditions that occur during one tidal cycle, and less than those that occur during routine commercial trawling operations. Therefore, the near bottom suspended sediment concentrations associated with the jet plow are within the range of natural variability resulting from tidal currents, waves, storms, trawling, and vessel propulsion.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to physical oceanography would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from several potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent, cumulative sediment suspension and deposition. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on recent experience it could be needed in the next 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. In any event, as discussed in Appendix 5.2-C, sediment deposition resulting from the cable installation would be minimal and localized, and is not expected to contribute to any

significant cumulative impact. Future USACE maintenance dredging in Hyannis Harbor would be the subject of an additional NEPA document.

The submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance dredging. Therefore, no significant cumulative effects to physical oceanographic conditions are expected in the area of the North Channel crossing.

A new submarine transmission cable has been proposed by National Grid that involves the installation of a second electric transmission cable between Cape Cod and Nantucket. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. At this crossing, and in its near vicinity, the impacts of each project would be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and are of short duration, these temporary impacts are not likely to occur at the same time. Thus the area would likely have assimilated the deposited sediment from whichever of these two projects is installed first by the time the second project is constructed.

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the Project area. However, these marina dredging projects, if they were to occur, are very localized, and not likely to result in sediment suspension and deposition that would be coincident with the cable installation (the closest point of which would be a minimum of .5 miles (805 meters) from the closest marina). Thus, no significant cumulative impact is anticipated from such activities.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts expected to oceanographic conditions since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

Secondary Impacts

There would be no secondary impacts to oceanographic conditions associated with the construction staging/laydown activities occurring at Quonset Point.

5.2.5 Mitigation

Oceanographic conditions have been considered in Project siting and design, in order to avoid and / or minimize impacts within the Project area. The monopile-type foundation system represents the foundation type system that results in the least amount of seabed disturbance. Minimal disturbance of sand and sediment would take place in association with pile driving activities. To mitigate potential effects on bathymetry, the Applicant proposes to install a grouping of scour control mats anchored below the seabed to mitigate scour potential at each WTG. The mats would include artificial fronds to reduce the water particle velocity at the seabed, allowing suspended sediments to settle on the mats as a result of the decreased velocity. This type of viscous drag frond system has been proven to eliminate scour conditions immediately upon installation (see Appendix 4.0-A).

A demonstration project involving the installation of two test scour mats around one of three piles supporting the SMDS was initiated in October of 2003 to evaluate the effectiveness of the artificial frond scour mat to prevent scour. Visual inspection of the scour mats around the SMDS pile on June 13, 2004 indicated that the scour mats are functioning as anticipated with an accumulation of approximately 0.82 feet (0.25 meters) of sand in various areas of the mats. The other two unprotected piles show scouring of up to approximately 2 feet (0.61 meters).

By burying the cables beneath the seafloor, water depths, sediment transport regime, tidal or freshwater circulation patterns, and/or wave current regime would not be significantly affected. A specific discussion of the Project's consistency with MCZM policies and Chapter 91 compliance are addressed in Section 7.0, and consistency with the Wetlands Protection Act and local Bylaws is addressed in Section 5.8.

While mitigation is not warranted for sediment transport regime effects, post-construction monitoring would occur, as described in Section 6.0. Resource types and conditions that have been identified for monitoring in the Project area include: seabed conditions, noise, submerged aquatic vegetation, benthic invertebrate community and habitat conditions, shellfish and fisheries, birds, sea turtles and marine mammals. If any effects were noted during the course of monitoring activities, mitigation would be coordinated with the appropriate agencies.

5.3 Benthic and Shellfish Resources

5.3.1 Introduction

This section describes existing macrobenthic and shellfish resources and potential impacts to these resources in the Project area. Regulatory authorities and consistency are discussed in Section 7.0. The information contained in this section was obtained from literature review, agency consultations, site investigations, and review of existing site investigation data. Information on commercial shellfish resources in Nantucket Sound was obtained from the NMFS and MDMF to characterize the shellfish resources in Nantucket Sound. Information on shellfish resources in the nearshore Project area and at the landfall was obtained through communication with MDMF and the Town shellfish constables.

Macrobenthic organisms (or benthos) include those organisms that live either on or beneath the seabed floor and include worms, crustaceans, small clams, snails, and other macroinvertebrates. Benthic resources have been evaluated in accordance with the specific requirements established for the Project in the MEPA scoping process and further refined in the EIS Scope of Work. The discussion provides a general characterization of the benthic habitat along with a description of macroinvertebrate community composition, abundance, and relative diversity at the site. Based on communication with USEPA (Colarusso, 2002) and USACE (2002a, 2002b), a specific sampling program design, protocol, and methodology were developed and subsequently implemented (please refer to Appendix 5.3-A and 5.3-B for a detailed discussion on protocols and methodology).

Section 5.3.2 summarizes studies completed to evaluate benthic and shellfish resources. Existing conditions are described in Section 5.3.3. Potential project impacts and mitigation measures are discussed in Sections 5.3.4 and 5.3.5, respectively. References utilized for this section are listed in Section 5.3.6.

5.3.2 Studies Completed

5.3.2.1 Benthic Resources

Comprehensive benthic field investigations were conducted by the Applicant in support of the Project in addition to a literature review of benthic conditions within Nantucket Sound and agency consultations. As an initial step, benthic fauna data available for Nantucket Shoals and Georges Bank were obtained and reviewed by Battelle (2001). While a wide range of existing data and reports were available for many areas within Nantucket Sound, recently collected data were found to be somewhat limited, particularly in the Project area. Therefore, the Applicant conducted three separate field surveys in the Project area, which are summarized below.

2001 Benthic Macroinvertebrate Field Sampling Program

An assessment of the benthic organisms along the proposed and alternative submarine cable routes connecting Horseshoe Shoal to Lewis Bay and Popponesset Bay, respectively, was conducted during August 2001, along with an assessment of the benthic organisms associated with the Proposed Site (Appendix 5.3-A). The purpose of this survey was to assess benthic community composition (taxonomic richness and relative abundance) within the Project area. One benthic sample was obtained via surface grab methods at each of 46 locations, consistent with the sediment core sampling program for the Project (Appendix 5.3-A, Figure 1). Sample locations were chosen to reflect the range of benthic habitats (Gibson et al., 2000) along the proposed and alternative cable routes originating from Lewis and Popponesset Bay as well as within the proposed location of the Wind Park on Horseshoe Shoal. Benthic macroinvertebrates in each sample were separated from the sediment and debris, identified to the lowest practical taxonomic level, and enumerated.

2002 Benthic Macroinvertebrate Field Sampling Program

An assessment of the benthic macroinvertebrate community at the Proposed Site (Horseshoe Shoal), as well as at Monomoy-Handkerchief Shoal and Tuckernuck Shoal in Nantucket Sound, was conducted during late spring 2002 (Appendix 5.3-B). The information presented built on results previously reported from the late summer 2001 benthic assessment (Appendix 5.3-A), which focused specifically on Horseshoe Shoal.

Each of the three Nantucket Sound study areas was evaluated with consideration for specific habitat variables such as water depth, sand wave presence, and sediment type, which are generally accepted as the primary factors influencing benthic community abundance and diversity in Nantucket Sound (Theroux and Wigley, 1998; Zajac, 1998; Colarusso, 2002). Information reviewed to characterize conditions across the three areas included published charts and reports (NOAA, 2001; O'Hara and Oldale, 1987) as well as results of geophysical surveys conducted by Ocean Surveys Inc. (OSI) during 2001 and classification of surficial marine sediments from vibracores, borings, and benthic grab samples collected during 2001 and 2002 (Appendix 5.3-B, Section 2.1).

One benthic sample was obtained via surface grab from each of 33 pre-determined locations (Appendix 5.3-B, Figure 4). Sample locations were selected to be representative of the range of depths, sediment types, and sand wave conditions present within each of the three areas evaluated in Nantucket Sound. It should be noted that not all areas evaluated contained all habitat conditions (e.g. sand waves occurred only on the Horseshoe Shoal site and shallow depths were not present at the Monomoy-Handkerchief Shoal site). The sampling program was designed to allow statistical comparisons to be made among these physical oceanographic parameters and benthic organism community composition. Based on communication with USEPA (Colarusso, 2002), it was agreed that a minimum of five samples per habitat type would provide sufficient statistical power for evaluating differences in the benthic resources associated with the major habitat types (e.g., depth, substrate type, and sand wave presence) within each of the three Nantucket Sound study areas.

2003 Shellfish and Benthic Macroinvertebrate Survey of Lewis Bay

A shellfish and benthic organism survey was conducted during the summer of 2003 to describe shellfish and other benthic organisms occurring in Lewis Bay within the Town of Yarmouth shellfish area that would be crossed by the proposed cable route (Appendix 5.3-C). Shellfish and other benthos were surveyed at distinct locations along the proposed route in Lewis Bay using a clam rake, a ¼-inch mesh box sieve, and a manually operated bottom dredge, as appropriate, and all sample locations were mapped. The clam rake, the box sieved samples, and the dredge were each employed at each sampling location so that all components of the benthic community could be adequately characterized. Approximately 600 feet (183 meters) of the recreational shellfish bed in Lewis Bay would be crossed by the cable route (Figure 5.3-6), of which the 200 feet (61 meters) closest to shore would be crossed through the use of HDD and the remaining 400 feet (122 meters) would be crossed via jet plow. A pre-excavation pit would also be required to make the transition from the seaward terminus of the HDD conduit to the submarine cable system.

5.3.2.2 Shellfish Resources

Review of the scientific literature suggests that relatively few studies pertaining to shellfish resources specific to the Proposed Site and submarine cable route in Nantucket Sound are available. One source of information on shellfish resources was obtained from the MDMF bi-annual research trawl surveys designed to collect fishery-independent information on abundance and distribution of fish and invertebrates from Massachusetts' waters. Since 1978, trawl surveys have been conducted in May and September of each year. The sampling program is based on a stratified random design. The coastal waters are stratified into geographic zones (strata) based on depth and area. Pre-determined trawl locations are allocated in proportion to the area of each stratum and then selected randomly within each stratum. Data from trawl locations within the boundaries of the Wind Park site on Horseshoe Shoal in Nantucket Sound were analyzed. Results relevant to shellfish species are presented below in Section 5.3.3.5, with results for finfish species presented in Section 5.4.3.2. Most of the data from the MDMF research trawl data pertain to finfish species. The detailed results of these analyses at the Wind Park site and two other sites in Nantucket Sound are provided in Appendix 5.4-A.

Additional information relevant to commercial shellfish resources in Nantucket Sound, but not specific to the three shoal areas, is available from NMFS and MDMF. Both NMFS and MDMF monitor commercial shellfish landings in Nantucket Sound, and information from these programs was used to characterize commercial shellfish resources

in the Nantucket Sound area. For the purposes of monitoring commercial fishery landings, NMFS divides the coastal waters of the U.S. into statistical areas. Nantucket Sound is designated by NMFS as Statistical Area 538/Sub-area 075. Commercial fishermen report landings (including certain shellfish) to NMFS through a mandatory reporting system and indicate the statistical area where the species were caught. NMFS refers to these data as "vessel trip reports." NMFS vessel trip report data were obtained for an eight-year period (1994-2001) for available shellfish species from Sub-area 075, and were used to characterize commercial shellfish resources and landings in Nantucket Sound. The results are summarized below in Section 5.3.3.5, and are presented in detail in Appendix 5.4-A.

Through its Management Information Systems and Fisheries Statistics Project, MDMF maintains a database on commercial harvesting of lobster and shellfish as well as other "regulated" fisheries. Like NMFS, for the purposes of monitoring fishery resources in Massachusetts' waters, the coastal waters are divided into statistical areas. Nantucket Sound is designated by MDMF as Statistical Reporting Area 10 and is equivalent to NMFS Sub-area 075. Commercial fishermen are required to submit catch reports for various fisheries including shellfish, lobster, and the conch pot fishery. MDMF catch data were obtained for an eleven-year period (1990-2000) for available shellfish species from MDMF Area 10, and were used to characterize commercial shellfish resources and landings in Nantucket Sound. The results are summarized below in Section 5.3.3.5, and are presented in detail in Appendix 5.4-A.

Information on shellfish resources in the nearshore Project area and at the landfall was obtained through communication with MDMF and the Town shellfish constables. A field study of the commercial shellfish resources along the cable route through Lewis Bay was conducted during 2003. The results of this study are provided as Appendix 5.3-C.

5.3.3 Existing Conditions

Since this document is intended to provide a variety of agencies, stakeholders, and the public with the information necessary to complete a review of the project, the analysis of the Project area has been separated to describe the benthic community seaward and within the Massachusetts territorial waters, which are generally defined as within 3 nautical miles (5.6 km) of the low water mark of shore.

It is important to note that all of the literature reviewed indicated that sand, and to a lesser extent, mud and other fine-grained sediments, are by far the dominant bottom substrate in the Project area. Boulders, cobbles, and submerged aquatic vegetation (SAV) are not common, although these substrates are reported to occur sporadically throughout the project area. Consequently, previous studies of the area, including this evaluation, have focused on the benthic community associated with sandy-substrate as the most appropriate means for describing and quantifying the benthic resources of the area. Bottom sediment maps for the project area are provided in Appendix 5.3-B. For a discussion of the occurrence of rock substrate within the Project area see Section 5.4, for a discussion of SAV occurrence within the Project area see Section 5.8.

Field studies conducted within the Project area during the summer of 2001 and the spring of 2002 were designed to characterize the benthic community of the dominant habitats present (coarse-grained sand, fine-grained sand, sand wave presence or absence, and differing depths) during the seasonal periods that are generally reported to have the greatest biological diversity and the highest macroinvertebrate abundance. By focusing on the dominant habitats during the peak period of abundance, this characterization of the benthic community describes an existing condition that is likely to approximate the maximum with regard to benthic community diversity and abundance for the Project area. The baseline condition described in this section is well suited toward evaluating impacts following construction since the post-construction survey would be conducted during the same season as these surveys.

5.3.3.1 Benthic Resources

Based on literature reviewed, Nantucket Sound is generally reported as a highly productive area for benthic invertebrates with numbers of benthic organisms typically averaging in excess of 2,000 organisms/m^2 (Theroux and Wigley, 1998). The studies conducted in support of the Project found macroinvertebrate abundances in the Project area averaging 4,180 organisms/m^2 at Horseshoe Shoal during 2001 and 7,574 organisms/m^2 across all

three of the shoals studied in Nantucket Sound during 2002. It is likely that the abundance averages documented during this study are higher since data collection was focused in the spring and summer which are typically the periods of peak abundance. However, it is also possible that the higher numbers of organisms found in the current studies may be due to differences in the gear employed. Historically, mesh used to sieve samples may have been larger than that used during the current studies (500 µm) which may have resulted in more organisms being retained on the sieve in the current studies. The benthic faunal diversity (i.e., numbers of species and numbers of individuals per species) in Nantucket Sound is reported to be lower than diversity in the rest of the Southern New England Shelf (Theroux and Wigley, 1998).

As indicated in Section 5.1 and Appendix 5.3-B, the sandy substrate of Nantucket Sound is dynamic and mobile, as indicated by ripple marks and sand waves. The magnitude and frequency of sand movements has a marked influence on the structure and abundance of the benthic communities. Organisms living on or in these sandy sediments are adapted for movement or settlement in sand and recovery from natural burial.

Literature reviewed indicates that the most abundant taxa (taxa is defined in this document as either a distinct species or a group of similar species in the same genus, family, or order based on the level of taxonomic identification employed) in the Nantucket Sound benthic fauna are crustaceans and mollusks, followed by polychaete worms (Avery et al., 1996). Among the crustaceans, amphipods are reported to be by far the most abundant. The sandy sediments of Nantucket Sound are reported to support a diverse assemblage of amphipod species. These conclusions are supported by the assessments conducted for the Project during 2001 and 2002 (Appendices 5.3-A and 5.3-B). However, samples collected from the offshore waters during 2002 were dominated by Nematoda (roundworms), comprising (by number) 45% of the macroinvertebrate communities sampled from Horseshoe shoal (Appendix 5.3-B, Table 4).

Bivalves are reported to be the most abundant and diverse of the mollusks, while Gastropods (snails) are also reported to be common (Pratt, 1973). According to MDMF (2001), there is reported to be a heavily populated area of northern quahog (*Mercenaria mercenaria*) in the shoals east of Horseshoe Shoal. Bay scallops (*Argopecten irradians*) are reported to occur in shallow waters of Nantucket Sound, primarily in areas near seagrass beds. Also, two species of large gastropod whelks (*Busycotypus canaliculatum* and *Busycon carica*) are reported to be quite abundant in the coastal waters of Nantucket Sound (Davis and Sisson, 1988). While the sampling program in 2001 was not specifically designed to capture these larger sized commercial shellfish species, the sampling program was modified in 2002 to ensure that the larger organisms that might occur deeper in the sediment would be accounted for in the analysis (see Appendix 5.3-B). None of these mollusk taxa were identified in the samples collected from the Project area during the benthic resource studies conducted in 2001 or 2002 (Appendices 5.3-A and 5.3-B). In 2003, a shellfish survey was conducted in Lewis Bay to specifically locate larger mollusks in the vicinity of the Project's landfall (Appendix 5.3-C). Northern quahogs were documented in the near shore areas associated with the Town of Yarmouth shellfish beds.

The annelid fauna of Nantucket Sound is also reported to be diverse (Theroux and Wigley, 1998). Maurer and Leathem (1981) identified 333 species of polychaete worms in sandy sediments from Georges Bank and Nantucket Shoals. Many of these species occur in the deeper waters of Nantucket Sound. Biomass is reported to be lower in shallow areas of Nantucket Sound (Theroux and Wigley, 1998). This is most likely due to the unstable sandy sediments in these shallow waters. Many polychaete species are a favorite prey of several species of demersal fish, particularly winter flounder (*Pseudopleuronectes americanus*) (Buckley, 1989). Annelids, particularly the Polychaeta, were extremely abundant and diverse in the samples collected during 2001 (37 taxa identified) and 2002 (29 taxa identified) (Appendices 5.3-A and 5.3-B).

5.3.3.2 Results of 2001 Benthic Macroinvertebrate Field Sampling Program

Ninety-five taxa were identified in the benthic grab samples collected for the Project during the 2001 sampling program (for a full list of taxa identified during 2001 sampling refer to Table 3 of Appendix 5.3-A). The most diverse and abundant taxonomic class found was Amphipoda (amphipods or scuds). Seven of the 46 grab sites within Nantucket Sound were dominated by amphipods, with a maximum of 95% (by number) at one site (number BG-G7) located approximately 1.5 miles (2.4 km) north of Halfmoon Shoal (Appendix 5.3-A, Figure 1). The two amphipod taxa that reached the greatest abundances ($>13{,}000/m^2$) were of the families Ampeliscidae and Ischyroceridae. In all instances in which amphipods were found in these high densities, the samples were

collected from areas on or in the immediate vicinity of Horseshoe Shoal. This is consistent with data reported in the literature (Sanders, 1958; Avery et al., 1996), which reported very high densities of amphipods from sandy bottom substrates sampled in shallow waters throughout Nantucket Sound.

In addition to large numbers of amphipods, sampling also revealed a wide variety of gastropods within the Project area. The gastropods were often found in relatively high densities, including along the proposed submarine cable route. Overall, species composition documented as part of this study was consistent with data reported in earlier studies of Nantucket Sound, Georges Bank, and the Southern New England Shelf (Pratt, 1973; Theroux and Wigley, 1998; Wigley, 1968), particularly for samples collected at the offshore sites.

Results of the 2001 Benthic Sampling Program Outside of Massachusetts Waters

Results of the 2001 benthic sampling program that would describe benthic community composition outside the 3-nautical mile (5.6 km) limit would include all samples collected from Horseshoe Shoal as well as those samples collected from portions of two alternate interconnecting routes located outside the 3-nautical mile (5.6 km) limit. The benthic community outside the 3-nautical mile (5.6 km) limit was found to be dominated by Amphipoda (amphipods or scuds). The two most abundant taxa, Ampeliscidae (four-eyed amphipods) and Ischyroceridae (fouling amphipods), comprised more than 68% of the macroinvertebrate community (by number) outside of the 3-nautical mile (5.6 km) limit during 2001 (Table 5.3-1). Other common taxa collected from outside of the 3-nautical mile (5.6 km) limit included *Crepidula fornicata*, *Crepidula convexa*, *Glycera dibranchiata* (bloodworm), and Nematoda. These six taxonomic groups represented 86% of all organisms (by number) found in samples collected outside of the 3-nautical mile (5.6 km) limit during the 2001 study (Table 5.3.1).

In total, 65 benthic taxa were documented to occur outside the 3-nautical mile (5.6 km) limit and within the Project area at Horseshoe Shoal. The average number of taxa per sample documented outside the 3-nautical mile (5.6 km) limit at Horseshoe Shoal during 2001 was 9.2 taxa/sample. The average number of organisms/m^2 outside the 3-nautical mile (5.6 km) limit was found to be 5,611 during the 2001 study.

Results of the 2001 Benthic Sampling Program Inside of Massachusetts Waters

Of the 46 samples collected for the Project area during the 2001 study, three of the samples were obtained from within Lewis Bay and 5 samples were collected along the route connecting Horseshoe Shoal to Lewis Bay within the 3-nautical mile (5.6 km) limit of the Project area. Within the 3-nautical mile (5.6 km) limit, the benthic community was dominated by the gastropods *Crepidula convexa* (convex slippersnail) and *Crepidula fornicata* (common Atlantic slippersnail) during the 2001 study (Table 5.3-1). Slippersnails occurred in only seven of the 46 samples collected during 2001, yet when they were found, they were found in extremely high densities (>8,000/m^2). The patchiness in their distribution is believed to be a result of the patchiness of the underlying substrate, which has been found to have stones and boulders interspersed throughout the predominantly sandy material (Section 5.1). Slippersnails, which disperse through planktonic larvae (Collin, 2001), are able to form accumulations of free-standing clusters on the seabed when larvae settle and metamorphose on a single stone. Other larvae would subsequently settle on the pioneer slippersnail, but eventually the pioneer individual dies and releases its hold on the original substrate, so that the cluster becomes free-standing (Rayment, 2001). *Crepidula fornicata* is reported to typically be found attached to shells and stones on soft substrates or in muddy or mixed muddy areas (Rayment, 2001).

Other common taxa from samples within the 3-nautical mile (5.6 km) limit included Phoxocephalidae (hood-headed amphipods), Nematoda (roundworms), *Lumbrineris* sp. (opal worms), and Oligochaeta (aquatic worms). These six taxonomic groups represented nearly 69% of all organisms (by number) found in samples collected within the 3-nautical mile (5.6 km) limit (Table 5.3-1). In total, 50 benthic taxa were documented to occur within the 3-nautical mile (5.6 km) limit of the Project area. The average number of taxa per sample documented within the 3-nautical mile (5.6 km) limit was 11.6 taxa/sample. The average number of organisms/m^2 within the 3-nautical mile (5.6 km) limit was found to be 2,017 during the 2001 study.

5.3.3.3 Results of 2002 Benthic Macroinvertebrate Field Sampling Program Outside of Massachusetts Waters

The purpose of the second benthic assessment during the spring of 2002 was to evaluate the benthic community at the Wind Park site and two other areas within Nantucket Sound, all of which are outside the 3-nautical mile

(5.6 km) limit. In addition, the spring 2002 assessment allowed for a seasonal comparison of the benthic community at the Proposed Site (Horseshoe Shoal) by comparing the spring 2002 data with the summer 2001 data. Results of this study relative to Horseshoe Shoal are presented below.

Based on the 2001 field surveys, Horseshoe Shoal is characterized by water depths of 8-60 feet (2.4-18.3 meters), medium and fine sand, and sand wave coverage over approximately 50% of its area. The sampled benthic community of Horseshoe Shoal was composed of a variety of organisms including worms, snails, clams, and crustaceans. A total of 48 benthic macroinvertebrate taxa from 9 Classes were recorded in the samples analyzed from the 12 sampled sites (Appendix 5.3-B, Table 2). A complete list of benthic organisms identified on Horseshoe Shoal throughout the 2002 study is presented in Table 3 of Appendix 5.3-B. In general, during the spring season, Horseshoe Shoal was found to support a macroinvertebrate community with an average diversity of 9.9 taxa per sample and an average abundance of 9,060 organisms/m^2 in 2002. A summary of the macroinvertebrate community statistics for Horseshoe Shoal is presented in Table 2 of Appendix 5.3-B. The six most dominant taxa for Horseshoe Shoal in spring 2002 are presented in Appendix 5.3-B, Table 4. Three of the 48 total taxa found on Horseshoe Shoal account for over 80% of the organisms collected with the six dominant taxa representing over 90% of the community (Appendix 5.3-B, Table 4). In contrast, these six taxa represented only 75% of the community at Horseshoe Shoal during 2001. Overall, the most dominant taxon (by number) was found to be Nematoda (roundworms), followed by Ampeliscidae (four-eyed amphipods).

The six dominant taxa at Horseshoe Shoal were markedly different in the spring of 2002 compared to the late summer of 2001 (Appendix 5.3-B, Table 4). Nematoda were much more dominant in the spring of 2002 compared to the summer of 2001 (i.e. the average number of Nematoda individuals per m^2 was much greater in 2002 - Appendix 5.3-A, Table 1 and Appendix 5.3-B, Table 1). In addition, the two snail species *Crepidula convexa* and *Crepidula fornicata* ranked highly in the top six taxa collected during the summer (2001) but did not appear in the top six during spring (2002). This change in the ranking of *Crepidula* taxa was due to the marked reduction in the average number of *Crepidula spp*. individuals per m^2 in the spring of 2002 (Appendix 5.3-B, Table 1). In addition, three crustacean families ranked in the six most dominant taxa during summer 2001 as opposed to two in spring 2002. This may be attributable to the specific life cycles of these organisms, resulting in differences in their seasonal patterns of abundance or may be attributable to inter-annual variability in these populations.

The benthic organisms recorded from sediment depths greater than 5 cm are presented in Table 5 of Appendix 5.3-B. It is recognized that some of these organisms are not typical of deep sediments and are likely to have been incorporated with deep sediment organisms as a result of residual sediment from the upper 5 cm of the dredge being passed through the sieve. Despite the addition of these residual organisms, very few organisms were observed at any site in sediment depths greater than 5 cm. This validates the data collected during the 2001 study that analyzed only the top 5 cm of sediment, although it is recognized that samples collected in nearshore areas may not yield similar results. More importantly, this analysis also reveals that the majority of benthic organisms living at Horseshoe Shoal, including the larger shellfish and polychaetes, live in the top 5 cm of sediment. This may be due to the nature of the area's shifting sediments, which would have a greater potential to bury organisms that were deeply embedded or sedentary (Rhodes et al., 1978; Sanders, 1956).

Finally, it should be noted that benthic community abundance and diversity was not significantly different on Horseshoe Shoal during the late summer 2001 sampling period versus the spring 2002 sampling period (Appendix 5.3-B, Table 6).

5.3.3.4 Conclusions from Benthic Field Investigations

Overall, benthic community composition, documented as part of the 2001 and 2002 studies, was consistent with data reported in earlier studies of Nantucket Sound, Georges Bank, and the Southern New England Shelf (Sanders, 1956; Wigley, 1968; Pratt, 1973; Theroux and Wigley, 1998). These previous studies found the benthic community of Nantucket Sound to have a lower than average invertebrate diversity as compared to the rest of the Southern New England Shelf. However, density and biomass was found to be relatively high. This is not surprising, as it is understood that only a limited number of taxa are capable of withstanding the shifting, sandy substrates characteristic of these shallower waters. Consequently, these productive shallow water habitats are able to support greater densities of each successfully adapted organism.

In addition, there is natural variability in most benthic communities, since these communities are constantly subjected to a combination of physical and biological factors which results in a high degree of environmental variability (Sanders, 1956; Zajac, 1998). It also follows that a high sample-to-sample variability was found in total invertebrate abundance. This supports the conclusion of earlier research that also revealed the benthic community of Nantucket Sound to be highly variable from season to season and location to location (Wigley, 1968). It is believed that the patchy nature of "microhabitats" (defined as the specific combination of habitat elements in the place occupied by an organism for a specific purpose) in terms of such parameters as depth, substrate type, temperature, light penetration, food availability, shelter, disturbance, currents, and predation could be the reason for such variability (Sanders, 1958; DeLeuw et al., 1991; Howes et al., 1997).

Despite the relatively limited number of samples collected for this assessment, an obvious link between depth, sediment type, and macroinvertebrate community diversity was observed. However, the data also showed that there was no such link between these variables and overall macroinvertebrate abundance. The only microhabitat variable investigated that was shown to significantly ($P<0.10$) affect macroinvertebrate abundance was the presence or absence of sand waves. The unstable sand wave environment was predominantly inhabited by more motile organisms capable of avoiding the shifting sands (e.g., some amphipod taxa or the tanaid *Leptognathia caeca*) or by organisms that could burrow out from beneath them once they became buried (e.g., the bivalve *Tellina agilis*, Nematoda, Oligochaeta, or a number of the Polychaeta). Interestingly, *Tellina agilis* was the only shellfish (bivalve or gastropod) that was found in any sample taken from a sand wave. Gosner (1978) describes *Tellina agilis* as a mobile and actively burrowing bivalve.

5.3.3.5 Shellfish Resources

Analysis of MDMF Research Trawl Data

Using the MDMF trawl information from 1978 to present, a likelihood-of-occurrence analysis was conducted to determine which species collected during these surveys were considered very common, variably common, less common, rare, very rare, or not observed at the Wind Park site in Nantucket Sound. The rules for assigning the species to a given occurrence category were subjectively assigned (see Appendix 5.4-A). Since most of the species collected in the MDMF trawls are finfish, this analysis is discussed in more detail in the Finfish Resources section (Section 5.4.3.2) and Appendix 5.4-A. The results from this analysis that pertain to shellfish species are summarized briefly here.

The analysis of the MDMF research trawl data at the Wind Park site by season indicated that channeled whelk was considered very common in the spring and variably common in the fall from trawls on Horseshoe Shoal. The knobbed whelk was considered very common in trawls from Horseshoe Shoal in the fall, but less common in the spring. Lady crab and spider crab were considered very common from trawls on Horseshoe Shoal during both the spring and fall. Shellfish species that were considered rare, very rare, or not observed in trawls from Horseshoe Shoal include American lobster, bay scallop, Atlantic surf clam, blue mussel, and northern horse mussel.

Commercial Shellfish Resources in Nantucket Sound

Various species of shellfish are harvested commercially from Nantucket Sound. Shellfish species harvested in this area include mussels, quahogs, bay scallops, surf clams, soft shell clams, and conch. Conch is the generic term for various species of whelk such as the knobbed whelk, channeled whelk, and lightning whelk, which are common gastropods in the Sound. Data provided from NMFS vessel trip reports suggest that various species of conch are an important fishery in Nantucket Sound. For any given year from 1994 through 2001, the conch species constituted more than 90% of the total annual shellfish landings (see Appendix 5.4-A, Table 3). Total annual shellfish landings ranged from lows of approximately 10,000 pounds to highs of approximately 330,000 pounds during this 8-year period (Figure 5.3-1).

MDMF monitors the fish pot fishery for conch in Nantucket Sound separately from shellfish harvested using other methods such as rakes or various shellfish dredges. Figure 5.3-2 presents the annual landings of conchs from fish pots in Nantucket Sound from 1992 through 2000. Catch reports for conch were not required prior to 1992; therefore, landings prior to this year were not available for review. The MDMF data suggest that conch landings from fish pots have shown a general decline from 1992 through 2000. Fishing pressure, as gauged by the

number of licenses issued, appears to have declined over the years as well (i.e., 47 licenses in 1993-1995 to 24 licenses in 2000), however it should be noted that the trend in licenses alone may not be completely representative of fishing pressure.

MDMF data for total annual shellfish landings in Nantucket Sound from methods other than fish pots are presented in Figure 5.3-3. These annual landings from 1990 through 2000 total approximately 24.7 million pounds. Surf clams appear to be the most common species harvested over the 11-year period in Nantucket Sound, constituting approximately 52% of the total shellfish landings reported to MDMF for this time period. Mussels are the second most common species of shellfish harvested, constituting 35% of the total landings reported to MDMF over this time period. The various species of conch harvested from Nantucket Sound, using methods other than fish pots (discussed above) from 1990 through 2000, account for 13% of the total landings. Quahogs (ocean quahogs, mixed quahogs, and littlenecks), bay scallops, sea scallops, and soft shell clams account for less than 1% of the total shellfish landings from 1990 through 2000 (Table 5.3-2).

Although northern quahogs (*Mercenaria mercenaria*) seem to account for a low percentage of commercial shellfish landings in Nantucket Sound, they are reported as abundant in shallow coastal estuaries that empty into Nantucket Sound (MacKenzie, 1997) and are an important fishery within Massachusetts (MDMF, 2001). In 2001, MDMF instituted a regulated permit for this species. According to MDMF staff (MDMF, 2001), a heavily populated northern quahog area exists in the shoals to the east of Horseshoe Shoal. This area is referred to as the "quahog grounds," and is specifically targeted by commercial fishers (MDMF, 2001).

Bay scallops (*Argopecten irradians*) occur in shallow waters of Nantucket Sound, primarily in areas near seagrass beds. According to MDMF (2001), bay scallops are a negligible fishery within Massachusetts. However, sea scallops (*Placopecten magellanicus*) are a commercially viable species reportedly occurring offshore in the Mid-Atlantic, Georges Bank and the Gulf of Maine with the area of greatest abundance being Georges Bank (Packer et al., 1999).

As presented in detail in Appendix 5.4-A, approximately 24.7 million pounds of shellfish were harvested from Area 10, Nantucket Sound from 1990 through 2000 with sea scallops comprising approximately 0.002% (~413 total lbs landed) of the total shellfish landings in Nantucket Sound reported to MDMF from 1990 through 2000, and there is no evidence of a viable commercial fishery for scallops within Nantucket Sound.

American Lobster Fishery in Nantucket Sound

The American lobster (*Homarus americanus*) is found throughout New England, and a commercial fishery for this species exists in all coastal states from Delaware to Maine. Commercial permits for American lobster are issued for both inshore fishermen (within the 3-nautical mile (5.6 km) territorial limit) and offshore fishermen (outside of the 3-nautical mile (5.6 km) territorial limit). There are 14 areas designated by MDMF in the nearshore waters of Massachusetts for reporting lobster catch. The Project area lies within MDMF Area 10, which encompasses Nantucket Sound.

A relatively small lobster fishery exists within the waters of Nantucket Sound. McBride and Hoopes (1999) report that the Area 10 lobster fishery supplied only 0.4% (of nearly 10 million pounds) of the total Massachusetts inshore waters harvest in 1999. The yield from adjacent areas (Areas 9 and 11-14) was low, with each contributing less than 4% of the total harvest. Areas 2 through 8, along the northern coast above Cape Cod Bay, overwhelmingly produced the highest catches.

Total lobster landings for Area 10 from 1990 through 2000 are estimated at approximately 345,000 pounds, or an annual average of approximately 31,000 pounds (Figure 5.3-4). From 1990 to 1993, lobster landings increased from 8,000 pounds to approximately 50,000 pounds. Landings declined again in 1994 and 1995, appeared to climb in 1996 and 1998, but declined to below 20,000 pounds in 2000, the lowest landings observed since 1992. Lobsters migrate inshore and offshore with response to changes in water temperature. Therefore, although the commercial season for lobster is open year round in Nantucket Sound, peak landings occur during the summer months from June through August and into September (Figure 5.3-5) when water temperatures are warmer and lobsters are likely to be more abundant in the relatively shallow waters of Nantucket Sound.

For a more detailed discussion on lobster landings, please refer to Appendix 5.4-A.

Shellfish Resources in Nearshore Areas Inside of Massachusetts Waters and in Lewis Bay

Nearshore areas including Lewis Bay contain many shellfish resources and are utilized for both commercial and recreational shellfishing (See Appendix 5.3-C for a detailed field assessment of Lewis Bay). Shellfishing activities in Massachusetts are mainly managed through local shellfish constables within each town. Typically, town shellfish departments designate certain areas for recreational or family harvesting. In addition, waters often contain discrete areas of privately licensed shellfish areas or grants that are managed or farmed privately for certain species of shellfish.

As part of shellfish management programs, certain towns on Cape Cod, including the Town of Yarmouth, purchase seed and adult shellfish to propagate and supplement natural shellfish stocks in rivers and bays throughout their respective towns. The participating town shellfish departments, in conjunction with the MDMF, open and close these areas on a rotating schedule, depending on water quality and shellfish availability. Once the proposed submarine cable route enters the 3-nautical mile (5.6 km) state jurisdictional limit and approaches town boundaries, it enters Town of Yarmouth waters, crosses into Town of Barnstable waters in the outer portion of Lewis Bay, then continues through the inner portions of Lewis Bay within the Town of Yarmouth to the proposed landfall at New Hampshire Avenue in the Town of Yarmouth (Figure 3-67).

The small portion of the submarine cable route within Town of Barnstable jurisdiction is primarily in the outer portions of Lewis Bay and offshore where there is no substantial commercial or recreational shellfish harvesting or aquaculture activity (Marcotti, 2002). This portion of Lewis Bay contains some quahogs, scallops, and soft shell clams. Some scalloping activity occurs in the vicinity of Egg Island, and the Town is considering opening up some of the offshore areas for quahog harvest (Marcotti, 2002). There are no shellfish propagation projects or privately-licensed shellfish grants in this outer portion of Lewis Bay within Town of Barnstable jurisdiction (Marcotti, 2002).

The majority of the submarine cable route inside town boundaries is located within Town of Yarmouth jurisdiction. Lewis Bay contains hard shell clams/quahogs (*Mercenaria mercenaria*), soft shell clams (*Mya arenaria*), scallops, and a limited number of eastern oysters (*Crassostrea virginica)*. Quahogs are, by far, the most prevalent shellfish species in Lewis Bay. Most of these resources occur in Lewis Bay in areas managed through the Town's shellfish propagation program or in privately licensed shellfish grant areas (Caia, 2002). Lewis Bay is utilized for both commercial and recreational fishing.

The Town of Yarmouth has several designated recreational shellfish areas that are open only for recreational purposes to Town residents. One of these areas extends from Colonial Acres east to the Englewood Breakwater (Figure 5.3-6), within the direct path of the submarine cable route, and one area is in Mill Creek (Figure 5.3-7), outside of the submarine cable route. Both of these areas are enhanced on an annual basis with seed shellfish purchased from the Parker River Upwellers (shellfish nursery) through the Town's shellfish propagation program (Caia, 2002). According to the Town of Yarmouth's website, propagation efforts in the town are currently focused on maintaining the quahog fishery, re-establishing the oyster fishery, restoring the bay scallop fishery, and re-establishing historic soft shell clam beds.

The proposed submarine cable route coincides with approximately 600 feet (183 meters) of the designated recreational shellfish area in Lewis Bay (Figure 5.3-6). This shellfish area is a summer relay area for the depuration of contaminated shellfish from Fall River and Mount Hope Bay. The Town of Yarmouth has another summer relay area located in Lewis Pond, outside of the Project area. Contaminated shellfish are typically relayed to these designated areas by mid-June and are required to remain there for a period of one year, during which harvesting from these areas is prohibited. Recreational harvesting in these areas occurs every other year corresponding to the cycle and schedule of relay activities (Caia, 2002). A shellfish and benthos survey was conducted during the summer of 2003 to describe shellfish and other benthic organisms occurring in the town shellfish area along the proposed cable route (Appendix 5.3-C). Results indicated that the diversity and abundance of shellfish and benthic organisms in this bed were comparable to observations by prior researchers at similar sites.

There are also several privately licensed shellfish areas or grants in Lewis Bay that are managed or farmed privately for certain species of shellfish. None of these grants is located within the direct path of the proposed submarine cable route (Figure 5.3-8).

Shellfish maps obtained from MassGIS and the Yarmouth Shellfish Constable (Caia, 2002) indicate that the waters surrounding the majority of the submarine cable route through Lewis Bay have been designated as an approved shellfish growing area. Approximately 600 feet (183 meters) from the Yarmouth landfall, the waters change designation from an approved to a conditionally approved shellfish growing area (Figure 5.3-9). Approved shellfish areas are open for harvest of shellfish for direct human consumption subject to local rules and state regulations. Conditionally approved shellfish areas are open for harvest of shellfish for direct human consumption during the time the area is approved (typically based on water quality and shellfish availability).

5.3.4 Analysis of Impacts

Potential impacts to benthic and shellfish resources associated with the construction and operation of the Project relate directly to the area of seafloor either temporarily disturbed during Project construction or altered for a longer term by the presence of the Project (see Table 5.3-3). The Project has been planned, sited, and designed to avoid or minimize impacts to benthic and shellfish resources within the Project area. While limited localized impacts to the benthic environment are anticipated during Project construction and operation, measures would be implemented to prevent and minimize these impacts. These measures include using state-of-the-art hydraulic jet plow for cable installation, using HDD to install cables to minimize impacts to shoreline and intertidal zones, monopile foundations for WTG towers, scour control mats, and post-construction monitoring to document habitat disturbance and recovery (see Section 6.0). No adverse impact to benthic and shellfish resources is anticipated from submarine cable system normal operations (see Section 5.13). Potential thermal impacts would be minimized by proper cable system design and burial of cables beneath the seafloor. Potential impacts and proposed mitigation measures are discussed in greater detail below.

5.3.4.1 Potential Impacts Outside of Massachusetts Waters

Activities potentially affecting benthic and shellfish resources beyond the 3-nautical mile (5.6 km) state territorial limit include installation of monopile foundations, inner-array cables, and the submarine cable system. These activities involve direct seabed disturbance from the driving of monopiles, jet plowing, and installation-associated vessel anchoring. Potential impacts to seabed associated with these activities are anticipated to be limited in area. Specialized monopile foundations were selected which minimize the seabed footprint and sediment disturbance. Jet plow cable embedment technology was selected to minimize seabed disturbance and sediment dispersion during cable embedment. Jetting of the cables would involve high-pressure water (250 psi) that is sprayed (jetted) out of nozzles lowered on a pair of cutting arms into the sediment. The injected water fluidizes the sediment and allows the cable to fall into this trench zone before the sediments resettle. Impacts to infauna and less mobile epifauna would include injury and mortality due to the sediment fluidizing action of the high-pressure water jets and/or burial. The timing and duration of the above installation components is previously discussed in detail in Section 4.0.

Construction, Operation and Decommissioning Impacts

The area of potential seafloor impact was calculated based on the proposed Project design and construction methodologies. The length of cable necessary to link all of the wind turbine towers to the ESP is approximately 78 miles (125.5 km). A zone of disturbance between 4 and 6 feet (1.2 and 1.8 meters) wide is anticipated in order to bury the inner-array cables to the target depth of 6 feet (1.8 meters). Therefore, the area of seafloor anticipated to be disturbed during installation of the inner-array cables is between approximately 1,647,360 and 2,471,040 square feet/37.81 and 56.73 acres (153,045 and 229,567 square meters). In addition, two 3-foot (0.9-meter) wide skid pontoons would ride along the surface of the sediment on either side of the jet plow to control the depth of cable embedment. The pontoon impacts resulting from the installation of the inner-array cables would, therefore, be 2,471,040 square feet/56.73 acres (229,567 square meters). This would result in a combined temporary disturbance of up to 4,942,080 square feet/113.45 acres (459,134 square meters) of sea bottom within the WTG, or approximately 0.75% of the 24 square mile area defined as the total Project area (Table 5.3-3).

Due to the relatively shallow water depths in Nantucket Sound, shallow draft vessels/barges which typically use anchors for positioning are necessary for installation. Deeper draft vessels equipped with dynamic positioning thrusters therefore cannot be used. Impacts associated with the anchoring, positioning, and movement of cable installation barges are expected to occur along all cable installation paths. The area of this impact would vary depending upon bottom material composition, water depth, and sea and weather conditions; however, given the properties of anchor behavior as described by the U.S. Navy (Taylor, 2002; NCEL, 1987; NAVFAC, 1985), it is possible to determine an average area of impact per anchor deployment. Based on the width of each anchor (10.6 feet (3.23 meters) including stabilizer bar), the number of anchors needed to secure and move a vessel (6), and the required setting drag length in deep water (20 feet (6.1 meters)), it is estimated that up to 7,230 square feet/mile/0.17 acre/mile (672 square meters/mile) would be temporarily impacted from deployment and retrieval of anchors. The anchor impact would disturb the sediment to a depth of 4 to 6 feet (1.2 to 1.8 meters) at each anchor deployment, leaving a temporary irregularity to the seafloor with localized mortality of infauna. In addition, the area of seafloor swept by the anchor line as the jetting barge moves along the cable route was calculated to be 311,880 square feet/7.16 acres (28,975 square meters) per linear mile of cable. This impact would be minimized through the use of mid-line anchor buoys. The anchor line sweep impacts would be expected to disturb sediment to a depth of up to 6 inches (15.2 cm) (Algonquin Gas Transmission Company, 2000), although this includes the most biologically active zone. Organisms that would be likely to be impacted by anchor line sweep would include mollusks and other sessile species, which comprise the majority of taxa in the Project area. Mobile organisms, such as crabs, Tanaidacea, Mysidacea, and certain species of Polychaeta and Amphipoda, are likely to be able to avoid anchor line sweep impacts.

The total anchoring anchor and anchor sweep impact anticipated during the installation of 78 miles (125.5 km) of inner-array cables of would be approximately 24,890,580 square feet/571.41 acres (2,312,411 square meters), or approximately 3.71% of the Project area (Table 5.3-3). Two parallel circuits would be installed to span the approximately 12.2 mile (19.6 km) route between the ESP and the mainland; approximately 5.6 miles (9.0 km) of this distance lie outside the state territorial limit. The area of seafloor outside the state territorial limit anticipated to be disturbed during submarine cable system installation is between approximately 236,544 and 354,816 square feet/5.43 and 8.15 acres (21,976 and 32,963 square meters) for these two circuits. Pontoon impacts associated with this portion of the submarine cable system installation would be 354,816 square feet/8.15 acres (32,963 square meters) for these two circuits. In addition, vessel anchoring and the associated anchor line sweep occurring during construction in this area are anticipated to impact approximately 3,574,032 square feet/82.05 acres (332,038 square meters). Therefore, temporary impacts associated with the installation of the two circuits of the submarine cable system between the ESP and the state territorial limit would result in total impacts of up to 98.35 acres, or approximately 0.64% of the Project area (Table 5.3-3).

In addition to temporary construction related impacts associated with the installation of submarine cable systems, it is also anticipated that there would be temporary impacts to the seafloor in the vicinity of each proposed wind turbine tower associated with the anchors and jack-up barges that would be erecting each tower. It may be possible to employ jack-up barges without the use of anchors, but this would be dependant upon sea conditions at the time. To be conservative, it is assumed that anchoring would be required at all WTG locations and at the ESP during each phase of construction.

It is anticipated that 4 anchors would be deployed to position and stabilize the jack-up barge at each of the 130 wind turbine locations as well as for each of the 6 ESP pilings. The area of seafloor that would be temporarily disturbed would be highly dependent on the type of sediment, the depth of water as well as sea and wind conditions. Assuming that each of the 4 anchors disturb an area of bottom approximately 10.6 feet (3.23 meters) wide (width of anchor including stabilizer bar) and up to 12 feet (3.6 meters) long (the length of drag necessary to set the anchor) the average area of seafloor that would be temporarily disturbed to install each of the 130 turbine tower pilings and the 6 ESP pilings would be 509 square feet/0.01 acres (47 square meters) per piling or a total of 69,224 square feet/1.59 acres (6,431 square meters).

Anchor line sweep associated with the installation of the 130 pilings and the 6 ESP pilings would be anticipated to impact 9,202 square feet/0.21 acres (855 square meters) per anchor, for a total of 36,808 square feet/0.85 acres (3,420 square meters) per piling location (assuming 4 anchors are deployed) and a total of 5,005,888 square feet/114.92 acres (465,062 square meters). In addition to anchoring and anchor line sweep, the four to six jacking legs of the jack-up barge are anticipated to have pads that contact the sea floor with an area of 172

square feet/0.0039 acres (19 square meters) each. Therefore, the maximum anticipated area of temporary impact associated with the jack-up barge for installation of the WTG and ESP pilings (136 in total) would be 140,352 square feet/3.22 acres (13,039 square meters).

Once the pilings have been erected, a second vessel would need to anchor and jack-up at each piling in order to install the turbines, blades and other equipment at each piling. In addition, a vessel would also need to anchor and jack-up in the vicinity of the ESP pilings in order to construct the ESP platform. A third vessel would need to anchor and jack-up at each tower and at the ESP to connect the inner-array cables to the WTGs and the ESP platform. Finally, a vessel would then need to anchor at each of the 136 pilings in order to install scour control mats that surround each piling.

Based on the above assumptions and calculations, it is anticipated that the combined total temporary impact from anchoring, anchor line sweep, and jack-up barge use associated with the installation of the turbine towers and association equipment, the ESP platform, connecting the inner array cables (via J-tubes) to the WTGs, and installing the scour control mats would be approximately 20,861,856 square feet/478.92 acres (1,938,130 square meters), or 3.12% of the total Project area (Table 5.3-3).

Although some mortality of benthos and shellfish residing in the area of temporary disturbance resulting from monopile and cable installation is anticipated, such impacts would be limited because of the relatively small area of sediment disturbance of a commonly occurring habitat type. In general, it is widely recognized that benthic invertebrates are able to opportunistically invade unoccupied areas after disturbance (Hynes, 1970; Rosenberg and Resh, 1993; Rhoads et al., 1978; Howes et al., 1997). For these reasons, the limited area of direct disturbance is unlikely to result in anything more than a localized, temporary impact to the benthic community.

Limited long-term (permanent) impacts associated with the installation of the pilings needed to support the wind turbine towers and the ESP would also be anticipated to affect the benthic resources in the Project area. The number of round pilings to be constructed includes 130 for the wind turbine towers and 6 to support the ESP. The diameter of each of the wind turbine pilings would be 16.75 feet (5.1 meters) at the seafloor for pilings located in water depths of 0 to 40 feet (0 to 12.2 meters), and 18.0 feet (5.5 meters) for pilings located in water depths of 40 to 50 feet (12.2 to 15.2 meters). The ESP pilings would have a diameter of 42 inches (106.7 cm) at the seafloor. This results in an area of direct impact equal to 220 square feet/0.005 acre (20 square meters) for each 16.75-foot (5.1-meter) diameter wind turbine tower piling (102 pilings) and 255 square feet/0.005 acre (21 square meters) for each 18-foot (5.5-meter) diameter wind turbine tower piling (28 pilings). Impacts of approximately 9.6 square feet/0.0002 acre (0.9 square meter) per piling for the ESP would also be expected. This yields a total area of permanent impact of approximately 29,637 square feet/0.68 acre (2,753 square meters) for the 130 wind turbine towers and the 6 ESP pilings. This is approximately 0.0046% of the Project area (Table 5.3-3). The portions of these pilings existing above the sea floor would be removed as part of the decommissioning phase of the Project

Scour protection would be installed around each of the pilings to minimize scour associated with prevailing currents. Several options were considered, however, it was determined that the use of synthetic fronds designed to mimic seafloor vegetation would afford the necessary scour protection while minimizing potential alterations to the benthic and fish communities typically associated with Horseshoe Shoal. This is because the synthetic fronds (scour control mats), when secured to the bottom as a network, trap sediments and become buried. This scour protection approach is more consistent with the low bottom relief of Horseshoe Shoal than traditional boulder revetment. Each scour control mat has an area of 135 square feet/0.003 acre (13 square meters), and it is estimated that 6 mats would be required to protect each wind turbine piling. Therefore, the area to be protected with scour control mats around each piling would be 810 square feet/0.02 acre (75 square meters), which yields a total area of scour protection of 105,300 square feet/2.42 acres (9,783 square meters) for the 130 wind turbine towers and 4,860 square feet/0.11 acre (452 square meters) for the 6 ESP pilings. Scour protection would, therefore, alter approximately 0.016% of the Project area (Table 5.3-3). However, these mats would be suitable for colonization by many benthic organisms following installation.

The vertical structure that would be created from the installation of wind turbine towers is not anticipated to result in adverse impacts to the ecology of the immediate Project area or to Nantucket Sound. The walls of the towers represent a source of new hard substrate with a vertical orientation in an area that has a limited amount

of such habitat. Organisms that may initially be supported by such structures are likely to include algae, barnacles, hydroids, sponges, tunicates, bryozoans, anemones, and possibly mussels, all of which occur in other areas of hard substrate within Nantucket Sound. Additional organisms, such as crabs, gastropods, nudibranchs, polychaetes, oligochaetes, and nematodes may also utilize the structures once algal or fouling organism growth becomes established. It should also be noted that if invasive species were present in the Project area, these would also need to be included among the list of potential colonizing species. Fish species that may be attracted to the structures are discussed in Section 5.4.

Several isolated rocks and areas of coarse glacial till do exist in shoal areas throughout Nantucket Sound, and are likely to support benthic communities similar to those that may become established on the WTGs. Although the monopile foundations would create additional attachment sites for benthic organisms that require fixed (non-sand) substrates, the additional amount of surface area being introduced (approximately 1,200 square feet/0.03 acre (111 square meters) per tower, assuming an average water depth of 30 feet (9.1 meters)) would be a minor addition to the hard substrate that is already present. Furthermore, the wide spacing (0.34 to 0.54 nautical mile (629 to 1,000 meters) apart) of these monopile structures would not result in the creation of a concentrated area of vertical or hard substrate that may otherwise act as a larger reef. Therefore, it is likely that these isolated structures would generate a small amount of additional patch reef type habitat, common in the Sound, and would not substantially alter the ecology of Nantucket Sound. Other types of similar artificial hard substrate can be found throughout harbor and port areas within the Sound that have pilings associated with wharfs and breakwaters constructed over the decades for the protection of anchorages and harbors.

Indirect impacts to benthic fauna and shellfish from submarine cable and monopile installation activities are anticipated to be temporary and localized. Due to the predominance of sands in the Project area, sediment resuspension associated with construction activities is anticipated to be relatively low and confined to the area immediately surrounding tower foundations and cable routes. In the predominantly sandy sediments, elevated suspended sediment concentrations from the jet plow are estimated to occur in a limited area in close proximity to the cable trench and exist for short durations of less than an hour or so at any fixed location (Appendix 5.2-C). Sediments in the Project area were found to have relatively low contaminant concentrations (see Section 5.1). Therefore, the resuspension of these sediments during foundation placement and cable embedment is not anticipated to have a long-term adverse affect on the seabed, marine water quality, or aquatic biota.

The sandy substrate of Nantucket Sound is dynamic and mobile, as indicated by ripple marks and sand waves (Appendix 5.3-B). The magnitude and frequency of sand movements has a marked influence on the structure and abundance of the benthic communities (Appendix 5.3-B). Consequently, most organisms living on or in these sandy sediments are adapted for movement or settlement in sand and recovery from burial and should not be adversely impacted by the Project. Migration of sand waves across the shoals is not expected to be adversely affected by the presence of the WTGs, which would be widely spaced (minimum of 2,066 feet (629 meters) between WTG edges) and have highly localized connections to the seabed.

In addition, the naturally dynamic environment of the Project area is already subject to fluctuations in suspended sediment concentrations at the seabed/water interface as a result of relatively strong tidal currents and wind and storm generated waves, particularly in shoal areas. Consequently, benthic organisms in the Project area are adapted to relatively wide fluctuations in water column suspended sediment concentrations and should not be substantially impacted by short-term sediment resuspension associated with Project construction.

Based on MDMF catch data, it does not appear that the lobster stock is plentiful south of Cape Cod, and no data have been found which indicate the presence of a significant lobster population in Nantucket Sound or on Horseshoe Shoal. Direct impacts to lobsters are expected to be minimal, with potential mortality limited to less mobile individuals in the direct path of construction activities. Hydraulic jet-plow embedment would limit these impacts to a very narrow corridor, and suspension of sediments during monopile and cable installation is not expected to result in significant indirect impacts as these sediments tend to settle very quickly. Indirect impacts from sediment suspended within the water column would be temporary, as any suspended sediment is expected to settle quickly.

Adult lobsters are mobile and have complex sensory capabilities that allow them to avoid temporary disturbances of seabed sediments (Jury et al., 1995). Lobsters naturally occur in turbid areas (Stewart, 2000) and, therefore,

should not be adversely affected by temporary and localized sediment disturbance associated with Project construction. A review of the scientific literature by the USACE revealed that most aquatic organisms, including juvenile lobsters, are not seriously affected by temporary exposure to increased suspended solids such as those associated with dredging operations (USACE, 1991).

Since all cables associated with the Project are to be buried with a minimum of 6 feet of cover below present bottom, these cables would not create a physical barrier that could interfere with lobster or other shellfish migration or use of existing habitats or nursery areas. The timing and sequencing of construction (described in detail in Section 4.0) should enable lobster or other shellfish migration routes that may exist in the Project area to remain unimpaired. This expected lack of impairment is due to the relatively short duration of construction activities within any one specific area of the overall Project area, and the fact that cables are embedded instantly rather than laid on the seafloor for a prolonged period of time which could block migration routes. Lobsters are able to traverse complex terrain and travel over substantial topographic features. As with Projects utilizing similar submarine cable embedment methods, if a temporary minor depression in the seabed remains after cable installation, this is similar to other natural topographic relief, is not expected to prevent lobsters from crossing the cable areas, and is not expected to interfere with lobster migration (Fogerty, 2000).

Lastly, the ESP would have a surface area of 20,000 square feet/0.46 acre (1,858 square meters) that has the potential to affect the benthic community that resides beneath this location as a result of its shading effect. However, it is expected that the direct impacts of this shading on the benthic community would be negligible, given that the ESP would be placed approximately 39 feet (12 meters) above the MLLW datum plane in 28 feet (8.5 meters) of water. The shadow cast by the ESP is anticipated to move rapidly across the bottom of the seafloor over the course of a day. Given that there is not any vascular vegetation or much macroalgae in the location of the ESP site, the impact to benthic plant community from changes in sunlight exposure is also expected to be negligible. For a discussion of submerged aquatic vegetation (SAV) associated with the Project area see Section 5.8.

With regard to decommissioning, impacts associated with the removal of all Project-related structures are expected once the Project exceeds its useful life. Removal of the structures above the seafloor (wind turbine towers, foundations, ESP, submarine cables, and scour control mats) would be expected to result in temporary seafloor impacts of a magnitude compared to that incurred during installation. In addition to structures located above the seafloor, the network of inner array cables and the cables submarine cable system linking the ESP to the mainland would be extracted from the bottom sediments during the decommissioning process. This action would result in temporary resuspension of bottom sediments along each cable path and anchor and anchor line impacts associated with any required vessel anchoring similar to or slightly less than during the installation phase.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to benthic and shellfish resources would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from various potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

Although it is recognized that a wide range of natural (storms) and man induced (fishing, construction, anchoring, etc.) disturbances occur on a regular basis in these relatively shallow waters, the cumulative impacts associated with the project would not be anticipated to rise to a level above the normal background level of disturbance. The benthos and shellfish in the shallow waters of Nantucket Sound are continually recovering from some form of recent disturbance and are well adapted to these conditions. Therefore, no significant cumulative impacts to benthic resources or shellfish are expected from construction of the WTGs, the inner-array cables, or the two submarine cable circuits within federal waters. Any impacts from construction activities are expected to be localized and temporary.

A new submarine transmission cable between the south shore of Cape Cod and Nantucket has been proposed by National Grid, and its proposed route may be in the vicinity of the Wind Park and its inner array cables in

Nantucket Sound. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at his crossing point. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and of short duration, these temporary impacts are not likely to occur at the same time. Thus, any areas where both projects may result in impacts as a result of jet plow cable embedment would likely have assimilated the deposited sediment from the first project installation by the time the second project is constructed. As such, there are no significant cumulative impacts expected to benthos that would result form the installation of both projects.

The submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance dredging. Therefore, no significant cumulative effects to benthic resources are expected in the area of the North Channel crossing.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts expected to benthic resources since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

Secondary Impacts

The only potential impact associated with construction staging/laydown activities at Quonset would be potential pier improvements. This would have a potential for limited temporary displacement and habitat disturbance for benthic and shellfish resources. No specific plans for pier improvement are known at this time.

5.3.4.2 Potential Impacts Inside of Massachusetts Waters

Activities potentially affecting benthic and shellfish resources within the 3-nautical mile (5.6 km) state territorial limit are limited to those associated with installation of the submarine cable system. These activities involve direct seabed disturbance from the jet plowing and installation/decommissioning-associated vessel anchoring. Potential impacts to benthic habitat, macroinvertebrates, shellfish, and lobsters associated with these activities are anticipated to be minimal and extremely limited in area. Jet plow cable embedment technology was selected to minimize seabed disturbance and sediment dispersion during cable embedment. The area of potential seafloor impact was calculated based on the proposed Project design and construction methodologies. Of the approximately 12.2 miles (19.6 km) of submarine cable required to join the ESP to the mainland, approximately 6.6 miles (10.6 km) of this lie inside the state territorial limit.

A zone of disturbance between 4 and 6 feet (1.2 and 1.8 meters) wide is anticipated in order to bury each of the two submarine cable system circuits to the target depth of 6 feet (1.8 meters). Therefore, the area of seafloor to be disturbed during installation of the submarine cable system along its proposed route and inside the state territorial limit is between approximately 278,784 and 418,176 square feet/6.40 and 9.60 acres (25,900 and 38,850 square meters). In addition, two 3-foot (0.9 meter) wide skid pontoons would ride along the surface of the sediment on either side of the jet plow to control the depth to which the trench is plowed. The pontoon impacts resulting from the installation of the submarine cable system along its proposed route and inside the state territorial limit would therefore be 418,176 square feet/9.60 acres (38,850 square meters). This would result in a combined temporary disturbance of up to 836,352 square feet/19.2 acres (77,700 square meters) of sea bottom or approximately 0.125% of the Project area (Table 5.3-3).

Additionally, impacts associated with the anchoring, positioning and movement of the cable installation barge are expected to occur during the installation process inside the state territorial limit. The area of this impact would vary depending upon bottom material composition, water depth, and sea and weather conditions; however, given the properties of anchor behavior as described by the U.S. Navy (Taylor, 2002; NCEL, 1987; NAVFAC, 1985) it is possible to determine an average area of impact per anchor deployment. Based on the width of each anchor (10.6 feet (3.23 meters) including stabilizer bar), the number of anchors needed to secure and move a vessel (6), and the required setting drag length in deep water (20 feet (6.1 meters)), it is estimated that up to 7,230 square

feet/mile/0.17 acre/mile (672 square meters) would be temporarily impacted from anchoring activities. In addition, the area of seafloor swept by the anchor line as the jetting barge moves along the cable route was calculated to be 311,880 square feet/7.16 acres (28,975 square meters) per linear mile of cable. This impact would be minimized whenever possible through the use of mid-line anchor buoys. Anchoring and anchor sweep associated with vessel positioning and anchoring during installation of the submarine cable system inside the state territorial limit would result in approximately 4,212,252 square feet/96.70 acres (391,331 square meters) of disturbance, or approximately 0.625% of the Project area (Table 5.3-3). The anchor line sweep impacts would be expected to disturb sediment to a depth of up to 6 inches (15.2 cm), which includes the most biologically active zone. Organisms that would be likely to be impacted by anchor line sweep would include mollusks and other sessile species, which comprise the majority of taxa in the Project area. Mobile organisms, such as crabs, Tanaidacea, Mysidacea, and certain species of Polychaeta and Amphipoda, are likely to be able to avoid most of the anchor line sweep impacts.

Impacts to shellfish resources in Lewis Bay from jet plowing are expected to be localized, short-term, and minimal. The direct impacts from jet plow disturbance would be extremely limited in area as summarized above and would be limited to the area within and in the immediate vicinity of the jet plow activity. The indirect impacts from jet plow installation include temporary and localized increases in sediment deposition and suspended sediment concentrations. Due to the limited and short-term nature of the jet plow activity, temporary and localized increases in sediment deposition and suspended sediment concentrations are expected to have minimal impacts to shellfish in Lewis Bay (Berry et al., 2003). Most of the shellfish in Lewis Bay are hard clams (quahogs) (Caia, 2002; Appendix 5.3-C). Clams are filter feeders with the ability to selectively filter their desired food (plankton) while rejecting less desirable sediment (Rupert and Barnes, 1991). When there are high concentrations of suspended sediment, clams have the ability to close their shells and stop filtering (Berry et al., 2003). Since the jet sled is pulled along at a rate of 300 feet per hour (91 meters per hour), the elevated suspended sediments along any one section of the seafloor would be limited in duration (Appendix 5.2-C), and of insufficient time to cause harm due to cessation of respiratory or feeding when the shells are closed (Berry et al, 2003). Further, clams can use their muscular foot to burrow or bury to retreat from harsh conditions and can "dig out" when conditions improve (Rupert and Barnes, 1991). The cable installation process would be analogous to a storm event, which causes an increase in suspended sediment load for a short period of time for which clams have the ability to close and survive for the duration of such events.

The proposed cable route avoids privately licensed shellfish areas or grants in Lewis Bay (see Figure 5.3-8). Approximately 600 feet (182.9 meters) of the recreational shellfish bed in Lewis Bay would be crossed by the cable route (Figure 5.3-6) with the 200 feet (61 meters) closest to shore to be crossed through the use of HDD. Localized and temporary impacts to the benthic community are also likely to occur from the creation of the pre-excavation pit that would be required to make the transition from the seaward terminus of the HDD conduit to the submarine cable system. The pre-excavation pit would temporarily impact 2,925 square feet/0.07 acre (272 square meters) of seafloor, or approximately 0.0004% of the Project area. This results in approximately 12,525 square feet/0.29 acre (1,164 square meters) of direct disturbance to the recreational shellfish bed (2,925 square feet/0.07 acre (272 square meters) from pre-excavation pit and 9,600 square feet/0.22 acre (892 square meters) from jet plow embedment of the two submarine cables). The Applicant would provide the Town of Yarmouth with funds to mitigate for this direct impact in accordance with the Town's policy for shellfish mitigation.

Decommissioning impacts associated with the removal of the submarine cable system linking the ESP to the shoreline facilities are expected to result in temporary resuspension of bottom sediments along each cable path and in association with any required vessel anchoring. The impacts from this activity are expected to be similar or slightly less than those during installation associated with direct sediment disturbance and sediment resuspension.

Cumulative Impacts

As stated above, other activities in the past, present, or future which may contribute to cumulative impacts to benthic and shellfish resources would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable between the south shore of Cape Cod and Nantucket has been proposed by National Grid, and its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and of short duration, these temporary impacts are not likely to occur at the same time. Thus, any areas where both projects may result in impacts as a result of jet plow cable embedment would likely have assimilated the deposited sediment from the first project installation by the time the second project is constructed. As such, there are no significant cumulative impacts expected to benthos that would result form the installation of both projects.

The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent, cumulative sediment suspension and deposition. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on recent experience it could be needed in the next 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. Future USACE maintenance dredging in Hyannis Harbor would be the subject of an additional NEPA document. In any event, as discussed in Appendix 5.2-C, sediment deposition resulting from the cable installation would be minimal and localized, and would not substantially contribute to any cumulative impact.

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the Project area. However, these marina dredging projects are very localized and not likely to result in sediment suspension and deposition that would be coincident with the cable installation, nor would the impacts to benthos from these activities be substantial. Thus, no significant cumulative impacts are anticipated from these activities.

5.3.4.3 Onshore

Once onshore, the cable route and other onshore facilities would not occur in areas with benthic resources.

5.3.5 Mitigation

The Project has been planned, sited, and designed to avoid or minimize impacts to benthos and benthic habitat within the Project area. While limited localized impacts are anticipated during Project construction and operation, measures would be implemented to prevent and minimize these impacts. These measures include using state-of-the-art hydraulic jet plow for cable installation (see Section 4.0), monopile foundations for WTG towers, and post-construction monitoring to document habitat disturbance and recovery (see Section 6.0). In addition, use of mid-line buoys on anchor lines would reduce the amount of anchor line sweep impacts. The duration and sequencing of construction has been designed to minimize the period of disturbance (see Section 4.0).

The monopile-type foundation system represents the foundation system type that would result in the least amount of seabed disturbance (see Sections 3.0 and 4.0). The Project also minimizes impacts by using jet plow embedment methods for installing the inner-array and submarine cable systems. The jet plow method is considered to be the most effective and least environmentally damaging alternative when compared to traditional mechanical dredging and trenching operations. This method of laying and burying the cables simultaneously ensures the placement of the submarine cables at the target burial depth with minimum bottom disturbance and the majority of fluidized sediment settling back into the trench. For these reasons it is the installation methodology that appears to be preferred by state and federal regulatory agencies based on review of past precedent setting projects. Installation of the submarine cables by jet plow embedment minimizes sediment disturbance and suspension.

Impacts to benthos and benthic habitat in Lewis Bay within 200 feet (61 meters) of shore would be minimized by using HDD methodology to transition the submarine cable system to the shore. HDD techniques also appear to be favored by state and federal regulatory agencies based on review of past precedent setting projects. The

cofferdam system and other containment described in Section 4.0 would minimize the risk of release of drilling fluid.

Scour control around each permanent vertical structure would be achieved through the use of biologically neutral scour control mats. These mats are designed to mimic seafloor vegetation through the use of synthetic fronds. This approach is more consistent with the low relief aspects of the Horseshoe Shoal bottom than traditional high-relief boulder fortification.

The Applicant would work with the Town Shellfish Constable to appropriately avoid or minimize impacts to designated shellfish areas from installation of the submarine cable. The Applicant would provide the Town of Yarmouth with funds to mitigate for the direct area of impact within the Town's designated recreational shellfish bed in accordance with the Town's mitigation policies. Potential conflict with commercial lobstering activity and gear, if there is any in the Project area at the time of construction, would be minimized by notifying registered lobster fishers well in advance of mobilization as to the location and timeframe of Project construction activities, as well as a daily broadcast on marine channel 16 as to the construction activities for that and upcoming days.

No adverse impact to benthic and shellfish resources is anticipated from heat associated with submarine cable system operation (see Section 5.13). Potential thermal impacts would be minimized by proper cable system design and burial of cables beneath the seafloor.

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) require that an Essential Fish Habitat (EFH) consultation be conducted for any activity that may adversely affect important habitats of federally managed marine and anadromous fish species. The Magnuson-Stevens Act, and the requirements that specifically address benthos and benthic resources with regard to EFH protection, are discussed in Appendix 5.4-C.

5.4 Finfish Resources and Commercial/Recreational Fisheries

5.4.1 Introduction

Both federal and state agencies monitor and/or manage fishery resources within Nantucket Sound. The National Marine Fisheries Service (NMFS) manages commercial and recreational fishing activities in all coastal states throughout the U.S. The Commonwealth of Massachusetts, primarily through its Division of Marine Fisheries (MDMF), also monitors the fishery resources in its coastal waters.

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) require that an Essential Fish Habitat (EFH) consultation be conducted for any activity that may adversely affect important habitats of federally managed marine and anadromous fish species. EFH is defined as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity" (16 U.S.C. 1802(10)). "Waters" in the above definition refer to the physical, chemical, and biological properties of aquatic areas that are currently being used or have historically been used by fish. "Substrate" refers to sediment, hard bottom, or other underwater structures and their biological communities. The term "necessary" indicates that the habitat is required to sustain the fishery and support the fish species' contribution to a healthy ecosystem. Nantucket Sound is designated as EFH for several fish and invertebrate species (see Section 5.4.4), and an EFH Assessment was conducted for these species as they relate to Proposed Project activities (Appendix 5.4-C).

This section describes existing fisheries resources and potential impacts to fisheries and fish habitat in the Project area. Statutory authorities and compliance are discussed in Section 7.0. The information contained in this section was obtained from literature review, agency consultations, site investigations, and review of existing site investigation data. Studies relied upon with regard to finfish resources and commercial/recreational fisheries are discussed in Section 5.4.2. Existing habitat conditions in Nantucket Sound are described in Section 5.4.3.1. A description of finfish species, including their expected temporal occurrence in Nantucket Sound and the Project area, is summarized in Section 5.4.3.2 and described in detail in Appendix 5.4-A. The evaluation of commercial and recreational fisheries data in Nantucket Sound using available databases from NMFS and MDMF is summarized in Sections 5.4.3.3 and 5.4.3.4, and described in detail in Appendix 5.4-A. A summary of the designated EFH species in the Project area is provided in Section 5.4.4. The complete EFH assessment is

provided in Appendix 5.4-C. The EFH assessment includes an evaluation of the life history characteristics of each species with designated EFH and the potential direct, indirect, and cumulative impacts of the Project to these species and their associated habitat. A summary of the results from the recreational intercept survey conducted is provided in Section 5.4.3.4 (see Appendix 5.4-B for the detailed report).

Section 5.4.5 provides information about the Project's potential impacts, with impacts discussed separately for state and federal waters. Specific potential impacts evaluated in Sections 5.4.5.1 and 5.4.5.2 include potential changes to habitat types and sizes, the potential effect of the WTG monopile foundations acting as fish aggregating structures, structural habitat alteration, an evaluation of the potential impacts of shading from Project structures, and an evaluation of the potential impacts of underwater sound and vibration during construction/decommissioning and operation. Additional detail on noise-related studies and potential impacts is provided in Section 5.11. The assessment of potential impacts on specific fishing techniques and gear types used by commercial and recreational fishermen and potential conflicts with existing fishery use patterns is discussed in Section 5.4.5.3. Mitigation measures are discussed in Section 5.4.6.

The Project's effects on currents and circulation, sediment transport, wave disturbance, water quality, scouring, and shoreline erosion (landfall) are addressed in Section 5.2. A discussion of the interconnections between benthic, fish, and avian resources and predator-prey interactions is included in Section 5.7. Potential effects on the commercial and recreational fishing industries are discussed in Section 5.16.

5.4.2 Studies Completed

5.4.2.1 Finfish Resources

Review of the scientific literature suggests that relatively few studies pertaining to finfish resources have been conducted specifically within the Proposed Project location in Nantucket Sound and Lewis Bay. Available data from studies published by NMFS, MDMF, and others for Nantucket Sound were reviewed and prioritized with regard to applicability to the Project. The primary sources of information used to characterize finfish resources in Nantucket Sound are summarized below.

NMFS Research Trawl Data

Independent of commercial and recreational landings, NMFS collects "fishery independent" data through a bi-annual bottom research trawl survey program. Otter trawl surveys are conducted throughout the U.S. in the spring and fall of each year to characterize the abundance and distribution of various fish and invertebrate species that are commonly collected using this method. A standardized sampling protocol is used throughout the coastal waters; however, some inshore areas are not sampled. Discussions with NMFS suggested that the bi-annual research trawl data from NMFS is not available for Nantucket Sound and that these bi-annual trawl surveys occur farther offshore from Nantucket Sound (Brown, 2004). Therefore, this dataset was not available for assessing finfish resources for this Project.

EFH Species

NMFS also describes EFH for marine species throughout the U.S. In the Northeast, NMFS works with the New England Fishery Management Council (NEFMC) and the Mid-Atlantic Fishery Management Council (MAFMC) to define essential habitat for key species in New England coastal waters, including those of Nantucket Sound. NMFS generates documents for each species describing the various life history stages of each species and the habitat necessary for survival of the various life history stages. These documents describe the basic biology, ecology, and behaviors of the species including information on food preferences, migratory behaviors, and spawning. This information was gathered and used in conjunction with other field and literature data to conduct an EFH Assessment for the Cape Wind Project.

MDMF Research Trawl Data

Researchers at MDMF are involved in studies evaluating the basic biology and ecology of anadromous fishes, lobster, northern shrimp, tautog, and recreational species such as sharks, big game species, bluefin tuna, and striped bass in all state waters. In addition to monitoring commercial landings and species-specific investigations, MDMF also conducts bi-annual research trawl surveys to collect fishery-independent information on abundance and distribution of fish and invertebrates from Massachusetts' waters. Since 1978, trawl surveys have been

conducted in May and September of each year. The sampling program is based on a stratified random design. The coastal waters are stratified into geographic zones (strata) based on depth and area. Pre-determined trawl locations are allocated in proportion to the area of each stratum and then selected randomly within each stratum. Trawls consist of 20-minute tows at a speed of 2.5 knots. A ¾ size North Atlantic type, two seam otter trawl is used for all surveys. The net contains a 6.4 mm cod end liner to retain smaller juveniles. Data from trawl locations within the boundaries of the proposed WTG array on Horseshoe Shoal (the Wind Park) in Nantucket Sound were analyzed and results are presented below in Section 5.4.3.2. Detailed information on these data can be found in Appendix 5.4-A.

5.4.2.2 Commercial Fisheries

Review of the scientific literature suggests that relatively few studies pertaining to commercial fishery resources have been conducted specific to the vicinity of the Proposed Site in Nantucket Sound. Both NMFS and MDMF do, however, monitor the fishery resources in waters of Nantucket Sound as a whole. The information from these programs has been used to characterize the commercial fishery resources in the Nantucket Sound area.

NMFS Commercial Data

Data on commercial fisheries have long been collected by NMFS. For the purposes of summarizing commercial landings in the U.S., NMFS divides the coastline into statistical sampling areas. The waters around Cape Cod and the Islands are designated as NMFS Statistical Area 538 with Nantucket Sound designated as Sub-area 075. NMFS records landings by these statistical areas and/or sub-areas. In the Northeast, prior to 1994, all landings information was collected through a voluntary reporting system. Fish landings and price information were collected by NMFS port agents at the point of initial sale of the catch through dealer reports or "weigh out receipts." This voluntary "weigh out" reporting was replaced in June 1994 with a mandatory reporting system. The mandatory reporting system continues today and involves fishermen submitting logbooks (vessel trip reports) of their catch. These data were used to evaluate the commercial landings in Nantucket Sound. The results are summarized below in Section 5.4.3.3 and are presented in detail in Appendix 5.4-A.

MDMF Commercial Data

As a state agency, the MDMF also monitors and studies the marine resources under its jurisdiction, including the monitoring of the commercial harvest of marine finfish, shellfish and lobster. MDMF has several programs aimed at managing the marine resources and the harvesting of those resources. One of these programs includes the Fisheries Dependent Investigations and Management Information Systems and Fisheries Statistics Projects. The Fisheries Dependent Investigation Project monitors catch and by-catch composition of some of the state's fisheries. The Management Information Systems and Fisheries Statistics Project maintains a commercial database for lobster, shellfish, and other "regulated" fisheries. Like NMFS, for the purposes of monitoring fishery resources in Massachusetts' waters, the coastal waters are divided into statistical areas. Nantucket Sound is designated by MDMF as Area 10 and is equivalent to NMFS Sub-area 075. Commercial fishermen are required to submit catch reports for various fisheries including shellfish, lobster, striped bass, the fish weir fishery, the gill net fishery, and the fish pot fishery (scup, sea bass, and conch). This information was used to characterize the fish and shellfish resources in Nantucket Sound, and is summarized below in Section 5.4.3.3 and presented in detail in Appendix 5.4-A.

5.4.2.3 Recreational Fisheries

NMFS Recreational Data

In addition to commercial landings, NMFS also monitors recreational fishing throughout the country using a Marine Recreational Fisheries Statistics Survey (MRFSS). MDMF does not conduct its own recreational surveys, but helps to fund the NMFS MRFSS surveys in Massachusetts' counties. These surveys are conducted through telephone interviews or face-to-face interviews with recreational anglers at various ports. Unlike the commercial information, recreational fisheries data are not reported using a statistical sampling grid of the coastal waters. Instead, NMFS interviewers record the county where the survey was conducted, or if a phone interview was used, the county where anglers reported they visited to participate in recreational fishing activities. Surveyors question anglers as to where they fished, how long they fished, what types of gear they used, as well as what species they caught. For the purposes of characterizing the recreational fishing in Nantucket Sound, interview data from three counties surrounding Nantucket Sound (Barnstable, Dukes and Nantucket) were obtained. It can be assumed

that at least some portion of the anglers surveyed from these counties were, in fact, fishing within Nantucket Sound. Recreational fisheries summaries are presented below in Section 5.4.3.4, and are described in detail in Appendix 5.4-A.

Recreational Intercept Survey

To better estimate the fishing by party/head boats and charter boats in Nantucket Sound, an intercept survey was conducted from August 2002 through November 2002 (Appendix 5.4-B). Both party/head boats and charter boats are a common platform for recreational fishing activities, particularly for those individuals who do not have access to a personal boat. In many vacation locations along the coast of the U.S., party/head boats and charter boats are an important part of the local economy. A party/head boat is a boat that accepts individually paying passengers on a first come, first served basis and takes these individuals (often more than 20 people/boat) for a day or ½ day of fishing. A charter boat is unique from a party/head boat in that the boat is reserved in advance by a small group of anglers that pay a set fee.

The primary objective of the survey was to collect information on the existing recreational fishing effort by party/head boats and charter boats in Nantucket Sound to evaluate the potential impact of the Project on this type of recreational fishing activity. A second objective of the survey was to gather more detailed information on the specific species sought by recreational anglers fishing in Nantucket Sound. The survey was designed to be answered by the captains or crew of the party/head boats and charter boats. Registered party and charter boat captains who would potentially fish in the area were identified, contacted via phone, and questioned. Additionally, a map depicting the locations of the Wind Park and other areas in Nantucket Sound was sent to the captains in hopes they would identify specific fishing locations within the Sound. The results of these telephone interviews are briefly discussed below in Section 5.4.3.4, and presented in detail in Appendix 5.4-B.

5.4.3 Existing Conditions

5.4.3.1 Habitat Conditions of Nantucket Sound

Resources which are a component of the overall finfish environment in Nantucket Sound are discussed in the following sections and their associated Appendices: Section 5.1 (sediment conditions), Section 5.2 (physical oceanographic conditions including water depths/bathymetry, currents, waves, salinity, temperature, sediment transport regimes, and ambient near-bottom suspended sediment concentrations), Section 5.3 (benthic habitat and benthic resources), and Section 5.9 (water quality).

As discussed in Section 5.2, the bathymetry in Nantucket Sound is irregular, with a large number of shoals present in various locations throughout the glacially formed basin. Charted water depths in the Sound range between one and 70 feet (0.3 and 21.3 meters) at MLLW (see Figure 5.2-1). The proposed Wind Park site is located on Horseshoe Shoal, a prominent geological feature in the center of the Sound. Depths on Horseshoe Shoal are as shallow as 0.5 feet (0.15 meters) at MLLW. Water depths between Horseshoe Shoal and the Cape Cod shoreline are highly variable, with an average depth of 15 to 20 feet (4.6 to 6.1 meters) at MLLW.

As discussed in Section 5.1, Nantucket Sound generally contains sand-sized marine sediments, with localized patches of clay, gravel and/or cobbles. Medium-grained sands predominate atop the U-shaped Horseshoe Shoal (the Proposed Site), with fine-grained sands found in the east opening embayment. The sandy substrate of Nantucket Sound is dynamic and mobile, producing ripple marks and sand waves. The magnitude and frequency of sand movements has a marked influence on the composition and abundance of the benthic communities. Organisms living on or in these sandy sediments are adapted for movement or settlement in sand and recovery from burial. Section 5.1 contains more detailed information on the sediment and geology conditions in Nantucket Sound, while Section 5.3 discusses benthic resources in Nantucket Sound including areas of potential hard substrate. Areas of known submerged aquatic vegetation are discusses in Section 5.8.

5.4.3.2 Finfish Resources

The waters of Nantucket Sound support a diverse fish community. Both commercial and recreational fishing are conducted in the Sound. During the summer months, a temperature gradient forms off the east coast of Cape Cod that demarcates the cold-water fishes to the north and warmer water fishes to the south (Freeman and

Walford, 1974). This gradient, however, is variable and tends to oscillate north and south along a 20-40 mile (32-64 km) section of the Cape Cod shoreline. Due to its geographic location and the temperature gradient observed along Cape Cod, Nantucket Sound serves as a migratory pathway for many warm-water species that pass through the Sound moving into Cape Cod Bay and Massachusetts Bay. The area also serves as a northern border for several summer migrants including scup, northern fluke, and black sea bass.

The MDMF research trawl survey dataset is one of the most complete datasets available to characterize finfish resources in the Project area and was used to provide an understanding of finfish resources in the Project area. There are, however, limitations to these data. The long-term research trawl program is not designed to statistically test for similarities/differences in finfish abundance and/or distribution between specific sites. Any results from abundance/distribution analyses using these data must be interpreted cautiously. The timing of the surveys (May and September) does not allow the surveys to adequately represent the abundance and distribution of finfish over the entire year, but is timed to coincide with seasons when either adults or juveniles are available inshore. Additionally, the gear type (otter trawls) and methods used during the survey are similar to gear used by commercial fishermen and are more effective at collecting demersal and semi-pelagic species. True pelagic species (i.e., Atlantic mackerel) and highly migratory species such as bluefin tuna are not frequently caught in bottom trawls. Therefore, any analysis evaluating species occurrence may not represent accurate abundance and distribution for these pelagic species. The MDMF research trawl data from all trawl locations within the boundaries of the Wind Park in Nantucket Sound were evaluated to provide some estimate of finfish resources in this area. Analyses of these data and fishery information from other sources (biological and physical) have been used to provide an understanding of finfish resources in the Project area.

Using the MDMF research trawl information from 1978 to present, a likelihood-of-occurrence analysis was conducted to determine which species collected during these surveys were considered very common, variably common, less common, rare, very rare, or not observed at the Wind Park site in Nantucket Sound. The rules for assigning the species to a given occurrence category were subjectively assigned (see Appendix 5.4-A). An analysis of the MDMF research trawl data at the Wind Park site by season is presented below. The detailed results of these analyses at the Wind Park site and two other sites in Nantucket Sound are provided in Appendix 5.4-A.

Since 1978, a total of 78 species were sampled through the MDMF bi-annual research trawl surveys. The likelihood of occurrence of these species in otter trawls for spring and fall for the Wind Park site in Nantucket Sound is presented in Tables 5.4-1 and 5.4-2, respectively. The number of species listed as generally common in otter trawls (i.e., very common, variably common, and less common) is similar across seasons (Tables 5.4-1 and 5.4-2; Appendix 5.4-A).

The results of the analysis suggest that the following species are very common in trawls conducted at the Wind Park site during the spring and fall: lady crab, longfin squid, northern searobin, unclassified spider crabs, and summer flounder. During the spring, little skate, winter flounder, windowpane and winter skate are also considered very common in trawls. Other important species such as Atlantic cod, black sea bass, butterfish, cunner, tautog, and scup are variably common or less common in trawls within the Wind Park site in the spring. Rare and very rare species in trawls during the spring include alewife, American shad, Atlantic herring, Atlantic mackerel, blueback herring, Atlantic surfclam, bay anchovy and northern shortfin squid, among others (Table 5.4-1). Again, it is important to note that, although the data suggest that species such as the Atlantic mackerel are rare or very rare, pelagic species are not collected as frequently using otter trawls and the information on these species may not accurately reflect their abundance.

The species collected in the trawls at the Wind Park site during the fall are similar to those observed during the spring; however, those species considered very common in trawls during the spring (e.g., windowpane and winter flounder) seem less common (windowpane) or even rare in trawls during the fall (winter flounder). Many of the finfish species observed in Nantucket Sound exhibit migratory behaviors, and are likely to move into and out of areas as water temperatures change. During the winter and early spring, certain species would concentrate on the shoal areas in Nantucket Sound to feed and/or spawn, whereas others would move off the shoals into channels or deeper waters. For example, winter flounder are known to move off the shoals into channels and deeper waters during the summer months when the shallow waters on the shoals heat to higher temperatures. Winter flounder are known to move back to the shoal areas in autumn when water temperatures

begin to cool. In May, water temperatures in Nantucket Sound are still cool, and winter flounder are likely to be more common then than in September, when water temperatures can remain warm. Summer flounder, on the other hand, are found on the shoals when water temperatures are warmer and move to deeper areas when the shoal waters become cooler.

Black sea bass, butterfish, scup and smooth dogfish are also considered very common in trawls from the Wind Park site during the fall. The various whelk species (channeled and knobbed) are classified as very common or variably common in trawls at the Wind Park site in the fall. During the fall, winter flounder appear to be rare in trawls at the Wind Park site compared to their "very common" status in the spring. Some of the species that are not observed at all during the fall trawl surveys include alewife, American shad, Atlantic cod, Atlantic herring, Atlantic mackerel, Atlantic menhaden, and northern shortfin squid, among others (Table 5.4-2). Again, the abundance of pelagic species such as Atlantic mackerel may be underrepresented due to preference of sampling gear (i.e., otter trawl) for more demersal species.

Using the research trawl data from 1990 through the present, Catch Per Unit Effort (CPUE) was calculated for the fall (i.e., September) and spring (i.e., May) for the Wind Park site and two other sites in Nantucket Sound. The number of tows used to calculate CPUE for any given site, year and season ranged from one to four tows; in several instances, no data were available for a particular year at a given site. In general, mean CPUE across the 1990 through 2002 time period was lower at all three shoals during the spring surveys than during the fall surveys (Figure 5.4-1). During the spring, mean CPUE at Horseshoe Shoal (mean CPUE = 225 fish/tow) was lower than that observed at either Monomoy-Handkerchief Shoal or Tuckernuck Shoal (mean CPUE = 425 fish/tow and 592 fish/tow, respectively) (Appendix 5.4-A, Attachment D). During the fall, CPUE estimates were at least an order of magnitude higher than those observed during the spring and were very similar across the three shoals. Mean CPUE in the fall was calculated to be 5,545 fish/tow at Horseshoe Shoal, 5,546 fish/tow at Monomoy-Handkerchief Shoal and 4,966 fish/tow at Tuckernuck Shoal (Appendix 5.4-A, Attachment D).

As expected, the amount of variation observed in the CPUE estimated both within an individual site and between sites for any given season was large (Appendix 5.4-A, Attachment D). An Analysis of Variance (ANOVA) was used to determine if the CPUE was, in fact, significantly different between the Wind Park site and the other two shoals during the fall and spring. The results of the ANOVA analysis indicate that during both the fall and spring surveys, CPUE was not significantly different at Horseshoe Shoal, Monomoy-Handkerchief Shoal, and Tuckernuck Shoal.

5.4.3.3 Commercial Fisheries

NMFS and MDMF Commercial Fisheries Data

Nantucket Sound supports a commercial fishery for various finfish species, squid, shellfish (including conch) and lobster. From 1994 through 2001, approximately 4.3 million pounds of finfish and squid were harvested from Nantucket Sound (NMFS vessel trip report data for area 075; Figure 5.4-2). Squid, both *Loligo* and *Illex*, are important commercial fisheries in this region and are reported with the finfish landings. Although the data suggest a substantial increase in landings from 1994 through 2000 (Figure 5.4-2), the trend may in fact be due to the accuracy with which the fishermen reported their landings as they adjusted to the new mandatory reporting requirements that began in 1994.

The top ten species of finfish and squid landed by commercial fishermen in Nantucket Sound (Sub-area 075), as reported from NMFS vessel trip reports from 1994 through 2001, include squid, Atlantic mackerel, black sea bass, summer flounder, scup, menhaden, butterfish, tautog, winter flounder, and bluefish (Figure 5.4-3). A total of approximately 1.8 million pounds of squid were harvested from Nantucket Sound between 1994 and 2001, suggesting that squid comprise 42% of the total landings (excluding shellfish and lobster) for this region. The dominant species, the longfin squid, *Loligo*, represents 87% of the squid catch. The shortfin squid, *Illex*, constitutes 4% of the catch, and the remaining 9% of the squid were not identified.

Gear types used by commercial fishermen in Nantucket Sound for harvesting finfish species include otter trawls, gill nets, fish weirs, pound nets, seines, various types of pots/traps, as well as hand lines. Finfish landings reported for the specific gear types from NMFS vessel trip reports indicate that the greatest landings were from otter trawls (see Appendix 5.4-A, Table 1). Hand lines, fish pot/traps and fish weirs also produced significant

catches. The fish weir fishery, gill net fishery, and the fish pot fishery for sea bass and scup are monitored independently by MDMF. Annual landings from the fish weirs from 1990 through 2000 in Nantucket Sound (MDMF Area 10) are shown in Figure 5.4-4. Figure 5.4-5 presents landings from the gill net fishery, and Figure 5.4-6 presents landings from the fish pot fishery for sea bass and scup.

Total landings from the fish weir fishery in Nantucket Sound from 1990 through 2000 are estimated at 11.3 million pounds, averaging approximately 1 million pounds per year. Species collected from the fish weirs included migratory pelagic species such as albacore tuna, amberjack, Atlantic mackerel, bluefish, bonito, king mackerel, Spanish mackerel, as well as more resident demersal and groundfish species including summer flounder, winter flounder, witch flounder, sea bass, butterfish, menhaden, scup, weakfish, various herrings, and squid. The three top species landed in fish weirs during the 1990 through 2000 period were Atlantic mackerel (mean = 432,910 lbs/yr), squid (mean = 386,450 lbs/yr), and scup (mean = 103,587 lbs/yr). Over the 11-year period, both squid and scup showed a downward trend in total landings from fish weirs and Atlantic mackerel landings fluctuated over the years peaking to an annual high of 876,160 pounds in 1997 (Figure 5.4-4).

Gill nets do not appear to be fished with any consistency in Nantucket Sound. Gill net landings were reported from January through June and then again in August in 1992, 1993, 1995, and 1999. Only one commercial gill net license was issued for the area in 1992, 1995, and 1999 and three licenses were issued in 1993. Given the low gill net fishing effort, the total landings from the gill net fishery in Nantucket Sound from these four years totaled approximately 192,000 pounds (Figure 5.4-5). In 1992, only Atlantic mackerel were collected in the gill nets. The diversity of species has increased slightly in the other years and species collected include cod, haddock, hake, summer flounder, winter flounder, witch flounder, yellowtail flounder, monkfish, pollock, tautog, cusk, various skates, and dogfish. On an annual basis, total landings from gill nets were greatest in 1995 (165,000 pounds) due to the large landings of dogfish (approximately 158,000 pounds).

Both scup and sea bass are important fisheries in Nantucket Sound. Many commercial fishermen have licenses for the harvesting of these species using fish pots. Since 1990, 20 to 38 fishermen have fished pots for sea bass in Nantucket Sound. Total sea bass landings using fish pots from 1990 through 2000 were approximately 1.8 million pounds. From 1990 to 1992, sea bass landings dropped substantially (from 336,000 pounds to 40,000 pounds). Since 1992, however, total landings have steadily increased to a high of 419,000 pounds in 1999 (Figure 5.4-6). Landings dropped again in 2000. Seasonally, sea bass landings are highest in May and June, averaging over 61,000 pounds per year in May and over 50,000 pounds per year in June over the 11-year period.

Catch reports for the harvesting of scup from fish pots have only been required since 1994. Similar to sea bass, many commercial fishermen have licenses for the harvesting of scup from fish pots. In 1994, 47 fishermen fished pots for scup. This number has declined through the years to a low of 21 fishermen fishing pots for scup in Nantucket Sound. Total scup landings from fish pots from 1994 through 2000 were approximately 1.2 million pounds. Landings have declined from 1994 to 2000 from approximately 277,000 pounds in 1994 to 17,000 pounds in 2000 (Figure 5.4-6). Seasonally, scup landings are highest in June, averaging approximately 82,000 pounds per year from 1994 to 2000.

One other important fishery in Nantucket Sound is the striped bass fishery. This fish is harvested both recreationally and commercially in the region. The commercial fishery for this species is a hook and line fishery, and the season runs from July through September. MDMF monitors the striped bass that are landed and sold to market as well as those that are caught and released, or kept by the fishermen. Seasonally, striped bass landings that are sold to market appear to be greatest during the month of July (mean of 17,614 pounds per year landed from 1990-2000; Figure 5.4-7). By September, far fewer striped bass were landed and sold to market (mean of 1,210 pounds per year from 1990-2000). Total striped bass landings (based on those sold to market) for Nantucket Sound from 1990 through 2000 were estimated at approximately 320,000 pounds. Figure 5.4-8 presents the annual landings for striped bass in Nantucket Sound. From 1990 to 1994, total annual landings did not exceed 15,000 pounds. From 1995 through 1998, annual striped bass landings increased steadily to a high of 80,000 pounds in 1998. Annual landings decreased to below 50,000 pounds in 1999 and 2000.

Appendix 5.4-A contains detailed analyses of the commercial data presented above for finfish and squid. Summaries of all data received from NMFS and MDMF can be found in this appendix.

Commercial Seasons and Gear Types

A summary of the commercial seasons and gear types for some of the top species of finfish and squid landed by commercial fishermen in Nantucket Sound is discussed below. The commercial long-finned squid fishery opens on April 23rd and ends May 31st of each year (MDMF, 2001). The fishery can be extended by the MDMF Director for up to two weeks (June 14th) if squid size remains large and bycatch of other species remains low based on observer data (MDMF, 2001). The commercial summer flounder (fluke) fishery generally opens around the first week of July, and lasts from four to eight weeks. The beginning and length of the season depends on many factors, including population presence and filled quotas, but is generally characterized as July and August (MDMF, 2001).

For both the squid and fluke fisheries, mobile gear[72] renders the most success, and the otter trawl is the most popular method. MDMF has compiled statistics on the number of boats licensed to fish for squid and fluke in all of Massachusetts. These data indicate that, in 2001, of the 34 boats licensed to fish squid in Massachusetts, 31 used mobile gear. Similarly, of the 58 boats licensed to fish fluke in Massachusetts in 2001, 40 used mobile gear (MDMF, 2001). It is important to note that these boats could fish anywhere in Massachusetts waters, and all of these boats do not necessarily fish in Nantucket Sound or the Project area. In addition, some boats may be licensed to fish for both fluke and squid; therefore, the total number of boats fishing for these species are not necessarily additive.

The preferred method for fishing Atlantic mackerel is by weir nets or pound nets, usually in springtime. These are nets that are set right off the beach or on sandbars (zero to three miles out (zero to five kilometers), and the fishery is licensed by the towns and, therefore, takes place within the three-nautical mile (5.6 km) limit of state waters.

The commercial scup and black sea bass fishery does not have defined openings and closures. Seasons are largely defined by filled quotas, and a season for either of these species can be broken up into several smaller seasons with different catch limits within one year. The preferred methods of fishing for these species are stationary, i.e., pots and fixed nets (MDMF, 2001).

5.4.3.4 Recreational Fisheries

Because of its location adjacent to several key vacation destinations (i.e., Cape Cod, Nantucket, and Martha's Vineyard), Nantucket Sound and the waters around the islands of Nantucket and Martha's Vineyard support a diverse array of recreational fishing activities. Data on recreational fishing are collected by NMFS (see Section 5.4.2.4). The information requested by NMFS using the MRFSS attempts to capture information on the numbers of individuals participating in the various types of recreational fisheries (i.e., hook and line, charter boat, private boat, etc.), the number of trips and hours spent fishing by the anglers, social and economic information of the anglers, as well as the numbers and species of fish caught. Recreational data as summarized from the MRFSS was obtained from 1990 through 2001 for the three counties surrounding Nantucket Sound: Nantucket, Dukes, and Barnstable. The results from this database query are presented in the discussion below.

The number of surveys conducted in Dukes, Barnstable, and Nantucket Counties over this 12-year period is presented in Table 5.4-3. This information provides an estimate of the proportion of individuals participating in recreational fishing activities in these counties for any given year. The true recreational fishing effort would be greater than this, since NMFS cannot target every angler for a given year. However, it is important to note that of those individuals interviewed by NMFS in these three counties, only a portion would have been engaged in recreational fishing activities in Nantucket Sound because these surveys likely include anglers engaged in fishing activities offshore, in waters further out on the Cape, further offshore to the south of Nantucket and Martha's Vineyard, or even in portions of Buzzards Bay.

NMFS summarizes the recreational fishing data in two-month intervals referred to as "waves" (NOAA Fisheries, 2001). NMFS waves are defined as follows:

- Wave 1: Jan-Feb;

[72] Mobile gear means any movable fishing gear or nets which are towed, hauled or dragged through the water for the harvest of fish, squid, and shellfish including but not limited to otter trawls, beam trawls, bottom and mid-water pair trawls, Scottish seines, Danish seines, Pair seines, and sea scallop dredges.

- Wave 2: Mar-Apr;
- Wave 3: May-Jun;
- Wave 4: Jul-Aug;
- Wave 5: Sep-Oct; and
- Wave 6: Nov-Dec.

Although recreational fishing may occur throughout the year in Nantucket Sound, NMFS does not report information for the New England region during Wave 1. Therefore, the numbers of surveys reported in Table 5.4-3 are only from March through December. According to NOAA, sampling efforts during January and February since 1980 were generally limited to the Pacific coast, Gulf coast states and the Atlantic coast of Florida. Historically, only about 5 percent of the annual recreational catch on the Atlantic and Gulf coasts is taken during Wave 1 (January - February). Furthermore, the costs to sample these months were very high because of low fishing activity, particularly in the North and Mid-Atlantic subregions. Therefore, in Jan/Feb of 1981 the MRFSS was not conducted in any region. In 1982, Jan/Feb data collection resumed on the Pacific and Gulf Coasts and also on the Atlantic Coast of Florida. With a few exceptions (GA 1985-1989, SC 1988, NC 1988-1992), the MRFSS has not been conducted in Jan/Feb on the Atlantic Coast north of Florida since 1980 (NOAA, 2004).

The recreational fishing pressure for Nantucket Sound is highest during the warmer months (i.e., June through September) when tourists are vacationing in the region. The mean number of hours fished by wave from 1990-2001 as reported by surveyed anglers is presented in Figure 5.4-9. As expected, the mean number of hours spent recreational fishing was greatest during Wave 4 (July-August) and was also high in Wave 3 (May-June) and Wave 5 (September-October). Very few hours were spent fishing in March and April (Wave 2). Regardless of month, the average number of hours individual anglers engaged in recreational fishing activities did not vary greatly between years (Figure 5.4-10).

The majority (99.6%) of recreational anglers surveyed reported hook and line as gear type used for recreational fishing activities, and most recreational anglers reported fishing from a private/personal or rented boat as the type or mode of recreational fishing. From 1990 through 2001, 46% of all anglers surveyed reported fishing from private/rental boats (Figure 5.4-11). Fishing from shore was also common, with approximately 40% of all anglers surveyed reporting fishing from shore. Fishing from shore includes any structure such as a pier, dock, or structure built over the water; any rock wall built out into the water or parallel to the shore to restrain currents or protect a harbor; a breakwater device; bridges; causeways; beaches; or banks.

The number of anglers reporting the use of party/charter boats was much lower than those reporting the use of private boats or fishing from shore. Only 13.6% of anglers surveyed reported fishing from a party boat or charter boat. A party boat (often referred to as a head boat) is a boat on which fishing space and privileges are provided for a fee. The vessel is operated by a licensed captain and crew. A charter boat is also operated by a licensed captain and crew, however, the anglers are part of a pre-formed group that "charters" the boat, captain and crew for a specific price and time.

Common species caught by the recreational anglers surveyed by NMFS interviewers included bluefish, Atlantic mackerel, scup, striped bass, winter flounder, summer flounder, menhaden and tautog. The number of individual fish that anglers reported catching appears to have increased from 1990 through 2001. However, it is important to note that if an angler is surveyed multiple times over the years, he or she may become more familiar with survey questions and may be likely to provide more detailed information on the catch. NMFS survey interviewers observed approximately 10% of the catches reported by anglers fishing from shore, fishing from party/charter boats, or fishing from private/rental boats from 1990 through 2001. The greatest numbers of fish caught by individual anglers were reported from those using private/rental boats (Figure 5.4-12). Anglers fishing from party/charter boats also reported catching large numbers of fish. Those anglers fishing from shore reported the lowest numbers of fish.

To better estimate the party boat and charter boat industry in Nantucket Sound, a telephone survey to registered party/charter boat captains in the region was conducted from September through November 2002 (Appendix 5.4-B). A total of 30 party and charter boat captains were contacted and questioned. Twenty-seven of the 30 respondents were operators of charter boats, while only three were party boat operators. The operators of the party and charter boats were asked approximately how many days they fish over the course of the year. In

general, both charter and party boat operators reported fishing an average of 150 days per year. Many of the operators mentioned that they often make several trips per day. Therefore, the number of days fishing does not necessarily correspond to the total number of trips. Surveyed captains reported a total of 1,752 half-day trips and 430 full-day trips. The number of anglers fishing from party boats and charter boats varied depending on the size of the vessel. Most charter vessels could accommodate five to six passengers, whereas most of the party boats mentioned taking between 20-30 anglers per trip.

Both party and charter boats operators mentioned that the most sought after species on both types of fishing excursions are striped bass, various tunas, and scup. Bluefish, bonito, sea bass, sharks, and cod are also common species that anglers aboard these vessels tend to catch. As anticipated, most of the species are caught on trips during the months of May through September, since more people tend to engage in fishing activities using party and charter boats during these months.

The party and charter boat captains were also questioned on specific areas they take anglers to fish. The majority of the party boat and charter boat captains reported that for short (half-day trips) they did not take their anglers to the Proposed Site. The captains reported that the areas they fished most included Squibnocket, Elizabeth Islands, Vineyard Sound, South Beach, Nauset, Buzzards Bay, Stage Harbor, Old Man, shoreline areas near Dennis/Harwich, Canyons, regions south of Martha's Vineyard, Nantucket Shoals, Muskeget Channel, and Great Point. The areas around Monomoy Island and those around Tuckernuck Island were also fished on half-day trips, but not as frequently as the locations listed above.

For full day trips aboard party boats and charter boats, the captains reported fishing the shoal areas around Horseshoe Shoal, Monomoy Island and Tuckernuck Island. From the 430 full-day trips reported within the most recent 12 months, approximately 56% of these trips were to the shoal areas around Monomoy Island. Twenty-one percent of the trips were to the Horseshoe Shoal region, and 9% were to the shoal areas around Tuckernuck Island. The remainder of the full-day trips reportedly occurred in areas east of Monomoy Island, south of Martha's Vineyard, and regions southeast of Nantucket. More details on the recreational intercept survey and the results are presented in Appendix 5.4-B.

5.4.4 Essential Fish Habitat Assessment

Habitat within the Project area has been designated EFH for 17 federally managed fish and three federally managed invertebrates. Therefore, the Magnuson-Stevens Act requires the assessment of potential impacts to the 17 federally managed fish and three federally managed invertebrates, which include: Atlantic cod (*Gadus morhua*), scup (*Stenotomus chrysops*), black sea bass (*Centropristis striata*), winter flounder (*Pseudopleuronectes americanus*), windowpane (*Scophthalmus aquosus*), summer flounder (*Paralichthys dentatus*), yellowtail flounder (*Limanda ferruginea*), Atlantic butterfish (*Peprilus triacanthus*), Atlantic mackerel (*Scomber scombrus*), blue shark (*Prionace glauca*), shortfin mako shark (*Isurus oxyrhinchus*), bluefin tuna (*Thunnus thynnus*), king mackerel (S*comberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), cobia (*Rachycentron canadum*), little skate (*Leucoraja erinacea*), winter skate (*Leucoraja ocellata*), long-finned squid (*Loligo pealei*), short-finned squid (*Illex illecebrosus*), and the surf clam (*Spisula solidissima*). A summary of specific life stage EFH designations for these species is provided in Table 5.4-4. Only one EFH "Habitat of Particular Concern" (HAPC's) has been identified in the Project area[73]. Eelgrass beds, when located within summer flounder EFH, have been designated as HAPC's by MAFMC. A detailed EFH assessment is provided in Appendix 5.4-C.

5.4.5 Analysis of Impacts

Fisheries resources may be impacted by Project construction, operation/maintenance, and decommissioning. Potential direct, indirect, and cumulative impacts to finfish that could occur during these Project phases at the Proposed Site (Horseshoe Shoal) are discussed in Sections 5.4.5.1 and 5.4.5.2 for activities that would occur in federal waters (beyond 3 nautical miles (5.6 km)) and state waters (within 3 nautical miles (5.6 km)), respectively. A discussion of the potential impacts on specific fishing techniques and gear types used by commercial and recreational fishermen and potential conflicts with existing fishery use patterns is discussed in

[73] http://www.nero.noaa.gov/ro/doc/list.htm

Section 5.4.5.3. Socioeconomic impacts directly pertaining to the commercial and recreational fishing industry are discussed in Section 5.16.

5.4.5.1 Potential Impacts Outside of Massachusetts Waters

5.4.5.1.1 Direct Impacts

Construction/Decommissioning:

- ***Finfish Habitat Loss***

The installation of the monopiles, inner-array cables, and two submarine cable circuits would physically displace sediment at specific locations. The total permanent direct area of benthic habitat loss from WTG and ESP monopile foundations and installation of scour control mats would comprise 0.02% of the total Project area (Table 5.3-3). Additional temporary impacts to the seafloor in the vicinity of each proposed WTG and the ESP are expected to occur as a result of the anchors and jack-up barges involved in construction. Temporary impacts that could be anticipated from installation of the WTGs and ESP include disturbance associated with vessel positioning, anchoring, and anchor line sweep. This temporary disturbance could comprise up to approximately 3.1% of the total Project area (see Section 5.3 and Table 5.3-3 for further detail).

The total temporary direct area of benthic habitat disturbance from jet plow embedment of the inner-array cables and the two circuits comprising the submarine cable system in federal waters would be approximately 0.4% of the total Project area (Table 5.3-3). The impact from jet plow embedment of the inner-array cables and two submarine cable circuits would be temporary, with suspended sediments anticipated to settle and refill cable trenches and areas immediately surrounding the cable trenches shortly after embedment (see Section 5.2 and Appendix 5.2-C for more detail). Additionally, temporary impacts associated with cable installation barge positioning, anchoring, anchor line sweep, and the pontoons on the jet plow device are expected to occur along all cable installation paths. Total anticipated temporary impacts to benthic habitat from anchoring and pontoons during the installation of the inner array cables and two submarine cable circuits in federal waters would comprise approximately 4.7% of the total Project area (see Section 5.3 and Table 5.3-3 for further detail). The impacts associated with anchor line sweep during positioning of the cable lay vessel would also be localized and temporary and would primarily affect the sediments to a depth of between 3 and 6 inches (7.6 and 15.2 cm) (Algonquin Gas Transmission Company, 2000). Anchoring locations would have disturbances to several feet deep in a small [quantify size] disturbance area around each anchor. While numerous anchor re-positionings would occur, the cumulative area is still small (see Section 5.3).

Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction due to the lack of pile driving activities associated with construction (see Section 4.5). Benthic habitat is similar throughout Nantucket Sound, and thus demersal finfish in the area of Project construction/decommissioning are likely to be able to find suitable benthic habitat adjacent to the Project area or in other areas of the Sound. Pelagic species are likely to be able to occupy the water column in other parts of the Sound. Finfish are expected to rapidly return to these areas once construction in the specific area is ceased or completed or following decommissioning.

- ***Finfish Mortality and/or Displacement***

Project construction/decommissioning is not expected to result in measurable direct mortality to adult and juvenile pelagic finfish, since these life stages are mobile in the water column and are capable of avoiding or moving away from the disturbances associated with construction. During winter construction periods, demersal finfish may experience higher levels of injury or mortality since avoidance of anchors and anchor cables may be hampered due to sluggish response under cold water conditions. No measurable effects on populations would be expected. Displacement of juvenile and adult finfish is likely to be temporary and localized, as no stressor is likely to extend great distances or for long durations associated with any of the construction activities. Demersal eggs and larvae of finfish, however, may experience localized increases in physical abrasion, burial or mortality during Project construction due to their limited motility. The greatest areal impacts to demersal eggs and larvae would occur from anchor positioning and anchor line sweep during construction. However, the total anticipated temporary impact to the upper sediments from anchoring in federal waters would comprise less than 7.4% of the total Project area. Larvae in the latter stages of development are capable of some motility, which may allow for movement from the construction area. Pelagic eggs and larvae are not likely to be substantially affected.

Predatory fish species, which may feed on larvae, may be temporarily displaced from the area as a result of disturbance during construction or decommissioning activities. Project decommissioning-related impacts are expected to be similar to or less than impacts during construction.

- ***Elevated Total Suspended Solids (TSS)***

Construction activities associated with installing the monopile foundations, scour control mats, and the inner-array cables and submarine cable system would result in a temporary and localized increase in suspended sediment concentrations. Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction. Elevated total suspended solids (TSS) can negatively impact the ability of some finfish to navigate, forage, and find shelter. The pile driving hammer and jet plow technology that would be used to install the monopile foundations and the submarine cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum. Due to the predominant presence of fine to coarse-grained sand in Nantucket Sound, localized turbidity associated with Project construction or decommissioning is anticipated to be minimal and confined to the area immediately surrounding the monopiles, the inner-array cables, and the two submarine cable circuits. Sediments disturbed by construction or decommissioning activities are expected to settle back to the sea floor within a short period of time (one to two tidal cycles). In addition, the Project area is situated in a dynamic environment that is subject to naturally high suspended sediment concentrations in near-bottom waters as a result of relatively strong tidal currents and wind and storm generated waves, particularly in shoal areas. Therefore, marine organisms in this area are accustomed to substantial amounts of suspended sediment and should not be substantially impacted by a temporary increase in turbidity from Project activities. No substantial impact to finfish is expected as a result of temporarily elevated TSS levels caused by Project construction or decommissioning.

- ***Acoustical Impacts***

Vella (2002) suggests that certain sounds associated with the construction of an offshore wind farm may have an adverse effect on local fish populations, causing them to move away from the area temporarily. The maximum submarine sound generated during the Project would occur during construction activities, particularly during the installation of the monopile foundations. The jet plow embedment process for laying the submarine cable system and inner-array cables produces no sound beyond that produced by typical vessel traffic (Center, 2003). The cable installation barge would produce sound typical of vessel traffic already occurring in Nantucket Sound.

Finfish are likely to avoid the immediate area around a monopile while it is being driven. Nonetheless, as discussed in Section 5.11, simulations of the temporary, maximum underwater sound expected to be produced by Project activities reveal levels would be below 180 dB beyond a 500 meter (1,640-foot) Initial Safety Radius for the protection of marine mammals. Therefore, at this distance, underwater sound would be well below levels that would cause permanent damage to finfish (see Table 5.4-5). Any impacts to fish within 500 meters (1,640 feet) would be minimized by using a "soft start" of the pile driving equipment to allow fish to move away from the area in response to construction sound. Only two pieces of pile driving equipment will be present within the Project area at any one time, and they are unlikely to be operating simultaneously. For additional details on construction please refer to Section 4.0.

Direct measurements made during the installation of the SMDS on Horseshoe Shoal, as well as modeling simulations to evaluate underwater sound during all phases of the Project, suggest that acoustical impacts on local fish populations would be minimal. Some localized effects may be experienced by fish near the construction activities if they do not move from the area. However, impacts to finfish would be minimized by the underwater sound level monitoring that would be conducted for protected marine species during initial construction using a NMFS-approved observer at the site (see Section 2.1 of Appendix 5.11.-A)[74]. Section 5.11 provides a detailed discussion of the sound levels that were measured and can be anticipated during construction activities of this Project.

Sounds generated during monopile and cable removal are expected to be less than those generated during pile driving operations associated with WTG foundation installation because pile driving will not be required during

[74] It is anticipated that, similar to the SMDS permit conditions, if measured levels exceed the 180 dB threshold, an expanded site-specific Safety Zone radius corresponding to the 180 dB threshold will be established and the NMFS approved observer will be advised of the expanded action area.

removal and decommissioning activities (see Section 4.5). Therefore, underwater sound generated during Project decommissioning is not likely to cause substantial impacts other than temporary avoidance behavior in finfish.

- ***Increased Vessel Traffic***

Project construction would result in increased vessel traffic between the WTG array site, the submarine cable system route, and Quonset, RI (where construction laydown is planned to occur). Fish typically show a variety of avoidance behaviors when a noise-emitting vessel is detected. Different types of fish respond in different ways to noise originating from ocean vessels: pelagic species tend to dive deeper in the water column, while demersal species make lateral movements. Most fish species, whether pelagic or demersal, have been observed to increase their swimming speed when vessel noise is detected. The typical distance at which fish react to vessel noise is generally 328-656 feet (100-200 meters), although extremely noisy vessels can elicit responses as far as 1,312 feet (400 meters) away (Mitson, 1995). Finfish in the Project vicinity are likely to display avoidance behaviors to vessels; however, these behaviors would be short-term and would likely be similar to the avoidance behaviors observed during pleasure boat activity, ferry traffic, or fishing activity. Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction.

- ***Habitat Shift From Structure-Oriented To Non-Structure Oriented System After Monopile Removal***

As discussed below under operation/maintenance impacts, the presence of the WTG monopile foundations and ESP piles is not predicted to dramatically impact finfish species composition from pre-Project conditions. During Project operation, both pelagic and more demersal finfish species may concentrate around the WTGs as prey items settle on the monopiles, however, the species composition is not expected to change substantially from pre-Project conditions. Similarly, no cumulative impact to finfish resources is anticipated from removal of the monopiles; however, removal would result in a localized shift from a structure-oriented habitat near the WTGs and ESP to the original shoals-oriented habitat present prior to the Project with a return of pre-construction benthic conditions.

- ***Removal Of WTGs As Fish Aggregating Devices***

As discussed below under operation/maintenance impacts, several finfish species within the Proposed Site may benefit from the presence of the monopiles, which may act as fish aggregating devices and provide additional habitat. These species include Atlantic cod, black sea bass, cunner, tautog, and scup. Removal of the monopiles would eliminate this structure-oriented habitat that these species prefer and may cause these species to disperse elsewhere. If any of these fish species were subject to increased fishing pressure during the life of the Project, removal of the monopiles may allow subsequent dispersal of the aggregated fish, thereby reducing fishing pressure on these species in the Project area.

Operation / Maintenance:

- ***Vibration And Sound From WTGs***

Fish are sensitive to vibration (underwater sound waves). The lateral line, a sensory organ that runs lengthwise along the body of fish, helps the fish to navigate and detect food in the water column. Research conducted at offshore wind farms in Europe suggest that the very low vibration from wind turbines do not impact fishes in the region. Dolphins have been observed congregating to feed around the turbines at Great Britain's first wind farm, Blyth Offshore in Northumberland (AMEC, 2002). Dolphins are recognized as possessing highly sensitive sensory systems and would presumably avoid the area if the vibration proved irritating or hazardous. Additionally, because dolphins were observed engaged in feeding behaviors around these turbines, fish (i.e., prey of the dolphin) were also likely present.

At the Näsrevet Windfarm in Sweden, Westerberg (1999) observed that cod appear to be more numerous in the waters immediately around the wind turbines than in nearby areas. Westerberg postulated that this species may have become habituated to the increase in decibel level during normal operation. This type of habituation has also been observed around oil rig platforms (Vella, 2002). Westerberg (1999) also reported that the normal operational sounds of a wind farm did not greatly impact the migration of eels.

Modeling simulations to evaluate underwater sound during all phases of the Project (Appendix 5.11-A) suggest that impacts to finfish from normal operation of the WTGs would be minimal or non-existent. Background sound

levels are reached within approximately 328 feet (100 meters) of any individual WTG, and levels 66 feet (20 meters) away from the WTG are generally less than 2 dBLs from baseline conditions. Section 5.11 presents a detailed discussion of the potential acoustical impacts of the Project. No sound would be emitted from the inner-array cables or submarine cable system during Project operation. Based on these modeling simulations and observations from offshore wind farms in Europe (Vella, 2002; Westerberg, 1999), it is anticipated that sound emissions from the WTGs for this Project would not substantially affect finfish populations in the area.

- ***Increased Vessel Traffic***

As with construction, increased vessel traffic from operation and maintenance activities in the Project vicinity would likely result in temporary avoidance behavior by finfish. These behaviors, however, would be short-term and would likely be similar to the avoidance behaviors observed during pleasure boat use, ferry traffic, or fishing activity.

- ***Electromagnetic/Thermal Emissions From Submarine Cables***

Potential direct impacts to fish species from electromagnetic/thermal emissions during the normal operation of the inner-array cables and the two submarine cable circuits are expected to be minimal. The cable system (for both the inner-array cables and each of the submarine cable circuits) is a three-core solid dielectric AC cable design, which was specifically chosen for its minimization of environmental impacts and its reduction of any electromagnetic field. The proposed inner-array and submarine cable systems for the Project would contain grounded metallic shielding that effectively blocks any electric field generated by the operating cabling system. Since the electric field would be completely contained within those shields, impacts are limited to those related to the magnetic field emitted from the submarine cable system and inner-array cables. As described in Section 5.13, the magnetic fields associated with the operation of the inner-array cables or the submarine cable system are not anticipated to result in an adverse impact to fish species (ICNIRP 2000; Adair, 1994; Valberg et al., 1997).

Because the inner-array cables and the two submarine cable circuits connecting the WTGs to the landfall would be buried 6 feet (1.8 meters) below the seabed, they would not pose a physical barrier to fish passage. The considerable depth to which the cables would be buried would allow benthic organisms to colonize and demersal fish species to utilize surface sediments without being affected by the cable operation. The burial depth also minimizes potential thermal impacts from operation of the inner-array cables and two submarine cable circuits. In addition, these cable systems utilize solid dielectric AC cable designed for use in the marine environment that does not require pressurized dielectric fluid circulation for insulating or cooling purposes. Finfish would not be directly impacted during the normal operation of the inner-array or submarine cable systems.

- ***Shading***

Because the 130 WTGs would be spaced approximately 0.34 by 0.54 nautical miles (629 by 1,000 meters) apart, the shading from the WTGs on the water would have little direct impact on the finfish community. The ESP would have a surface area of 20,000 square feet (1,858 square meters) that could potentially affect the benthic habitat beneath this location as a result of its shading effect. However, it is expected that the direct impacts of this shading on the benthic habitat would be negligible, given that the ESP would be located approximately 39 feet (12 meters) above the MLLW datum plane in 28 feet (8.5 meters) of water and occupies a very small area of a commonly occurring benthic habitat.

- ***Alterations To Currents, Waves And Circulation***

In general, it is not anticipated that any slight changes to waves, currents, and circulation in the immediate vicinity of each WTG would directly impact finfish populations. As described in Section 5.2 and Appendix 5.2-A, no effects beyond the immediate vicinity of an individual WTG are anticipated from the operating WTG array, since they are spaced approximately 0.34 to 0.54 nautical miles (629 to 1,000 meters) apart.

- ***Habitat Shift From Non-Structure Oriented To Structure-Oriented System***

The presence of 130 WTG monopile foundations and 6 ESP piles in Nantucket Sound has the potential to shift the area immediately surrounding each monopile from a non-structured system to a structure-oriented system, with potential localized changes to benthic and finfish community assemblages. Both pelagic and more demersal finfish species may tend to congregate around the monopiles; however, because the WTGs within the array

would be spaced approximately 0.34 by 0.54 nautical miles (629 by 1,000 meters) apart, the overall environment and finfish species composition in the Project area and Nantucket Sound is not predicted to substantially change from pre-Project conditions.

- ***WTGs Acting As Fish Aggregating Devices***

The WTG monopile foundations and ESP piles may attract finfish and benthic organisms, thereby acting as fish aggregating devices (FADs). Bombace (1997) states that man-made submarine structures can serve to reduce the mortality rate during the critical recruitment phase, increase food availability, and provide shelter for reproductive adults. Bohnsack (1989) states that species most likely to benefit from artificial structures, such as the monopiles, are those with demersal, philopatric, territorial, and reef-obligate life histories. Several finfish species within the Proposed Site and other shoals in Nantucket Sound display these characteristics in some or all of their life history stages, and thus may benefit from the presence of the monopiles. These species include Atlantic cod, black sea bass, cunner, tautog, and scup. However, as stated above, because the WTGs within the Wind Park would be spaced approximately 0.34 by 0.54 nautical miles (629 by 1,000 meters) apart, the overall environment and finfish species composition in the Project area is not predicted to substantially change from pre-Project conditions.

- ***Potential Repairs to Cable Systems or WTGs***

In the event that a WTG or a section of the inner-array or submarine cable systems require repair during operation, methodologies for conducting this repair are expected to be similar to those used during construction or decommissioning. Therefore impacts are expected to be similar to potential construction impacts previously identified; however, impacts would be limited to the immediate vicinity of the WTG or portion of the cable system requiring repair.

5.4.5.1.2 Indirect Impacts

Construction/Decommissioning:

- ***Prey Mortality And/Or Displacement***

Benthic habitat loss would likely cause mortality to the benthic organisms (i.e., prey for finfish) in the footprints of the construction activities, thereby temporarily disrupting finfish feeding in the area. The greatest areal impacts to surficial benthic habitat and therefore to benthic prey species would occur from anchor positioning and anchor line sweep. However, as discussed in more detail in Section 5.3, the total anticipated temporary impact to the upper sediments from anchoring in federal waters would comprise less than 7.4% of the total Project area. Therefore, sufficient food base is expected to be available for foraging fish species. In fact, during actual construction disturbance activities affecting the benthos, injured or displaced benthic invertebrates may provide a short-term opportunity for increased feeding by fish.

In general, the disturbance of the benthic environment from Project construction would be short-term and localized because many benthic invertebrate species are capable of opportunistically recolonizing benthic sediments after disturbance (Hynes, 1970; Rosenberg and Resh, 1993; Rhoads et al., 1978; Howes et al., 1997). In addition, because benthic habitat is similar throughout Nantucket Sound, similar benthic communities (i.e., prey organisms) would be located in many areas and finfish would be able to find suitable prey in areas adjacent to the Project area and other regions of the Sound. As disturbed benthic habitat is recolonized by benthos, as discussed above, finfish would resume foraging in those areas as prey items become more abundant. Therefore, impacts to finfish from mortality or displacement of prey species would be minimal.

During decommissioning activities, benthic communities that have recolonized sediments initially disturbed during Project construction, such as along the inner array cable and two submarine cable circuits and over the filled-in scour control mats, would be disturbed once again. Post-decommissioning recolonization is expected, and in the interim, finfish in the Project area are likely to be able to find similar prey items adjacent to the Project area or in other areas of the Sound.

- ***Prey Displacement From Elevated TSS***

The deposition of sediments suspended during construction or decommissioning activities would be primarily limited to the immediate vicinity of the monopile foundations, scour control mats, and along the inner-array cables and two submarine cable circuits. Existing benthic community structure in Nantucket Sound is influenced

by the area's dynamic sediment transport regime. The seabed in this area is mobile due to strong wind and tidal current conditions. Organisms living on or in these sandy sediments are adapted for mobility in sand and recovery from burial, and are expected to opportunistically recolonize the disturbed sediments from adjacent areas. Sedimentation and elevated TSS concentrations resulting from Project construction or decommissioning is expected to be localized and temporary, and would not likely permanently alter benthic communities in the Project area. Thus, finfish should not be detrimentally affected by the temporary loss of prey items due to sedimentation/elevated TSS concentrations during Project construction or decommissioning. In addition, since benthic habitat is similar throughout Nantucket Sound, finfish are likely to be able to find suitable benthic habitat and prey items adjacent to the Project area or in other areas of the Sound. As disturbed benthic habitat is recolonized by benthos, as discussed above, finfish would resume foraging in those areas as prey items become more abundant.

- ***Bioaccumulation From Consuming Contaminated Prey***

Recent studies indicate that sediments in the Project area are predominantly sand, and that chemical constituent concentrations are below established thresholds in applicable reference sediment guidelines. Specifically, all of the chemical constituents detected in sediment core samples obtained from the proposed WTG site and along the submarine cable route had concentrations below Effects Range-Low (ER-L) and Effects Range-Median (ER-M) marine sediment quality guidelines (Long et al., 1995) (see Section 5.1). Therefore, the temporary and localized disturbance and suspension of these sediments during foundation placement and inner array and submarine cable installation is not likely to result in increased incorporation of contaminants at low trophic levels. Similarly, the temporary and localized disturbance and suspension of these sediments during structure and cable removal is not likely to result in increased incorporation of contaminants at low trophic levels. Finfish are thus unlikely to experience increased bioaccumulation of contaminants via consumption of prey items from the Project area.

Operation/Maintenance:

- ***Prey Displacement Due To Submarine Vibration***

It is unlikely that finfish prey organisms would be displaced due to submarine vibration occurring during operation of the WTGs. The presence of fish near European wind farms suggests that prey items are also available near the wind turbines while they are in operation (see WTGs as fish aggregating devices, below). In addition, vessel traffic and associated vessel noise is not expected to adversely affect prey species of finfish.

5.4.5.1.3 Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to finfish and commercial/recreational fisheries would include other submarine cable or pipeline installations, dredging activities, trawling, installation of pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable has been proposed by National Grid between Cape Cod and Nantucket. Its proposed route would only cross the Project's submarine cable route in the vicinity of Hyannis Harbor, well within the Massachusetts 3-mile limit (as discussed below in Section 5.4.5.2.3). Outside of Massachusetts waters, at its closest point the proposed route of the Nantucket Cable would be approximately 2 miles (3.2 km) from the Wind Park and its inner array cables in Nantucket Sound. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and are of short duration, these temporary impacts are not likely to occur at the same time. Thus, any areas where both projects may result in impacts as a result of jet plow cable embedment would likely have assimilated the deposited sediment from the first project installation by the time the second project is constructed. As such, there are no significant cumulative impacts expected to finfish that would result from the installation of both projects.

The submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance

dredging. Therefore, no significant cumulative effects to finfish are expected in the area of the North Channel crossing.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts expected to finfish since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

5.4.5.1.4 Secondary Impacts

The only potential impact associated with construction staging/laydown activities at Quonset would be potential pier improvements. This would have a potential for limited temporary displacement and habitat disturbance for finfish resources. No pier improvements are known to be required at this time.

5.4.5.2 Potential Impacts Inside of Massachusetts Waters

The only portion of the Project located in Massachusetts waters is the two 115 kV submarine cable circuits. The WTG array is located entirely outside of Massachusetts waters, and those impacts are discussed in Section 5.4.5.1.

5.4.5.2.1 Direct Impacts

Construction/Decommissioning:

- ***Benthic Habitat Loss***

Within Massachusetts waters, the total temporary direct area of benthic habitat (benthic, prey, wetlands, etc) disturbance from installation of the two submarine cable circuits (including anchoring) would comprise approximately 116 acres or 0.75% of the total Project area (see Table 5.3-3). The impact from jet plow embedment of the two submarine cable circuits would be temporary as suspended sediments resettle and refill the cable trenches and areas immediately surrounding the cable trenches (see Section 5.2 and Appendix 5.2-C for more detail). The impacts associated with anchoring and positioning of the cable installation vessel would also be localized and temporary and cable sweep would only affect the sediments to a depth of between 3 and 6 inches (7.6 and 15.2 cm) (Algonquin Gas Transmission Company, 2000). Anchoring locations would have disturbances to several feet deep in a small disturbance area around each anchor. While numerous anchor re-positionings would occur, the cumulative area is still small (see Section 5.3).

Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction. Benthic habitat is similar throughout Nantucket Sound, and thus demersal finfish in the area of Project construction/decommissioning are likely to be able to find suitable benthic habitat adjacent to the submarine cable route or in other areas of the Sound. Pelagic species are likely to be able to occupy the water column in other parts of the Sound. Finfish are expected to rapidly return to these areas once construction or cable removal activities in the specific area is ceased or completed.

Benthic habitat could be directly affected by the HDD borehole end dredging activities within Lewis Bay; however, dredging would be limited to a volume of 840 cubic yards (642.2 cubic meters) and would be contained within the cofferdam. The excavated material would then be disposed of at an approved upland disposal location. The area enclosed by the cofferdam would be approximately 2,925 square feet (272 square meters) (Table 5.3-3), a minimal area compared to surrounding habitat in Lewis Bay. When the temporary cofferdam sheeting is removed, a depression in the sediment surface would likely result that could be several feet deep. This depression would be allowed to naturally fill in over time through natural sediment resuspension, deposition, movement and consolidation. Due to the limited and contained nature of the dredging activities within the cofferdam and the limited area affected by the depression in the sediment surface after cofferdam removal, no substantial impacts to benthic or finfish habitat are expected. These activities would not be required during decommissioning. See Section 4.3.5 for additional detail.

- ***Finfish Mortality And/Or Displacement***

Submarine cable system installation and HDD borehole end construction activities are not expected to result in direct mortality to adult and juvenile pelagic finfish since these life stages are mobile in the water column and are capable of avoiding or moving away from the disturbances associated with construction. Removal of the two submarine cable circuits is expected to result in temporary and localized impacts to finfish similar to or less than those discussed under Project construction. During winter construction periods, demersal finfish may experience minor levels of injury or mortality since avoidance of construction/decommissioning activities may be hampered due to sluggish response under cold water conditions. No measurable effects on populations would be expected. In addition, it is likely that construction/decommissioning activities would not occur between December and April of any given year (some of the colder months) due to unsafe sea conditions; thereby further minimizing impacts during the time of year when these species would be more susceptible to injury or mortality. Displacement of juvenile and adult finfish is likely to be temporary and localized. Demersal eggs and larvae of finfish, however, may experience localized increases in physical abrasion, burial, or mortality during cable installation due to their limited motility. The greatest areal impacts to demersal eggs and larvae would occur from anchor positioning and anchor line sweep during construction. However, the total anticipated temporary impact to the upper sediments from anchoring in Massachusetts waters would comprise approximately 2.2 acres and the impact from anchor line sweep would comprise approximately 94.5 acres, less than 0.65% of the total Project area (Table 5.3-3). Larvae in the latter stages of development are capable of some motility, which may allow for movement from the cable installation area. Pelagic eggs and larvae are not likely to be substantially affected. Predatory fish species, which may feed on the larvae, may be temporarily displaced from the area as a result of disturbance during cable installation or cable removal activities.

- ***Elevated Total Suspended Solids (TSS)***

Submarine cable system installation would result in a temporary and localized increase in suspended sediment concentrations. Impacts from cable removal would be short-term and localized and are expected to be similar to or less than impacts during cable installation. Elevated total suspended solids (TSS) can negatively impact the ability of some finfish to navigate, forage, and find shelter. The jet plow technology that would be used to install the two submarine cable circuits was selected specifically for its ability to minimize sediment disturbance. Due to the predominant presence of fine to coarse-grained sand in Nantucket Sound, localized turbidity associated with cable installation or removal is anticipated to be minimal and confined to the area immediately surrounding each of the submarine cable circuits. Suspended sediments are expected to settle back to the sea floor within a short period of time (one to two tidal cycles) (see Section 5.2 and Appendix 5.2-C for more detail). In addition, the Project area is situated in a dynamic environment that is subject to naturally high suspended sediment concentrations in near-bottom waters as a result of relatively strong tidal currents and wind and storm generated waves, particularly in shoal areas. Therefore, marine organisms in this area are accustomed to substantial amounts of suspended sediment on an irregular basis and should not be substantially impacted by a temporary increase in turbidity from Project activities. No substantial impact to finfish is expected as a result of temporarily elevated TSS levels from cable installation or removal.

Sediment suspension during excavation of the HDD borehole ends in Lewis Bay would be minimal since these activities would be contained within the cofferdam. In addition, the top of the sheet piles for the cofferdam would be cut off approximately two feet (0.61 meters) above mean high water in order to contain turbidity associated with dredging for the HDD borehole end transition (see Section 4.3.5). These activities would not be required during decommissioning.

- ***Acoustical Impacts***

Underwater sound created by installation of the submarine cable system with jet plow technology would primarily result from sound associated with the cable installation vessel(s) and vessel traffic transiting from shore to the WTG site. Underwater sound created by submarine cable system removal would also primarily result from noise associated with vessels and support vessels needed to remove the submarine cable and vessel traffic transiting from shore to the WTG site during decommissioning. The actual jet plow device produces no sound beyond that produced by typical vessel traffic. As discussed below, finfish in the vicinity of the submarine cable system route in Massachusetts waters may display avoidance behavior during submarine cable system installation or vessel transit to and from the WTG site, however, these behaviors would be short-term and would likely be similar to the avoidance behaviors observed during heavy pleasure boat use, ferry traffic, or heavy fishing activity in the area.

No adverse impacts to fish are expected from the HDD methodology used to transition the submarine cable to the onshore cable system in Lewis Bay. Due to the sound-insulating qualities of earthen materials (the sediment), and the fact that the drilling would take place through unconsolidated material, the HDD transition is not anticipated to transmit any vibration from the sediment to the water, i.e. it would not add any sound into the water column. The installation of sheet steel for the cofferdam would utilize a low-noise vibratory method and would not use impact pile driving. Therefore, underwater sound effects from the cofferdam installation would also be minimal and temporary. These activities would not be required during decommissioning.

- ***Increased Vessel Traffic***

Project construction would result in increased vessel traffic between the submarine cable route, and Quonset, RI. Fish typically show a variety of avoidance behaviors when a noise-emitting vessel is detected. Different types of fish respond in different ways to noise originating from ocean vessels: pelagic species tend to dive deeper in the water column while demersal species make lateral movements. Most fish species, whether pelagic or demersal, have been observed to increase their swimming speed when vessel noise is detected. The typical distance at which fish react to vessel noise is generally 328-656 feet (100-200 meters), although extremely noisy vessels can elicit responses as far as 1,312 feet (400 meters) away. (Mitson, 1995). Finfish in the vicinity of the submarine cable system route in Massachusetts waters are likely to display avoidance behavior during submarine cable installation or vessel transit to and from the WTG site; however, these behaviors would be short-term and would likely be similar to the avoidance behaviors observed during heavy pleasure boat use, ferry traffic, or heavy fishing activity in the area. Removal of the two submarine cable circuits is expected to result in temporary and localized impacts to finfish similar to or less than impacts during Project construction.

Operation/Maintenance:

- ***Electromagnetic/Thermal Emissions From Submarine Cable System***

Potential direct impacts to fish species from electromagnetic/thermal emissions during the normal operation of the two submarine cable circuits are expected to be minimal. The cable system (for each of the submarine cable circuits) is a three-core solid dielectric AC cable design, which was specifically chosen for its minimization of environmental impacts and its reduction of any electromagnetic field. The proposed submarine cable system for the Project would contain grounded metallic shielding that effectively blocks any electric field generated by the operating cabling system. Since the electric field would be completely contained within those shields, impacts within Massachusetts waters are limited to those related to the magnetic field emitted from each of the 115 kV submarine cable circuits. As described in Section 5.13, the magnetic fields associated with the operation of the submarine cable system would not result in an adverse impact to fish species.

Since the two submarine cable circuits connecting the WTGs to the landfall would be buried 6 feet (1.8 meters) below the seabed, they would not pose a physical barrier to fish passage. The considerable depth to which the cable circuits would be buried would allow benthic organisms to colonize and demersal fish species to utilize surface sediments without being affected by the cable operation. The burial depth also minimizes the thermal impacts from the two operating submarine cable circuits. In addition, the cable system utilizes solid dielectric AC cable designed for use in the marine environment that does not require pressurized dielectric fluid circulation for insulating or cooling purposes. Neither finfish nor essential fish habitat would be directly impacted during the normal operation of the submarine cable system.

- ***Increased Vessel Traffic***

As with construction, increased vessel traffic from operation and maintenance activities in Massachusetts waters would likely result in temporary avoidance behavior by finfish. These behaviors, however, would be short-term and would likely be similar to the avoidance behaviors observed during pleasure boat use, ferry traffic, or fishing activity.

5.4.5.2.2 Indirect Impacts

Construction/Decommissioning:

- ***Prey Mortality and/or Displacement***

As previously discussed, within Massachusetts waters, the total temporary direct area of benthic habitat disturbance from installation of the two submarine cable circuits (including anchoring) would comprise

approximately 116 acres or 0.75% of the total Project area (see Table 5.3-3). This temporary displacement of benthic habitat would result in the mortality and/or dispersal of some benthic organisms that are prey items for demersal finfish. The greatest areal impacts to surficial benthic habitat and therefore to benthic prey species would occur from anchor positioning and anchor line sweep. However, as discussed in more detail in Section 5.3, the total anticipated temporary impact to the upper sediments from anchoring in Massachusetts waters would comprise less than 0.65% of the total Project area. Therefore, sufficient food base is expected to be available for foraging fish species.

Benthic habitat could be directly affected by the HDD borehole end dredging activities within Lewis Bay; however, dredging would be limited to a volume of 840 cubic yards (642.2 cubic meters) and would be contained within the cofferdam. The excavated material would then be disposed of at an approved upland disposal location. The area enclosed by the cofferdam would be approximately 2,925 square feet (272 square meters), a minimal area compared to surrounding habitat in Lewis Bay. When the temporary cofferdam sheeting is removed, a depression in the sediment surface would likely result that could be several feet deep. This depression would be allowed to naturally fill in over time through natural sediment resuspension, deposition, movement and consolidation. Due to the limited and contained nature of the dredging activities within the cofferdam and the limited area affected by the depression in the sediment surface after cofferdam removal, no substantial impacts to benthic habitat are expected. See Section 4.3.5 for additional detail.

In general, benthic invertebrates such as amphipods, polychaetes, and oligochaetes are expected to opportunistically recolonize the disturbed benthic sediments from areas adjacent to the submarine cable system route and within the HDD borehole end excavation in Lewis Bay. In the interim, since benthic habitat is similar throughout Nantucket Sound, finfish in the Project area are likely to find similar prey items in areas adjacent to the submarine cable route or in other areas of the Sound. As disturbed benthic habitat is recolonized by benthos, as discussed above, finfish would resume foraging in those areas as prey items become more abundant.

During the submarine cable system removal, benthic communities that have recolonized sediments initially disturbed along the submarine cable system route would be disturbed once again. However, once the cable system has been removed, recolonization of these sediments is expected. In the interim, finfish in the Project area are likely to find similar prey items in areas adjacent to the submarine cable route or in other areas of the Sound.

- ***Prey Displacement From Elevated TSS***

The deposition of sediments suspended during cable embedment or cable removal in Massachusetts waters would be primarily limited to the immediate vicinity of the submarine cable route. Sediment suspension during excavation of the HDD borehole ends in Lewis Bay would be minimal since these activities would be contained within the cofferdam. In addition, the top of the sheet piles for the cofferdam would be cut off approximately two feet (0.61 meters) above mean high water in order to contain turbidity associated with dredging for the HDD borehole end transition (see Section 4.3.5).

Organisms living on or in these sediments are adapted for mobility and recovery from burial, and are expected to opportunistically recolonize the disturbed sediments from adjacent areas. Sedimentation and elevated TSS concentrations resulting from cable installation or removal is expected to be localized and temporary, and would not likely permanently alter benthic communities in the Project area. Thus, finfish should not be detrimentally affected by the temporary loss of prey items due to sedimentation/elevated TSS levels during cable installation or removal. In addition, since benthic habitat is similar throughout Nantucket Sound, finfish are likely to be able to find suitable benthic habitat and prey items adjacent to the submarine cable route or in other areas of the Sound. As disturbed benthic habitat is recolonized by benthos, as discussed above, finfish would resume foraging in those areas as prey items become more abundant.

- ***Bioaccumulation From Consuming Contaminated Prey***

Recent studies indicate that sediments along the submarine cable route are predominantly sand, and that chemical constituent concentrations are below established thresholds in applicable reference sediment guidelines. Specifically, all of the chemical constituents detected in sediment core samples obtained along the proposed submarine cable route had concentrations below ER-L and ER-M marine sediment quality guidelines (Long et al., 1995) (see Section 5.1). Therefore, the temporary and localized disturbance and suspension of these sediments

during cable installation is not likely to result in increased incorporation of contaminants at low trophic levels. Similarly, the temporary and localized disturbance and suspension of these sediments during submarine cable system removal is not likely to result in increased incorporation of contaminants at low trophic levels. Finfish are thus unlikely to experience increased bioaccumulation of contaminants via consumption of prey items from the Project vicinity.

- ***Bentonite Breakout Prevention and Minimization***

The HDD operation within Lewis Bay would be designed to include a drilling fluid fracture or overburden breakout monitoring program to minimize the potential of drilling fluid breakout into waters of Lewis Bay. Although it is anticipated that drilling depths in the overburden would be sufficiently deep to avoid pressure-induced breakout of drilling fluids through the seafloor bottom, a bentonite monitoring program would be implemented for the detection of possible fluid loss (see Section 4.3.5). In the unlikely event of drilling fluid release, the bentonite fluid density and composition would cause it to remain as a cohesive mass on the seafloor in a localized slurry pile similar to the consistency of gelatin. This cohesive mass can be quickly cleaned up and removed by divers and appropriate diver-operated vacuum equipment; thereby minimizing any long-term impacts to finfish or finfish habitat. These activities are not required during decommissioning. Please refer to Section 4.3.5 for additional detail.

Operation/Maintenance:

No indirect impacts to finfish resources are expected from the normal operation and maintenance of the submarine cable system within Massachusetts waters. Specifically the magnetic fields associated with the operation of the two submarine cable circuits would not result in an adverse impact to prey of finfish (see Section 5.13). The considerable depth to which the two submarine cable circuits would be buried would allow benthic organisms to colonize surface sediments without being affected by the cable operation. In addition, vessel traffic is not expected to adversely affect prey species of finfish. Should repairs be required due to accidental damage or malfunction of the cable, localized effects similar to those discussed for construction/decommissioning would occur in the vicinity of the repair area.

5.4.5.2.3 Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to finfish and commercial/recreation fisheries would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent, cumulative sediment suspension and deposition. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on recent experience it could be needed in the next 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. Future USACE maintenance dredging in Hyannis Harbor would be the subject of an additional NEPA document. In any event, as discussed in Appendix 5.2-C, sediment deposition resulting from the cable installation would be minimal and localized, and would not substantially contribute to any cumulative impact. Since potential dredging will not likely occur simultaneously to the submarine cable installation, no other significant cumulative impacts to finfish (i.e. noise, habitat disturbance) are expected.

A new submarine transmission cable has been proposed by National Grid between Cape Cod and Nantucket. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. At this crossing, and in its near vicinity, the impacts of each project would be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and are of short duration, these temporary impacts are not likely to occur at the same time. Thus, the area would not likely have increased water column sediment loadings from the first

project installation at the time the second project is constructed and no significant cumulative impacts to finfish are anticipated.

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the Project area. However, these marina dredging projects, if they were to occur, are very localized and not likely to result in sediment suspension and deposition that would be coincident with the Project's cable installation (the closest point of which would be a minimum of .5 miles (805 meters) from the closest marina), nor would the impacts to finfish from these activities be substantial. Thus no significant cumulative impacts are anticipated from such activities

5.4.5.3 Potential Impacts to Commercial and Recreational Fishing Activities and Interaction with Commercial Fishing Gear

Potential concerns related to the commercial fishing industry as identified by agencies, special interests, and the public included potential gear conflicts with the proposed WTGs or cable systems, restrictions on fishing activity, and construction impacts. These concerns were taken into consideration by the Applicant in the planning and design of the Project. The Project is not anticipated to have substantial impacts to commercial fishing activities, since there would be no restriction on fishing activities within the Wind Park during Project operation, and the inner-array cables and two submarine cable circuits would be buried to a minimum of 6 feet (1.8 meters) below the seabed to avoid the potential for conflicts with fishing vessels and gear operation. Commercial fishing activities may be affected to the extent that the WTGs represent structures during the navigation of vessels with mobile fishing gear or the placement of trap or pot lines. However, this effect should be minimal since the WTGs would be spaced 0.34 by 0.54 nautical miles (629 by 1,000 meters) apart, requiring only slight course corrections to avoid them.

The proposed Project should not adversely affect recreational fishing in Nantucket Sound. The majority of recreational anglers surveyed in the MRFSS program from the three counties surrounding Nantucket Sound reported hook and line as gear type used and most recreational anglers reported fishing from a private/personal or rented boat as the type or mode of recreational fishing. Since the WTGs within the array would be spaced 0.34 by 0.54 nautical miles (629 by 1,000 meters) apart, the physical presence of these structures should not interfere with recreational fishing activity, including maneuvering of recreational vessels (see Section 5.12 for more detail) or using recreational fishing gear. The presence of the WTG monopile foundations may enhance recreational fishing for certain species such as Atlantic cod, black sea bass, cunner, tautog, and scup (see "WTGs acting as fish aggregating devices" in Section 5.4.5.1.1). The Project should not affect other modes of recreational fishing such as fishing from shore since the shoreline will be drilled under and shoreline areas will remain undisturbed.

As discussed in Appendix 5.4-B, a telephone intercept survey was conducted from September through November 2002 to better estimate the party boat and charter boat industry in Nantucket Sound. The results of this survey indicated that charter vessel companies do not frequently visit Horseshoe Shoal with their passengers, when compared with the frequency of visits to the other sites. Bluefish was the species cited as the most frequently caught species at Horseshoe Shoal. Although it appears that charter/party boat companies do not frequently visit Horseshoe Shoal, the construction and operation of the Project should not interfere with any recreational fishing conducted from charter or party boats in the Project area, and once constructed, may, in fact, enhance recreational fishing for certain species discussed above.

Additional information on potential Project impacts to navigation and vessel operation, including commercial and recreational fishing vessels is provided in Section 5.12. A discussion of the potential socioeconomic impacts to the commercial and recreational fishing industry is provided in Section 5.16.

5.4.6 Mitigation

Impacts to finfish resources, finfish habitat, and commercial and recreational fisheries are anticipated to be temporary and/or localized in nature. A summary of how the Project has been designed to avoid, minimize or mitigate impacts to finfish resources, finfish habitat, and commercial and recreational fisheries is provided below.

Finfish Resources and Habitat

While limited localized impacts are anticipated during Project construction and operation, measures would be implemented to prevent and minimize these impacts. These measures include using state-of-the-art hydraulic jet plow for cable installation (see Section 4.0), monopile foundations for WTG towers, and post-construction monitoring to document habitat disturbance and recovery (see Section 6.0).

The monopile-type foundation system represents the foundation system type that would result in the least amount of seabed disturbance (see Sections 3.0 and 4.0). Minimal disturbance of sediment would take place by WTG installation activities. This installation method would result in only temporary impacts to finfish and finfish habitat in the immediate vicinity of the construction activities. During installation of the monopiles, impacts from pile driving equipment would be minimized by using a "soft start" of the pile driving equipment to allow fish to move away from the area in response to construction sound.

The Project also minimizes impacts by using jet plow embedment methods for installing the inner-array and submarine cable systems. The jet plow method is considered to be the most effective and least environmentally damaging alternative when compared to traditional mechanical dredging and trenching operations. This method of laying and burying the cables simultaneously ensures the placement of the submarine cables at the target burial depth with minimum bottom disturbance and the majority of fluidized sediment settling back into the trench. Jet plow embedment is also the installation methodology that appears to be preferred by state and federal regulatory agencies based on review of past precedent setting projects. Installation of the submarine cables by jet plow embedment minimizes sediment disturbance and suspension and results in only temporary impacts to finfish resources and habitat in and immediately adjacent to the cable installation areas. Impacts to finfish and finfish habitat in Lewis Bay within 200 feet (61 meters) of shore would be minimized by using HDD methodology to transition the submarine cable system to the mainland. HDD techniques also appear to be favored by state and federal regulatory agencies based on favorable comments and past approvals of projects.

Commercial/Recreational Fisheries

Potential concerns related to the commercial fishing industry as identified by agencies, special interests, and the public – including potential gear conflicts with the proposed WTGs or cable systems, restrictions on fishing activity, and construction impacts – have been taken into consideration in the development of the Project. Measures proposed to minimize or avoid potential fisheries impacts are reflected in the proposed Project design, construction and operation. Some examples of mitigation proposed to avoid or minimize impacts to the commercial fishing industry include: no restrictions on fishing activities within the Wind Park during Project operation; the WTGs would be marked with USCG-approved lighting to ensure safe vessel operation; and the inner-array cables and two submarine cable circuits would be buried to a minimum of 6 feet (1.8 meters) below the seabed to avoid the potential for conflicts with fishing vessels and gear operation. The Applicant plans to work cooperatively with commercial/recreational fishing agencies and interests to ensure that the construction and operation of the Project would minimize potential impacts to commercial and recreational fishing interests. Potential conflict with commercial fishing activity and gear would be minimized by notifying registered fishermen of the location and timeframe of Project construction activities well in advance of mobilization with updates throughout the construction period including a daily broadcast on marine channel 16 as to the construction activities for that and upcoming days.

Additional information on impact avoidance, minimization, and mitigation related to commercial and recreational fishing vessel navigation/operation and socioeconomics of the commercial and recreational fishing industries is provided in Sections 5.12 and 5.16, respectively.

5.5 Protected Marine Species

5.5.1 Introduction

This section describes existing protected marine resources and potential impacts to protected marine species and habitat in the Project area. Species covered in this section include those marine animals that are protected under Federal and Massachusetts Endangered Species Acts and the Marine Mammal Protection Act. Regulatory authorities and consistency are discussed in Section 7.0. The information contained in this section was obtained from literature review, agency consultations, site investigations, and review of existing site investigation data.

Section 5.5.2 describes studies completed for the assessment of protected marine species. Existing conditions within the Project area are discussed in Section 5.5.3, including a discussion of marine mammals while a biological assessment is provided in Section 5.5.4 and Appendix 5.5-A.

The USACE, as the lead federal permitting agency for the Project, is mandated by Section 7 of the ESA to consult with the Department of Commerce (typically via NMFS) and the Secretary of Interior (typically via USFWS) if any federally protected species may be affected by the project. This consultation includes preparation of a Biological Assessment to determine if the proposed action is likely to result in adverse effects to threatened or endangered marine species. Accordingly, the USACE has initiated consultations with NMFS and USFWS to ensure that the Project does not "...jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of the critical habitat of such species" (50 CFR Part 402). A summary of the contents of the Biological Assessment is included in Section 5.5.4, with the full Biological Assessment included as Appendix 5.5-A.

All marine mammals are protected under the Marine Mammal Protection Act (MMPA) (16 U.S.C. §§ 1361 *et seq.*). The MMPA established a moratorium, with certain exceptions, on the taking of marine mammals in U.S. waters and by U.S. citizens on the high seas,[75] and on the importing of marine mammals and marine mammal products into the United States. Part of the responsibility that NMFS has, under the MMPA, involves monitoring populations of marine mammals to make sure that they stay at optimum levels. If a population falls below its optimum level, it is designated as "depleted," and a conservation plan is developed to guide research and management actions to restore the population to healthy levels. The MMPA allows the incidental, but not intentional, "taking" by U.S. citizens engaged in activities other than commercial fishing of small numbers of marine mammals if, after notice and opportunity for public comment, NMFS determines that appropriate regulations have been met. The 1994 amendments to the MMPA provide that this regulation requirement may be waived if the proposed activity results in only harassment, and no serious injury or mortality is anticipated.

State-listed rare species are protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 1331A) and its implementing regulations (321 CMR 10.00) and the Massachusetts Wetlands Protection Act (WPA) (M.G.L. c. 131, s.40) and its implementing regulations (310 CMR 10.00). MESA prohibits the "taking" of rare plant and wildlife species. A description of the state-protected species that may occur in Nantucket Sound is summarized in Section 5.5.3.2 and described in detail in Appendix 5.5-B. The gray seal (listed as a Species of Special Concern by the Commonwealth of Massachusetts) is addressed in this section, and discussed in more detail in Section 5.5.5 and Appendix 5.5-B. Other marine mammals protected under the MMPA that could occur in Nantucket Sound are discussed in Section 5.5.3.3. Additional detail on the harbor seal is provided in Appendix 5.5-B.

A description of the potential direct, indirect, and cumulative impacts of the WTG array and associated submarine cables during Project construction/decommissioning and operation/maintenance is provided in Section 5.5.6. Potential impacts associated with the Project relating to marine protected resources and habitat in federal waters (outside the 3 nautical mile (5.6 km) limit) are discussed separately from those in State waters (within the 3 nautical mile (5.6 km) limit). Specific potential impacts addressed include: potential impacts of underwater sound and vibration on protected marine species; tolerance or thresholds of protected species to sound and vibration; potential biological or ecological effects from a change in the acoustical environment; and potential effects to marine mammals of exposure to 60 Hz EMF greater than 85mG. The complete analysis of noise and EMF related studies and potential impacts are provided in Section 5.11 and 5.13, respectively. An analysis of potential Project impacts to marine habitat related to alterations of currents and circulation, sediment transport, wave disturbance, water quality, scouring, and shoreline erosion (landfall) is provided in Section 5.2. Section 5.5.7 discusses Project mitigation measures.

5.5.2 Studies Completed

Review of scientific literature, including stock assessment reports, and consultation with resource management agencies, suggest that few studies of protected whale and turtle species have been conducted within Nantucket

[75] The term "high seas" is defined under the U.N. Convention on the Law of the Sea to mean "...all parts of the sea that are not included in the exclusive economic zone, in the territorial sea or in the internal waters of a State, or in the archipelagic waters of an archipelagic State."

Sound. A comprehensive literature search targeting protected whale, seal, and reptile species in Nantucket Sound and acoustical impacts to marine mammals and reptiles was conducted to obtain information on protected marine species in Nantucket Sound and potential impacts of the proposed Project to these resources. In addition, researchers from the Protected Resources Branch at the NMFS Northeast Fisheries Science Center, the Sea Turtle Stranding and Salvage Network, the Center for Coastal Studies, and the University of Rhode Island, were contacted to obtain additional stock assessment, sighting, stranding, and population studies information.

USACE is consulting with NMFS pursuant to Section 7 of the ESA to determine whether the Project may adversely affect listed species (see Appendix 5.5-A). Please refer to Section 7.0 for information on the ESA consultation process.

5.5.3 Existing Conditions

5.5.3.1 Federally-Listed Species Protected under the ESA

The following three federally endangered species of cetaceans may occur in the Nantucket Sound area and could potentially be impacted by the Proposed Project: humpback whales (*Megaptera novaeangliae*), fin whales (*Balaenoptera physalus*), and North Atlantic Right Whales (*Eubalaena glacialis*) (Kurkul, 2002). Most whales are found in areas where their primary food source can be easily located. The primary feeding grounds for many whales are located further offshore from Nantucket Sound at Stellwagen Bank, in Cape Cod Bay, and in the Gulf of Maine. The bathymetric and oceanographic features that favor dense aggregations of whale prey species are not developed in Nantucket Sound to the same extent that they are farther north, around Stellwagen Bank, Jeffreys Ledge, Browns and Bacaro Banks, and in the Great South Channel (Kenney and Winn, 1986). Historically and at present, Nantucket Sound does not appear to be an important area for these species of whales (see Appendix 5.5-A).

Additionally, the following three federally endangered or threatened species of marine reptiles are known to occur in Nantucket Sound: loggerhead turtles (*Caretta caretta*), Kemp's ridley turtles (*Lepidochelys kempii*), and leatherback turtles (*Dermochelys coriacea*) (Kurkul, 2002). Loggerhead turtles and leatherback turtles can be expected to be present in Nantucket Sound when water temperatures are favorable, from early summer through late fall. Leatherbacks are more commonly reported in Massachusetts waters than other sea turtle species, and densities are likely associated with inshore concentrations of jellyfish. Kemp's ridley turtles occasionally visit Massachusetts waters, and are known to be stunned by cold water in Cape Cod Bay during fall and winter months. Because Kemp's ridley turtles have been observed feeding in shallow waters of Vineyard Sound and Buzzards Bay in summer months, they may also be present in Nantucket Sound during the summer and fall. Additional detail on these federally protected species that may occur in Nantucket Sound can be found in the Biological Assessment included as Appendix 5.5-A.

5.5.3.2 State Protected Species

There are no state listed threatened and/or endangered species located in the Project area. However, the gray seals (*Halichoerus grypus*) are common in the waters of Nantucket Sound. The gray seal is listed as a Massachusetts Species of Special Concern. Gray seals have known year-round breeding and pupping grounds in Nantucket Sound at Monomoy and Muskeget Islands (approximately 10.5 nautical miles (19.4 km) and 7.0 nautical miles (13 km), respectively, from the Wind Park site). Though Monomoy and Muskeget islands have been identified as habitat for year-round breeding populations (Waring et al., 2001), winter and spring use of these areas is highest (NHESP, 2002). Since there is no defined migratory behavior for gray seals, a large portion of the population may be present in Nantucket Sound year-round, although the actual numbers are not as plentiful as harbor seals. Generally, there is some adult seal movement north during spring and summer out of Nantucket Sound to the waters of Maine and Canada for pupping, as seen with harbor seals (Waring et al., 2001). During summer and winter avian surveys conducted by Cape Wind, several hundred gray seals were observed on sandbars in the Muskeget Island area. Detailed information on the gray seal can be found in Appendix 5.5-B.

5.5.3.3 Marine Mammals

In addition to ESA/MESA-listed marine mammals, several other species of marine mammals may occur in the waters of Nantucket Sound that are protected under the MMPA. These species include the harbor seal, harp seal, hooded seal, white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale.

Harbor Seal

Harbor seals (*Phoca vitulina concolor*) pup in New Hampshire, Maine, and Canadian waters in the spring and summer, but many juveniles overwinter in Nantucket Sound, and adults may be found in the Sound year round. Tuckernuck and Muskeget Islands (approximately 8.5 nautical miles (15.7 km) and 7.0 nautical miles (13 km), respectively, from the Wind Park site) are important haul-out sites for harbor seals. These islands in Nantucket Sound serve as important overwintering habitat for this species.

Despite its abundance throughout New England, little is known about natural mortality in this species (Katona *et al.* 1993). Major causes of human-induced harbor seal mortality include marine pollution and habitat destruction, but mortality mainly stems from drowning in active or abandoned fishing nets. In recent years, harbor seal mortality has been related to the Northeast multispecies sink gillnet fishery, which covers the Gulf of Maine and southern New England, and the Mid-Atlantic coastal gillnet fishery. The total estimated average fishery-related mortality or serious injury in the Northeast multispecies sink gillnet fishery for the period of 1995 to 1999 was 893 harbor seals. The estimated annual mortality attributed to the mid-Atlantic coastal gillnet fishery for the period of 1995 to 1999 is two harbor seals (Waring *et al.* 2001). Harbor seal strandings occur in southern New England during the winter period, and have been attributed to vessel strikes, fishing gear entanglement, entrainment in power plant intakes, oils spills, storms, abandonment, and disease (Waring *et al.* 2001). The harbor seal is not listed as threatened or endangered under the ESA, and is not considered a strategic stock[76] under the MMPA. Detailed information on harbor seals can be found in Appendix 5.5-B.

Harp Seal

The harp seal (*Phoca groenlandica*) occurs throughout much of the north Atlantic and Arctic Oceans, and in recent years, has been sighted in winter and spring months at the extreme southernmost reaches of its range from mid-Atlantic waters through New England (Waring et al., 2001). The largest of three stocks of harp seals is the eastern Canadian stock, with breeding herds off the coasts of Newfoundland and Labrador, and in the Gulf of St. Lawrence. The other two stocks occur off the coasts of the former Soviet Union and Greenland. Abundance of harp seals in Canadian waters is estimated at 5.2 million (Waring et al., 2001). Existing data are insufficient to estimate harp seal abundance in U.S. waters (Waring et al., 2001). Given their distribution range, it is possible that harp seals have the potential to occur in Nantucket Sound. Annual harp seal strandings are increasing and 51 of 224 reported strandings occurred in Massachusetts in 1997 and 1998 (Waring et al., 2001). The harp seal is not listed as threatened or endangered under the ESA, and it is not considered a strategic stock under the MMPA.

Hooded Seal

The hooded seal (*Cystophora cristata*) occurs throughout much of the north Atlantic and Arctic Oceans, in deeper water than harp seals are typically found. Hooded seals are highly migratory, and have been sighted as far south as Puerto Rico. In recent years, they have been sighted with increasing frequency in waters from Maine to Florida, in the winter and spring months (Waring et al., 2001). The three stocks of hooded seals in the world are identified by their breeding locations. Two stocks occur in the northwest Atlantic. One stock has breeding grounds in the Davis Strait off of Newfoundland. A second eastern Canadian stock has breeding herds off the coasts of Newfoundland and in the Gulf of St. Lawrence. The third hooded seal stock occurs off of eastern Greenland. Abundance of hooded seals in Canadian waters is estimated at 400,000. Existing data are insufficient

[76] Under the MMPA, the term "strategic stock" means a marine mammal stock - (A) for which the level of direct human-caused mortality exceeds the potential biological removal level; (B) which, based on the best available scientific information, is declining and is likely to be listed as a threatened species under the Endangered Species Act of 1973 within the foreseeable future; or (C) which is listed as a threatened species or endangered species under the Endangered Species Act of 1973 (16 U.S.C. 1531 et seq.), or is designated as depleted under this Act.

to estimate hooded seal numbers in U.S. waters (Waring et al., 2001). Given their distribution range, it is possible that hooded seals have the potential to occur in Nantucket Sound.

The total annual estimated fishery-related mortality or serious injury to this stock in U.S. waters for the period of 1993 to 1997 is 6 hooded seals (Waring et al., 2001). Incidental bycatch of hooded seals has been observed in the Northeast multispecies sink gillnet fishery (Waring et al., 2001). Commercial harvest of hooded seals is not allowed in the Gulf of St. Lawrence (below 50°N) and in the Davis Strait (Waring et al., 2001). Approximately 50 hooded seals have stranded each year during the period of 1994 to 1997 (Waring et al., 2001). Some of these strandings occurred in Massachusetts. The hooded seal is not listed as threatened or endangered under the ESA, and it is not considered a strategic stock under the MMPA.

White-sided Dolphin

The white-sided dolphin (*Lagenorhynchus acutus*) occurs in temperate and polar waters in the North Atlantic, typically over the continental shelf to the 100-meter (328-foot) isobath. In the western North Atlantic, white-sided dolphins are believed to form three stocks, the Gulf of Maine stock, the Gulf of St. Lawrence stock, and the Labrador Sea stock. The Gulf of Maine stock ranges from Hudson Canyon to Georges Bank, and in the Gulf of Maine to the Bay of Fundy (Waring et al., 2001). The best available estimate for the abundance of the Gulf of Maine stock of white-sided dolphins is 51,640, with a minimum population estimate of 37,904 (Waring et al., 2001). Given their distribution range, it is possible that white-sided dolphins have the potential to occur in Nantucket Sound.

The total annual fisheries-related mortality estimate for the period of 1995 to 1999 is 136 white-sided dolphins (Waring et al., 2001). Incidental bycatch has been observed in the Northeast sink gillnet fishery, the mid-Atlantic coastal gillnet fishery, the pelagic drift gillnet fishery, the North Atlantic bottom trawl fishery, and the Atlantic squid, mackerel, and butterfish trawl fisheries (Waring et al., 2001). Mass strandings of white-sided dolphins are common. A stranding event may involve over 100 animals, and several have occurred in Massachusetts waters (Waring et al., 2001). Causes of these strandings are not known. One mass stranding of 70 animals was reported near Wellfleet, Massachusetts between January 29 and February 3, 1998 (Waring et al., 2001). The white-sided dolphin is not listed as threatened or endangered under the ESA, and it is not considered a strategic stock under the MMPA.

Striped Dolphin

The striped dolphin (*Stenella coeruleoalba*) is distributed worldwide in temperate, tropical, and subtropical seas. In the western North Atlantic, striped dolphins occur from Nova Scotia south into the Caribbean and the Gulf of Mexico, frequently in continental shelf waters along the 1,000-meter (3,281-foot) isobath (Waring et al., 2001). The best available estimate for the abundance of the western Atlantic striped dolphin is 61,546, with a minimum population estimate of 44,500 (Waring et al., 2001). Given their distribution range, it is possible that striped dolphins have the potential to occur in Nantucket Sound.

The total annual fisheries-related mortality estimate for the period of 1994 to 1998 is 7 striped dolphins (Waring et al., 2001). Incidental bycatch has been observed in the pelagic drift gillnet fishery and the North Atlantic bottom trawl fishery (Waring et al., 2001). During the period of 1995 to 1998, seven striped dolphins stranded in U.S. waters from Massachusetts to Florida. The striped dolphin is not listed as threatened or endangered under the ESA, and it is not considered a strategic stock under the MMPA.

Common Dolphin

The common dolphin (*Delphinus delphis*) is distributed worldwide in temperate, tropical, and subtropical seas. In waters off the northeastern United States, common dolphins are associated with Gulf Stream features and are widespread from Cape Hatteras to Georges Bank over the 656- to 984-foot (200- to 300-meter) isobaths or prominent underwater topographic features (Waring et al., 2001). The common dolphin migrates onto Georges Bank, the Scotian Shelf, and the continental shelf off Newfoundland in summer and autumn months. The best estimate for the abundance of the common dolphin off the U.S. and Canadian Atlantic coasts is 30,768, with a minimum population estimate of 23,655 (Waring et al., 2001). Given their distribution range, it is possible that common dolphins have the potential to occur in Nantucket Sound.

The total annual fisheries-related mortality estimate for the period of 1995 to 1999 is 406 common dolphins (Waring et al., 2001). Incidental bycatch has been observed in the pelagic drift gillnet fishery, the pelagic pair trawl, the pelagic longline fishery, the mid-Atlantic coastal gillnet fishery, the North Atlantic bottom trawl fishery, the Northeast multi-species sink gillnet fishery, and the Atlantic squid, mackerel, and butterfish trawl fisheries (Waring et al., 2001). During the period of 1992 to 1998, 94 common dolphin strandings were reported in U.S. waters from Massachusetts to North Carolina. Two mass strandings on Cape Cod in 1997 and 1998 involved ten and nine dolphins, respectively. The common dolphin is not listed as threatened or endangered under the ESA, but is considered a strategic stock under the MMPA.

Harbor Porpoise

The harbor porpoise (*Phocoena phocoena*) is primarily an inshore species. During the summer, harbor porpoises are concentrated in the northern Gulf of Maine and the southern Bay of Fundy region, generally in waters less than 492 feet (150 m) deep. This stock of harbor porpoises, which migrates south into the mid-Atlantic region, is considered one population, separate from three other distinct populations in the Gulf of St. Lawrence, Newfoundland, and Greenland areas (Waring et al., 2001). During fall and spring months, harbor porpoises are widely distributed from New Jersey to Maine. Low densities of harbor porpoises are found in waters off New York and north to Canada in the winter. No specific migratory routes to the Gulf of Maine/Bay of Fundy region have been identified. The best estimate for the abundance of the Gulf of Maine/Bay of Fundy population is 89,700, with a minimum population estimate of 74,695 (Waring et al., 2001). Given their distribution range, it is possible that harbor porpoises have the potential to occur in Nantucket Sound.

The average annual mortality estimate of harbor porpoises for the year 1999 attributable to U.S. fisheries was 381 porpoises, down significantly from previous years following the implementation of a take reduction plan for the U.S. Atlantic gillnet fishery (Waring et al., 2001). Recent mortality has occurred in the U.S. Northeast sink gillnet fishery, the mid-Atlantic coastal gillnet fishery, and in the Canadian Bay of Fundy groundfish sink gillnet and herring weir fisheries. Other human-induced mortality may occur from hunting in some areas of the western North Atlantic. During the period of 1994 to 1999, 691 harbor porpoise strandings were reported from Maine to North Carolina. Many of these strandings occurred in Massachusetts. NMFS considers the Gulf of Maine/Bay of Fundy harbor porpoise stock as a strategic stock, though the stock has been removed from the ESA candidate species list by the NMFS (Waring et al., 2001).

Long-finned Pilot Whale

The long-finned pilot whale (*Globicephala melas*) occurs along the edge of the U.S. continental shelf in the winter and early spring. A second species of pilot whale, the short-finned pilot whale, also occurs in the western North Atlantic. Difficulty distinguishing the two species in the field prevents separate abundance and mortality estimates. The long-finned pilot whale primarily occurs north of mid-Atlantic waters. Distribution of this species is widespread, ranging from North Carolina to Africa and north to Iceland, Greenland, and the Barents Sea (Waring et al., 2001). Further stock definition is under development. The best available estimate for the abundance of both pilot whale species in U.S. waters is 14,524, with a minimum estimate of 11,343 (Waring et al., 2001). Given their distribution range, it is possible that pilot whales have the potential to occur in Nantucket Sound.

The total annual fisheries-related mortality estimate for the period of 1995 to 1999 is 245 pilot whales, including both species (Waring et al., 2001). Incidental bycatch has recently been observed in the pelagic drift gillnet fishery, the pelagic longline fishery, the pelagic pair trawl fishery, the North Atlantic bottom trawl fishery, the squid, mackerel, and butterfish trawl fisheries, and the Nova Scotia trawl fisheries. Mass strandings are common in pilot whales. During the period of 1992 to 1998, 71 long-finned pilot whales stranded between Maine and South Carolina, including a mass stranding involving 22 animals in Massachusetts waters in 1992. Causes of these strandings are not known. The long-finned pilot whale is not listed as threatened or endangered under the ESA, but is considered a strategic stock under the MMPA.

Minke Whale

Minke whales (*Balaenoptera acutorostrata*) occur throughout polar, temperate, and tropical waters. The minke whale is the third most abundant great whale in the U.S. Atlantic Exclusive Economic Zone (EEZ) (CeTAP, 1982). Minke whales off the east coast of the U.S. are part of the Canadian east coast population, one of four minke populations recognized in the North Atlantic. The range of this population extends south from Canada to the Gulf

of Mexico, but distribution is primarily concentrated in New England waters, with most sightings occurring during spring and summer months. The best available current abundance estimate for minke whales in the western North Atlantic is 4,018, from surveys conducted in 1995 and 1999, with a minimum estimate of 3,515 whales (Waring et al., 2001). This species is found in open seas primarily over continental shelf waters, but occasionally enters bays, inlets, and estuaries. Given their distribution range, it is possible that minke whales have the potential to occur in Nantucket Sound.

Minke whale incidental catches have been observed in U.S. waters in the mid-Atlantic coastal gillnet fishery, the Gulf of Maine and mid-Atlantic lobster trap/pot fishery, and the Atlantic tuna purse seine fishery. Not all incidental catches have resulted in mortality. The annual mortality estimate from these fisheries for the period of 1995 to 1998 is 2.4 minke whales (Waring et al., 2001). Other human-induced mortality occurs from hunting in some areas of the North Atlantic, and from collisions with vessels. Minke whales inhabit coastal waters during much of the year and thus are frequently in the vicinity of a variety of vessel traffic. The minke whale is not listed as threatened or endangered under the ESA nor is it designated as a strategic stock under the MMPA.

5.5.4 Biological Assessment (BA)

A BA under the Federal ESA was conducted to determine if the proposed action is likely to result in adverse effects to threatened or endangered marine species (Appendix 5.5-A). The NMFS has notified the Applicant that the following federally endangered or threatened species may occur in the Nantucket Sound area, and could potentially be impacted by the Project: humpback whales (*Megaptera novaeangliae*), fin whales (*Balaenoptera physalus*), North Atlantic Right Whales (*Eubalaena glacialis*), loggerhead turtles (*Caretta caretta*), Kemp's ridley turtles (*Lepidpchelys kempii*), and leatherback turtles (*Dermochelys coriacea*). Detailed information on the population status and trends, seasonal distribution, food and feeding behaviors, and known disturbance and mortality factors for these six species is included in Appendix 5.5-A.

Specific NMFS concerns regarding these protected whale and turtle species include potential impacts from construction and decommissioning of the Project, electromagnetic fields, vibration/noise, and changes in ecosystem dynamics. Detailed discussions of potential impacts from Project construction/decommissioning and operation/maintenance to the specified whale and turtle species are included in the Biological Assessment (Appendix 5.5-A) and in Section 5.5.6 below.

5.5.5 Pinniped Assessment

A detailed evaluation was performed for two pinniped species that may occur in the vicinity of the Project area: the gray seal (*Halichoerus grypus*) and the harbor seal (*Phoca vitulina concolor*) (Appendix 5.5-B). The gray seal is listed as a Species of Special Concern by the Commonwealth of Massachusetts. The MESA prohibits the "taking" of any rare plant or animal species listed as Endangered, Threatened, or of Special Concern by the Massachusetts Division of Fisheries & Wildlife (M.G.L c.131A and regulations 321 CMR 10.00). Both pinniped species are also protected under the MMPA.

The population status and trends, seasonal distribution, food and feeding behaviors, and known disturbance and mortality factors were evaluated for these two pinniped species to assess potential impacts of the Project (Appendix 5.5-B). Detailed discussions of the potential impacts of Project construction/decommissioning and operation/maintenance to gray and harbor seals can be found in the Pinniped Assessment (Appendix 5.5-B) and in Section 5.5.6 below.

5.5.6 Analysis of Impacts

Protected marine species may be impacted by Project construction/decommissioning and operation/maintenance. Potential direct, indirect, and cumulative impacts to protected marine species that could occur during these Project phases are discussed in Sections 5.5.6.1 and 5.5.6.2 for activities that would occur in federal waters (beyond 3 nautical miles (5.6 km)) and state waters (within 3 nautical miles (5.6 km)), respectively.

5.5.6.1 Proposed Activities Outside of Massachusetts Waters

5.5.6.1.1 Potential Direct Impacts

Construction/Decommissioning:

- ***Acoustic Harassment***

Project construction would require marine construction activities and increased vessel traffic to install the monopiles and cable system. These activities would generate localized and temporary submarine noise that has the potential to disturb or harm marine mammals and sea turtles in the Project vicinity. A complete discussion on acoustics is presented in Section 5.11 and Appendix 5.11-A.

The maximum submarine sound generated during construction of the Wind Park would occur during installation of the monopile foundations. The jet plow embedment process for laying the two submarine cable circuits and inner-array cables produces no sound beyond that produced by typical vessel traffic. The cable installation barge and associated support vessels would produce sound typical of vessel traffic already occurring in Nantucket Sound.

Sound levels measured during impact pile driving operations at the Utgrunden Wind Park in Sweden were used to model underwater sound impacts for this Project because the monopiles are similar in size and the same pile driving installation technique is proposed by the Applicant (see Section 2.3 of Appendix 5.11-A). The Utgrunden data show a maximum (L_{max}) sound level of 178 dBL at 1,640 feet (500 meters). Frequency plots from the Utgrunden data show the peak energy from pile driving occurred between 200 and 1,000 Hz, with underwater sound levels falling below background levels (inaudible) for frequencies below 5 Hz. NMFS suggests that 180 dBL represents the threshold level for preventing injury or harassment to marine mammals and sea turtles (Kurkul, 2002). The calculated maximum underwater sound levels (L_{max}) from the driving of one pile in the Wind Park would range from 170 dBL at a distance of 4,003 feet (1,220 meters) to 145 dBL at a distance of 13 miles (21 kilometers). See Section 5.11.2.6 and Appendix 5.11-A for additional detail on the temporary underwater sound levels expected throughout Nantucket Sound during pile driving activities. The sound levels anticipated to occur during Project construction at and beyond the 500-m Safety Radius[77] are below this level. Therefore, construction of the Project is not anticipated to cause physical harm to marine mammals or sea turtles. Underwater sound monitoring would be performed during initial monopile construction as was done to ensure protection of marine mammals and sea turtles during the installation of the SMDS foundation piles. Only two pieces of pile driving equipment will be present within the Project area at any one time, and they are unlikely to be operating simultaneously. For additional details on construction please refer to Section 4.0.

If marine mammals or sea turtles are present in the Project area, they are likely to temporarily avoid the area during construction activities. Studies off the California and Alaska coastlines have shown that most species of cetaceans adjust to the presence of offshore drilling equipment (Geraci and St. Aubin, 1987). However, studies of bowhead whales, a species similar to the North Atlantic Right Whale, in the Arctic indicate that individuals would often change course and behavior when exposed to the intense noise generated by active rigs and seismic vessels (Ljungblad et al., 1988; Richardson et al., 1985 and 1991). Bowhead whales in the Beaufort Sea react, at least briefly, to aircraft, ships, seismic exploration, marine construction, and offshore drill sites (Richardson and Malme, 1993). Gray seals habituated to construction activities, including pile installation, during construction of the Näsrevet Wind Farm in Sweden (Westerberg, 1999). To date, there is no conclusive evidence that this short-term disturbance leads to long-term effects on individual marine mammals or populations (Richardson et al., 1991).

[77] The 1,640–foot (500-meter) safety radius is based on a condition in the USACE Permit granted to the Applicant for construction and operation of the Scientific Measurement Devices Station (SMDS) [Permit No. 199902477]. The condition requires that sound level monitoring during pile driving procedures be conducted at an initial safety zone radius of 500 meters to determine compliance with the 180-dBL NMFS threshold. A similar safety radius was established by NMFS for pile installation at the San Francisco-Oakland Bay Bridge [SRS Technologies. 2004. San Francisco-Oakland Bay Bridge East Span Seismic Safety Project. Revised Marine Mammal Monitoring Plan.] [Illingworth & Rodkin, Inc. 2001. Pile Installation Demonstration Project Construction Report. *In:* San Francisco-Oakland Bay Bridge East Span Seismic Safety Project.]

Most baleen whales respond to constant, low-frequency sounds with broad-band intensities of more than 120 dB re 1 μPa[78] (Advanced Research Projects Agency, 1995). However, actual thresholds for behavioral responses to sounds in the natural environment depend on the level of natural ambient sound. Whales apparently are able to distinguish sounds in their optimum frequency range that are 10 to 20 dB re 1 μPa above ambient levels at the same frequency (Richardson et al., 1991). The sensitivity of sea turtles to acoustic disturbance has not been well studied. Turtles may use acoustic signals within their environment for orientation to natal beaches (Lenhardt et al., 1983). In addition, loggerhead turtles swam towards the surface when exposed to low frequency, high-intensity sounds (20-80 Hz, 175-180 dB) while underwater (Lenhardt, 1994), and may exhibit similar behavior if present during pile driving activities. This may increase the risk of vessel strikes during pile driving activities. However, given the rarity of sea turtle observances in Nantucket Sound and that little vessel traffic would be present in the vicinity of pile driving activities, sea turtles should be able to easily avoid vessels moving at slower speeds, such as those associated with Project construction (NMFS, 2001; NMFS, 2002).

There are conflicting reports of the short-term effects of vessel engine sound on marine mammals (i.e*.,* some species of whales react to sounds at great distances, as far as 2.5 miles (4 km), some do not) (Ljungblad et al., 1988; MMS, 1992). There is limited evidence that abrupt changes in vessel RPMs may disturb whales (Watkins, 1986); however, it appears that they readily acclimate to the noise in their environment. Overall, reactions to human-generated noise vary not only between species, but also within species (Richardson et al., 1991). Some studies suggest that whales may react to short-term acoustic disturbances by moving away from the sound source, changing breathing and diving patterns, or through possible distressed behavioral displays (NMFS, 1991).

Vessel sounds generally fall in the range of 150 to 200 dB re 1 μPa, with peak frequencies in the 5 to 2000 Hz range, and highest intensities below 100 Hz (Scrimger and Hietmeyer, 1991). Sound intensity, particularly at higher frequencies, tends to increase with the size of the vessel. Supertankers and large container ships may have a maximum broad-band sound source level of 190 to 200 dB re 1 μPa at 1 m from the source (Richardson et al., 1991). Sounds produced by tugboats towing barges probably produce underwater sounds with peak intensities in the frequency range of whale auditory capability of about 165 dB re 1 μPa (Buck and Chalfant, 1972; Miles et al., 1987; Malme et al., 1989). These sounds attenuate naturally in the water to about 120 dB re 1 μPa at about 2 nautical miles from the source. Small outboard motor vessels produce broad-band sounds of about 150 dB re 1 μPa at 1 m; these sounds are attenuated to the range of 85 to 140 dB re 1 μPa at a distance of 164 feet (50 meters) from the source (Richardson et al., 1991). The sounds of vessels would be clearly audible to whales, seals, and turtles in the vicinity of the Project area and transit routes.

The threshold intensity of constant or impulsive sounds for injury to the hearing apparatus of marine mammals and turtles is about 200 to 220 dB re 1 μPa (Greenlaw, 1987; McCauley, 1994). The present scientific consensus is that serious problems in a marine mammal's hearing capability would not arise at received transient sound levels of <180 dB re 1 μPa. At higher received levels or greatly extended continuous duration one cannot be certain, and the general consensus is that this 180 dB level should be considered as the point above which some potentially serious problems in marine mammals' hearing capability could start to occur (HESS, 1997; ONR, 1998; NMFS, 1998).

Increased underwater sound levels from monopile installation activities and increased vessel traffic are expected to be below the 180 dB threshold, as discussed in Section 5.11, and therefore are not expected to cause auditory damage. Temporary avoidance behavior in marine mammals and sea turtles in the Project vicinity is expected during Project construction. These behavior changes would be short-term and would likely be similar to the avoidance behaviors observed during heavy pleasure boat use, ferry traffic, or heavy fishing activity in the area. The rarity with which the protected whale species and sea turtles occur within Nantucket Sound and the significant distances between Project activities within the Wind Park site and seal haul-out and breeding sites further reduce the potential of Project-related acoustical impacts to these species.

Sounds generated during monopile and cable removal are expected to be of similar or lower intensity than during pile driving operations and submarine cable embedment. Therefore, underwater sound generated during Project

[78] Above air sound is referenced to 20 μPa, while underwater sound is referenced to 1 μPA. As a result, an identical sound pressure wave in air and underwater is recorded differently in the two fluids.

decommissioning is not likely to cause impacts other than temporary avoidance behavior in marine mammals and sea turtles as discussed above.

- ***Increased Vessel Traffic - Harassment***

There is evidence that some cetaceans may have been displaced from traditional feeding and wintering areas due to increased vessel traffic in Pacific waters (Baker et al., 1982; Forestell, 1986). However, evidence from whale watching and fishing activities in Massachusetts waters indicates that humpback and fin whale species and seals readily acclimate to the presence of large and small motor vessels (Watkins, 1986). Moreover, the vessel routes proposed to be used by Project vessels do not occur in areas where there have been high concentrations of whale or sea turtle sightings. Sea turtles and seals do not appear to be overly disturbed by the physical presence of, or sounds produced by vessels and vessel traffic, and may simply dive when approached by a vessel and avoid areas of intensive human activity (Vella et al., 2001; Westerberg, 1999; NMFS, 2001; NMFS, 2002). Vessels would not transit in proximity to seal haul-outs and should not cause disturbance to hauled-out seals

If marine mammals or sea turtles are present in the Project area, temporary avoidance behavior is expected in response to Project-related vessel traffic. These behavior changes would be short-term and would likely be similar to the avoidance behaviors observed during heavy pleasure boat use, ferry traffic, or heavy fishing activity in the area. Thus, increased vessel traffic during Project construction or decommissioning is not expected to adversely impact marine mammals or sea turtles.

- ***Increased Vessel Traffic - Vessel Strikes***

Several shipping lanes transect Nantucket Sound. Construction and decommissioning activities for this Project would introduce additional vessel traffic steaming from Quonset, RI to Nantucket Sound. Marine mammals and sea turtles may be at risk of collisions with Project-related vessels; however, as stated above, the vessel routes proposed to be used by Project vessels do not occur in areas where there have been high concentrations of marine mammal or sea turtle sightings, which reduces the probability of close encounters with Project vessels.

Documented occurrences of marine mammal and sea turtle collisions indicate that collisions occur primarily with large, fast moving vessels such as container ships, tankers, or military vessels (George et al., 1994; NMFS, 2002; Kraus, 1990; Laist et al., 2001). Vessels moving at slower speeds (less than 14 knots), such as the construction vessels to be used for the Project, are less likely to cause collisions (Laist et al., 2001) and can be avoided by most marine mammals and sea turtles. Humpback, right, and fin whales should be able to detect and avoid tugboats, barges, and other slow-moving Project vessels. The responses of these whales, however, are unpredictable and may depend on the activity of the whale at the time, or its previous experience with other motor vessels. Humpback whales are relatively tolerant of boats, but, due to this habituation, may be more susceptible to ship collisions. Fin and right whales appear to be more wary of approaching boats, and are likely to move away from vessels (Watkins, 1986).

Although sea turtles are likely to dive at the approach of a vessel, they are still at risk of boat-related injuries. Ship strikes appear to be a significant source of mortality for sea turtles, and vessel-related injuries have increased in recent years (Teas, 1994a,b). However, as discussed above, sea turtles should be able to avoid vessels moving at slower speeds, such as those associated with Project construction (NMFS, 2001; NMFS, 2002). In addition, sea turtles present in Nantucket Sound are likely to be foraging and their feeding behaviors may also reduce the risk of collisions. While feeding, sea turtles spend most of their time submerged with feeding dives lasting from about four minutes to as long as two hours (Renaud and Carpenter, 1994). During these long periods of submergence, sea turtles are not particularly vulnerable to collisions with vessels.

- ***Elevated Total Suspended Solids (TSS)***

Construction activities associated with installing the monopile foundations, scour control mats, and submarine cables would result in a temporary and localized increase in suspended sediment concentrations. Decommissioning-related impacts would also be short-term and localized, and are expected to be similar to or less than impacts during construction due to the absence of any pile driving activities. The pile driving hammer and jet plow technology that would be used to install the monopile foundations and the submarine cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum. Due to the predominant presence of fine to coarse-grained sands in Nantucket Sound, localized turbidity associated with Project construction or decommissioning is anticipated to be minimal and confined to the area immediately

surrounding the monopiles and the submarine cable route (typically within several hundred feet). Sediments disturbed by construction or decommissioning activities are expected to settle back to the sea floor within a short period of time (one to two tidal cycles). Therefore, impacts to marine mammals or sea turtles that may occur in the Project area due to elevated TSS are anticipated to be minimal and temporary.

- ***Disturbance Of Gray And Harbor Seal Haul Out And Breeding Grounds***

Gray and harbor seals can be expected to occur in Nantucket Sound year-round and could be subject to impacts as discussed above. However, known breeding and haul out sites do not coincide with the Proposed Wind Park site in Nantucket Sound. Monomoy and Muskeget Islands are known breeding grounds for the gray seal. The WTG array is proposed to be located approximately 10.5 and 7.0 nautical miles (19.4 and 13 km) from Monomoy and Muskeget Islands, respectively. Tuckernuck and Muskeget Islands are important haul-out locations for harbor seals. The Wind Park site is approximately 8.5 nautical miles (15.7 km) from Tuckernuck Island. Since the Project's proposed location is approximately 7 to 11 nautical miles (13 to 20.4 km) from haul-out and breeding sites, gray and harbor seals utilizing these breeding and haul-out grounds are not likely to be adversely affected by Project construction or decommissioning, including the passage of project vessels.

Westerberg (1999) reported that gray seals rapidly habituated to construction activities, including pile installation, at the Näsrevet Wind Farm in Sweden, only showing alarm when support vessels moved within hundreds of meters of the seals. In addition, these gray seals were not disturbed at their haulout site, located approximately 6.5 nautical miles (12 km) from construction activities at the Näsrevet Wind Farm.

- ***Habitat Shift From Structure-Oriented To Non-Structure Oriented System After Monopile Removal***

Removal of the WTG monopile foundations and ESP piles at the time of decommissioning would result in a localized shift from a structure-oriented habitat near the WTGs and ESP to the original shoal-oriented habitat present prior to construction of the Project. However, as discussed in more detail under operation/maintenance impacts, below, the presence of the WTG monopile foundations and ESP piles is not expected to substantially impact marine mammal and sea turtle movement and populations from pre-Project conditions. As a result, no significant impact to these resources is anticipated from removal of the monopiles.

Operation/Maintenance:

- ***Submarine Vibration From WTGs***

Acoustic modeling of underwater operational sound at the Wind Park was performed for the design wind condition which corresponds to the maximum underwater operational sound for the Project (see Section 5.11.2.4). Baseline underwater sound levels under the design wind condition are 107.2 dBL (see Section 5.11.2.3.1). The predicted underwater sound level from operation of a WTG is 109.1 dBL at 66 feet (20 meters) from the monopile (i.e., only 1.9 dBL above the baseline sound level), and this total sound level falls off to 107.5 dBL at 164 feet (50 meters) and declines to the baseline level at a relatively short distance of 361 feet (110 meters). Since the WTGs would be spaced approximately 0.34 to 0.54 nautical miles (629 to 1,000 meters) apart, submarine vibration impacts from the operation of the 130 WTGs in the Wind Park would not be additive. Therefore, the operational effects of the Project are anticipated to be minimal, with no adverse effect to marine mammals or sea turtles. Lending support to this conclusion are observations from Great Britain's first wind farm, Blyth Offshore in Northumberland, where dolphins have been observed congregating to feed around the turbines (AMEC, 2002). Dolphins are marine mammals recognized as possessing highly sensitive sensory systems and would presumably avoid the area if the vibration proved irritating or hazardous.

- ***Increased Vessel Traffic – Harassment And Vessel Strikes***

As previously discussed, evidence from whale watching and fishing activities in Massachusetts waters indicates that marine mammals readily acclimate to the presence of large and small motor vessels (Watkins, 1986) and sea turtles do not appear to be overly disturbed by the physical presence of and sound produced by vessels and vessel traffic (NMFS, 2001; NMFS, 2002). The majority of Project-related vessel traffic during operation is anticipated to consist of smaller crew boats and slower moving vessels similar to those used during construction. Marine mammals and sea turtles should be able to avoid these types of vessels. Although operation and maintenance activities would generate vessel traffic, such traffic is anticipated to typically consist of only two vessel trips per working day for 252 days out of the year. In addition, the vessel traffic associated with the

Project would not occur in areas where there have been high concentrations of marine mammal and sea turtle sightings, which further reduces the probability of harassment from Project vessels. If marine mammals or sea turtles are present in the Project area, temporary avoidance behavior by any marine mammals and sea turtles in the Project vicinity may occur in response to Project related vessel traffic. However, behavior changes would be short-term and would likely be similar to the avoidance behaviors observed during pleasure boat use, ferry traffic, or fishing activity in the area. Therefore, the limited increase in vessel traffic during Project operation/maintenance is not expected to adversely impact marine mammals or sea turtles in the Project area.

- ***Electromagnetic/Thermal Emissions From Submarine Cable And Inner-Array Cables***

Potential direct impacts to marine mammals or sea turtles from electromagnetic/thermal emissions during the normal operation of the inner-array cables and the two submarine cable circuits are expected to be negligible. The cable system (for both the inner-array cables and each of the submarine cable circuits) is a three-core solid dielectric AC cable design, which was specifically chosen for its minimization of environmental impacts and its reduction of any electromagnetic field. The proposed inner-array and submarine cable systems for the Project would contain grounded metallic shielding that effectively blocks any electric field generated by the operating cabling system. Since the electric field would be completely contained within those shields, impacts are limited to those related to the magnetic field emitted from the submarine cable and inner-array cables. As described in Section 5.13, the magnetic fields associated with the operation of the inner-array cables or the submarine cable system are not anticipated to result in an adverse impact to marine mammals or sea turtles (ICNIRP, 2000; Adair, 1994; Valberg et al., 1997).

Because the inner-array cables and the two submarine cable circuits connecting the Wind Park to the landfall would be buried approximately 6 feet (1.8 meters) below the seabed, thermal impacts from the operating cable systems at the seabed surface would be minimal. The cable system would generate a limited amount of heat that is absorbed by, and dissipated into, the surrounding subsurface environment. This loss of heat to the sediments is essential for proper operation of cables. Any increase in sediment temperatures resulting from operations of the submarine cables are expected to be on the order of fractions of a degree, which may not be measurable and is not expected to impact protected marine species (CWA, 2003). In addition, these cable systems utilize solid dielectric AC cable designed for use in the marine environment that does not require pressurized dielectric fluid circulation for insulating or cooling purposes. There would be no direct impacts to marine mammals, sea turtles, or their habitat during the normal operation of the inner-array or submarine cable systems.

- ***Disturbance Of Gray And Harbor Seal Haul Out And Breeding Grounds***

Operation and maintenance activities are expected to generate less vessel traffic and less sound than construction activities, typically involving two vessel transits from shore a day for about 250 days a year. This represents a negligible increase over current vessel traffic in Nantucket Sound. As previously discussed, known haul-out and breeding sites are at a minimum 7 to 11 nautical miles (13 to 20.4 km) from the proposed Project location site in Nantucket Sound; therefore, seals are not likely to be adversely affected by Project operation and maintenance.

- ***Habitat Shift From Non-Structure-Oriented To Structure-Oriented System From Monopile Installation***

The presence of 130 monopile foundations, 6 ESP piles and their associated scour control mats in Nantucket Sound has the potential to shift the area immediately surrounding each monopile from a soft sediment habitat system to a structure-oriented system, with potential localized changes to marine mammal and sea turtle movement in the Project area, as well as to the benthic and finfish community assemblages upon which these animals may forage.

However, because the WTGs and scour control mats within the array would be spaced approximately 0.34 by 0.54 nautical miles (629 by 1,000 meters) apart, movement and populations of marine mammals and sea turtles that may occur in the vicinity are not predicted to substantially change from pre-Project conditions. The additional amount of surface area being introduced is relatively small (approximately 0.03 acres/1,200 square feet (111.5 square meters) per tower assuming an average water depth of 30 feet (9.1 meters) below MHW) and the wide spacing of these monopiles is also not expected to greatly increase the production of finfish and benthic invertebrates in the Project area (see Sections 5.3 and 5.4). Therefore, the overall environment, benthic

community composition, and finfish species composition in the Project area and Nantucket Sound is not predicted to substantially change from pre-Project conditions. As discussed in Section 4.0, scour protection would be installed around each of the pilings to minimize scour associated with prevailing currents. Several options were considered, however, it was determined that the use of synthetic fronds designed to mimic seafloor vegetation would afford the necessary scour protection while minimizing potential alterations to the benthic and fish communities typically associated with Horseshoe Shoal. For more information on WTG and scour control mat installation and impacts, please refer to Section 4.0, Appendix 4.0-A and Section 5.3.

5.5.6.1.2 Potential Indirect Impacts

Construction/Decommissioning:

- ***Prey Mortality And/Or Displacement***

Prey organisms of marine mammals and sea turtles in the Project area may be temporarily affected by sound generated during construction and by construction activities themselves. Decommissioning-related impacts are expected to be similar to or less than impacts during construction. Submarine anthropogenic (manmade) sounds may cause a temporary and localized displacement of finfish (see Section 5.4), but are unlikely to cause displacement of benthic invertebrates (see Section 5.3) or pelagic (i.e., plankton) prey of marine mammals or sea turtles in the vicinity of Project construction.

Project construction/decommissioning activities are not expected to result in direct mortality to adult and juvenile pelagic finfish since these life stages are mobile in the water column and are capable of avoiding or moving away from the disturbances associated with construction. During winter construction periods, demersal finfish may experience higher levels of injury or mortality, since avoidance of anchors and anchor cables may be hampered due to sluggish response under cold water conditions. Displacement of juvenile and adult finfish is likely to be temporary and localized. Demersal eggs and larvae of finfish, however, may experience localized increases in physical abrasion, burial or mortality during Project construction or decommissioning due to their limited motility. Marine mammals, primarily seals that may feed on finfish would be able to find suitable prey in areas adjacent to the Project area and other regions of the Sound during Project construction/decommissioning, or they may have a short-term increased opportunity to feed on injured fish and macroinvertebrates.

The total temporary impacts to the seabed (benthic habitat for prey species) during construction are discussed in Sections 5.3 and 5.4. Benthic habitat loss would likely cause mortality to the benthic organisms in the footprints of construction/decommissioning activities. However, because benthic habitat is similar throughout Nantucket Sound, similar benthic communities (i.e., prey organisms) would be located in many areas, and those marine mammals and sea turtles that may occur in the Sound would be able to find suitable prey in areas adjacent to the Project area and other regions of the Sound. In addition, as discussed in Section 5.3 and 5.4, areas of temporary impact are expected to be rapidly recolonized by opportunistic benthic invertebrates.

Pelagic prey tends to be highly variable both temporally and seasonally, and animals foraging on these food sources regularly move with the food source. Temporary disturbance to pelagic prey is likely to mimic typical temporal and spatial variability, and pelagic prey is likely to be available in other parts of the Sound. Project construction or decommissioning is not likely to adversely affect the ability of marine mammals and sea turtles that may occur in the Sound to forage successfully, as suitable prey items are likely to occur in areas adjacent to the Project and elsewhere in the Sound.

- ***Bioaccumulation From Consuming Contaminated Prey***

Marine mammals and sea turtles bioaccumulate contaminants from their ocean environment almost exclusively through their food sources. Rather than passive or active uptake of chemical contaminants directly from solution across permeable body surfaces the potential mechanism by which sediments suspended during Project construction can harm sea turtles and whales is through bioaccumulation of sediment-associated chemicals through ingestion of contaminated prey.

There is very little potential for marine mammals and sea turtles to bioaccumulate chemical contaminants in their tissues from consuming prey in the Project area, because analysis of sediment core samples obtained from the Project area indicated that sediment contaminant levels were below established thresholds in reference sediment

guidelines. Specifically, all of the chemical constituents detected in sediment core samples obtained from the proposed Wind Park site and along the submarine cable route had concentrations below Effects Range-Low (ER-L) and Effects Range-Median (ER-M) marine sediment quality guidelines (Long et al., 1995) (see Section 5.1). Therefore, the temporary and localized disturbance and suspension of these sediments during foundation placement and inner array and submarine cable installation/decommissioning is not likely to result in increased incorporation of contaminants at low trophic levels. Marine mammals and sea turtles are unlikely to experience increased bioaccumulation of chemical contaminants in their tissues from the consumption of prey items in the Project vicinity.

Operations and maintenance of WTGs will involve the utilization of lubricating oil, cooling liquids, and grease, all of which will be located in the nacelle or hub. The WTG has been carefully configured to contain any fluid leakage and prevent overboard discharges. The possibility of leaks may occur in two different situations: (1) during service and maintenance and (2) during operation. During the servicing and maintenance of a WTG, a spill could happen during oil changes of hydraulic pump units or the gearbox oil conditioning system. During WTG operation leakage may occur as the result of broken gear oil hoses/pipes, and / or broken coolant hoses/pipes. Gear oil leaks will be contained within the hub and main bed frame and/or tower as described above. Coolant leaks can occur on a number of locations within the nacelle and will be contained inside the nacelle fiberglass cover.

In order to minimize and mitigate any minor spill incidents, all service vessels will be equipped with oil spill handling equipment. In addition, waste collection systems will be installed on board each WTG. The waste collection system is based on a container system for easy and safe handling during transfer from/to turbine-service vessel-dock. The waste will be separated (i.e., used oil, coolant liquids, filters, paper/rags, etc.) for correct disposal once the containers are off-loaded at the dock.

The ESP will have small amounts of lubricating oil, greases and coolants in pumps, fans, air compressors, emergency generators and miscellaneous equipment plus diesel fuel. The ESP will also have four oil-cooled step up transformers. The ESP will have sealed, leak-proof decks, which will act as fluid containment. In addition, spill containment kits will be available near all equipment. The details of spill containment equipment and related spill control measures will be provided in Spill Prevention Control and Countermeasure (SPCC) Plan prior to operation of the facility.

Due to the amount of oil, required for the WTGs and the ESP, the Project requires development of an SPCC Plan according to 30 CFR 254. The SPCC Plan will address all applicable components of the Project including the WTGs and the ESP.

For more details on WTG and ESP fluid containment and the SPCC plan, please refer to Sections 4.6 and 4.7 of the DEIS-DEIR.

In open water, marine organisms such as fish and whales have the ability to swim away from a spill by going deeper in the water or further out to sea, reducing the likelihood that they will be harmed by even a major spill. Marine animals that generally live closer to shore, such as turtles, seals, and dolphins, risk contamination by oil that washes onto beaches or by consuming oil-contaminated prey (USEPA, 2004)

- ***Removal Of WTGs As Fish Aggregating Devices***

As discussed below under operational impacts, finfish aggregated at the WTGs would likely be dispersed when the monopiles are removed during decommissioning. Marine mammals, particularly seals, that may have exploited these aggregations, would have to forage elsewhere. Similarly, any sea turtles that may have been attracted to the WTGs for feeding on benthic invertebrates would have to forage elsewhere. However, the additional amount of surface area being introduced is relatively small (approximately 0.03 acres/1,200 square feet (111.5 square meters) per tower assuming an average water depth of 30 feet (9.1 meters) below MHW) and the wide spacing of these monopiles (0.34 to 0.54 nautical miles (629 to 1,000 meters) apart) is not expected to greatly increase the production of finfish and benthic invertebrates in the Project area (see Sections 5.3 and 5.4). Therefore, marine mammal or sea turtle populations that consume finfish or colonizing benthic invertebrate prey are not likely to increase due solely to the presence of the monopiles and these animals are not expected to be greatly affected by removal of the WTGs and the subsequent dispersal of prey.

Operation / Maintenance

- ***WTGs Acting As Fish Aggregating Devices***

The WTG monopile foundations would represent a source of new hard substrate with a vertical orientation in an area that has a limited amount of such habitat. Therefore, the WTG monopile foundations and ESP piles may attract finfish and benthic organisms, potentially indirectly affecting marine mammals or sea turtles by causing changes in prey distribution or abundance. Bohnsack (1989) found that fish species most likely to benefit from artificial structures are those with demersal, philopatric, territorial, and reef-obligate life histories. Several finfish species known to occur in Nantucket Sound display these characteristics in some or all of their life history stages, and thus may benefit from the presence of the monopiles. These species include Atlantic cod, black sea bass, cunner, tautog, and scup. Benthic species that may initially be supported by such structures are likely to include algae, barnacles, hydroids, sponges, tunicates, bryozoans, anemones, and possibly mussels, all of which occur in other areas of hard substrate within Nantucket Sound. Additional organisms, such as crabs, gastropods, nudibranchs, polychaetes, oligochaetes, and nematodes may also utilize the structures once algal growth becomes established.

The listed whale species do not rely on these finfish or benthic organisms as prey and occur only rarely in Nantucket Sound; therefore, they are not expected to be influenced by potential finfish or benthic organism aggregations at the individual WTG monopiles. Potential finfish aggregations at the monopiles are not likely to affect foraging sea turtles, although the benthic invertebrates that may attach to the monopiles could provide an additional food source for some sea turtles. If finfish aggregations occur at the monopile foundations, the individual WTGs may be attractive to seals as a feeding area. Although the monopile foundations would create additional attachment sites for benthic organisms that require fixed (non-sand) substrates and additional structure that may attract certain finfish species, the additional amount of surface area being introduced would be a relatively small addition to the hard substrate that is already present (see Section 5.3). Due to small amount of additional surface area in relation to the total Project area and Nantucket Sound, and the spacing between WTGs (0.34 to 0.54 nautical miles (629 to 1,000 meters) apart), the new additional structure is not expected to affect the overall environment, benthic community composition, finfish species composition, or populations of foraging marine mammals or sea turtles in the area. Therefore, it is unlikely that these isolated structures would substantially affect the ecology of Nantucket Sound, and the Project area is not predicted to significantly change from pre-Project conditions.

- ***Prey Displacement Due To Submarine Vibration***

Fish and invertebrate prey items of marine mammals and sea turtles are not expected to be affected by operations of the WTGs. Acoustic modeling of Project underwater operational sound was performed for the design wind condition (see Section 5.11.2.4). Baseline underwater sound levels under the design wind condition are 107.2 dBL (see Section 5.11.2.3.1). The predicted underwater sound level from operation of a WTG is 109.1 dBL at 66 feet (20 meters) from the monopile (i.e., only 1.9 dBL above the baseline sound level), and this total sound level falls off to 107.5 dBL at 164 feet (50 meters) and declines to the baseline level at a relatively short distance of 361 feet (110 meters). Since the WTGs would be spaced approximately 0.34 to 0.54 nautical miles (629 to 1,000 meters) apart, submarine vibration impacts from the operation of the 130 WTGs in the Wind Park would not be additive. The operational effects of the Project are minimal and would not adversely affect prey of marine mammals or sea turtles.

- ***Prey Displacement Due To Electromagnetic / Thermal Emissions From Submarine Cable***

Potential EMF/thermal impacts to prey of marine mammals or sea turtles during the normal operation of the inner-array cables and two submarine cable circuits are expected to be minimal. Because the inner-array cables and the two submarine cable circuits connecting the Project to the landfall would be buried approximately 6 feet (1.8 meters) below the seabed, they would not pose a physical barrier to fish passage. The considerable depth to which the submarine cables would be buried would allow benthic organisms to colonize and demersal fish species to utilize surface sediments without being affected by the cable operation. As previously discussed, the burial depth of the inner-array and submarine cable systems also minimizes potential thermal impacts from cable system operation. In addition, these cable systems utilize a three-core solid dielectric AC cable designed for use in the marine environment that does not require pressurized dielectric fluid circulation for insulating or cooling purposes and which was specifically chosen for its minimization of environmental impacts and its reduction of any

electromagnetic field (see Section 4). It is unlikely that prey items of marine mammals or sea turtles (i.e., finfish, invertebrates, and plankton) would be directly impacted during the normal operation of these submarine cables (see Section 5.13).

5.5.6.1.3 Cumulative Impacts

Construction/Decommissioning:
In addition to the proposed Project, other activities which may contribute to cumulative impacts to protected marine species would include other submarine cable or pipeline installations, dredging activities, trawling, installation of pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable has been proposed by National Grid between Cape Cod and Nantucket. Its proposed route would only cross the Project's submarine cable route in the vicinity of Hyannis Harbor, well within the Massachusetts 3-mile limit (as discussed below in Section 5.5.6.2.3). Outside of Massachusetts waters, at its closest point, the proposed route of the Nantucket Cable would be approximately two miles (3.2 km) from the Wind Park and its inner array cables in Nantucket Sound. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. Any impacts from construction activities are expected to be localized and temporary. As such, there are no significant cumulative impacts expected to marine protected species that would result from the installation of both projects.

The submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance dredging. Therefore, no significant cumulative effects to marine protected species are expected in the area of the North Channel crossing.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts expected to marine protected species since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

Operation/Maintenance:
As discussed on, based upon the lack of any other active USACE Section 10 Applications proposing similar, large-scale offshore wind power generation projects or other offshore projects in Federal waters off the southern Massachusetts coast, it is anticipated that the cumulative impacts from operation and maintenance of this and other projects would be negligible. In general, the potential for any impacts to marine protected species is small, given the rarity with which the protected whale species and sea turtles occur within Nantucket Sound and the significant distances between Project operation and maintenance activities within the Wind Park site and seal haul-out and breeding sites.

5.5.6.1.4 Secondary Impacts

There are no potential offshore secondary impacts to marine protected species associated with construction staging/laydown activities at Quonset. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility and its waterfront piers are currently not operating at full occupancy, and no significant in-water alterations are known to be necessary to accommodate the Project's staging activities. Thus, there would be no secondary impacts to marine protected species.

5.5.6.2 Proposed Activities Inside of Massachusetts Waters

5.5.6.2.1 Potential Direct Impacts

Construction/Decommissioning:

- ***Acoustic Harassment***

Underwater sound created by installation of the two submarine cable circuits with jet plow technology would primarily result from sound associated with the cable installation vessel(s) and vessel traffic transiting from shore to the Wind Park site. The actual jet plow device produces no sound beyond that produced by typical vessel traffic. No adverse impacts to marine mammals or sea turtles are expected from the horizontal directional drilling (HDD) methodology used to transition the submarine cable to the shore cable system in Lewis Bay. Due to the sound-insulating qualities of earthen materials (the sediment) and the fact that the drilling would take place through unconsolidated material, the HDD transition is not anticipated to transmit vibration from the sediment to the water (i.e., it would not add appreciable sound into the water column). The installation of sheet steel for the cofferdam would utilize a low-noise vibratory method, and would not use impact pile driving. Therefore, underwater sound effects from cofferdam installation would also be minimal and temporary. As a result, the main acoustical impacts during construction activities in Massachusetts waters would be limited to that generated by vessel traffic.

There are conflicting reports of the short-term effects of vessel engine sound on marine mammals (i.e., some species of whales react to sounds at great distances, some do not). There is limited evidence that abrupt changes in vessel RPMs may disturb whales (Watkins, 1986); however, it appears that they readily acclimate to the noise in their environment. Overall, reactions to human-generated noise vary not only between species, but also within species (Richardson et al., 1991). Some studies suggest that whales may react to short-term acoustic disturbances by moving away from the sound source, changing breathing and diving patterns, or through possible distressed behavioral displays (NMFS, 1991). Reactions have been documented as far as 2.5 miles (4 km) from the vessel (Ljungblad et al., 1988; MMS, 1992).

Vessel sounds generally fall in the range of 150 to 200 dB re 1 μPa, with peak frequencies in the 5 to 2000 Hz range, and highest intensities below 100 Hz (Scrimger and Hietmeyer, 1991). Sound intensity, particularly at higher frequencies, tends to increase with the size of the vessel. Supertankers and large container ships may have a maximum broad-band sound source level of 190 to 200 dB re 1 μPa at 1 m from the source (Richardson et al., 1991). Sounds produced by tugboats towing barges probably produce underwater sounds with peak intensities in the frequency range of whale audition of about 165 dB re 1 μPa (Buck and Chalfant, 1972; Miles et al., 1987; Malme et al., 1989). These sounds attenuate naturally in the water to about 120 dB re 1 μPa at about 2 nautical miles (3.7 km) from the source. Small outboard motor vessels produce broad-band sounds of about 150 dB re 1 μPa at 1 meter; these sounds are attenuated to the range of 85 to 140 dB re 1 μPa at a distance of 164 feet (50 meter) from the source (Richardson et al., 1991). The sounds of vessels would be clearly audible to whales and sea turtles in the vicinity of the submarine cable system route and vessel transit routes. However, these sounds would be too weak to cause physical harm to marine mammals or sea turtles.

Most baleen whales respond to constant, low-frequency sounds with broad-band intensities of more than 120 dB re 1 μPa (Advanced Research Projects Agency, 1995). However, actual thresholds for behavioral responses to sounds in the natural environment depend on the level of natural ambient sound. Whales apparently are able to distinguish sounds in their optimum frequency range that are 10 to 20 dB re 1 μPa above ambient sound at the same frequency (Richardson et al., 1991). The sensitivity of sea turtles to acoustic disturbance has not been well studied. Turtles may use acoustic signals within their environment for orientation to natal beaches (Lenhardt et al., 1983). In addition, loggerhead turtles swam towards the surface when exposed to low frequency, high-intensity sounds (20-80 Hz, 175-180 dB) while underwater (Lenhardt, 1994). However, typical vessel sounds do not seem to disturb sea turtles. Therefore, the sound added to the marine environment by submarine cable installation activities is unlikely to adversely affect sea turtles.

The threshold intensity of constant or impulsive sounds for injury to the hearing apparatus of marine mammals and turtles is about 200 to 220 dB re 1 μPa (Greenlaw, 1987; McCauley, 1994). The present scientific consensus is that physical injury to a marine mammal's hearing capability would not arise at received transient sound levels

of <180 dB re 1 μPa. At higher received levels or greatly extended continuous duration one cannot be certain, and the general consensus is that this 180 dB level should be considered as the point above which some potentially serious problems in marine mammals' hearing capability could start to occur (HESS, 1997; ONR, 1998; NMFS, 1998).

NMFS has identified 180 dBA as the threshold level for preventing injury or harassment to marine mammals and sea turtles (Kurkul, 2002). Increased underwater sound from submarine cable installation activities and increased vessel traffic would be below the 180 dB threshold, as discussed in Section 5.11, and therefore are not expected to cause auditory damage. In addition, these sounds will be temporary in any one location and will occur within a localized area along the submarine cable route, as opposed to occurring in one stationary work site. Nantucket Sound also frequently experiences heavy vessel traffic from a variety of vessels; therefore, the slight increase in vessel traffic caused by the Project should not alter the acoustical environment of this area above the normal baseline sound. Temporary avoidance behavior in marine mammals and sea turtles in the Project vicinity is expected during Project construction, though behavioral changes would be short-term and would likely be similar to the avoidance behaviors observed during heavy pleasure boat use, ferry traffic, or heavy fishing activity in the area. In addition, the vessel traffic associated with the Project would not occur in areas where there have been high concentrations of marine mammal and sea turtle sightings, which further reduces the probability of acoustic harassment from Project vessels.

Underwater sound generated during submarine cable removal is expected to be of similar or lower intensity than during initial jet plow operations, and is not likely to cause impacts to marine mammals or sea turtles other than the temporary avoidance behavior discussed above.

- ***Increased Vessel Traffic - Harassment***

There is evidence that some cetaceans may have been displaced from traditional feeding and wintering areas due to increased vessel traffic in Pacific waters (Baker et al., 1982; Forestell, 1986). However, evidence from whale watching and fishing activities in Massachusetts waters indicates that humpback and fin whale species and seals readily acclimate to the presence of large and small motor vessels (Watkins, 1986). Moreover, the vessel routes proposed to be used by Project vessels do not occur in areas where there have been high concentrations of whale or sea turtle sightings. Sea turtles and seals do not appear to be overly disturbed by the physical presence of or sounds produced by vessels and vessel traffic, and may simply dive when approached by a vessel and avoid areas of intensive human activity (Vella et al., 2001; Westerberg, 1999; NMFS, 2001; NMFS, 2002).

If marine mammals or sea turtles are present in the Project area within Massachusetts waters, temporary avoidance behavior is expected in response to Project-related vessel traffic, though behavioral changes would be short-term and would likely be similar to the avoidance behaviors observed during heavy pleasure boat use, ferry traffic, or heavy fishing activity in the area. Thus, increased vessel traffic during submarine cable installation or removal is not expected to adversely impact marine mammals or sea turtles.

- ***Increased Vessel Traffic - Vessel Strikes***

The state territorial waters in the vicinity of the submarine cable route already experience high levels of boat traffic. Both construction and decommissioning activities would temporarily introduce additional vessel traffic from Quonset, RI to the cable locations. Vessel traffic en route to the Wind Park site would also cross through state territorial waters.

Documented occurrences of marine mammal and sea turtle collisions indicate that collisions occur primarily with large, fast moving vessels such as container ships, tankers, or military vessels (George et al., 1994; NMFS, 2002; Kraus, 1990; Laist et al., 2001). Vessels moving at slower speeds (less than 14 knots), such as the construction vessels that would work on the Project, are less likely to cause collisions (Laist et al., 2001) and can be avoided by most marine mammals and sea turtles. Humpback, right, and fin whales should be able to detect and avoid tugboats, barges, and other slow-moving Project vessels within Massachusetts waters. The responses of these whales, however, are unpredictable and may depend on the activity of the whale at the time, or its previous experience with other motor vessels. Humpback whales are relatively tolerant of boats, but, due to this habituation, may be more susceptible to ship collisions. Fin and right whales appear to be more wary of approaching boats, and are likely to move away from vessels.

Although sea turtles are likely to dive at the approach of a vessel, they are still at risk of boat-related injuries. Ship strikes appear to be a significant source of mortality for sea turtles, and vessel-related injuries have increased in recent years (Teas, 1994a,b). However, as discussed above, sea turtles should be able to avoid vessels moving at slower speeds, such as those associated with Project construction (NMFS, 2001; NMFS, 2002). In addition, sea turtles present in Nantucket Sound are likely to be foraging and their feeding behaviors may also reduce the risk of collisions. While feeding, sea turtles spend most of their time submerged with feeding dives lasting from about four minutes to as long as two hours (Renaud and Carpenter, 1994). During these long periods of submergence, sea turtles are not particularly vulnerable to collisions with vessels.

Because vessel traffic associated with the Project would not occur in areas where there have been high concentrations of marine mammal and sea turtle sightings and because marine mammals and sea turtles would likely be able to avoid slow moving vessels associated with construction, vessel strikes to protected marine species from Project-related vessels is unlikely.

- ***Elevated Total Suspended Solids (TSS)***

Submarine cable system installation would result in a temporary and localized increase in suspended sediment concentrations. Submarine cable removal impacts would also be short-term and localized and would be expected to be similar to or less than impacts during construction. The jet plow technology that would be used to install the two submarine cable circuits was selected specifically for its ability to minimize sediment disturbance. Due to the predominance of fine to coarse-grained sand in Nantucket Sound, localized turbidity associated with cable installation or removal is anticipated to be minimal and confined to the area immediately surrounding the submarine cable system route (typically within several hundred feet). Suspended sediments are expected to settle back to the sea floor within a short period of time (see Section 5.2 and Appendix 5.2-C). In addition, the Project area is situated in a dynamic environment that is subject to naturally high suspended sediment concentrations in near-bottom waters as a result of relatively strong tidal currents and wind and storm generated waves, particularly in shoal areas. Impacts to marine mammals and sea turtles from elevated TSS are expected to be minimal and temporary.

Sediment suspension during excavation of the HDD borehole in Lewis Bay would be minimal, since these activities would be largely contained within a cofferdam. In addition, the top of the sheet piles for the cofferdam would be cut off approximately two feet above mean high water in order to contain turbidity associated with dredging for the HDD borehole end transition (see Section 4.3.5). Furthermore, it is unlikely that marine mammals or sea turtles would be present this close to shore in Lewis Bay. Therefore, no impacts to these protected marine species would occur from the limited, contained sediment suspension during excavation of the HDD borehole ends in Lewis Bay. These activities would not be required during decommissioning.

- ***Disturbance Of Gray And Harbor Seal Haul-Out And Breeding Grounds***

Gray and harbor seals can be expected to occur in Nantucket Sound year-round. However, known breeding and haul out sites do not coincide with vessel or construction/decommissioning activity within Massachusetts waters. Monomoy and Muskeget Islands are known breeding grounds for the gray seal, and Tuckernuck and Muskeget Islands are important haul-out locations for harbor seals. Project-related construction and decommissioning activities and vessel traffic in Massachusetts waters would occur greater than 11 nautical miles from these breeding and haul-out sites.

At the Näsrevet Wind Farm in Sweden, gray seals rapidly habituated to construction activities and only showed alarm when support vessels moved within hundreds of meters of the seals (Westerberg, 1999). In addition, gray seals were not disturbed at their haul-out site, located approximately 6.5 nautical miles (12 km) from construction activities at the Näsrevet Wind Farm. Since Project-related construction/decommissioning activities and vessel traffic in Massachusetts waters would occur greater than 11.0 nautical miles (20.4 km) from these breeding and haul-out sites, gray and harbor seals utilizing breeding and haul-out grounds in or near Nantucket Sound are not likely to be adversely affected by WTG, ESP, or submarine cable installation or removal.

Operation/Maintenance:

- ***Increased Vessel Traffic***

No operation/maintenance activities are required for the submarine cable system under normal conditions. Although vessel traffic would occur in Massachusetts waters along the transit routes from shore to the Wind Park site to conduct operation/maintenance activities, such traffic is anticipated to typically consist of only two vessel trips per working day for 252 days out of the year. If marine mammals or sea turtles are present in the Project area within Massachusetts waters, temporary avoidance behavior is expected in response to Project-related vessel traffic, though behavioral changes would be short-term and would likely be similar to the avoidance behaviors observed during pleasure boat use, ferry traffic, or fishing activity in the area. Any marine mammals or sea turtles in the Project vicinity should also be able to avoid slow moving Project vessels.

- ***Electromagnetic/Thermal Emissions From Submarine Cable***

Potential direct impacts to marine mammals or sea turtles from electromagnetic/thermal emissions during the normal operation of the two submarine cable circuits are expected to be negligible. The cable system is a three-core solid dielectric AC cable design, which was specifically chosen for its minimization of environmental impacts and its reduction of any electromagnetic field. The proposed submarine cable system for the Project would contain grounded metallic shielding that effectively blocks any electric field generated by the operating cabling system. Since the electric field would be completely contained within those shields, impacts within Massachusetts waters are limited to those related to the magnetic field emitted from the two 115 kV submarine cable circuits. As described in Section 5.13, the magnetic fields associated with the operation of the submarine cable system are not anticipated to result in an adverse impact to protected marine mammals or sea turtles (ICNIRP, 2000; Adair, 1994; Valberg et al., 1997).

Since the two submarine cable circuits connecting the Wind Park to the landfall would be buried approximately 6 feet below the seabed, potential thermal impacts from cable system operation at the seabed surface would be minimal. In addition, the submarine cable system utilizes solid dielectric AC cable designed for use in the marine environment that does not require pressurized dielectric fluid circulation for insulating or cooling purposes. There would be no direct impacts to marine mammals, sea turtles, or their habitat from electromagnetic/thermal emissions during the normal operation of the submarine cable system.

- ***Disturbance Of Gray And Harbor Seal Haul-Out And Breeding Grounds***

Gray and harbor seals can be expected to occur in Nantucket Sound year-round. Gray seals rapidly habituated to construction activities at the Näsrevet Wind Farm in Sweden, only showing alarm when support vessels moved within hundreds of meters of the seals (Westerberg, 1999). Gray seals were not disturbed at their haul-out site, located approximately 6.5 nautical miles (12 km) from construction activities at the Näsrevet Wind Farm. Operation and maintenance activities are expected to generate less vessel traffic and less sound than construction activities. Known haul-out and breeding sites are a minimum of 11.0 nautical miles (11 km) from any vessel traffic associated with operation and maintenance activities in Massachusetts waters; therefore, seals are not likely to be adversely affected by Project operation and maintenance.

5.5.6.2.2 Potential Indirect Impacts

Construction/Decommissioning:

- ***Prey Mortality and/or Displacement***

Prey organisms of marine mammals and sea turtles in Massachusetts waters of the Project area may be affected by vessel sound generated during submarine cable installation and by the cable embedment activities themselves. Impacts related to submarine cable removal are expected to be similar to or less than impacts during construction. Submarine anthropogenic sounds generated by vessel traffic and operation may cause a temporary and localized displacement of finfish (see Section 5.4), but are unlikely to cause displacement of benthic invertebrates (see Section 5.3) or pelagic (i.e., plankton) prey of marine mammals or sea turtles in the vicinity of Project construction.

Submarine cable installation and HDD borehole end construction activities are not expected to result in direct mortality to adult and juvenile pelagic finfish, since these life stages are mobile in the water column and are

capable of avoiding or moving away from the disturbances associated with submarine cable installation. Pelagic prey tends to be highly variable both temporally and seasonally, and animals foraging on these food sources regularly move with the food source. Temporary disturbance to pelagic prey is likely to mimic typical temporal and spatial variability, and pelagic prey is likely to be available in other parts of the Sound. Submarine cable installation or removal is not likely to adversely affect the ability of those marine mammals and sea turtles to forage successfully, as suitable prey items are likely to occur in areas adjacent to the submarine cable route or elsewhere in the Sound.

Removal of the two submarine cable circuits is expected to result in temporary and localized impacts to finfish similar to or less than those discussed under Project construction. During winter construction periods, demersal finfish may experience higher levels of injury or mortality since avoidance of anchors and anchor cables may be hampered due to sluggish response under cold water conditions. No measurable effects on fish populations would be expected. Displacement of juvenile and adult finfish is likely to be temporary and localized. Demersal eggs and larvae of finfish, however, may experience localized increases in physical abrasion, burial or mortality during submarine cable installation or removal due to their limited motility. Marine mammals, primarily seals that may feed on finfish would be able to find suitable prey in areas adjacent to the submarine cable route and other regions of Nantucket Sound during Project construction/decommissioning or they may have a short-term increased opportunity to feed on injured fish and macroinvertebrates.

The total temporary impacts to the seabed (benthic habitat for prey species) in state waters during construction/decommissioning are discussed in Sections 5.3 and 5.4. This temporary displacement of benthic habitat would result in the mortality and/or dispersal of some benthic organisms that are prey items for marine mammals and sea turtles. However, because benthic habitat is similar throughout Nantucket Sound, similar benthic communities (i.e., prey organisms) would be located in many areas and those marine mammals and sea turtles that may occur in the Sound would be able to find suitable prey in areas adjacent to the submarine cable route and in other regions of the Sound. In addition, as discussed in Section 5.3 and 5.4, areas temporarily impacted by submarine cable embedment or removal are expected to be rapidly recolonized by opportunistic benthic invertebrates.

- ***Bioaccumulation From Consuming Contaminated Prey***

Marine mammals and sea turtles bioaccumulate contaminants from their ocean environment almost exclusively through their food sources. The potential mechanism by which sediments suspended during Project construction can harm sea turtles and whales is through bioaccumulation of sediment-associated chemicals through ingestion of contaminated prey.

There is little potential for marine mammals and sea turtles to bioaccumulate chemical contaminants in their tissues from consuming prey along the submarine cable route, because analysis of sediment core samples obtained along the submarine cable route indicated that sediment contaminant levels were below established thresholds in reference sediment guidelines. Specifically, all of the chemical constituents detected in sediment core samples obtained along the submarine cable route had concentrations below ER-L and ER-M marine sediment quality guidelines (Long et al., 1995). Based on these results, the temporary and localized disturbance and suspension of these sediments during submarine cable installation, would not likely result in the increased incorporation of contaminants at low trophic levels. Similarly, the temporary and localized disturbance and suspension of these sediments during submarine cable removal is not likely to result in increased incorporation of contaminants at low trophic levels. Therefore, there is very little potential for marine mammals and sea turtles to experience increased bioaccumulation of chemical contaminants in their tissues from consumption of prey items in the Project vicinity.

- ***Bentonite Breakout Prevention and Minimization***

The HDD operation within Lewis Bay would be designed to include a drilling fluid fracture or overburden breakout monitoring program to minimize the potential of drilling fluid breakout into waters of Lewis Bay (see Section 4.3.5). The drilling fluid will consist of water (approximately 95%) and an inorganic, bentonite clay (approximately 5%). The bentonite clay is a naturally occurring hydrated aluminosilicate composed of sodium, calcium, magnesium, and iron. Although it is anticipated that drilling depths in the overburden would be sufficiently deep to avoid pressure-induced breakout of drilling fluids through the seafloor bottom, a bentonite monitoring program would be implemented for the detection of possible fluid loss (see Section 4.3.5). In the

unlikely event of drilling fluid release, the bentonite fluid density and composition would cause it to remain as a cohesive mass on the seafloor in a localized slurry pile similar to the consistency of gelatin. This cohesive mass can be quickly cleaned up and removed by divers and appropriate diver-operated vacuum equipment, thereby minimizing any long-term impacts to finfish or finfish habitat. Short-term impacts would consist of the covering of benthic organisms in the immediate area of release. These activities would not be required during decommissioning, and thus would not be an associated impact risk. Please refer to Section 4.3.5 for additional detail.

Operation/Maintenance:

- ***Prey Displacement Due To Electromagnetic/Thermal Emissions From Submarine Cable***

Potential impacts to prey items of marine mammals or sea turtles during the normal operation of the two submarine cable circuits are expected to be minimal. As stated above, the cable system is a three-core solid dielectric AC cable design, which was specifically chosen for its minimization of environmental impacts and its reduction of any electromagnetic field. As discussed in Section 5.13, the magnetic fields associated with the operation of the submarine cable system would not result in an adverse impact to fish or prey species of marine mammals or sea turtles.

Since the two submarine cable circuits connecting the Wind Park to the landfall would be buried approximately 6 feet below the seabed, it would not pose a physical barrier to fish or other animal passage. The considerable depth to which the cables would be buried would allow benthic organisms to colonize and demersal fish species to utilize surface sediments without being affected by the cable operation. As previously discussed, the burial depth also minimizes potential thermal impacts from the two operating submarine cable circuits. In addition, the cable system utilizes solid dielectric AC cable designed for use in the marine environment, and does not require pressurized dielectric fluid circulation for insulating or cooling purposes. It is unlikely that prey items of marine mammals or sea turtles (i.e., finfish, invertebrates, and plankton) would be directly impacted by EMF or thermal emissions during the normal operation or maintenance of the submarine cable system (see Section 5.13).

5.5.6.2.3 Cumulative Impacts

In addition to the proposed Project, other activities which may contribute to cumulative impacts to protected marine species would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable has been proposed by National Grid between Cape Cod and Nantucket. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. At this crossing, and in its near vicinity, the impacts of each project would be coincident in nature. However, as discussed above, protected species are not common in Nantucket Sound and, individually, these projects are not likely result in impacts to protected marine species. In addition, because sediment suspension and deposition impacts from jet plow cable embedment are expected to be minimal and of short duration, these temporary impacts are not likely to occur at the same time. Therefore, the area would not likely have increased water column sediment loadings from the first project installation at the time the second project is constructed. As such, there are no significant cumulative impacts expected to result from the installation of both projects.

The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent, cumulative sediment suspension and deposition. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on recent experience it could be needed in the next 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. Future USACE maintenance dredging in Hyannis Harbor would be the subject of an additional NEPA document. As discussed above, protected species, seal haul-out and breeding sites

are not common in the vicinity of Hyannis Harbor and, individually, these projects are not likely result in impacts to protected marine species. As such, there are no significant cumulative impacts expected to result from the installation of both projects.

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the Project area. However, these marina dredging projects, if they were to occur, are very localized and not likely to result in sediment suspension and deposition that would be coincident with the Project's cable installation (the closest point of which would be a minimum of 0.5 miles (805 meters) from the closest marina). Therefore, it is not likely to result in impacts to marine protected species that would be coincident with the cable installation.

5.5.7 Mitigation

The Project has been planned, sited, and designed to avoid and minimize impacts to protected marine species and habitat within the Project area in accordance with the ESA, MMPA, and MESA. A Biological Assessment (Appendix 5.5-A) was conducted to determine if the Project is likely to result in adverse effects to threatened or endangered marine species, and informal consultations have been initiated with NMFS and the USFWS have occurred to ensure that the protections under 50 CFR Part 402 and the MMPA would be upheld (see Appendix 5.5-A). While limited localized impacts are anticipated during Project construction and operation, measures would be implemented to prevent and minimize these impacts. These measures include posting a NMFS-certified observer on-site during initial construction activities; using state-of-the-art hydraulic jet plow technology for cable installation (see Section 4.0) and monopile foundations for the WTGs; and implementing post-construction monitoring to document habitat disturbance and recovery (see Section 6.0).

Although vessel traffic would increase during the period of the Project, collisions between Project vessels and whales, seals, or sea turtles are unlikely to occur. Potential vessel impacts to marine mammals or sea turtles would be minimized by requiring that Project vessels follow NOAA whale watching procedures[79] while in transit to and from the Wind Park site so as not to disturb any individuals that may be in the area.

Potential impacts to marine mammals and sea turtles associated with underwater sound levels created by pile driving would be minimized by conducting a "soft-start" to each piling event. This would help ensure that any marine mammals or turtles in the immediate vicinity would not receive damaging sound levels at the start of pile driving, and would provide them with the opportunity to leave the area. In addition, underwater sound monitoring would be performed during initial monopile construction. This would include posting a NMFS approved observer on-site during initial pile driving activities to monitor the area during construction. If listed species were observed within the Safety Zone by the NMFS approved observer, the observer would ensure that work would cease until the animal is clear of the work area and safety zone (see Section 5.11.2.7). These measures should provide adequate protection to avoid and minimize impacts to marine mammals and sea turtles.

No significant impacts are anticipated during Project operation; therefore, no mitigation is proposed. Similar measures to those described above for construction would be implemented during Project decommissioning to avoid and minimize potential impacts to marine mammals and sea turtles. Any mitigation measures that are developed through the ongoing consultation process with the NMFS would be implemented.

5.6 Terrestrial Ecology, Wildlife, and Protected Species

5.6.1 Introduction

This section describes the terrestrial ecology, wildlife, and habitats along the proposed transmission line route from the landfall location in Yarmouth to the Barnstable Switching Station. Regulatory authorities and consistency are discussed in Section 7.0. The information contained in this section was obtained from literature review, agency consultations, site investigations, and review of existing site investigation data.

State-listed rare species are protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 1331A) and its implementing regulations (321 CMR 10.00) and the Massachusetts Wetlands Protection Act (WPA)

[79] http://www.nero.nmfs.gov/ro/doc/nr051999.pdf

(M.G.L. c. 131, s.40) and its implementing regulations (310 CMR 10.00). MESA prohibits the "taking" of rare wildlife species in order to "harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity or attempt to engage in any such conduct, or to assist such conduct," as well as the "taking" of rare plants to "collect, pick, kill, transplant, cut or process or attempt to engage or to assist in any such conduct."

In order to implement MESA and rare species regulations under the WPA, the Natural Heritage and Endangered Species Program (NHESP) provides mapping of rare species habitat, and reviews projects proposed within these mapped habitats. Two forms of habitat maps are provided. Priority Habitats (PH) mapping represents areas of known state-protected rare plant and animal species occurrences in Massachusetts for use with MESA, while Estimated Habitats (WH) mapping depicts habitats of state-protected rare wetlands wildlife for use under the WPA. Compliance with the MESA and WPA is discussed in Section 5.6.5.

Federally-listed rare species are protected under the Federal Endangered Species Act of 1973 (16 USC 1531 et seq.), which prohibits the sale of and traffic in endangered or threatened species. It also prohibits a "take" of a listed species, defined as "to harass, harm, shoot, wound, kill, trap, capture, collect or attempt to engage in any such conduct."

Although no state- or federally-listed protected bat species are known to occur in southeastern Massachusetts (DeGraaf and Yamasaki, 2001), an evaluation of existing conditions and potential impacts to bats was conducted at the request of the USFWS and is included below.

Studies completed and sources reviewed in association with terrestrial ecology evaluation are discussed in Section 5.6.2. Existing conditions are described in Section 5.6.3. Sections 5.6.4 and 5.6.5 provide information regarding potential Project impact and proposed mitigation measures, respectively. References utilized in the preparation of this section are listed in Section 5.6.6.

5.6.2 Studies Completed

Information included in this section is based on existing published literature, literature review, agency consultation, mapped resources and field review conducted in October 2001 and August 2002. Mapped resources reviewed include the following: USGS aerial photographs dated April 3, 1995; Massachusetts Natural Heritage Atlas (2003 Edition) and MassGIS mapping of rare species; Natural Resource Conservation Service's (formerly the Soil Conservation Service) Soil Survey of Barnstable County (March 1993) and MassGIS mapping of soils; Massachusetts Aerial Photo Survey of Potential Vernal Pools (Spring 2001); and Town of Yarmouth Comprehensive Plan, Coastal Resources (March 20, 1997).

Additional information was obtained from correspondence with state and federal agencies, including the following: NHESP letters dated November 15, 2001, June 17, 2002, September 4, 2002, and October 23, 2003; USFWS letters dated July 10, 2002, September 25, 2002, and September 10, 2003; and Fact Sheets from the NHESP.

The Massachusetts Natural Heritage Atlas (2003 edition) and the October 23, 2003 letter from the NHESP indicate that the submarine transmission line route is located entirely within habitat for the Roseate Tern (*Sterna dougallii*) and Common Tern (*Sterna hirundo*), state-listed as endangered and special concern species, respectively. Potential impacts of the proposed work on these species are described in Section 5.7. A Biological Assessment of the Roseate Tern is provided in Appendix 5.7-H, and a Biological Review of the Common Tern is provided in Appendix 5.7-I.

A review of available scientific literature pertaining to bat foraging and migratory behavior, echolocation sensory systems, and collision risk associated with wind turbines was conducted for the seven species of bat that are known to occur in southeastern Massachusetts.

5.6.3 Existing Conditions

The proposed onshore transmission line route extends within paved roadways from the New Hampshire Avenue landfall in Yarmouth for approximately 4 miles (6.4 km) along Berry Avenue, Higgins Crowell Road, and Willow Street. The route then leaves the roadways, and extends along the NSTAR Electric ROW for approximately 2 miles (3.2 km) to the Barnstable Switching Station.

The Massachusetts Natural Heritage Atlas (2003 Edition) and MassGIS data indicate that the proposed onshore transmission line route intersects three Priority/Estimated Habitats of rare species at the following locations:

- Along Higgins Crowell Road, in the vicinity of Jabinettes Pond (PH 1617/WH 7288);
- Along Higgins Crowell Road, northwest of the Middle School (PH 1605/WH 7286); and
- Along Willow Street and the NSTAR Electric ROW, in the vicinity of Long Pond (PH 1567/WH 199).

According to NHESP, these three rare species polygons may contain or be utilized by the following nine state-listed plant species and five state-listed wildlife species (see Figure 5.6-1 and Appendix 5.6-A):

State-Listed Plants
1. Inundated Horned-sedge (*Rhynchospora inundata*), a threatened species;
2. Long-beaked Bald-sedge (*Rhynchospora scirpoides*), a species of special concern;
3. Plymouth Gentian (*Sabatia kennedyana*), a species of special concern;
4. Terete Arrowhead (*Sagittaria teres*), a species of special concern;
5. Wright's Panic-grass (*Dichanthelium wrightianum*), a species of special concern;
6. Common's Panic-grass (*Dichanthelium commonsonianum*), a species of special concern;
7. Mattamuskeet Panic-grass (*Dichanthelium mattamuskeetense*), an endangered species;
8. Pondshore Knotweed (*Polygonum puritanorum*), a species of special concern; and
9. Redroot (*Lachnanthes carolina*), a species of special concern.

State-Listed Wildlife
1. Comet Darner (*Anax longipes*), a species of special concern;
2. New England Bluet (*Enallagma laterale*), a species of special concern;
3. Scarlet Bluet (*Enallagma pictum*), a threatened species;
4. Pine Barrens Bluet (*Enallagma recurvatum*), a threatened species; and
5. Water-willow Stem Borer (*Papaipema sulphurata*), a threatened species.

According to the most recent USFWS letters, there are no federally-listed or proposed threatened or endangered species located within the proposed onshore transmission line route to the Barnstable Switching Station, with the exception of the occasional transient bald eagle (*Haliaeetus leucocephalus*) (see Appendix 5.6-A).

5.6.3.1 Road Segment

Upland vegetated communities located adjacent to the roadway portion of the proposed transmission line route are primarily pitch pine-oak forests dominated by white oak (*Quercus alba*), pitch pine (*Pinus rigida*), scrub oak (*Quercus ilicifolia*), lowbush blueberry (*Vaccinium angustifolium*), and sassafras (*Sassafras albidum*). Soils in these areas were observed to be sandy and are mapped as Carver coarse sand and Carver loamy coarse sand (NRCS, 1993).

In addition to upland forested habitats, the land adjacent to the roadway route includes commercial and residential properties and wetland communities. These wetlands include Jabinettes Pond, Thornton Brook, red maple swamps, an Atlantic white cedar swamp, and a coastal plain pond. Detailed descriptions of these wetlands are provided in Section 5.8 (Coastal and Freshwater Wetland Resources).

The diverse vegetative community adjacent to the roadways is expected to support a diverse wildlife population, particularly in areas located away from development and busy roadway intersections. However, the Project area within the paved roadways and roadway shoulders is not expected to provide nesting, breeding, feeding, or overwintering habitat for wildlife species.

5.6.3.2 ROW Segment

Within the NSTAR Electric ROW, upland vegetation is maintained as scrub/shrub community, with the primary cover consisting of interspersed woody and herbaceous species that vary in density along the ROW. Common species observed include black oak, sassafras, greenbrier (*Smilax glauca*), bearberry (*Arctostaphylos uva-uri*), poison ivy (*Toxicodendron radicans*), and knapweed (*Centaurea jacea*). Soils along the ROW consist of medium to coarse sands, and are mapped as Plymouth-Barnstable complex, very bouldery (NRCS, 1993).

As a result of "edge effect," the maintained NSTAR Electric ROW is likely to provide habitat for a diverse, but not unique, wildlife community. The vegetated uplands within the ROW are expected to provide habitat for a variety of snakes, songbirds, birds-of-prey, and rodents. In addition, white-tailed deer (*Odocoileus virginianus*), red fox (*Vulpes vulpes*), coyote (*Canis lupis*), Virginia opossum (*Didelphis virginiana*), striped skunk (*Mephitis mephitis*) and raccoon (*Procyon lotor*) are expected to utilize the ROW for browsing and/or hunting. The adjacent Long Pond, located near the intersection of Willow Street and the ROW, may support populations of turtles, amphibians, aquatic insects, and waterfowl, which may use the ROW for nesting or feeding.

5.6.3.3 Bats

Southeastern Massachusetts is included in the range of seven bat species (DeGraaf and Yamasaki, 2001). These species are the big brown bat (*Eptesicus fuscus*), red bat (*Lasiurus borealis*), northern myotis (*Myotis septentrionalis*), eastern pipistrelle (*Pipistrellus subflavus*), little brown myotis (Myotis lucifugus), silver haired bat (*Lasionycteris noctivagans*), and hoary bat (*Lasiurus cinereus*). Four of these species were documented during surveys within the Camp Edwards portion of MMR in 1999 and 2000, including the big brown bat, red bat, northern myotis, and the eastern pipistrelle (Massachusetts Army National Guard, 2001). The distance from MMR to the Barnstable Switching Station is approximately 14 miles (22.5 km); MMR to the proposed landfall is approximately 16 miles (25.7 km); and the distance from MMR to the closest point of the proposed Wind Park (at Horseshoe Shoal) is approximately 14.5 miles (23.3 km).

Due to their generally robust populations throughout their ranges, none of these bats are listed on the Massachusetts or federal lists of rare, threatened, or endangered species. Most of the seven bat species that occur in southeastern Massachusetts are classified as "uncommon to rare" in the southeastern Massachusetts portion of their ranges, and are not known to spend substantial periods over large bodies of open water such as Nantucket Sound (DeGraaf and Yamasaki, 2001). The characteristics of each are summarized below.

Big Brown Bat

The big brown bat inhabits cities, towns, and rural areas, and is less commonly found in heavily forested regions (Mulheisen and Berry, 2000). This bat tends to be a habitat generalist, using a variety of hardwood and softwood forests and features, especially still water, roads and trails, and regenerating shrub/sapling stands (DeGraaf and Yamasaki, 2001). This bat has been found in human dwellings, barns, silos, and churches, and has also been found roosting in storm sewers, expansion joint spaces in concrete athletic stadiums, and mines. Big brown bats breed from September through March, and the young are usually born in June. Hibernation begins in November. They usually travel no more than 30 to 50 miles (48.3 to 80.5 km) from maternity colonies to hibernation sites (Barbour and Davis, 1969; DeGraaf and Yamasaki, 2001; Kurta, 1995). Big brown bats feed primarily on coleopteran species, but also feed on a variety of insect prey. They forage at night, flying over a range of heights above ground from approximately 16 to 160 feet (4.9 to 49 meters) within approximately half a mile (0.8 km) of day roosts.

Red Bat

Red bats are fast flying bats that live throughout the Americas (Myers, 2000). They tend to choose habitats that are sparsely to moderately populated by humans, and are rare in heavily urbanized areas. Similar to the brown bat, the red bat utilizes hardwood and softwood forests as well as features such as still water, roads and trails, and regenerating shrub/sapling stands. They begin foraging 1 to 2 hours after sunset. Red bats breed from August through September, and the young are born the following year in late May to early June (DeGraaf and Yamasaki, 2001). Red bats are migratory, arriving in the northern climates in mid-April and leaving in late October. They would usually winter from Maryland to the Gulf States, typically hibernating in hollow trees and

choose roosting sites in dense foliage. Red bats are strong fliers, and are capable of covering great distances over water. They have been observed on Martha's Vineyard (DeGraaf and Yamasaki, 2001).

Northern Myotis

The northern myotis is largely associated with boreal forests (Ollendorff, 2002). In areas of North America and Canada, this bat roosts in buildings, under exfoliating bark, and in the cavities of trees. Caves and underground mines are its choice sites for hibernating. The northern myotis forages over ponds and clearings within forests, below tree canopy but above the shrub layer (DeGraaf and Yamasaki, 2001).

Eastern Pipistrelle

The eastern pipistrelle forages over streams and ponds and at the forest-field edge (Myers, 1999). Summer roosts are usually caves or mines, except in colder northern areas, where pipistrelles may be found in houses or hollow trees during summer months. The eastern pipistrelle performs short annual migrations between winter hibernation and summer nursery sites. Such travel is not known to exceed 50 miles (80.5 km), and averages 31 miles (49.9 km) or less (Snyder, undated). The eastern pipistrelle forages over water and along forest-field edges and typically avoids dense forests (DeGraaf and Yamasaki, 2001). It prefers to feed over rivers, pastures, and high in bordering trees and feeds on flies, beetles, ants, bugs, moths and wasps. They have been observed on Martha's Vineyard (DeGraaf and Yamasaki, 2001).

Little Brown Myotis

The little brown myotis forages over streams and ponds, where its diet consists of aquatic insects (mainly midges, mosquitoes, mayflies, and caddisflies) (DeGraaf and Yamasaki, 2001). This bat also feeds over forest trails and lakes in a forest-dominated landscape. The little brown myotis consumes beetles, moths, stoneflies, true bugs, and termites. Breeding occurs from September to October, and the young are born from mid-June to early July. The little brown myotis seeks cavities for shelter, roosting, and brooding. In summer, females brood their young in dark, warm sites such as barns, attics, caves, hollow tree cavities, and other protected areas. Roost sites are highly variable and not well known. Little brown myotis hibernate in clusters during the winter months. Caves or mines are preferred, but large tree cavities with favorable microclimates may be used (Snyder, undated).

Silver-Haired Bat

The silver-haired bat forages in mixed, coniferous and hardwood forest areas near lakes, streams, and ponds (DeGraaf and Yamasaki, 2001). This bat forages for emerging aquatic insects, flies, beetles, and moths often less than 20 feet (6.1 meters) above the surface. Foraging typically occurs around sunset. The silver-haired bat breeds in late September, and the young are born between June and July. Migration typically occurs in late October. The silver-haired bat migrates along coastal flyways in the northeast to the southern parts of its range before returning in April. They have been observed on Martha's Vineyard (DeGraaf and Yamasaki, 2001).

Hoary Bat

The hoary bat is found in forests, open cultivated areas, and small towns. It prefers coniferous forests but also utilizes woodland edges, deciduous woods, hedgerows, and trees in parks (DeGraaf and Yamasaki, 2001). Breeding occurs during September to November, and the young are born in late May to early June. The hoary bat begins foraging in the fifth hour after sunset, and tends to forage in uncluttered areas at heights 23 to 49 feet (7 to 15 meters) above the ground. It migrates to the southern United States and Central America during winter months.

5.6.4 Analysis of Impacts

The Project has been planned, sited, and designed to avoid or minimize impacts to protected species and their mapped habitats within the Project area. The proposed route is configured to utilize previously developed or disturbed transportation and utility corridors providing limited function for wildlife. While limited localized impacts are anticipated during Project construction and decommissioning, measures would be implemented to prevent and minimize these impacts. These measures include the location of the transmission line system below grade within existing roadways and rights-of-way (ROWs), and pre-construction monitoring to evaluate the presence of state-listed rare species within the Project area (see Section 6.0). Potential impacts and mitigation measures related to construction/decommissioning, operation, and maintenance of the Project are discussed in Section 5.6.5.

5.6.4.1 Potential Impacts Outside of Massachusetts Waters

This section is not applicable to terrestrial ecology, wildlife, and protected species. Potential impacts to bats associated with the Project are discussed below in Section 5.6.4.2.3.

5.6.4.2 Potential Impacts Inside of Massachusetts Waters and Onshore

Other than the resources discussed below and birds (discussed in Section 5.7), no other terrestrial areas occur inside of Massachusetts waters and no impacts would occur to terrestrial species.

5.6.4.2.1 Upland

Impacts to wildlife and vegetation communities from installation and operation along the proposed onshore transmission line route would be minimal, as all of the onshore portion of the transmission line system would be located below grade within existing roadways, roadway shoulders, and maintained ROWs.

Road Segment

As described in Section 4.0, the installation of the underground ductbank, transmission line, and underground vaults/manholes would require a minimum 10-foot (3-meter) wide trench to be excavated over approximately 4 miles (6.4 km) of existing roadways from the landfall at New Hampshire Avenue to the intersection of Willow Street and the NSTAR Electric ROW. This work would require the excavation of approximately 4.9 acres/213,444 square feet (19,830 square meters) of paved roadway and roadway shoulders.

According to the NHESP, the proposed transmission line route from the landfall to the NSTAR Electric ROW would traverse two habitats of state-listed rare species: PH 1617/WH 7288 at Jabinettes Pond; and PH 1605/WH 7286 at a coastal plain pond that discharges into Hawes Run. Since this portion of the route would be located within existing paved roadways and removal of vegetation is not required, no impacts to state-listed species within these habitats are anticipated.

ROW Segment

From Willow Street, the onshore transmission cable route would be installed within the existing NSTAR Electric ROW for approximately 1.9 miles (3.1 km) to the Barnstable Switching Station. The NSTAR Electric ROW is actively managed in accordance with NSTAR's routine vegetation management program.

The proposed onshore transmission cable route within the NSTAR Electric ROW would be installed using the same general methods used for the road route described above. The excavated trench would be a minimum of 8 feet (2.4 meter) wide over approximately 1.9 miles (3.1 km) from Willow Street to the Barnstable Switching Station. Approximately 36 manholes, associated with nine pairs of parallel vaults, would be required within the ROW. The manhole covers would be flush with the surface of the ground, to allow access for maintenance and repairs. After the installation of the transmission line is complete, the excavation would be backfilled to the original grade and the area would be seeded with an erosion control seed mixture for stabilization. The total width of workspace disturbance would be approximately 25 feet (7.6 meters), including construction access, laydown areas, and the 8-foot (2.4-meter) wide trench. This work would require the temporary disturbance of approximately 5.8 acres/252,648 square feet (23,471.6 square meters) of vegetation within the maintained ROW. A trench dewatering plan, if required, would be prepared and appended to the appropriate federal, state, and local permit applications. No additional land would be required at the Barnstable Switching Station; the existing Barnstable Switching Station property can accommodate the addition of the proposed transmission cable.

According to the NHESP, the proposed route along the ROW would traverse one state-listed rare species habitat, PH 1567/WH 439 at Long Pond. Of the 10 rare species that NHESP has mapped along this portion of the NSTAR Electric ROW, all are water-dependent species and are typically found only in coastal plain ponds. Because the proposed transmission line in this area would be more than 100 feet (30.5 meters) from all wetland areas, it is highly unlikely that these species occur within the uplands that would be temporarily disturbed by installation of the proposed transmission line. Furthermore, the entire proposed transmission line route is within a previously-disturbed ROW that regularly undergoes vegetative maintenance. Areas disturbed by construction and

decommissioning would be revegetated by seeding with an erosion control seed mixture. Therefore, no long-term adverse impacts to these rare species or their habitat are anticipated. Through the use of best management practices for stormwater runoff and erosion control as well as a project SPCC Plan, no soils or material from spills would enter Long Pond, which is located approximately 190 feet from the closest cable.

Temporary displacement and avoidance of active construction areas would have a localized and minor affect on wildlife present along the ROW route by causing them to temporarily abandon feeding, breeding, and resting activities. Small mammals, reptiles, and amphibians that utilize upland areas adjacent to Long Pond may experience limited displacement or mortality during construction/decommissioning, and some foraging opportunities for waterfowl and other wildlife may be lost for a season or two along the disturbed area until vegetation becomes reestablished. However, this represents a small fraction of the maintained ROW habitat available to these species, and these impacts would therefore not have a measurable affect on population levels. Most wildlife species are anticipated to move into similar nearby habitat areas until construction/decommissioning is completed and the disturbed areas become revegetated. The ROW is predominantly upland shrub habitat that is routinely maintained by NSTAR, including trimming of overhanging limbs of adjacent trees. It is anticipated that no mature trees would need to be cleared during Project construction or decommissioning.

A discussion of EMF and thermal affects on wildlife along the cable route and substation is provided in Section 5.13.

5.6.4.2.2 Wetland

No freshwater wetlands would be directly impacted by the proposed Project. Please refer to Section 5.8 for a complete description of the coastal and freshwater wetland resources and potential wetland impacts in the Project area.

5.6.4.2.3 Bats

Due to their generally robust populations throughout their ranges, none of the seven bat species that occur in southeastern Massachusetts (see Section 5.6.3.2) are listed on the Massachusetts or federal lists of rare, threatened, or endangered species. Most of the seven bat species that occur in southeastern Massachusetts are, however, uncommon in the southeastern Massachusetts portion of their ranges and are not known to spend substantial periods over large bodies of open water such as Nantucket Sound (DeGraaf and Yamasaki, 2001; Kurta, 1995). The land-based roosting, breeding, and foraging behavior of these bats (DeGraaf and Yamasaki, 2001), as well as their limited home ranges and echolocation sensory systems, suggest that the number of bats likely to be at risk of collision with wind turbines in the Nantucket Sound Project area is extremely low. Furthermore, these bats are unlikely to expend energy unnecessarily to forage over central Nantucket Sound, when their primary prey items (various insects) are generally found inland and in coastal areas.

Although bats have relatively good eyesight, most depend on a highly developed echolocation system to navigate, avoid obstacles, and capture insects in the dark (Harvey et al., 1999). Bats emit pulses of very high-frequency sound (inaudible to human ears) at a rate of a few to 200 per second, depending on the species. By using echolocation, bats can discern objects in their path by listening to the echoes reflected back to them (Witt, 1999). Bat echolocation and collision mortality studies suggest that only a small fraction of detected bat passes near turbines result in collisions (Johnson et al., 2002). Given that bats can detect large landscape and background features using echolocation at distances up to 328 feet (100 meters) (Griffin, 1970; Suthers, 1970), it seems unlikely that foraging bats would be unable to detect turbines. In addition, studies of captive hoary bats have shown that they are able to avoid colliding with moving objects more successfully than stationary ones (Jen and McCarty, 1978). In studies of foraging bats at the National Wind Technology Center in Golden, Colorado and a European wind park, bats were observed foraging within close proximity (1 meter in the European study) of an operating wind turbine, yet no mortality was documented (U.S. Department of Energy, 2002; Bach et al., 1999). Therefore, although a small number of bats may cross Nantucket Sound on an infrequent basis either during migration or local flights (although this would be uncommon), bats crossing the Sound should be capable of using echolocation to avoid wind turbines.

In studies of inland wind farms and bats, relatively few bat mortalities were recorded compared to local bat populations (e.g., Howe et al., 2002), and resident bat populations seemed to be at substantially less risk of collision with wind turbines than were migrants (West, 2002). Comparative study data from areas with relatively large numbers of bat species near turbines suggest that bat collision mortality during breeding season was "virtually non-existent" (West, 2002). During the breeding season, many of the bats found in southeastern Massachusetts tend to remain in close proximity to maternity colonies and roosting areas (e.g., Paradiso, 1969; Jackson, 1961). Therefore, the wind park is not expected to impact breeding populations. Based on the bat behavioral studies reviewed by West (2002), hoary and eastern red bats typically forage from treetop level to within a meter of the ground, silver-haired bats spend most of their time foraging at heights less than 19.7 feet (6 meters), and big brown bats forage from 23 feet (7 meters) to 33 feet (10 meters) above ground (Barclay, 1984; Fitzgerald et al., 1994). Little brown bats forage almost exclusively less than 16.5 feet (5 meters) above the ground (Fenton and Bell, 1979).

Most bat mortality documented at wind plants in the United States occurred in late summer and early fall and involved migrant or dispersing bats. Most of the recorded fatalities were comprised of migratory tree and foliage roosting bats, of which the hoary and eastern red bat were the most prominent species in the eastern United States and the Midwest (West, 2002). However, both hoary and eastern red bats prefer to forage over sites with woody plant cover and are positively associated with edge situations (Furlonger et al., 1987), neither of which is present in Nantucket Sound.

Migration behavior varies among the bats with range in southeastern Massachusetts. The eastern pipistrelle migrates less than 30 miles (48.3 km), generally over land, between its maternity colonies and hibernation sites (Kurta, 1995). Other species migrate from New England to their southern ranges, from the mid-Atlantic states to Central America. Although the migration patterns of these bats are not well-documented, central Nantucket Sound is not documented as a bat flyway. In addition, many species of bats make extensive use of linear features in the landscape such as ridges or rivers while commuting (Limpens and Kapteyn, 1991) and migrating (Humphrey and Cope, 1976; Timm, 1989), which may indicate a preference for overland migration routes. There is little information available about the heights at which bats migrate, however, Altringham (1996) reported that at least some groups of bats are known to migrate at altitudes higher than the Project rotor swept zone (i.e., above 417 feet (127 meters))

With regard to lighting of turbines and towers, this does not appear to affect bat collision rates. FAA lighting on turbines was not found to increase the probability of bat collisions at the Buffalo Ridge, Minnesota Phase III site (West, 2002).

In general, the collision risk to bats is expected to be minimal and similar to the risk from collision with other vertical structures including communication towers and lighthouses. Central Nantucket Sound is not preferred habitat for bats (DeGraaf and Yamasaki, 2001), so the potential collision risk of the Project to land-based resident bats would likely be extremely low. The bats that occur in southeastern Massachusetts generally prefer upland areas, have limited home ranges, and are unlikely to cross large open waterbodies like Nantucket Sound in large numbers or on a regular basis. While there may be limited collision risk for migratory bats, central Nantucket Sound is not known to be a bat flyway and bats' echolocation systems and other sensory mechanisms allow them to avoid obstacles such as wind turbines. In upland portions of the Project area, the transmission line system would be located below grade within existing roadways, roadway shoulders, and maintained ROWs. No tree clearing is proposed that would affect bat habitat.

5.6.4.3 Cumulative Impacts

In addition to the proposed Project, other activities in the past present or future which may contribute to cumulative impacts to terrestrial ecology, wildlife or protected species would include other upland cable or pipeline installations, excavation activities, construction of new commercial and residential structures, and other wind installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative). The cumulative impact from one potential activity that may occur within the location and timeframe of the proposed Project is discussed below.

There are no significant cumulative impacts to terrestrial ecology, wildlife, or protected species anticipated that would result from the installation of the onshore transmission line. Based on discussions with the Town of Yarmouth DPW and the MHD there are no other major projects scheduled for the vicinity and estimated construction timeframe for the onshore cable route. There are also no significant cumulative impacts expected should the onshore portion of National Grid's Nantucket Cable be installed at the same time of the onshore portion as the Project's cable system. The proposed Nantucket Cable's onshore route is more than a mile distant from the Project's proposed route and would pass through the central portion of Hyannis, while the Project's onshore route bypasses the center of town to the east.

5.6.4.4 Secondary Impacts

There are no potential onshore secondary impacts to terrestrial ecology, wildlife, or protected species associated with construction staging/laydown or decommissioning activities at Quonset. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy and no significant land alteration would be necessary to accommodate the Project's staging activities.

5.6.5 Mitigation

The Applicant would coordinate with the Yarmouth and Barnstable Conservation Commissions, the MADEP, and NHESP, as appropriate, to prevent impacts to state-listed species as part of the Project. Best management practices for sedimentation and erosion control and stormwater management would be employed during construction/decommissioning activities since these practices are required under NPDES construction stormwater permit general requirements. NPDES permit approval would be obtained prior to the start of construction. This would minimize the potential for indirect impacts to habitats off the proposed right-of-way. In addition, an SPCCP would be developed, as required by the NPDES permit requirements, to address the potential for accidental or unintentional spills and releases of potential pollutants, such as hydraulic fluid or diesel fuel. A pre-construction survey would be performed to document the occurrence of state-listed rare species along the NSTAR Electric ROW route. Should a state-listed species be located within the proposed transmission line route, a Conservation Permit under MESA would be obtained and efforts would be made to eliminate, minimize, or mitigate for any potential impacts. Site- and species-specific habitat requirements would be incorporated into the construction methods for the proposed route in order to avoid impacts to the state-listed plant and animal species and habitat. Post-construction monitoring would document habitat disturbance and recovery.

5.7 Avian Resources

5.7.1 Introduction

This section describes existing avian resources and potential impacts to birds and bird habitat within the Project area. The information was obtained from extensive literature reviews, several agency consultations, and recent multi-year site investigations and field surveys. Descriptions of the current avian resources in the Project area include information about the species, number, types of use and activities, and spatial and temporal patterns. The literature review yielded useful information regarding bird migration; bird flight during storms, foul weather, and fog conditions; food availability; predation; benthic habitat and benthic food sources; and the predator-prey interconnections between benthic, fisheries, and avian resources. The literature reviewed is cited either in this section, or in one or more of the thirteen (13) appendices that are included as supporting documentation for this section.

There are two Federal regulatory programs involved in the management and protection of avian resources under which the Project's potential impacts were assessed. Bird species listed by the USFWS as threatened or endangered under the Endangered Species Act are described and potential impacts assessed in this section of the DEIS. In addition, there are numerous bird species protected by the USFWS under the Migratory Bird Treaty Act, which are also addressed in this section.

Nantucket Sound is rich in avian and other wildlife resources, with hundreds of thousands of birds in residence, at least part of the year, and millions migrating through each spring and fall. The Sound is located within the

Atlantic flyway, and its particular location relative to the Gulf Stream and the Atlantic currents, its unique configuration of continental landforms, the input of continental waters, and the region's climate combine to attract millions of birds, fish, and other wildlife to its waters year-round. Two federally listed bird species--roseate tern and piping plover--are summer residents and migrate through the Sound twice-yearly.

Although incidental observations of birds in Nantucket Sound have been made over many years (Veit and Petersen, 1993), no systematic, quantitative studies have been conducted in the central portion of the Sound where the Project is proposed. The Applicant undertook quantitative studies over the period between 2001 and 2004 to more fully characterize the avian resource in the Project area and its surroundings. An initial avian risk assessment, derived from existing literature, reports, and databases, is discussed in Section 5.7.2.2.1. Taken together, the initial risk assessment and the knowledge accrued during the subsequent field investigations and further literature searches, advances the understanding of the spatial and temporal distribution of avian species within the Project area. It is with this sum of knowledge that the avian resource is characterized, potential impacts to birds from the Cape Wind Project have been evaluated, and possible mitigation measures are discussed.

A key element of the analysis of impacts of wind energy development on birds (and bats) is the concept of risk. An industry standard evaluation of risk via collision mortality is a function of avian use (no. birds/unit area/unit time), a measure of how much time birds spend in a given area; and the proportion of time spent flying at rotor height. Various quantitative measures are used including abundance, and abundance in the rotor swept area, as well as the number of birds/unit/unit time. Although these metrics are highly correlated with each other, they are not always correlated with risk for various reasons. Most importantly, risk is species and location specific. For example, some species simply do not fly into turbines, although their use/abundance in an area is high. Avian use of an area is a function of many biological and physical factors, including proximity to nesting sites, presence/absence of food, shelter or other habitat elements, possible displacement from other preferred habitats, etc. Time spent flying at rotor height is a function of the species (how much time it spends flying and at what heights it tends to fly), weather/wind, behavior (e.g, foraging, courtship, and migratory flight heights may all be different, and often are), etc. Other elements of risk include weather and season timing, because many of the large mortality episodes at communication towers have occurred during bad weather and because many birds migrate at night when it is more difficult to avoid obstacles. Predatory behavior by other birds (e.g., peregrine falcons) may contribute to a bird being at risk. Individual health and experience are also factors. These and other potential risk factors are addressed in the impact analysis presented below.

For compliance with Section 7 of the Endangered Species Act (ESA), a Biological Assessment (BA) is being prepared for two federally-listed avian species that occur within Nantucket Sound: the threatened Piping Plover (*Charadrius melodus*) and the endangered Roseate Tern (*Sterna dougallii*). The BA will be provided to the USFWS for their review of the project under the ESA. An evaluation of these two species has been prepared to support this EIS and provide readers a basic understanding of these two species relative to the proposed project (Appendix 5.7-H). A Biological Review (Appendix 5.7-I) was also prepared to address potential impacts to the Common Tern (*Sterna hirundo*), a State Species of Special Concern under the Massachusetts Endangered Species Act (MESA).

5.7.2 Existing Conditions

5.7.2.1 Overview

The open waters of Nantucket Sound are known to be an important wintering and migration-staging area for seaducks (eiders, scoters, and Long-tailed Ducks) that feed principally on bottom-dwelling invertebrates, as well as for diverse fish-eating species that vary by season, including mergansers, gulls, terns, loons, grebes, and others (Appendix 5.7-A). Roseate terns are known to be important members of this latter group in summer because they are frequently seen in Nantucket Sound and because of their federal and state protected status. The roseate tern is federally listed as endangered, while the common and least terns are state-listed species of special concern. In addition, many other species occur on or near the shores of the Sound, including shorebirds such as the federally threatened piping plover, wading birds, and other coastal waterbirds. Landbirds and other migrants (potentially numbering in the millions) pass over Nantucket Sound each spring and fall (Appendix 5.7-A). Nantucket Sound is located within the Atlantic flyway, and the shores of Cape Cod and surrounding islands,

particularly Monomoy Island, are important migratory stopover areas. According to Veit and Petersen (1993), Monomoy Island (approximately 12 nautical miles (22.2 km) northeast of the WTG site) is the most "spectacular" stopover area in Massachusetts. Migratory shorebirds feed on the flats at the north end of Monomoy while migrating passerines utilize ponds and thickets at the south end of the island (Veit and Petersen, 1993).

For this account, species are divided into two groups: waterbirds and landbirds. Waterbirds are defined as those species that spend the majority of their time in Nantucket Sound away from shore, and may be regular visitors to the study area for purposes of feeding or resting. Landbirds are defined as those species that spend the majority of their time near land or close to shore. In addition to species customarily recognized as "landbirds," this category includes shorebirds and wading birds, as well as migrants that pass overhead. These species may cross the study area and some could be affected by onshore and nearshore components of the Project.

5.7.2.2 Data Collection and Applicant Studies

Following the review of the initial avian risk assessment, additional studies were recommended to gain further knowledge about the spatial and temporal distribution of birds on Horseshoe Shoal and also two other shoal locations within Nantucket Sound. The studies also included areas outside these three shoal areas (Figure 5.7-1). These studies included direct observations, remote sensing, and additional literature reviews. The studies also provided further knowledge of the potential risks to birds from wind energy projects. Subsequent to the initiation of the Applicant's studies, Massachusetts Audubon Society (MAS) undertook field studies to obtain information on avian species composition and relative abundance. Federal and state cooperating agencies were consulted during the development of these studies. As fully presented in the Appendices, the following studies were used to describe avian resources on Horseshoe Shoal and the surrounding environs:

- Appendix 5.7-A: Preliminary Avian Risk Assessment for the Cape Wind Energy Project
- Appendix 5.7-B: A Comparison of the Years 2002-2003 with the Years 1989-2001, Using Historic Data on Winter Waterbirds
- Appendix 5.7-C: Preliminary aerial surveys conducted in July and September of 2001 to establish whether large numbers of terns and other summer species utilize the Project area.
- Appendix 5.7-D: Five aerial surveys and one boat survey conducted from March 17 through April 18, 2002.
- Appendix 5.7-E: Spring/Fall 2002 Avian Radar Studies for the Cape Wind Energy Project
- Appendix 5.7-F: Six aerial and seven boat surveys conducted from May 1 through August 30, 2002. Also included are results from 13 days of "ground-truthing" boat surveys conducted to complement the radar studies.
- Appendix 5.7-G: Eleven aerial and two boat surveys conducted from September 25, 2002 through February 21, 2003.
- Appendix 5.7-H: An Evaluation of Roseate Terns and Piping Plovers
- Appendix 5.7-I: Biological Review of the Common Tern for the Cape Wind Project
- Appendix 5.7-J: Bird Monitoring Using the Mobile Avian Radar System (MARS) Nantucket Sound, Massachusetts (Geo-Marine, Inc. Radar Report)
- Appendix 5.7-K: Six aerial surveys and one boat survey conducted from March 19, 2003 through June 2, 2003 and an additional aerial survey conducted outside Nantucket Sound on April 14, 2003.
- Appendix 5.7-L: Six aerial surveys and two boat surveys conducted from June 16, 2003 through August 29, 2003.
- Appendix 5.7-M: Twelve aerial surveys and one boat survey conducted from September 15, 2003 through February 27, 2004.

Additional summary descriptions of the investigation methods are provided below.

5.7.2.2.1 Initial Avian Risk Assessment

An initial avian risk assessment was conducted in 2001 to determine potential avian impacts from the Project. This initial assessment included a literature review of studies conducted at other offshore and onshore wind farm facilities located in the United States, Canada, and several European countries for which avian information was available. This assessment is titled Preliminary Avian Risk Assessment for the Cape Wind Energy Project and it is included in its entirety as Appendix 5.7-A.

The risk assessment included a description of known impacts at existing wind farms, the types of birds that frequent Nantucket Sound, known and suspected risk factors, and recommendations for further research. Because offshore wind farms are relatively new (the first was constructed in 1991), most of the available avian impact assessments are from land-based wind farm sites and less data is available assessing impacts offshore. However, due to some similarities in onshore and offshore wind farm configurations, many of the same principles and risk factors are likely to apply to both onshore and offshore projects. A summary of key findings of the initial risk assessment is presented below.

The two principal reported impacts to birds at existing wind power facilities are: (1) disturbance, displacement, or exclusion from suitable habitat; and (2) collision mortality resulting from the construction and presence of wind generation infrastructure. Minor displacement, disturbance and exclusion of birds at some terrestrial sites has been observed, although these findings are not consistent among sites and habituation to wind farm infrastructure has been observed frequently (Appendix 5.7-A).

Collision mortality has been studied intensively at approximately 12 onshore wind farms located in the United States (Appendix 5.7-A). The risk assessment found that the numbers of collision fatalities reported from wind farms are two to three orders of magnitude lower than those known to occur at guyed communication towers, tall buildings, windows, and highways (Erickson et al., 2001). The Erickson et al. (2001) studies of wind resource areas (WRAs) utilized wind turbine technology from both the 1980s and 1990s; he notes that newer generation wind plants that incorporate improvements in site planning and changes in the design in the wind turbines would reduce collision risk over that documented for the older technology evaluated (Erickson et al., 2001). To date, no population-level impacts have been documented as a result of avian collisions with onshore wind turbines, and no listed endangered or threatened species have been involved. The number of bird fatalities at the U.S. sites reviewed is low (see Appendix 5.7-A), with the exception of the Altamont Pass site in California where collisions of diurnal raptors have been reported (Orloff and Flannery, 1992).

Several factors differentiate the proposed Wind Park on Horseshoe Shoal from the existing facility at Altamont Pass:

- The Altamont Pass site has a large number and high density of turbines (approximately 69 WTGs per square mile (approximately 27 WTGs per km^2)), whereas the proposed Project would have 5.4 WTGs per square mile (2.1 WTGs per km^2);
- The Altamont Pass site has close spacing of turbines (as little as 80 feet (24 meters) between towers and 30 feet (9 meters) between adjacent turbine rotors, whereas the proposed Project would have spacing of approximately (2,066 to 3,281 feet (629 to 1,000 meters) between towers and 1,725 to 2,940 feet (526 to 896 meters) between turbine rotors;
- The Altamont Pass site has perch sites for raptors on turbines (lattice tower or accessible work platform), whereas the proposed Project would have tubular (monopole) towers; and
- The Altamont Pass site has highly dissected topography, with turbines placed on steep hillsides, whereas the WTGs for the proposed Project would be located on the ocean.

The initial assessment found that the risk to birds is likely to be low based primarily on the fact that, compared to locations on shore or immediately adjacent to shore, fewer birds use Horseshoe Shoal and those that do so are present for relatively short periods (seasonal) of time. It is important to note that the initial risk assessment also recognized that the information available on bird use of Horseshoe Shoal is quite limited and recommended additional studies to better assess risk to birds, particularly those species that may be present in the Project area for longer durations during the year. The assessment identified the need for further study of four groups of waterbirds (three species of terns, and several species of seaducks, seabirds, and diving birds) to establish how abundant they are and where they are distributed in the Project area and potential risks to these species. In response to the recommendations of the initial risk assessment, these species were intensively studied as part of the Cape Wind avian field studies conducted between 2001 and 2004. In addition, based upon the prospect of the Cape Wind project, MAS conducted aerial and boat surveys (funded by the Massachusetts Technology Collaborative) during the summers of 2002 and 2003 to study tern activity within Nantucket Sound (see Perkins et al 2003 and Perkins et al 2004). Findings from these reports are summarized below in section 5.7.2.2.2 and in Appendix 5.7-F, Appendix 5.7-H and Appendix 5.7-I.

The studies recommended in the initial risk assessment (Appendix 5.7-A) were undertaken to gain additional knowledge about the spatial and temporal distribution of birds on Horseshoe Shoal and also two other shoal locations within Nantucket Sound. The studies also included areas outside the three shoal alternatives (Figure 5.7-1). These studies included direct observations, remote sensing, and additional literature reviews. The studies also provided further knowledge of the potential risks to birds from wind energy projects.

5.7.2.2.2 Field Studies Conducted By the Applicant

This section describes the field survey program that was conducted by the Applicant, how the scope of these studies was established, the methods that were used, and how the results are presented. The findings of these field surveys have been incorporated into Section 5.7.2.3, with detailed results included as Appendices (Appendix 5.7-D, Appendix 5.7-F, Appendix 5.7-G, Appendix 5.7-K, Appendix 5.7-L and Appendix 5.7-M).

After receipt and review of the Preliminary Avian Risk Assessment (Appendix 5.7-A) in early 2001, including consultation with the cooperating agencies and the MAS, it was determined that additional studies of bird utilization of Nantucket Sound should include two designated alternative locations for the Wind Park in addition to the Proposed Site on Horseshoe Shoal. Further information regarding these alternative locations in Nantucket Sound can be found in Section 3.4.4. Studies were therefore planned not only for the Proposed Site on Horseshoe Shoal, but for an alternative site area near Monomoy-Handkerchief Shoal and another alternative site north of Tuckernuck Shoal and areas outside these three alternatives (Figure 5.7-1). The total area of Nantucket Sound is approximately 560 mi^2 (1,450 km^2), of which the study area consists of approximately 322 mi^2 (834 km^2), or 58% of the Sound. Horseshoe Shoal occupies approximately 42.5 mi^2, or 13% of the study area. Monomoy-Handkerchief Shoal consists of approximately 20.1 mi^2, or 6% of the study area, and Tuckernuck Shoal occupies approximately 34.4 mi^2, or 11% of the study area. In addition, radar studies of bird movements, especially during spring and fall migration periods, were also determined to be necessary.

Methods employed included: (1) preliminary aerial surveys to establish whether large numbers of terns and other summer species were present in the Project area; (2) systematic aerial surveys to examine quantitatively the numbers and distribution of waterbirds in the study area throughout the year; (3) boat surveys focused on waterbird distribution and behavior; (4) additional aerial observations of other parts of Nantucket Sound and adjacent areas to provide a context for the study area; (5) radar studies of bird movements during spring and fall migration periods; and (6) ground-truthing via direct observations, in conjunction with the radar operations, that contributed information about species presence and behavior. These field studies combined with existing literature on specific species behavior provide the necessary information to determine the spatial and temporal distribution of birds within Nantucket Sound. The results of the systematic surveys were assembled in six seasonal reports that combined the aerial and boat observations (Appendix 5.7-D, Appendix 5.7-F, Appendix 5.7-G, Appendix 5.7-K, Appendix 5.7-L, Appendix 5.7-M). The radar information was assembled into two reports focusing on the 2002 spring and fall migration seasons (Appendix 5.7-E and Appendix 5.7-J).

The information presented in this section and in the attached Appendices, has been compiled from systematic field surveys conducted in the period between March 2002 and February 2004, as well as preliminary studies conducted in July, September and December 2001. During the study period 54 aerial and 15 boat surveys were completed and 65 days of radar data were logged.

5.7.2.2.3 Aerial and Boat Surveys

Preliminary Aerial Surveys

Six preliminary aerial surveys were conducted during July and September 2001 to establish whether large numbers of terns were present in the Project area or likely to travel through the Project area. These preliminary surveys were conducted during the chick feeding period (June through mid-July) and pre-migratory staging period (August through mid-September). During these two periods, the federally endangered roseate tern is principally located, respectively, in northern Buzzards Bay (colonies on Bird Island in Marion and Ram Island in Mattapoisett) and at a pre-migratory staging area centered at a roost on South Beach, Chatham.

For these exploratory surveys, the approach selected was to visit oceanographic features such as shoals known to be preferred by foraging terns, both within and around Horseshoe Shoal, and intervening non-shoal areas, and to identify and count all terns observed. The purpose was to maximize encounters rather than to establish densities. The surveys showed that both Roseate and Common Terns occurred in Nantucket Sound during both periods, but found no evidence that the terns flew frequently over Horseshoe Shoal. The report from these surveys is attached as Appendix 5.7-C.

In December 2001, two additional flights were conducted to determine the presence and distribution of wintering waterbirds, such as eiders, scoter and long-tailed ducks. The purpose of these flights was to assist with delineating the area in the central portion of Nantucket Sound to be used in all subsequent aerial surveys that included the Proposed Site, other study areas, and an adequate surrounding area (Figure 5.7-1). The boundaries of the study area were designed to include all areas under study and surrounding waters sufficient to characterize the avifauna of the offshore parts of the Sound. This study area excludes the majority of waters within 1.2 miles (2 km) of land, because areas close to shore commonly have a different avifaunal community from the principal areas of concern. A small portion near the southern edge of the study area, approximately 5 mi^2 (13 km^2), was within 1.2 miles (2 km) of land (near Muskeget Island) in order to get adequate coverage of the alternative shoal located in this area.

Systematic Aerial Surveys

After conducting the preliminary aerial surveys and establishing the study area (Figure 5.7-1), 22 systematic aerial surveys for waterbirds were conducted during the first complete study-year (March 2002 to February 2003), and another 24 surveys were flown from March 2003 through February 2004. The principal purpose of these aerial surveys was to characterize the spatial and temporal distribution of avian species within Nantucket Sound by measuring bird densities (individuals/km) along 16 north/south transects of the study area. The altitude of flying birds was also estimated by the observer in relation to the survey plane and the water.

The total distance flown for each of the aerial surveys was approximately 258 linear miles (415 km). The surveys were conducted at an altitude of about 250 feet (75 meters), which was chosen as the lowest possible altitude in order to observe individuals clearly down to sea level with minimal disturbance to bird behavior. The 250-foot (75-meters) altitude corresponds approximately to the rotor hub height of the WTGs. Birds were counted and identified along transects spaced 1.2 miles (2 km) apart over a distance of 656 feet (200 meters) on each side of the transect (a total of 1,312 feet (~400 meters) except for the small area immediately below the plane) resulting in a total area surveyed of approximately 65 mi^2 (168 km^2) for each survey (Table 5.7-1). As shown in Table 5.7-1, a minimum of 19% of each shoal studied was sampled during each survey. This percentage of area surveyed was derived by multiplying the distance flown along each transect by the distance observed on each side of the plane (within which all birds were counted), and dividing by the total area of each shoal area being studied. A sample size of 19% is sufficient for estimating population densities (Norton-Griffiths, 1978). Surveys were flown at different times of the day, at different tides, and in somewhat varying weather (Table 5.7-2), but visibility was good or excellent during every survey (surveys were not conducted in inclement weather nor at night). Flights were also varied in their starting point and direction of flight.

A summary of the results from these aerial surveys is included in Section 5.7.2.4. Detailed results, field data, and distribution maps for these surveys are contained in Appendices 5.7-D, F, G, K, L and M.

Opportunistic Extended Aerial Surveys and Additional Aerial Surveys Outside the Study Area

Additional direct observations of birds were made in nearby areas to provide a wider context for the observations made in the principal study area and to identify the species that are present closer to shore. These additional observations included opportunistic extensions of 42 of the 46 systematic regular aerial surveys, principally along selected shorelines of Nantucket Sound, Vineyard Sound and Buzzards Bay. The results of these extended observations are presented in Appendices 5.7-F, 5.7-G, 5.7-K, 5.7-L and 5.7-M. One systematic survey of areas outside of Nantucket Sound was conducted on April 14, 2003 using the same observation methods as the systematic aerial surveys of the study area to determine avian density outside Nantucket Sound.

Boat Surveys

Boat surveys were conducted to supplement the aerial surveys and to enable closer study of the behavior of the birds encountered, especially with regard to reaction to the boat. The boat surveys were conducted on different

days than the aerial surveys during the same study period, and generally did not follow the predetermined transects established for the flights. Observations were recorded on species presence, as well as their numbers, altitude, direction of flight, and other behaviors. The altitude of flying birds was estimated in relation to the boat. A summary of the results from the boat surveys is included in Section 5.7.2.4. Detailed results for these surveys are contained in Appendices 5.7-D, 5.7-F, 5.7-G, 5.7-K, 5.7-L and 5.7-M.

5.7.2.2.4 Radar Study of Spring and Fall Migration

Radar studies were conducted during spring and fall migrations of 2002 to provide further knowledge regarding the abundance and behavior of birds that migrate through, forage in, and rest within the Project area. Radar has the ability to detect birds at greater ranges than the human eye (even when assisted with binoculars), as well as to measure behavioral attributes of birds. For example, radar can detect birds at several miles during a variety of conditions in fog, and even, sometimes, rainy conditions. Radar can also measure altitude, speed and flight direction. Radar can provide an indication as to the number and behavior of birds that use an area in a more thorough and efficient manner than other technologies, especially with respect to night migrating species. Marine surveillance and vertical radars were used to measure the numbers of birds present within the radar range during spring and fall migration periods, as well as their behavioral patterns when present.

Although radar data has not been validated as a reliable means of assessing risk to birds, it can provide information about abundance and behavior of birds at times of day and in places where direct visual observations are not possible. In that way, radar information, when considered with other the data sources used, may help to assess potential Project-related risk to birds. However, it must be pointed out that radar does have limitations in that it is unable to determine what the target on the screen represents. For example, each target may represent an individual bird, a flock of smaller birds, insects or bats.

Behaviors examined as part of the migration radar study included flight in various weather conditions (clear, foggy, and rainy), height and direction of flight, and characteristics of flight during day and night. The radar studies were conducted from May 8 to June 7, 2002, the peak spring migration period for most night-migrating songbirds and shorebirds (Veit and Petersen, 1993) and from September 3 to 30, 2002, the peak fall migration period for most night-migrating songbirds, terns and shorebirds (Veit and Petersen, 1993).

An avian radar specialist, Geo-Marine, Inc., utilized a Mobile Avian Radar System (MARS) to collect data on the movement of birds in the area. A MARS simultaneously employs two standard marine radar systems for detecting birds (see Appendix 5.7-J). The first radar, referred to as "TracScan" (a Furuno 1420, 30 kW, S-band (9.8 cm wavelength)) rotates horizontally through 360 degrees, to detect targets out to 4 nautical miles, measuring bird size, flight speed and direction. The second radar, a "VerCat" (a Furuno 1525, 25 kW, X-band (3.2 cm wavelength)), is tilted on its side to scan vertically and rotates in an east-west direction. The VerCat measures the altitude of targets passing within ¾ mile (1.2 km) of the radar from the top of the radar (in this case, 23-36 feet (7-11 meters) above mean sea level (asl)) up to 9,000 feet (2,743 meters) asl.

During aerial and boat surveys (and presumably during the radar observations as well), the majority (>90%) of birds (mostly seabirds and other waterbirds – loons, terns, etc.) were observed on the water or flying at altitudes below the lowest range of the radar. Therefore, a large percentage of birds flying below the rotor swept zone were probably not tracked by the radar.

The data were collected and analyzed to provide the following information about birds within the radar range:

- Numbers of birds aloft during one month each of the spring and fall migration seasons;
  - Types of migrants (small/slow-moving targets – mostly migrating songbirds and some foraging birds like gulls and terns vs. larger/faster-moving targets such as waterfowl like seaducks, shorebirds, loons, cormorants, etc.);
  - Numbers and types of birds aloft in day and night;
  - Numbers and types of birds aloft in different weather conditions (clear vs. fog vs. rain);
- Behavioral attributes of birds aloft during spring and fall migration seasons;

  - Numbers and types of birds that fly in different altitudinal strata during day and night (specifically the approximate 75 to 417 foot (23 to 127 meters) height range of the proposed turbine rotors, also referred to as the "rotor swept zone");
  - Direction of birds during day and night; and
- Description and quantification of large bird concentrations (large flocks migrating) and behaviors (gulls feeding and following fishing trawlers) and a determination as to whether these represent a potential risk to the birds involved.

Of particular interest were the relative and absolute numbers of birds of different types aloft over Nantucket Sound within radar range in fog and rain conditions, during both day and night. During inclement weather, some birds have greater difficulty avoiding obstacles, particularly at night (Erickson et al., 2001).

The spring 2002 radar survey was conducted offshore from aboard a 64-foot (19.5-meter) jack-up barge positioned at the southern edge of Horseshoe Shoal and "lifted" approximately 15 feet (4.6 meters) asl to provide a stable platform for the radar. Targets above approximately 23 feet (7 meters) asl were tracked. The fall 2002 radar study used the same basic protocols as those used during the Spring 2002 survey, except the fall 2002 study was land-based, at the northeast corner of Cape Poge, Martha's Vineyard (proximate to the Proposed Site and well-suited to observing migration for landbirds that had already begun flight). In the fall, the MARS system was located approximately 7 miles (11.2 km) southwest of the spring survey site on a bluff approximately 28 feet (8.5 meters) asl. Targets above approximately 36 feet (11 meters) asl were tracked.

During spring and fall 2002, a total of 1,837 hours of radar observation data were collected with the TracScan and VerCat radars. Observations were made during clear, rainy, and foggy conditions during both seasons. The majority of observations were conducted during clear conditions. During spring, TracScan data under rainy and foggy (not clear) conditions during the day and night accounted for 27.4% of the total radar time, and VerCat data under rainy and foggy (not clear) conditions during the day and night accounted for 25.3% of the total radar time. During fall, TracScan and VerCat data under rainy and foggy (not clear) conditions during day and night accounted for 24.7% and 25.0% of the total radar time, respectively.

Radar study results are discussed in Section 5.7.2.3.3, and a report detailing the results of the spring and fall radar studies is attached as Appendix 5.7-E ("Spring/Fall 2002 Avian Radar Studies for the Cape Wind Energy Project Nantucket Sound").

5.7.2.2.5 Validation of Representative Study Years

To validate whether the field studies occurred in years considered to have typical abundance levels of bird species in Nantucket Sound, existing databases from independent entities were reviewed to compare avian numbers in 2002 and 2003 with numbers over a longer period of time. The unusually warm temperatures experienced during the winter of 2002, estimated to be the warmest winter on record in New England, raised concerns whether the data collected during the winter of 2002 would be representative of a typical year based on historical observations. The following winter of 2003 was an usually cold winter with periods of ice cover in portions of Nantucket Sound.

The available databases from the vicinity of the Project area focused on winter waterbird and waterfowl inventories and included the MassWildlife/U.S. Fish and Wildlife Service (USFWS) annual mid-winter waterfowl inventory and National Audubon Christmas Bird Counts (CBC). The data on winter waterbirds from these inventories were used to compare the years 2002 and 2003 with the preceding 13-year period (1989 to 2001). Even considering the range of variation of winter weather conditions, this 13-year period was considered to be sufficient to encompass the range of year-to-year variation characteristic of modern waterfowl populations.

These inventories were evaluated to determine whether the total abundance levels for each species in 2002 and 2003 fell within the 95% confidence interval about the mean for each species during the previous 13-year period, or whether the data from 2002 and 2003 were above or below this interval. If the total number of a species observed in 2002 or 2003 fell within or above the 95% confidence interval identified above, these data were considered typical of winter abundances because they indicate that the same number or more birds were present in the years 2002 and 2003 compared to the previous 13 years.

Overall, this analysis demonstrated that the number of waterfowl and other waterbirds reported in the Audubon CBCs and MassWildlife surveys during the winters of 2002 and 2003, in general, represented typical abundance levels when compared to the abundance levels reported over the previous 13-year period. Based on this analysis, it can be inferred that the Cape Wind 2002 and 2003 avian field surveys were conducted in Nantucket Sound when waterfowl and waterbird species were present in generally typical numbers, and reflected abundances that are not significantly different from those found in most years. Thus, the 2002 and 2003 surveys were found to be reliable and valid indicators of the abundance of winter waterbird species in this area. Additional details of this statistical evaluation are provided in Appendix 5.7-B.

5.7.2.3 Results From Data Collected for this EIS

Between March 2002 and February 2004, 42 bird species were documented within the study area during the aerial and boat-based surveys (Tables 5.7-3, 5.7-4 and 5.7-5)(Figure 5.7-1). Figures 5.7-2 through 5.7-14 depict the 13 most abundant species/species group and the numbers of individuals observed within the entire study area during the 46 aerial surveys. During aerial and boat surveys, roughly 90% (more than 371,000 of 412,418) of the birds observed (mostly seabirds and other waterbirds) were on the water or flying at heights below 23 ft.

5.7.2.3.1 Waterbirds

Loons. Two species of loons (common and red-throated) were present in the study area in substantial numbers from November to May, and common loons were present in fewer numbers through the summer (June to August). The two species were not always distinguishable, and numbers are combined for this report. A total of 8,844 loons were observed within the study area during the study years, with peak numbers observed during the March 29 and April 5, 2002 (Appendix 5.7-D, Figure 5.7-2) and April 23, 2003 (Appendix 5.7-K, Figure 5.7-2) aerial surveys. Thereafter, numbers observed dropped to nearly zero until November when their numbers increased considerably. In late December, numbers observed dropped off once more and began to increase again in mid-February. These changes reflect the timing of migrations in the eastern United States and use of Nantucket Sound as a staging area during migration (Veit and Petersen, 1993). This trend continued through 2003 when observations of loons dropped off considerably in the summer months and increased again in November while migrating through the area in the fall. It is evident from the study years of surveys that more individuals migrate through the area in the spring than in the fall. Both species were generally distributed evenly throughout the study area (see Attachment 1 of Appendix 5.7-D, Attachment 2 of Appendix 5.7-G, and Attachment 2 of Appendix 5.7-K), and occurred singly or in small groups, except in spring, when flocks included as many as 100 individuals. For the 8,229 observations during the aerial surveys in the study area, 1,010 (12.3%) were observed in Horseshoe Shoal, 632 (7.7%) were observed in Monomoy-Handkerchief Shoal, 1,020 (12.4%) were observed in Tuckernuck Shoal, and 5,567 (67.7%) were observed outside the three shoal areas. Most loons were observed on the water or flying close to the surface at less than 35 feet (10 meters) asl, with approximately six of the 8,229 individuals (<0.1%) observed during aerial surveys seen flying at rotor height.

Grebes. Two species of grebes (horned and red-necked) are winter residents within Nantucket Sound. Grebes were not identified to the species level for most of the observations, because their small size makes it difficult to differentiate between grebe species during aerial surveys. A total of 319 grebes was observed within the study area during field investigations, of which 314 were seen during the aerial surveys. Of the 314 individuals observed in the study area, 35 (11.1%) were observed in Horseshoe Shoal, 9 (2.9%) were observed in Monomoy-Handkerchief Shoal, 36 (11.5%) were observed in Tuckernuck Shoal, and 234 (74.5%) were observed outside the three shoal areas. The other five grebes were observed during the boat surveys on April 17 and 18, 2002. Grebes were commonly observed during the winter and spring months and peaked in March (aerial survey on March 24, 2003 – 57 observed) (Tables 5.7-3, 5.7-4 and 5.7-5). They were not observed in either summer (with the exception of 2 on June 2, 2003) or early fall, and after the summer absence they were first observed in December of 2002 and in October of 2003. The largest numbers of grebes were present in the study area during January, March, April, and December. Grebes were widely distributed across the study area in small numbers, but were more numerous in the southern section of the study area on Tuckernuck Shoals (see Attachment 2 of Appendix 5.7-G and Attachment 2 of Appendix 5.7-K). Grebes were not identified to the species level for most of the observations, as it is difficult to differentiate between grebe species during aerial surveys due to their small

size. Grebes occurred singly or in small flocks on the water, rarely flying, with one individual out of the 314 individuals (0.3%) observed during aerial surveys seen flying at rotor height.

Wilson's Storm-petrel. This summer visitor (May-September; migrant from the southern hemisphere where it nests) is generally abundant offshore (500 to 1,000 per day per locality (Veit and Petersen, 1993)), and occasionally is numerous close to shore. During the surveys, 44 individuals were observed within the study area, occurring in small numbers on most summer observation days (June through August). This species was widely distributed, but generally more abundant in the eastern and southern parts of Nantucket Sound (Attachment 2 of Appendix 5.7-F). Twenty-nine were seen from the plane and 15 during boat and ground-truthing surveys, all flying below approximately 10 feet (3 meters) asl. These individuals were not distinguished from leach's storm-petrels, of which there is a small nesting colony on Penikese Island in Buzzards Bay, but this species is not known to occur in Nantucket Sound (Veit and Petersen, 1993). For the 29 observations during the aerial surveys in the study area, 0 (0%) were observed in Horseshoe Shoal, 1 (3.4%) were observed in Monomoy-Handkerchief Shoal, 5 (17.2%) were observed in Tuckernuck Shoal, and 23 (79.3%) were observed outside the three shoal areas.

Northern Gannet. A total of 2,052 northern gannets were recorded within the study area during the study years, of which 1,415 were seen during the aerial surveys. Northern gannets typically occur in Nantucket Sound from mid-March to early June and from mid-November to mid-January. The largest numbers of gannets were observed in April and May when many migrants pass through the area, and they increased again in November during their fall migration (see Figure 5.7-5, Attachment 1 of Appendix 5.7-D, Attachment 2 of Appendix 5.7-G, and Attachment 2 of Appendix 5.7-K). Gannets occurred singly and in flocks numbering up to 80 individuals throughout the study area. One large flock of about 300 individuals was observed just north of the study area on April 18, 2003. Some were observed on the water, but the majority was observed flying, sometimes above the altitude of the plane at approximately 250 feet (75 meters) asl. Among the 1,415 observations during the aerial surveys, 140 (9.9%) were observed in Horseshoe Shoal, 35 (2.5%) were observed in Monomoy-Handkerchief Shoal, 159 (11.2%) were observed in Tuckernuck Shoal, and 1,081 (76.4%) were observed outside the three shoal areas. The aerial surveys found gannets to be more abundant in the southern and eastern parts of the Sound (see Attachment 1 of Appendix 5.7-D, Attachment 2 of Appendix 5.7-G, and Attachment 2 of Appendix 5.7-K, and Attachment 2 of Appendix 5.7-M). Gannets were observed both on the water and flying, with 28 of the 1,415 individuals observed during aerial surveys seen flying at rotor height.

Cormorants. Double-crested and Great Cormorants are the two species of cormorant that utilize Nantucket Sound. They generally occur within the Sound at different times of the year, with a brief overlap during spring and fall. Great Cormorants are present within the study area during winter, while Double-crested Cormorants are present principally during summer months in much larger numbers. The two species are not readily distinguished from one another and are not differentiated in this account. A total of 2,743 cormorants were observed within the study area during the study years, most within 3 miles (4.8 km) of shore. During the aerial surveys, a total of 2,511 were observed, of which 2,506 were observed outside the three shoal areas and only one was recorded at Horseshoe Shoal and 4 were recorded in Alternative 3. Six individuals were observed on Horseshoe Shoal during boat-based observations. Cormorants were observed frequently in small groups or large dense flocks at daytime resting areas on Fernando's Fetch (a transient sandbar northwest of Muskeget Island), on Bishop & Clerks' Lighthouse near the northern edge of the Sound and along the shores of Muskeget Island. Those observed flying were typically low to the water's surface, and one flock of 40 individuals was observed flying at rotor height. Within the study area, the largest numbers were observed in October 2002, whereas in 2003, they were most common in June. Outside the study area, they were frequently observed close to shore and on the sandbars west of Monomoy, especially during the peak of abundance in August, a period of post-breeding dispersal for the Double-crested Cormorant.

Seaducks. Five species of seaducks migrate in large numbers through Nantucket Sound and adjacent waters in the spring and fall, and many are residents during the winter. These seaducks are divers that feed principally on benthic mollusks and crustaceans. In summer, when most individuals have left the area, small numbers of Common Eiders nest on Muskeget Island and also on the Elizabeth Islands, outside of Nantucket Sound (Veit and Petersen, 1993). A brief discussion of each of the five species of seaducks observed is presented below.

Common Eider. A total of 111,067 eiders were observed within the study area during the study period, representing approximately 26.9% of all birds observed during the surveys. In winter, from October to April,

eiders were present in substantial numbers, often occurring in large, dense "rafts" numbering thousands of birds, while others occurred in smaller groups. The large rafts extended beyond the edges of the study transects, and were not counted completely. They were most frequently observed on March 24, 2003 (>80/km^2) and on February 27, 2004 (>75/km^2). They were rarely observed in summer and numbers decreased significantly during the February 14, 2003 and February 2, 2004 aerial surveys, when large sections of the study area were frozen over. Eiders commonly assemble at patches where prey is available in high concentrations in shallow water (Guillemette et al., 1993). During the aerial surveys, 110,552 individuals were recorded within the study area. Of these, 5,800 (5.2%) were observed in Horseshoe Shoal, 791 (0.7%) were observed in Monomoy-Handkerchief Shoal, 1,120 (1.0%) were observed in Tuckernuck Shoal, and 102,844 (93.0%) were observed outside the three shoal areas. Most of the observations were in the southern part of the study area, between Tuckernuck Shoal and Martha's Vineyard, and in the northeastern part of the Sound near Monomoy (see Attachment 1 of Appendix 5.7-D, Attachment 2 of Appendix 5.7-G, Appendix 5.7-K and Appendix 5.7-M). During the summer, small numbers were observed near Muskeget Island, where a few pairs have nested each year since about 1973-75 (Veit and Petersen, 1993). During boat surveys, 279 eiders were observed in April 2002, 77 were observed in October 2002, 155 were observed in April 2003 and 1 was observed on August 27, 2003. These numbers are considerably lower than numbers observed during the aerial surveys conducted at approximately the same time, principally because the boats could not visit the shallow waters typically used by eiders. Eiders were observed both on the water and flying, with none of the 110,555 individuals observed during aerial surveys seen flying at rotor height.

Long-tailed Duck. A total of 54,242 Long-tailed Ducks were observed within the study area during the study period, representing approximately 13.2% of all birds observed in the surveys. Seasonal occurrence ran generally from October to April, with the last few individuals (18) observed during a boat survey in May 2002. None were recorded in summer. The largest numbers were seen during aerial surveys in March 2002 and November 2003 (see Figure 5.7-8), when migrants may use the Sound as a staging area. They were absent from May through September and were first observed in October each year. During the aerial surveys, 52,192 individuals were recorded. Of these, 4,103 (7.9%) were observed in Horseshoe Shoal, 2,685 (5.1%) were observed in Monomoy-Handkerchief Shoal, 2,493 (4.8%) were observed in Tuckernuck Shoal, and 42,911 (82.2%) were observed outside the three shoal areas. These ducks were more numerous in the northeastern corner and southern section of the Sound.

Long-tailed Ducks are understood to roost at night in Nantucket Sound and then fly in large flocks over Nantucket and Tuckernuck Islands to forage over the Nantucket Shoals during the day (Davis, 1997). These birds fly in flocks between daytime feeding areas on the shoals southeast of Nantucket and nocturnal roosts in the Sound (Davis, 1997). During the annual Christmas Bird Count of 2002 to 2003 for Nantucket, approximately 500,000 of these birds were counted. In the course of a preliminary project survey flight in December 2001, a large roost was located in the southern part of the Sound, north of Tuckernuck. Several attempts were made during the aerial surveys to investigate this phenomenon but were unsuccessful, in part because the birds start moving before sunrise and continue after sunset. In addition, the radar studies did not pick up these targets because the flights are outside the range of the radar in the southern part of Nantucket Sound. Flying Long-tailed Ducks were below 35 feet (10 meters) asl during all observations made from plane or boat. They are known to fly at higher altitudes over or near land during roosting flights.

Scoters. All three species of scoters (Black, White-winged, and Surf) were present in Nantucket Sound in large numbers through the winter, and migrants are known to pass through the area. Together the scoters comprised the largest group of birds observed during the study year, representing 51.6% of the total count. The three species have been grouped together for several reasons. Frequently the sightings could not be identified to species, especially when conditions for observation were less than ideal or when the ducks were in mixed flocks. Furthermore, the scoter species are not equally distinguishable: male Surf Scoters are often conspicuous on the water and White-winged Scoters are easily recognized in flight. Such differences would bias any summary of scoters identified to species.

A total of 212,872 scoters were observed during the study period. Peak numbers were observed from October through April, with the numbers starting to decline in mid-April (Tables 5.7-3, 5.7-4, and 5.7-5). The largest numbers of scoters were observed during the November 2003 aerial surveys when individuals are arriving for the winter and migrating through from their breeding colonies (see Attachment 2 of Appendix 5.7-M). Scoters

occurred in small groups and loose flocks numbering up to thousands of individuals, and were widely distributed in the Sound. Of the 205,802 observed during the aerial surveys, 15,222 (7.4%) were observed in Horseshoe Shoal, 18,678 (9.1%) were observed in Monomoy-Handkerchief Shoal, 30,419 (14.8%) were observed in Tuckernuck Shoal, and 141,483 (68.7%) were observed outside the three shoal areas. Very few scoters (13) were observed during the summer months in all of Nantucket Sound. Those observed in summer are likely to have included injured individuals, because the Sound is not known to be a molting site. Flying scoters were generally observed at altitudes less than 15 feet (4.6 meters) asl, with the exception of flocks of possible migrants at about 65 feet (20 meters) asl. Large numbers of scoters were observed southwest of Martha's Vineyard in flocks numbering up to 3,000 individuals on March 24, 2003. Of the 212,872 scoters observed during the aerial and boat surveys, four individuals were flying at rotor height on March 24 and April 18, 2003.

Red-breasted Mergansers. A total of 1,452 Red-breasted Mergansers were observed within the study area during field investigations. Red-breasted Mergansers were observed from October to April and they were not observed from late April through September during both study years. Of the 1,452 observations during the aerial surveys in the study area, 117 (8.1%) were observed in Horseshoe Shoal, 0 (0%) were observed in Monomoy-Handkerchief Shoal, 0 (0%) were observed in Tuckernuck Shoal, and 1,335 (91.9%) were observed outside the three shoal areas. Of the 117 observed within Horseshoe Shoal, 107 were seen on November 24, 2003. They generally occurred close to shore, near Muskeget and Tuckernuck Islands. None were observed flying at rotor height.

Goldeneyes. A total of eight Goldeneyes were observed in similar coastal locations as the Red-breasted Mergansers. Both species were also seen near shore in other parts of the Sound. Of the eight observed, six were observed during the aerial surveys, all of which were observed outside of the three alternative sites. None were observed flying at rotor height.

Gulls. Six species of gulls were observed during the surveys. Gulls are numerous year-round, with about 65,000 nesting in Massachusetts (Blodget and Livingston, 1996). A total of 6,229 individuals were observed during the field investigations. Gulls were observed on all 46 aerial surveys during the study years. Of these, the Great Black-backed Gull was the most abundant (2,220), followed by the Herring Gull (1,605), Bonaparte's Gull (1,444), Black-legged Kittiwake (319), Laughing Gull (150), and Ring-billed Gull (2). In addition, a total of 414 other individual gulls recorded during the surveys were not identified to species. Gulls were thinly and relatively evenly spaced throughout the study area (see Attachment 1 of Appendix 5.7-D, Attachment 2 of Appendix 5.7-G, Attachment 2 of Appendix 5.7-K, Attachment 2 of Appendix 5.7-L, and Attachment 2 of Appendix 5.7-M). They were most common in November and December during both study years, primarily due to the presence of Bonaparte's Gulls within the study area during that time of year. Of the 5,500 individuals observed during the aerial surveys, 227 (5.0%) were observed in Horseshoe Shoal, 132 (2.4%) were observed in Monomoy-Handkerchief Shoal, 552 (10.0%) were observed in Tuckernuck Shoal, and 4,539 (82.5%) were observed outside the three shoal areas. Gulls are abundant as year-round residents and migrants that travel over large areas of the Sound in search of food, often targeting schools of fish or working fishing boats. Many gulls were observed on the water and flying, with a total of 85 of the 5,500 individuals observed during aerial surveys (mostly Herring and Black-backed) seen in flight at rotor height. Four Parasitic Jaegers were observed foraging off Monomoy Island on the September 12, 2003 boat surveys.

Terns. These birds are summer residents: almost 20,000 pairs of four species nest in Massachusetts, the majority in the southeastern part of the state (Blodget, 2001). Three of these species – Common, Roseate, and Least terns – were observed within the study area from April to September (Appendices 5.7-F, 5.7-G and 5.7-K). All are species of concern, but particularly the federally-endangered Roseate Tern (see Section 5.7.4 and Appendix 5.7-H). The Black and Forsters Tern were also observed during the surveys. During the nesting season, most terns feed close to shore. There are no reports of large numbers of terns in the Project area, although terns are thought to be regular visitors to all parts of Nantucket Sound. During two summers (2002 and 2003) of aerial and boat surveys, MAS found relatively few terns on Horseshoe Shoal compared to other areas within Nantucket Sound (Perkins et al., 2003 and Perkins et al., 2004). The largest numbers found on Horseshoe Shoal was on May 15, 2003, when 90 terns were observed, of which none were Roseate terns. Once migration was completed and nesting began few terns were observed on Horseshoe Shoal (Perkins et al., 2004). Mass Audubon's findings were similar to that of the Applicant during the same time period. The largest number of

terns observed within the study area was on May 12, 2003, when the Applicant observed 526 terns within the study area, of which 165 (7.86/km^2) were observed on Horseshoe Shoal (Appendix 5.7-K).

A large post-breeding, pre-migration staging area for terns is located at South Beach/North Monomoy, near the northeastern corner of the Sound (Trull et al., 1999). This was verified by field studies conducted by the Applicant and MAS (Perkins et al., 2003, Perkins et al., 2004, Appendix 5.7-F, Appendix 5.7-K and Appendix 5.7-L). At this site, very large numbers of terns (more than 10,000) gather from August through September, often spending nights there and dispersing widely to feed. Some visit or cross the Project area, and may rest by day at several points along the shores of the Sound. All these birds are thought to return to South Beach each night. Foraging range is typically 3 miles (4.8 km), however, some birds may travel up to 20 miles (30 km). The South Beach staging area includes Roseate Terns from as far away as Maine and New York (Trull et al., 1999). Cape Cod and the Islands appear to be the major staging area for much of the New England population.

There are an estimated 20,000 nesting pairs of terns in Massachusetts (Blodget, 2001). A total of 8,755 terns were observed within the study area during the study period, from April to September in 2002 and from April to November in 2003 (Tables 5.7-3, 5.7-4, and 5.7-5). The combined results of the 2002 and 2003 studies by the applicant are shown in Figure 5.7-13. Common Terns were the most abundant (5,313), followed by Roseate (447), and Least (198) Terns, Black (40) and Forsters (2). However, 2,755 individual terns could not be identified to species, because Roseate and Common terns are similar in appearance and often occur in mixed flocks. A few Black Terns and Forster's Terns were observed during the summer of 2003. Observations outside the study area suggest that terns were more numerous outside the study area along the mainland shores than in the study area. During the aerial surveys, a total of 2,888 individuals were observed within the study area, of which 277 (9.6%) terns were observed in Horseshoe Shoal, 76 (2.6%) were observed in Monomoy-Handkerchief Shoal, 164 (5.7%) were observed in Tuckernuck Shoal, and 2,371 (82.1%) were observed outside the three shoal areas. During the aerial surveys, the number of flying terns recorded in each observation ranged from 1 to 201. Larger aggregations were infrequently encountered at roosting sites such as Fernando's Fetch (a transient exposed sandbar, present northwest of Muskeget Island during the surveys).

Altitude estimates were made for 5,112 flying terns; of these, 5,009 were within approximately 60 feet (18 meters) of the water surface and 103 were above 60 feet (18 meters) asl. Of the 103 observed above 60 feet, 100 were observed flying at heights 75 feet and above (within the rotor swept zone). Within the study area, 1 roseate tern was observed flying at approximately 75 feet, 49 common terns were observed flying at approximately 80 feet, and 50 mixed terns were observed at an altitude higher than 81 feet. Of these 100 terns observed within the rotor swept zone, none were observed within the Horseshoe Shoal Project boundary. Another flock of terns was estimated to be flying at 110 feet (33 meters) asl. They were flying in a southeasterly direction approximately 1 mile (2 km) off of Cape Poge on September 13, 2002. Mass Audubon observed very few terns flying within the rotor swept zone on Horseshoe Shoals during their field surveys (Perkins et al., 2003 and Perkins et al., 2004).

In 2002, 18 aerial surveys for Cape Wind were conducted from March to December. Terns were seen from May through September on the aerial surveys: these are reported in Appendices 5.7-F and 5.7-G. Within the Cape Wind study area, 1,801 terns (120 Roseate, 1,043 Common, 68 Least, and 570 Common-Roseate type) were recorded during the 2002 aerial surveys and 3,024 (205 Roseate, 1,205 Common, 112 Least, and 1,502 Common-Roseate type) were seen during the boat/groundtruthing 2002 surveys (Appendices 5.7-D, 5.7-F, and 5.7-G).

Also in 2002, MAS conducted 11 aerial surveys of Nantucket Sound from August 19 to September 19 to ascertain abundance and distribution of Roseate and Common Terns during the pre-migratory period (Perkins et al., 2003). Although the MAS methodology differed, their findings were very similar to those of the Applicant's surveys: in both studies terns were much less abundant over Horseshoe Shoal and other central ("offshore") parts of the Sound than near the northern and especially the eastern edges of the Sound. During the 11 flights, the observers recorded 5,721 terns in transects of width approximately 7,000 feet (2,133 m) (to limits of visibility), which included 634 Roseate, 1,767 Common, 3,311 Common-Roseate type and 9 Least Terns. The methods used by MAS were suited to counting but not measuring bird densities, although the findings seem to be similar to those of the Applicant's research team.

In 2003, 24 aerial surveys for Cape Wind were conducted from January to December, principally examining the same study area as in 2002: these are reported in Appendices 5.7 –G, K, L, and M. Terns were seen on every survey from April 18 to November 19 (Roseates from May 12 to September 15). Larger numbers were present on Horseshoe Shoal in May, fewer thereafter. The year 2003 was unusual in that exceptionally large numbers of terns were present in Buzzards Bay after the breeding season (J.J.Hatch, personal obs.) Within the Cape Wind study area, 1,086 terns (120 Roseate, 564 Common, 15 Least, 1 Forsters and 386 Common-Roseate type) were recorded during the 2003 aerial surveys and 2,843 (2 Roseate, 2,500 Common, 3 Least, 1 Forsters, 40 Black and 297 Common-Roseate type) were seen during the boat 2003 surveys (Appendices 5.7-G, 5.7-K, 5.7-L and 5.7-M).

Also in 2003, May 15– July 31, MAS examined tern activity during 13 boat surveys on Horseshoe Shoal and in three aerial surveys of a large study area in the Sound using narrow transects (unlike their 2002 surveys). These surveys showed similar temporal and spatial information to those reported by the Applicant. During the boat surveys, a total of 250 terns were observed on Horseshoe Shoal, and terns were recorded on all but four boat surveys. Terns were recorded on all three aerial surveys conducted by MAS: with 680 terns observed comprised of 472 Common Terns, nine Roseate Terns, and 199 Common-Roseate-type terns.

In summary, these surveys (including those by MAS), which were all conducted during conditions of good visibility, reported low numbers of Roseates, not only over Horseshoe Shoal, but also in areas from which commuting birds would cross that shoal on their way to and from a breeding colony (in Buzzards Bay) or a late-summer roost (on South Beach). These observations suggest that the numbers of Roseate Terns that regularly use Horseshoe Shoal are low in absolute numbers, as well as being relatively low with respect to other areas of Nantucket Sound and waters closer to the nesting colonies and to South Beach.

Auks (alcids). A total of 3,530 large alcids were observed in the study area during the study period. These were much more likely to be Razorbills than either species of Murre (Veit and Petersen, 1993), but specific identification was not established for most individuals. Alcids were seen throughout the study area from November to April (Tables 5.7-3, 5.7-4 and 5.7-5), with an unusual, unconfirmed individual on June 24, 2002. Alcids occurred singly or in small parties numbering up to 35 individuals and were relatively evenly distributed throughout the study area (see Attachment 1 of Appendix 5.7-D, Attachment 2 of Appendix 5.7-G, Attachment 2 of Appendix 5.7-K, and Attachment 2 of Appendix 5.7-M). During aerial surveys, a total of 3,455 individuals were observed within the study area, of which 426 (12.3%) were observed in Horseshoe Shoal, 290 (8.4%) were observed in Monomoy-Handkerchief Shoal, 408 (11.8%) were observed in Tuckernuck Shoal, and 2,331 (67.5%) were observed outside the three shoal areas. Other observations of alcids included a total of 50 Dovekies, recorded from January-May and one Atlantic Puffin (March), generally in association with Razorbills. All flying alcids were observed to fly below approximately 50 feet (15 meters) asl, which is below rotor height.

Additional Waterbirds Observed

The following waterbirds were additional species/species groups that were observed in the study area during the study years but do not necessarily represent abundant species.

Sooty Shearwater. This visitor from the southern hemisphere is seen regularly in Massachusetts coastal waters in the summer, and was recorded in Nantucket Sound on 6 dates during May, June, August, and October; three times during the ground-truthing surveys, twice during boat surveys and once during an aerial survey. Ten individuals were observed within the study area during the two study years. All were seen flying below approximately 25 feet (7.5 meters) asl. Only one was observed during the aerial surveys.

Other Ducks. A total of 14 Greater Scaup were observed in the southern section of the study area during the aerial survey on June 2, 2003. None were flying at rotor height. Also, a total of 109 American Black Ducks were observed on Muskeget Island on four aerial surveys in the fall of 2003.

Geese and Non-Seaducks. Large numbers of geese and non-seaducks pass close to shore during migration, and those that pass near or over the Project area are likely to do so at high altitudes. The few that were observed during field studies included small numbers of Canada Geese that may have been residents. The Canada Geese were observed at Muskeget Island and flying over Tuckernuck Island. In addition, a flock of 25 was observed flying through the study area on December 13, 2002 (Appendix 5.7-G) and 10 were observed on June 16, 2003 (Appendix 5.7-L). During the ground-truthing in September 2002, small numbers of high-flying

Snow Geese were observed from the bluff at Cape Poge. Of the 35 geese observed during the aerial surveys, none were flying at rotor height (Appendix 5.7-G and 5.7-L). In addition, seven Brandts were observed on the eastern part of the study area an February 2, 2004.

5.7.2.3.2 Landbirds

This section describes the landbird species that may cross the Project area but do not linger or forage there.

Shorebirds (sandpipers, plovers, etc.). Shorebirds are most numerous in the area as transients during migration, when the large areas of sand and mud near North Monomoy provide important staging areas of internationally recognized importance. Much smaller numbers occur at other sites around Nantucket Sound. Small numbers of shorebirds are summer residents in the area, including the threatened Piping Plover. This species is discussed in more detail in Appendix 5.7-H. Piping Plovers are beach-dwellers, and are found widely around the coastal areas of Nantucket Sound where they feed and nest, but do not typically occur in the Project area. As expected, few shorebirds and no Piping Plovers were observed during avian surveys for the Project. Some shorebirds may fly across these areas, from one side of the Sound to another, but no such observations have been recorded, and sightings of shorebirds on beaches do not suggest any concentrated flightlines in the Project area. The proposed landfall for the Project is located approximately 0.8 mile (1.3 km) from the nearest known nesting sites of Piping Plover on the opposite (seaward) side of Great Island and 1.5 mile (2.4 km) from nesting sites at Kalmus Beach/Dunbar Point, Hyannis and the north-western corner of Great Island. The Project's buried cables (at their closest point to nesting sites) would pass within approximately 820 feet (250 meters) of Kalmus Beach/Dunbar Point and approximately 1,210 feet (369 meters) of Great Island. Support vessels associated with the Project's cable installation would pass within approximately 670 feet (204 meters) of Kalmus Beach/Dunbar Point and 1,060 feet (323 meters) of Great Island (see Appendix 5.7-H for more details).

Migrating shorebirds typically climb rapidly when departing and are likely to fly over the Horseshoe Shoal area at high altitudes in the spring and fall, although they may fly at lower altitudes while descending to stopover sites such as Monomoy Island (Veit and Petersen, 1993). Identification of targets by radar is tentative, but many shorebirds are thought to fly from New England directly to South America, so that flights from Monomoy would pass east of the Project area (Griffin, 1974). Small numbers of three species/groups of shorebirds were observed during the surveys, including an American Oystercatcher on July 9th, 2003 on the shoreline of Muskeget Island. One Redknot and six unidentified sandpipers were observed off Cape Poge during boat-based field surveys and 20 Dunlins were observed on Muskeget Island during an aerial survey in October 2002.

Wading Birds (herons, egrets, ibis, etc.). These birds are numerous along the bays and estuaries of the Sound; small numbers may fly over the Project area, but are unlikely to linger at Horseshoe Shoal as the water depths are generally too deep for them to wade. During migration these species tend to fly at heights well above the rotor swept area. None were observed in the shoal study areas.

Raptors (hawks, owls, eagles, falcons, etc.). Except for an occasional osprey and, perhaps, peregrine falcon, these birds are not likely to be present at Horseshoe Shoal except by accident (blown offshore in storms or off course) and on rare occasions during migration. There are no topographic features (such as shorelines or shortest crossings) that funnel such migrants to the area. Eight osprey were observed during the boat surveys on August 15 and 22, 2002 and September 12, 2003. All were observed just offshore south of Falmouth, less than 1 mile from the shore, and none were observed in the shoal study areas. Osprey were observed foraging at a height of less than 50 ft, which is typical of their foraging behavior although at times they will forage from over 100 ft. Osprey likely forage in Lewis Bay, in proximity to the proposed submarine cable route for the Project. No peregrine falcons were observed in the study area.

Other Landbirds - Migration. Large numbers of migrating landbirds pass over Horseshoe Shoal at a wide range of altitudes during autumn and spring, occurring principally during limited periods (April through May and September through October). They are known to travel over a broad front rather than in narrow streams, but numbers flying over Nantucket Sound in both spring and fall are much lower than over the mainland to the northwest (Nisbet and Drury, 1967), even so numbers estimated to migrate through Nantucket Sound are still believed to be in the millions (Appendix 5.7-A). Radar was used to study bird movements in May and September 2002; information about migration patterns resulting from that study is discussed below and in Appendices 5.7-E

and 5.7-J. Very few songbirds or other similar passerines were observed visually in the study area. None were observed during the aerial surveys, and only 3 (2 swallows and 1 American goldfinch) were observed during the boat-based surveys (Table 5.7-3). These results were expected, since most songbirds migrate at night and are most likely to occur in the study area sporadically under special meteorological conditions. However, the small size of these birds means that they are easily missed, and boat or aerial based visual observations are unreliable indicators of numbers passing.

5.7.2.3.3 Radar Study Results

The following discussion summarizes the findings from Appendix 5.7-E. The number of targets, which may be individual birds or bats, flocks of birds or bats, or insects, observed during the radar study varied by season (spring vs. fall). Almost twice as many targets were observed in fall as in spring; this is to be expected since the numbers of fall-migrating birds include the young of the year. In total, 1,052,761 targets were observed by TracScan radar (approximately 38% in spring and 62% in fall). In total, 491,306 targets were observed by VerCat radar (approximately 31% in spring and 69% in fall). The number of targets also varied depending on whether they were observed during day or night and the majority of night flying birds were observed flying at greater heights.

Most targets observed by TracScan were small or slow-moving targets (possibly migrating songbirds and gulls or terns foraging or soaring over the water). Slow targets outnumbered fast targets (waterfowl, loons, cormorants, shorebird flocks, etc.) by approximately 3:1 in the spring and by approximately 2:1 in the fall. Passage rate, the number of birds/hr/km of front (an imaginary plane extending from the earth's surface to the sky, perpendicular to a migration corridor), is a measure of the concentration of birds passing through the plane. The length of the plane (km of front) is defined by the width of the stream of migrating birds. During fall, there was little difference between passage rates of fast (34.6) versus slow (46.7) targets in daytime, although at night there were three times more slow (102.5) targets moving than fast (31.9) targets. The passage rate for slow birds targets in the fall at night (102.5) was more than twice the daytime rate (46.7), whereas nighttime rates for fast birds (31.9) in the fall were similar to daytime rates (34.6) (Appendix 5.7-E, Table 4). Both spring and fall passage rates of slow and fast targets (primarily migrants, as opposed to many nonmigrants during daytime) at night (53.3 in spring, 134.5 in fall) were equal to or lower than migration rates derived from radar and ceilometer[80] studies of migration in New York, Vermont, and Maine. These passage rates are also much lower than migration traffic rates reported from the southeastern United States (Appendix 5.7-E). Within the limits of the study approach, this suggests that concentrations of night migrating birds that cross Nantucket Sound are similar to or less than migration passage rates further inland. These data suggest that the concentrations of night-migrating birds may be lower across Nantucket Sound than other studied areas along the eastern coast.

Most birds tracked with the TracScan radar were observed when weather was clear (no rain and/or fog). In fall, 72% (night) to 88% (day) of slow targets, and 66% (night) to 90% (day) of fast targets were observed during clear weather. Similar percentages of targets observed during clear weather were found in spring: of the slow targets, 59% (night) to 82% (day) were observed during clear weather and of the fast targets, 53% (night) to 79% (day) were observed during clear weather. It was not possible to determine whether the birds that were flying during inclement weather were flying above fog or rain.

Flight direction during both spring and fall varied greatly among individuals and groups of birds. Mean flight direction during spring for slow moving targets was bimodal; i.e., back and forth along a northwest to southeast axis. For faster, usually larger targets, the predominant direction was to the northeast. During fall, variation in flight direction was greater than in spring, but also bimodal, with slow moving targets flying mostly to the northwest and southeast, whereas fast moving targets flew mostly to the northeast and southwest.

As described in Appendix 5.7-E, flight direction varied greatly, even within a migration season and within slow and fast targets. Some of the variation among slow moving targets during daytime in spring and fall is likely attributable to foraging flights of gulls, terns (mostly fall), nonmigrants (onshore, fall only), and migrants.

[80] A device used for measuring the height of the base of clouds, often used by ornithologists to assist in determining bird migration counts.

Of the 491,306 total targets observed by VerCat, 127,697 (26%) were recorded at rotor swept height. Of the 221,059 daytime targets, 83,083 (38%) were observed at rotor swept height, and of the 270,247 nighttime targets, 44,614 (17%) were recorded at rotor swept height. Approximately 89% of the fall nighttime targets and 68% of the spring nighttime targets were recorded at heights greater than 418 ft (127.4 meters) asl, the top of the proposed rotor swept height. Other studies have suggested that most night-migrating birds fly at higher altitudes than birds migrating during the day, and while the Applicant's radar data support this observation, the studies were limited in duration with overlapping coverage from two locations within Nantucket Sound (Appendix 5.7-E).

Many birds, in particular seaducks, regularly fly below the range of the radar, indicating that the actual percentage of birds within the rotor swept zone, as described above, may be lower than that found during radar surveys. For example, greater than 95% of the birds for which altitudes were estimated during aerial and boat-based surveys in Nantucket Sound from 2002-2004 were outside of the rotor swept zone (Appendices 5.7-F, 5.7-G, 5.7-K, 5.7-L and 5.7-M). The great majority (>90%) of flying birds (i.e., seaducks) observed during these surveys were below 20 feet (6.1 meters) asl, either on the water or flying just above the water and below the lower threshold of the range of the radar, and therefore would not have been detected by radar. Of the 394,585 waterbirds observed during daytime aerial surveys for the Project, only approximately 365 (or 0.09%) were observed within the rotor swept zone.

5.7.2.4 Summary of Existing Conditions

The principal wintering seaducks (Common Eider, Long-tailed Duck, and Scoters) reported during the two plus years of field observations of offshore parts of the Sound were less abundant on Horseshoe Shoal than other parts of the Sound. The number of individuals observed in Horseshoe Shoal (25,125) comprised 6.8% of total seaducks observed during the aerial surveys, which is substantially lower than the 13% expected if the birds had been evenly distributed across the study area (Table 5.7-7). For Monomoy-Handkerchief Shoal, the number of individuals observed (22,154) comprised 6.0% of total seaducks observed during the aerial surveys, which is on target with the 6% expected if the birds were evenly distributed across the study area. For Tuckernuck Shoal, the number of individuals observed (34,032) comprised 9.2% of total seaducks observed during the aerial surveys, which is lower than but close to the 11% expected if the birds were evenly distributed across the study area (Table 5.7-7). The largest percentages of seaducks (primarily scoter and eiders) observed were found outside the three shoal areas (287,238 (77.9%)): principally near Monomoy Island and Tuckernuck Island.

For the terns observed during the aerial surveys in the study period (primarily during the summer), 9.6% (277/2,888) were observed in Horseshoe Shoal, 2.6% (76/2,888) in Monomoy-Handkerchief Shoal, 5.7% (164/2,888) in Tuckernuck Shoal, and 82.1% (2,371/2,888) outside the three shoal areas (Table 5.7-8).

Results from the Applicant's field studies indicate that the offshore areas of Nantucket Sound have relatively few species of seabirds and that most landbird migrants pass overhead at high altitudes. Horseshoe Shoal, compared with the other shoal areas studied (Monomoy-Handkerchief Shoal and north of Tuckernuck Shoal) and with other areas of Nantucket Sound, exhibits lower abundance and diversity for species found in the area than the other two shoals. For species such as loons, gulls and razorbills, the proportions in Horseshoe Shoal compared to other areas studied suggest similar abundance and distribution of the three shoals. Studies conducted by the Applicant (year round) and MAS (summer) (Perkins et al., 2003 and Perkins et al., 2004) show that areas near Monomoy Island and the southwestern part of the study area (Figure 5.7-1) have higher densities of birds present throughout the year compared to Horseshoe Shoal. For example, during the fall 2002 to winter 2003 aerial surveys (Appendix 5.7-G), eiders were the only species that had a higher density in Horseshoe Shoal (71/km^2) compared to the other two shoal areas (10 and 4/km^2), and there was a much higher density of eiders outside the three shoal areas (195/km^2). Overall tern densities were greatest outside the three shoal areas (Table 5.7-8), with the largest number near Monomoy Island and the southern part of the study area (Appendices 5.7-C, 5.7-F, 5.7-K and 5.7- L, and Perkins et al., 2003 and Perkins et al. 2004).

Overall, the studies have shown that the diversity and numbers of birds at Horseshoe Shoal is a small subset of those that are found in other parts of Nantucket Sound and the adjacent coast and shoreline. The presence and use of the Horseshoe Shoal area by that subset is limited, indicating that the species or individuals that may be

present at Horseshoe Shoal are likely to be present for relatively short periods of time for foraging and migrating through.

Waterbirds were far more commonly observed than landbirds. The most common waterbirds observed were wintering or transient scoters and eiders. Other than night-migrating songbirds observed by radar (estimated to be songbirds based on flight characteristics) to be flying at altitudes of approximately 1,000 feet (305 meters) asl, very few landbirds (<50) were observed in the study area.

Most of the targets (83% (280,841/338,040)) in the fall and 49% (74,952/153,266) in the spring) detected by the radar over the study area were flying at altitudes above the 75 to 417 foot (23 to 127 meters) asl rotor swept zone. Most of those observed within the rotor swept zone were observed during the daytime (83,083 of 127,697) (Appendix 5.7-E), when obstacles are more visible and, thus, more easily avoided by birds (Erickson et al., 2001). A total of 44,614 targets were identified in the rotor swept zone at night. In addition, greater than 95% (approximately 392,000 of 412,418) of the birds observed during aerial and boat-based surveys of the study area from 2002-2004 were outside of the rotor swept zone; the vast majority (roughly 90%: more than 371,000 of 412,418) of birds observed during these surveys were below 23 feet, either on the water or flying just above the water, and therefore would not have been detected by radar. Of the 394,585 waterbirds observed during daytime aerial surveys for the Project, only approximately 365 (or 0.09%) were observed within the rotor swept zone.

5.7.3 Analysis Of Impacts

The Cape Wind Project will be the first of its kind offshore in North America. The effects of wind park development on avifauna has been intensively studied for 12 on-shore facilities in the U.S. (Appendix 5.7-A), and, while much of what has been learned on-shore is applicable to off-shore development, there may be issues that have not yet been identified. The impact assessment sections below discuss potential biological and physical impacts of the proposed Project to the bird habitat, bird species, and groups of species discussed in Section 5.7.2.3. The potential impacts discussed in the following sections are based upon project specific field research that was conducted from 2001 through 2004, and an extensive literature search on existing wind farms and other vertical structures such as communications towers. Based on the existing literature and the knowledge and input of several experts, including cooperating agencies and private sector biologists, the following potential direct and indirect impacts were identified.

Potential Direct Impacts:

- mortality due to ground-disturbing activities (upland cable portions of the Project);
- mortality due to collisions with WTGs (including rotors, towers, and platforms), helicopters, construction vessels and equipment; and
- mortality due to nest abandonment resulting from human activity near nesting areas.

Potential Indirect Impacts:

- disturbance, displacement, or exclusion from suitable habitat, especially during critical periods such as breeding, nesting, and staging before and after migration;
- disturbance, displacement, or exclusion of fish from suitable habitat, thereby causing bird disturbance, etc., and physiological stress;
- impacts to lower food chain biota, such as benthic organisms during construction;
- long-term, alteration of ocean currents by monopile towers, leading to changes in food distribution and availability; and
- reduction in the visibility of prey and or inhibition/cessation of photosynthesis caused by suspended sediments during construction.

These potential impacts are discussed in the following sections arranged by the three project phases: offshore construction/decommissioning; operation and maintenance; and onshore construction and operation.

5.7.3.1 Potential Impacts during Offshore Construction/Decommissioning

5.7.3.1.1 Disturbance/Displacement and Habitat Modification

It is expected that some temporary displacement of birds would result from the disturbance associated with construction and decommissioning activities (increased vessel traffic, presence of equipment, human presence, and noise). Sediment plumes could cause fish to avoid the construction site, which could also displace the birds. During construction, birds in the immediate vicinity of construction/decommissioning activities could be temporarily displaced out to a distance of about two thousand feet (several hundred meters) from the activities (see Appendix 5.7-A). Bird species that may be utilizing the area for feeding or resting purposes may temporarily avoid the immediate area of construction or decommissioning. However, construction and decommissioning activities would be temporary, and would occur only in a small portion of the entire Project area at any one time. It is expected that it would take approximately two construction seasons to construct or to decommission the entire project (see Section 4.0 for a description of the construction activities).

Some bird species are more likely to avoid the immediate area of construction/decommissioning than others. Species such as alcids, seaducks, loons, grebes, certain diving birds, and some pelagic species would be less likely to feed or rest in the immediate area during construction (Appendix 5.7-A). However, since benthic habitat is similar throughout Nantucket Sound, birds are likely to be able to find suitable benthic habitat and associated prey items adjacent to the immediate area under construction or in other areas of the Sound. Given the relative percentage of the study area for each of the shoal areas (13% for Horseshoe Shoal, 6% for Monomoy-Handkerchief Shoal, and 11% Tuckernuck Shoal), surveys indicate that abundance of these bird species, mentioned above, was typically less at Horseshoe Shoal than at the other studied shoal areas or in the balance of the study area.

Other species – such as terns, gulls, and cormorants – may continue their activities, including feeding within a few feet of construction activities, because these species habituate rapidly to human structures/presence and have been observed and documented to forage near such structures/presence on a regular basis (Appendix 5.7-H). Terns, gulls, and cormorants were observed in abundance during aerial and boat surveys, typically in greater numbers in areas outside of Horseshoe Shoal than within, except during the March 17, 2003 through June 2, 2003 aerial surveys when tern density was highest at Horseshoe Shoal. The presence of vessels and construction activities should have negligible effects on foraging terns because they are regularly observed foraging in close proximity to vessels and waterfront locations where there is substantial human activity.

The jet plow embedding procedures are expected to have only transient and negligible effects because almost all of the sediment will be deposited within 200 ft of the trench and the increase in TSS will be transient (< one hour) and localized (about 20 mg/liter at 1,500 feet from the trench). See sediment modeling information in Appendix 5.2-C. The majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (generally minutes to less than one hour at any fixed location) (see Appendix 5.2-C). The majority of sediments suspended during foundation installation are conservatively expected to settle within the immediate vicinity of the foundations within one to two tidal cycles because the volume of sediment that would be suspended during the pile driving is expected to be minimal. This expectation is based on the predominance of sand sized sediments in the Wind Park area and the fact that the volume of sediment suspended by pile driving would be much less than the sediment volume suspended by jet plow embedment of the submarine cables (refer to Section 5.2 and Appendix 5.2-C for information on expected settlement rates associated with jet plow embedment). In addition, because the monopiles are hollow and open-ended, subsurface sediments would be encased within the monopile, providing additional structural support and minimizing disturbance of sediment from installation activities. This suspension of sediment into the water column is temporary and localized and would have only minor short-term effects on avian foraging either in terms of causing an avoidance response of the turbid area or in reducing foraging opportunity and success within the turbid area. Disturbance from construction activities to species such as migrating land birds is also expected to be minimal, since these birds would be found at high altitudes above the construction activities as documented in Appendices 5.7-A and 5.7-E.

During Project construction, and to a much lesser extent during decommissioning, disturbances to the seafloor from burying (or removing) the cables and installing (or removing) foundations would lead to temporary and

localized increases in turbidity and to temporary changes to/displacement of bottom fauna. This could have minor indirect effects on birds by temporarily affecting their prey and food availability (see Section 5.7.6.4.4). Cable installation techniques would avoid long-term disruption of the benthic zone through the use of jet plow embedment, which is recognized as the most environmentally acceptable cable embedment method (see Section 4.3.4). It is possible that benthic disturbance from cable and monopile installation may slightly increase avian foraging if injured invertebrates become more susceptible to avian predation.

The proposed landfall for the Project is on the northeastern side of Lewis Bay in Yarmouth, at the end of New Hampshire Avenue (Figure 3-68). This location is not immediately adjacent to any known bird nesting sites, including those of the Piping Plover and Least Tern (see Section 5.7.3.2 and Appendix 5.7-H and 5.7-I), and is not known to be an important feeding area for any shorebirds or wading birds. Therefore, construction and decommissioning activities near the landfall are not expected to disturb or displace shorebirds or wading birds or significantly alter their habitat.

Likewise, the construction activity at offshore windplants can also result in some permanent displacement. An influx of new boat traffic, work barges moored for extended periods, cranes and other powered equipment are operating, and people are present where they typically are not. Underwater activities cause temporary disturbance to the ocean floor, which will stir up ocean sediments releasing sediment into the water, similar to dredging or clamming activities. Depending on the activity and location (pile driving, cable installation, WTG mounting) this disturbance during the construction phase of wind power projects may last several months to more than a year. To our knowledge, no studies of this type of disturbance have been conducted, primarily because this disturbance is short-lived. It should also be noted that unlike onshore wind power facilities, nesting birds are not likely to be disturbed by most offshore facilities (they nest onshore) and some construction activity may actually attract birds from great distances in a similar fashion to fisheries activities (clamming, long-lining, etc.).

5.7.3.1.2 Disturbance from Vessel Traffic

Project construction and decommissioning would result in increased vessel traffic between the WTG array site, the submarine cable system route, and Quonset, Rhode Island (the planned construction staging area). This increased vessel traffic is expected to have negligible effects on most waterbirds and shorebirds, including loons, cormorants, gulls, terns and plovers, because these birds are generally not disturbed by vessel traffic (Appendix 5.7-H). However, increased vessel traffic would likely disturb seaducks and cause them to fly away from Project vessels (based on direct observations during the boat surveys). Although seaducks may exhibit avoidance behavior in the vicinity of Project vessels, these behaviors would likely be no different from the avoidance behaviors exhibited towards ferry traffic, recreational boating or fishing activity in the area. In addition, construction vessels would affect only small portions of the Project area at any one time. Landbirds, including the transient migrants, would be unaffected, since these birds would typically be found at high altitudes above the construction activities as documented in Appendices 5.7-A and 5.7-E. Other species – such as terns, gulls, and cormorants – may continue their activities, including feeding within a few feet of construction vessels and activities, because these species habituate rapidly to human structures/presence and have been observed and documented to forage near such structures/presence on a regular basis (Appendix 5.7-H). Terns, gulls, and cormorants were observed in abundance during aerial and boat surveys, typically in greater numbers in areas outside of Horseshoe Shoal than within, except during the March 17, 2003 through June 2, 2003 aerial surveys when tern density was highest at Horseshoe Shoal. The presence of vessels and construction activities should have negligible effects on foraging terns because they are regularly observed foraging in close proximity to vessels and waterfront locations where there is substantial human activity.

During periods when wind and wave conditions are unsuitable for boat transfers, personnel could be ferried by helicopter to the helicopter-landing platform on the ESP, if necessary. Helicopters would have a temporary disturbance effect on birds in the Project area during approach, landing, and departure on the ESP helicopter platform. It is expected that any birds in the immediate vicinity of the ESP during helicopter take-off and landing would react by flying away from the area. However, this disturbance would be temporary, and birds are expected to return to the area after the helicopter departs. The overall effects of helicopters are expected to be small because the frequency of use of helicopters is expected to be relatively low.

5.7.3.1.3 Effects on Bird Migration

Disturbance from construction activities to species such as migrating birds is expected to be minimal, since migrants are typically found at higher altitudes (Appendices 5.7-A and 5.7-E) above construction activities and due to the temporary nature of construction and decommissioning.

According to the radar study (Appendix 5.7-E), migrants are less likely to fly during foul weather conditions ranging from a high of 47% (11,338/24,196: spring night large/fast targets) to a low of 10% (13,242/128,861: fall day large/fast targets). Since construction would generally be limited during storms, particularly at night, impacts to migrants during such conditions are anticipated to be minimal. Vapor lights (likely to be a metal halide) may have the potential to attract birds especially during inclement weather, and may increase risk of collision to migratory birds if some of the turbines are in operation. However, it is likely that nighttime construction for the installation of the towers and nacelles would take place only during clear conditions. Construction will be limited to only a few locations at any one time and if occurring at night, lighting would be limited to that necessary for worker safety. To the extent possible construction lighting would be downward directed task lighting.

Construction and decommissioning activities would likely pose a similar risk to migrating bird species as typical commercial and recreational boat traffic and other types of offshore infrastructure and construction such as other cable or pipeline installations and dredging activities, except for the erection of towers, which will impact the airspace. However, construction of the proposed Project would occur over a longer period of time and possibly at night if sea state and weather conditions allow.

5.7.3.1.4 Indirect Impacts

Indirect effects on bird species during construction or decommissioning could occur from seabed disturbance and temporarily elevated suspended sediment concentrations, as discussed above under Section 5.7.3.1.1. These indirect effects could include temporary prey displacement, possible attraction to a sediment plume associated with cable jetting, and the potential for bioaccumulation of possible contaminants.

Pile-driving technologies would be employed to install the WTG monopile foundations, and jet plow embedment technology would be used to install the submarine cable system and inner-array cables (Section 4.3.4). These technologies were selected specifically for their ability to minimize sediment disturbance and would minimize the area affected by a temporary increase in suspended solids that could potentially affect fish and bird foraging on a short-term basis. Disturbed sediments are expected to settle back to the sea floor within a short period of time and to be rapidly recolonized by benthic organisms (potential avian prey populations). The Project area is situated in a dynamic environment that is subject to naturally-high suspended sediment concentrations in near-bottom waters as a result of relatively strong tidal currents and wind and storm generated waves, particularly in shoal areas (see Section 5.2). Therefore, marine organisms in this area are accustomed to substantial amounts of suspended sediment on an irregular basis and should not be substantially impacted by a temporary increase in turbidity from Project activities (see Section 5.4.5.1).

Sediment disturbance resulting from Project construction is expected to be localized and temporary and is unlikely to permanently alter benthic communities in the Project area other than at the WTG monopiles (See Section 5.3.4.1). In general, it is widely recognized that benthic invertebrates are able to opportunistically invade unoccupied areas after disturbance (Hynes, 1970; Rosenberg and Resh, 1993; Rhoads et al., 1978; Howes et al., 1997). While, the bottom immediately around the monopile will be disturbed, scour protection mats will be installed to facilitate reestablishment of bottom conditions and prevent large scale transport of sediments. The use of the synthetic fronds in the scour protection mats are designed to mimic seafloor vegetation that would afford the necessary scour protection while minimizing potential alterations to the benthic and fish communities typically associated with Horseshoe Shoal. Therefore, finfish feeding on the benthos, or birds feeding on benthos or finfish, should not be adversely affected by the temporary displacement of prey items during Project construction or decommissioning. As disturbed benthic habitat is recolonized by benthos and prey items become more abundant, finfish and birds would resume foraging in those areas. Indirect effects on bird species, from temporary prey displacement during construction or decommissioning, is expected to be localized and short-term.

Due to the good quality (no elevated concentrations of contaminants) of sediments at Horseshoe Shoal site, bioaccumulation of contaminated sediments is not anticipated to affect birds in the Project area. Recent studies indicate that sediment contaminant levels in the Project area were below established thresholds in reference sediment guidelines (see Section 5.1.2.2). Any small amount of contaminants that might be present in suspended sediments is likely to remain adsorbed to sediment particles and be rapidly redeposited onto the bottom as the particles settle.

A potentially beneficial indirect effect from sediment disturbance during construction or decommissioning is related to increased prey abundance in the temporary plume of elevated suspended sediments. The jet plow embedment, and possibly, monopile installation, could release certain organisms from the seabed, making them easy prey for fish and avian predators. Feeding fish would in turn attract fish-eating birds such as gulls, terns, and gannets. This type of impact may be beneficial to those bird species on a localized and short term duration.

5.7.3.1.5 Cumulative Impacts

In addition to the proposed Project, other activities which may contribute to cumulative impacts to avian resources would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from various potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, will likely result in additional concurrent, cumulative sediment suspension and deposition. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on recent experience it could be needed in the next 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. In any event, as discussed in Appendix 5.2-C, sediment deposition resulting from the cable installation would be minimal and localized, and would not substantially contribute to any cumulative impact.

Similarly, the submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. The North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance dredging. Therefore, no cumulative effects from the cable installation are expected in the area of the North Channel crossing.

A new submarine transmission cable between the south shore of Cape Cod and Nantucket has been proposed by National Grid, and its proposed route may be in the vicinity of the Wind Park and its inner array cables in Nantucket Sound. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. At this crossing, and in its near vicinity, the impacts of each project would be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and of short duration, these temporary impacts are not likely to occur at the same time. Thus, any area where both projects may result in impacts as a result of jet plow cable embedment would likely have assimilated the deposited sediment from the first project installation by the time the second project is constructed. Since both projects involve relatively short duration activities where they cross, disturbance and avoidance affects on birds would not represent a harmful combined duration.

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the Project area. However, these types of marina dredging projects, if they were to occur, are very localized and not likely to result in sediment suspension and deposition that would be coincident with the cable installation (the closest point of which would be a minimum of 0.5 miles (805 meters) from the closest marina). Bird species occupying or using areas of marinas are typically adapted to frequent vessel activity and would not be adversely affected if coinciding projects were undertaken with the Cape Wind Project. Thus, no significant cumulative impacts are anticipated from these activities.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts expected to birds, since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

In summary, no significant cumulative impacts to bird species or habitat are expected from construction or decommissioning of the WTGs, the inner-array cables, or the submarine cable system.

5.7.3.1.6 Secondary Impacts

There are no potential offshore secondary impacts to birds associated with construction staging/laydown activities at Quonset. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility and its waterfront piers are currently not operating at full occupancy, and no significant in-water alterations would be necessary to accommodate the Project's staging activities. Thus, no secondary impacts to birds have been identified.

5.7.3.2 Potential Impacts during Offshore Operation/Maintenance

5.7.3.2.1 Collision Risk Evaluation

Fatality resulting from collisions with wind turbine rotors has been studied extensively in both the United States and Europe where thousands of commercial sized wind turbines are now operating. Avian mortality is a possible consequence of erecting tall structures, and mortality due to collisions with the Cape Wind project may result in an unavoidable impact on avifauna. At most terrestrial wind power facilities, the numbers of bird fatalities have been low overall. For example, Erickson et al. (2001) concluded that the number of fatalities attributable to wind turbines in the United States may average 1 to 2 birds per turbine per year. A comparison of the birds estimated to be killed by wind turbines with other sources of human-induced mortality helps to put the risk and potential impact of wind turbines in perspective. As discussed in detail in Appendix 5.7-A, the numbers of fatalities for wind turbines are orders of magnitude smaller than for other human mortality sources. For example, on an annual basis, approximately 100 million to 1 billion birds die from collisions with glass windows (Klem, 1990), over 8 million birds are killed annually in Wisconsin alone (Coleman and Temple, 1996), 120 million birds die from hunting activities (Gill, 1995), and 4 to 5 million birds die from colliding with communication towers (Manville, 2000). In contrast, it is estimated that the number of annual bird mortalities attributable to wind turbines is about 28,000 to 33,000 birds (Erickson et al., 2001). State and federally regulated hunting, which accounts for approximately 120 million birds killed per year, has not been found to impact populations of any bird species (Gill, 1995). In light of these other impacts from man-made structures, the number of birds killed by wind turbines is unlikely to cause bird population declines.

In Europe, there is greater experience with coastal wind power sites, although no data are available from large offshore wind farms. At a small coastal wind farm in northeastern England, monitoring that began in 1991 (pre-construction) and continues post-construction has included regular beach surveys for dead birds. Only approximately 3% of the bird corpses found on the beaches during the monitoring program was attributed to the wind farm, and a majority of those were gulls. For Horseshoe Shoal, there may be risks to gulls when following fishing boats and to Northern Gannets while foraging. Both of these birds were observed flying at or above the plane's altitude during aerial surveys and both hunt prey from within the rotor-swept zone (75 to 417 feet (23 to 127 meters) asl). However, the majority of waterbirds observed in the Project area during avian surveys were flying well below the height of the rotors.

Songbirds, shorebirds, and other "landbirds" migrating at night fly well above the altitude of the turbine rotors, therefore any limited collision mortalities are not expected to have population-level effects. Results from the radar studies conducted by Cape Wind and from existing literature confirm that a large majority of night migrants fly at altitudes well above the turbine rotors (1,500 to 2,500 feet (457 to 762 meters) asl) (Appendix 5.7-E; Kerlinger, 1995; Kerlinger and Moore, 1989; Griffin, 1974; Able, 1970). For songbirds migrating at night, the literature shows that the average height of migration is usually 1,000 feet (305 meters) asl (Appendix 5.7 E). Radar studies by Gauthreaux (1972) of migrant songbirds flying over the Gulf of Mexico and southern Louisiana

during spring migration showed that fewer than 10% of all migrants flew below 1,000 feet (305 meters) asl, and more than 60-70% flew higher than 3,000 feet (915 meters) asl. Of the 491,306 total targets observed by VerCat, 127,697 (approximately 26%) were observed in the rotor swept zone. During spring and fall, 83,083 out of 221,059 (approximately 38%) were observed during the day in the rotor swept zone, and 44,614 out of 270,247 (approximately 17%) were observed at night in the rotor swept zone. For a more in-depth analysis of migration over the study area, see Appendix 5.7-E.

The risk of collision varies among bird species or groups of birds and is also highly dependent upon the duration of presence in the Project area and bird behavior, including the height at which birds fly. Such factors as weather also contribute to risk, as discussed in the sections below on Avian Use and Flight and Visibility. Risk to daytime fliers at sites in the eastern United States is likely to be lower, as has been demonstrated by previous studies (Kerns and Kerlinger, 2004; Nicholson, 2003). Erickson et al., (2001) also demonstrated that, at most newer onshore wind plants, night migrants were more numerous on the fatality lists than were day flying birds. Daytime migrants make up only a very small proportion of the birds killed by wind turbines (Erickson et al., 2001, Kerns and Kerlinger, 2004 and Nicholson, 2003). Based on these previous studies, risk to daytime fliers is likely to be lower. Therefore, when evaluating impacts, it is more important to examine the behavior of night flying birds, primarily migrants, since these are the birds that have been shown to be more susceptible to impacts from wind turbines.

Risk Factors

Factors thought to affect risk of collision-related mortality include the following.

- **Avian Use and Flight Height-** Risk of collision (resulting in mortality) is a function of avian "use" of an area. Use is sometimes defined as how much time birds spend in a given area (no. birds/unit area/unit time) and the proportion of time spent flying at rotor height, or abundance and behavior while within a prospective turbine area. Use and abundance are generally correlated and for the Cape Wind project use is simply abundance in the Wind Park area and abundance by species within the rotor height. Avian use of an area is a function of many biological and physical factors, including proximity to nesting sites, presence/absence of food, shelter or other habitat elements, possible displacement from other preferred habitats, etc. Time spent flying at rotor height is a function of species specific behavior (how much time it spends flying and at what heights it tends to fly), weather/wind, behavior (e.g, foraging, courtship, and migratory flight heights may all be different, and often are), etc.

- **Species-** The number of fatalities from bird collisions with turbines also varies with species. While many fatalities involving raptors have been observed at the Altamont Pass Project (APWRA) in California, only several dozen raptor fatalities per year have been reported from all other wind projects in the U.S. Songbirds are the most common species involved in collisions with wind turbines at most terrestrial wind power sites, including collisions during nighttime migration and daytime activities.

- **Turbine Design Features-** Five features of turbine design have the potential to affect the level of collision risk for avian species, as discussed below.

  - Height – turbine height has not been demonstrated as a risk factor in collisions although shorter, 60-foot towers may be more dangerous to raptors (Orloff and Flannery, 1992) in situations like the Altamont. Communication towers taller than 500 feet are more risky to night-migrating birds than those less than this height (Kerlinger, 2000, analysis of towers listed in Shire et al., 2000).

  - Number of Perch Sites (Lattice vs. Tubular Towers) – tubular towers that do not have perch sites for raptors and other birds are thought to present less risk than towers on which perching is possible. Perching is believed to be both a direct and indirect risk to birds. The direct risk is the potential for collision while attempting to perch or take off from an operating turbine. The indirect risk is likely to be through increased use due to habituation. Turbines that permit perching allow birds to use areas in very close proximity to turbines and habituate to turbine operations, and thus are likely to approach operating turbines and collide with rotors. Perching on the nacelles of larger turbines may be possible, and may be a unique problem with the Cape Wind facility, as it would be located in an otherwise perchless environment and thus would likely be attractive to birds that perch. However, a review of onshore

studies at various wind plants with tubular towers does not reveal that many birds perch on nacelles (Kerlinger, 2004).

- Turbine Spacing – Some of the highest fatality rates of raptors have been found at turbines in the APWRA in areas where towers are only 80-100 feet apart, (where rotor tips are only 30-40 feet apart) – wider spacing may result in fewer fatalities. It is believed that raptors flying between these turbines while hunting ground squirrels sometimes collide with rotors (Orloff and Flannery 1992). While the relationship between spacing and collisions has not been tested thoroughly, it may be that a greater amount of open space between turbines would enable movement through the wind park with less risk to birds. Conversely, if birds were to perceive tightly spaced turbines as a barrier, they might avoid the wind park altogether, thereby greatly reducing risk. Turbines with closer spacing may simply have less open space for birds to fly between them. This relationship has yet to be tested and there is no data for waterbirds or waterfowl; therefore, the issue of turbine spacing is not included in the analysis below.

- Rotor RPM and Tip Speed – larger, slower rotating turbines seem to be no more risky on a rotor-swept-area basis than smaller and faster rotating turbines, but only one empirical (Howell, 1997) study and one theoretical (Tucker 1996) study have been done. Hodos (2001) has reported that tip speed is what matters most, although the tips of larger rotors may be more visible than those on smaller rotors that travel at the same speed. These hypotheses need more testing, although at the modern wind plants with turbines that rotate at slower speeds, fatalities numbers have been relatively small. Since this issue has not been resolved, it is not included in the analysis presented below.

- Lighting – towers without FAA lighting are less likely to be involved in collisions of night migrating song and other birds because it is the lights that attract birds to towers (Avery et al., 1980, U. S. Fish and Wildlife Service 2000.). White strobes are believed to be less attractive than red incandescent lights (U. S. Fish and Wildlife Service 2000, S. Gauthreaux and Belser, 1999 address to the Communication Tower Working Group), but this has not been demonstrated in a completely controlled situation. A recent analysis by Kerlinger (2004) revealed no large-scale fatality events have occurred at wind turbines with FAA lighting (red flashing strobe-like or incandescent flashing lights) and that there is no difference in fatality rates between unlit turbines and turbines with red flashing L-864 lights. Wind turbines lack the steady burning red FAA lights (L-810), which are present in multiples of 2 or 3 on communication towers. Most experts believe that flashing lights are far better than steady burning lights (consensus of experts at the U. S. Fish and Wildlife Service Communication Tower Working Group, February 11, 2004, Washington, DC). Thus, there is no evidence that the red flashing, strobe-like lights on wind turbines attract any type of birds. It should also be stated that a broad review of the literature by P. Kerlinger revealed that many of the birds (terns, shorebirds, waterfowl) that fly over Nantucket Sound have never been demonstrated to be attracted to FAA lighting of any kind, or other lighting (lighthouses, etc.).

- **Numbers of Turbines**– The large number of turbines in Altamont Pass (APWRA) are a significant risk factor; the greater the number of turbines, the more potential for collisions. The shear number of turbines in places like the APWRA and their density are likely to be a risk factor. In the APWRA there are now 5,400 turbines, down from a maximum of 7,000 in about 1990. The density there is 67.5 turbines (obstacles) per square mile. This high risk site is quite different from sites like the wind projects at Ponnequin where there are slightly more than 20 per square mile or in Pennsylvania where there are about 4 to 8 per square mile. It is likely that risk increases with density of obstructions since more of a unit area is occupied by structures. However, the number of turbines to be erected is a function of the need for power and the ability to transport power to load areas. Since the Proposed Action is for 130 turbines, the analysis is based on 130 turbines.

- **Topography**– In the APWRA fatalities of Golden Eagles and Red-tailed Hawks are two to three times more likely to occur at end of row turbines that are situated on steep hills or canyon walls or at turbines that are in the middle of strings that are at the bottom of a canyon or steep valley – notch or dip in a ridge. This factor was so well documented (Orloff and Flannery 1992) that it has been incorporated in the Alameda and Contra Costa county, California, recommended practices for siting new or repowered wind turbines. Keeping turbines on level ground in the APRWA, and perhaps other sites, is likely to reduce risk of collision. In marine environments, the surface is flat, except for waves and the sea bottom, so this relationship may not apply.

However, shorelines and islands often concentrate both land and seabirds into flight lines within restricted areas, thereby increasing risk of collision.

- **Visibility –** Visibility has been demonstrated to be an important risk factor for predicting collisions at tall communication towers with FAA lights (Avery et al. 1980). On nights with poor visibility (fog, rain, snow, or low cloud cover, night migrating song and other birds are attracted to communication tower lights and often collide with the guy wires. At unlit turbines, the risk of collision may be greater at night or at dawn or dusk because moving rotors may not be detectable. Fog and other conditions that make seeing towers difficult have been associated with fatalities at terrestrial communication tower sites (Trapp, 1998). Eiders and scoters have been shown to detect and avoid offshore turbines at night in both the Netherlands (Winkelman, 1995) and at offshore towers at Tuno Knob in Denmark (Tulp et al., 1999). It is not known how poor visibility caused by rain or fog would impact waterbirds in marine environments, although their movements are more limited at such times.

- **Predatory Birds** - Predatory behavior by other birds (e.g., peregrine falcons) may contribute to a bird being at risk, although there are relatively few raptors found more than a mile from shore in Nantucket Sound, as opposed to onshore where prey density is greater.

- **Individual Experience -** Young-of-the-year with less flying experience are likely to be at greater risk than more experienced adults.

Risk by Bird Group

The data collected for the Cape Wind project provide some presence/absence information--42 bird species were documented in the study area, and it can be assumed that all of these species occur on Horseshoe Shoal at some time and to varying extents. The following discussion serves to present the collision risk relative to the abundance and distribution data presented in Section 5.7.2 for the various bird groups and the risk factors discussed above.

Oceanic/Pelagic Seabirds. Gannets would primarily be at risk while feeding during migration as they pass through the area and to a lesser degree during the winter months when fewer individuals are present. When gannets spot prey from high altitudes, they typically plunge-dive into the water in pursuit of that prey and may be at higher risk while diving because of the fast and focused flight. Storm-petrels, shearwaters, and other pelagic seabirds might be at risk while foraging on Horseshoe Shoal during migration and in summer. Flight of these birds is primarily restricted to altitudes less than about 15-20 meters both while foraging and migrating. Pelagic seabirds such as Leach's Storm-Petrel are known to be attracted by bright lights (Montevecchi et al., 2001; Pfand, 1996), such as those on oil rigs, city parking lots, and stadiums (mercury vapor lamps). These types of lights would not be used for this Project, so impacts would be limited to possible collisions while foraging and migrating.

Gulls and Terns. Gulls are present in the Project area throughout the year. They forage in the area, especially when following fishing boats, and flight occurs at rotor height, so collision-related mortality is likely. Since gulls tend to habituate to most man-made structures, they are likely to habituate to the turbines, which could increase risk of collision.

Terns are present in the Project area from April through September and are likely to fly at rotor height during migration and courtship, and while foraging. Terns might attempt to perch on the turbine platforms, the ESP, and possibly the nacelles, and thus would be at increased risk of collision. However, the platforms and the ESP will be protected with deterrent devices. During courtship displays, the terns spiral steeply upward, sometimes to heights of 300 feet (100 meters) or more, so any displays conducted from platforms could result in collisions with rotors and possibly towers. Additionally, the platforms may provide fish shelters (structures under which to hide) which could attract fish and thus terns to the turbines. Turbine platforms would be equipped with bird deterrents, such as wires on top of the rails to deter perching, thereby reducing the likelihood of tern collision with turbine blades during courtship displays (see Section 5.7.3.4). For more details on collision risk to roseate terns, please see Section 5.7.3.4.

Seaducks. Seaducks are present in the Project area for about six-seven months during migration and winter, when they are the most abundant type in Nantucket Sound, and they make daily (sometimes nocturnal)

movements to and from feeding areas within or near the Project area. Their distribution is strongly affected by storms. European studies have demonstrated collisions involving less than 1 dozen eiders at turbines built along jetties and about 63 diving ducks situated in saltwater lakes adjacent to the Wadden Sea (Winkelman, 1995). Wind turbine facilities in North America located in Minnesota (Buffalo Ridge), Iowa (Clear Lake), Wisconsin, and California (Solano County and Altamont) are situated in areas that experience high use by waterfowl, mostly geese and dabbling ducks during the migration seasons. At these sites, few individuals, primarily mallards are most often killed, of these types of species Minnesota (5), Iowa (0), Wisconsin (1), Solano County (1) and Altamont (7) have collided with turbines (Erickson et al, 2001). Though these waterfowl are dabbling ducks and geese, rather than seaducks, they are likely to have similar visual physiology and have similar ability to detect the presence of turbines. Like seaducks, they make foraging flights at night and often migrate at night (Bellrose, 1976). Interestingly, very few ducks of any species are known to collide with communication towers, including those more than 1,000 feet tall having nearly a mile of guy wires (Shire et al., 2000, Avery et al. 1980), so it seems that ducks are either not terribly susceptible to colliding with vertical structures or structures with FAA lighting or they are adept at avoiding these structures. However, seaducks are faster fliers and generally less maneuverable than dabbling ducks and other divers, so they may not be able to physically avoid turbines to the extent that dabblers can. Of the 377,432 seaducks observed during the aerial and boat surveys from March 2002 through February 2004, 54 (10 long-tailed ducks and 44 scoters) were observed flying at rotor height. Extrapolated to include 50% of the two-year study (since seaducks are in the project area 6 months of the year) 14,645 seaducks might be at rotor height. As evidence by the Winkleman 1995 study, diving ducks have collided with wind turbines. Thus, some amount of collision-related mortality of seaducks may occur. Because more than 35,000 eiders and a similar number of scoters are shot legally each year (Martin and Padding, 2002), fatalities in single digits per turbine per year, would not likely be biologically significant.

Cormorants. Double-crested cormorants occur in the Project area, most during a seasonal window that includes about one-half of the year (mostly September-November, March-May). Small numbers of Great Cormorants are present from November through April. Double-crested Cormorants were observed frequently during the day resting areas on Fernando's Fetch, Bishop & Clerks' Lighthouse, and on the sandbars west of Monomoy, but only four individuals were observed within any of the three shoals studied (one in Monomoy-Handkerchief Shoal and three in Tuckernuck Shoal) during the aerial surveys. While cormorants are typically observed closer to shore (Ward and Sutton, 2001), the ESP and access platforms on the WTGs may attract cormorants, although perching would be discouraged through the use of bird deterrents. Great cormorants are present during a smaller seasonal window, mostly in winter. Both species frequently perch on large, man-made structures and are likely to be attracted to the turbines as potential perching sites which may increase potential for collision, especially if birds repeatedly look for perches but are deterred. It is likely that they will learn that they cannot perch on turbines after a few unsuccessful attempts or they may not approach turbines while operating, as is the case for many birds that fly in daylight. Cormorant migration over water typically occurs during daylight, and while they frequently occur at rotor height, it is anticipated that they would see and avoid the turbines and rotors. Two sites through which large numbers of cormorants migrate (Blythe Harbor and Buffalo Ridge) have reported one cormorant fatality (Still et al., 1995, Strickland et al., 2000), however, the extent of potential mortality at the Cape Wind project is unknown. In light of the 47,000 Double-crested Cormorants annually killed via depredation permits, without significant impacts, even if hundreds collide with turbines the impact is unlikely to be biologically significant.

Other Divers (loons, grebes, alcids). The few studies of coastal migrating loons and grebes show that they usually do not fly above 100 feet (30.5 meters) above the waves, although over land they can fly at very high altitudes (Kerlinger and Moore, 1989). During the field studies they were occasionally observed flying between 100 and 200 ft asl. They occur within Nantucket Sound an estimated 9 months each year. Loons were relatively evenly distributed during the aerial surveys, suggesting that they would occur on Horseshoe Shoal, although the amount of time spent on the Shoal is unknown. Of the 8,817 loons observed during the aerial and boat surveys, six were observed at rotor height. Extrapolated to include 75% of the year that loons occur in Nantucket Sound, 2,440 loons could have occurred at rotor height. Because loons are diurnal migrants, risk of collision during migration may be lower than for night-migrating species, but overall risk is unknown. Alcids generally fly close to the sea surface, well below rotor height (personal observations Jeremy Hatch, Paul Kerlinger).

Shorebirds (Plovers, Sandpipers, and Allies). Studies from coastal European wind parks have demonstrated that shorebirds can be at risk of colliding with wind turbines during migration stopovers (Everaert et al., 2002).

Collisions did not seem to occur during active migration, but were instead associated with local flights between foraging and resting areas. There is likely to be little risk to the large numbers of night migrating shorebirds as their altitude usually is well above rotor height (in the neighborhood of 6,400 feet (2,000 meters) asl) (Richardson, 1978). Night migrating songbirds do not tend to collide in large numbers with even brightly lit structures such as lighthouses, spotlighted buildings, and heavily lighted communication towers with guy wires (see lists in Shire et al., 2000). The L-864 red flashing lights proposed for night-lighting of the WTGs have not been demonstrated to attract birds. Shorebirds making diurnal migration staging flights between Monomoy and Nantucket or among other islands and the Cape Cod shoreline may fly within the height range of rotors at times, and, while many are likely to see and avoid turbines, some unknown amount of mortality is likely to occur. For more details on collision risk to piping plovers, please see Section 5.7.3.4.

Raptors. Very few raptors are likely to be present at more than 3 miles (4.8 km) from shore and thus would rarely occur within the Project area (Kerlinger, 1989). They are most likely to occur in the project area for four months during migration (April to May, September to October). Individual birds migrating through the area would usually fly through the area only one time per season or per year. The general pattern for most migrating raptors is to fly directly between the nearest points of land and leap-frogging from island to island. In this case, the migration is most likely to occur between Monomoy and Nantucket and then on to Martha's Vineyard (Veit and Peterson, 1993). This route is well away from Horseshoe Shoal. The risk during other months is virtually nonexistent, because these species would rarely be present.

Ospreys and, to a far lesser extent, some falcons (peregrine and merlin), and bald eagles are known to forage over water, and thus may forage in the Project area. No ospreys were observed in the Project area during the aerial surveys, but seven ospreys were observed during the boat surveys in August 2002 and one osprey was observed outside the study area in Buzzards Bay/Vineyard Sound in April 2003. All were within 1 mile (1.6 km) of the shoreline (Table 5.7-5). To date, no osprey or merlin fatalities at wind plants have been reported; one peregrine fatality has been reported from the APWRA (Kerlinger and Hatch, 2001). The turbine platforms, the ESP, and possibly the nacelles provide potential perches for raptors, and, while perching deterrents would be used, birds searching for perches within the wind park would be at risk of collision. The project would result in an unknown, but likely low amount of raptor mortality given their low abundance in the project area.

Passerines and Other Landbirds (Night Migrating Songbirds). Night migrating songbirds, for the most part, are likely to fly at altitudes well above the turbine rotors and are not at great risk of collision (Kerlinger, 1995; Kerlinger and Moore, 1989; Able, 1970). Data from the radar studies that were conducted during the peak migration period showed that 127,697 out of 491,306 targets (26%) were flying within the rotor swept zone. Less than 10% (44,614) of the total were flying in the rotor swept zone at night, when risk of collision is likely to be greater.

Those birds that are caught out over the ocean at dawn often attempt to return to shore. These birds frequently fly at much lower altitudes (especially with head winds such as westerlies and northwesterlies in fall) and are likely to be within or below rotor height. In these situations, some may be at risk; with good visibility, however, these birds are likely to avoid the turbines. During poor visibility such as storms, fog, and foul weather, some birds could be at increased risk if they are attracted by the lights on the WTGs (Kerlinger and Kerns, 2003; Kerlinger, 2004). While night migrating songbirds are the most common species involved in collisions with wind turbines at most terrestrial wind power sites, the numbers killed have been small in relation to overall numbers and numbers that pass over wind plants. The highest fatality rates at onshore wind power facilities in the United States have been about 3 to 7 night migrating songbirds killed per turbine per year (Kearns and Kerlinger 2004, Nicholson 2003). Compared to other mortalities caused by collision with structures, Cape Wind song bird mortality is likely to be a minute fraction.

Conclusion. Data from existing literature and the Applicant's studies indicate that millions of birds likely migrate through Nantucket Sound each year, and 100s of thousands are summer residents, and 100s of thousands winter in the Sound (Appendix 5.7-A). Since one of the primary risk factors is bird use, and one of the elements of use is numbers of birds, it is assumed that use of the Sound is very high, especially during migration, and consequently, use of Horseshoe Shoal could also be considered high. Therefore, although not specifically determined by the Applicant, this analysis assumes that bird use of Horseshoe Shoal could be relatively high

because of the very high numbers of birds that use the Sound and the features of the shoal that promote bird foraging.

Flight height is another critical factor in determining risk of collision related mortality, and most mortalities are apparently the result of collisions with rotors; therefore, amount of time flying at rotor height is an important risk factor. The field studies indicated that roughly 95% (approximately 392,000 of 412,418) of the birds observed were flying below rotor height. However, the aerial and boat survey methods used are only snapshots of avian presence and relative abundance at the time of the survey. Although long term use patterns cannot be determined from such snapshots, the data also shows that flight in Nantucket Sound includes flight at rotor height, which puts birds at risk. Also, the number of birds flying at rotor height may actually be high. Allowing for the limitations of the radar study data described above, if all targets recorded were birds, 127,697 birds were at rotor height in 1,837 hours of data collection; on average, there were 69.5 birds/hour at rotor height. The radar studies were conducted during peak migration periods, so numbers would likely be smaller at other times of the year; alternatively, some of the targets may have been flocks so the actual number of birds may have been higher.

To estimate the numbers of birds that may fly in the rotor swept zone on an annual basis, the following approximations are presented for individual species groups. The following estimates are made on the basis of data collected over two years of aerial surveys and presented in an annualized format.

For the individual groups observed during the aerial field studies, 1 grebe was observed flying at rotor height in 202 hours of observation within the study area. The 202 hours of observation represents roughly 1.2% of the two year study, so over the course of two years, 75 grebes would have occurred at rotor height (grebes are present in the project area 9 months/yr (75%)). Adjusting for the portion of the study area sampled (19%), an estimated 328 grebes might have occurred at rotor height during the two year study period. On an annualized basis, 164 grebes could be expected to pass through the Project area at rotor height. Similarly, it is estimated that 1,350 loons, 4,091 northern gannets, 8,767 cormorants, 658 scoters, 18,629 gulls, and 10,958 terns may fly through the Project area at rotor height in a given year.

The radar data also provide a limited estimation of use during the two months sampled over Horseshoe Shoal. Assuming that the MARS recorded targets over a 172.6 sq km area (4 nautical mile radius), then 1,052,761 targets/ 1,837 hour/66.7 sq mi (172.6 sq km) = 3.3 birds/hour/km^2.

An estimated 127,697 targets were observed at rotor height during the two-month (1,837 hour) radar study. Assuming that all of these were birds, and extrapolating to a period of one year, an estimated 608,942 birds would be flying at rotor height over the course of a year. Also, some targets may represent flocks, and thus the 127,697 targets may actually represent more birds. For more detailed information on the radar studies please refer to Appendix 5.7-E. Since the radar study was conducted during peak migration and demonstrated higher numbers thatn the aerial snapshots, it may provide a high estimate of number of birds at rotor height, but in the absence of data to indicate otherwise, it is concluded that numerous birds fly at rotor height. While this extrapolation is based on spring and fall radar study data, data acquisition during winter months, which may be useful for evaluating the validity of the current extrapolation, is being planned. This data will likely be available prior to the issuance of a final EIS. Note that not all birds flying at rotor height would be expected to collide with the turbines; calculations indicate that many birds that do encounter the rotors would pass between the blades even without making any active response (Tucker 1996). Further, many species will actively avoid the turbines even when flying at rotor height (Winkleman 1992).

Collision mortality has been documented at 12 on-shore wind farms located in the United States. The numbers of collision fatalities reported from on-shore wind farms varies considerably among locations and among years (Erickson et al., 2001). At Altamont Pass, California, 256 fatalities were recorded over a 2-yr period, at Foote Creek Rim, Wyoming, 95 fatalities were recorded in one year, in Searsburg, Vermont, Algona, Iowa, and Somerset County, Pennsylvania, no fatalities were recorded during 3-6 month studies. Another factor that likely affects number of fatalities is number of turbines. Mortality rates for the 12 on-shore facilities studied ranged from 0 to 2.8 fatalities/turbine/year. Conservatively applying the highest rate (2.8 fatalities/turbine/year) to the proposed Cape Wind farm, an estimated 364 birds could be killed each year. As discussed above, a very small percentage of those birds that fly at rotor height would expected to collide with the WTGs. This number is a very

rough estimate--the Cape Wind farm is the first of its kind in the U.S. and the Nantucket Sound ecosystem is different from any that has been previously studied for wind development. An attempt has been made to document bird life in the project area including numbers of birds in the Sound and the potential numbers of birds flying at rotor height, it is possible that mortality rates might be different than those documented at on-shore sites.

The literature suggests that collision-related mortality of birds within wind farms is a relatively rare event; an estimate of 0 to 2.8 fatalities/turbine/yr is low compared to other causes of mortality, such as collisions with buildings (Erickson et al., 2001). Fatality resulting from collisions with wind turbine rotors has been studied extensively in both the United States and Europe. There are thousands of commercial sized wind turbines now operating in Europe and the United States. Virtually all of what is known comes from terrestrial wind power facilities, although a few studies have been conducted at coastal and offshore wind power facilities. As discussed in Appendix 5.7-A, at most terrestrial wind plants, the numbers of fatalities have been low overall. Erickson et al. (2001) recently reviewed the published and unpublished literature from the United States. They concluded that the number of fatalities attributable to wind turbines in the United States may average about 1-2 birds per turbine per year. The studies that are available from about a dozen sites in about 10 states range from no birds found at a given wind plant to hundreds of birds found at a facility over several years (Appendix 5.7-A). The number of fatalities from bird collisions with turbines varies with species and location. While many fatalities involving raptors have been observed at the Altamont Pass Project in California, fewer than five raptor fatalities have been reported from other wind projects in the U.S. (Appendix 5.7-A). Songbirds are the most common species involved in collisions with wind turbines at all other terrestrial wind power sites, but the numbers have been small. Some of these songbirds collide with turbines during nocturnal migration. Fewer than about 100 night migrating song and other birds have been reported from all the locations in the United States (Appendix 5.7-A).

Information on bird fatalities at wind turbines located in the water or offshore is limited because there are fewer non-terrestrial wind farms worldwide, and no data are available from large, offshore wind farms such as the proposed Cape Wind project. Turbines located in low-lying areas in the Netherlands adjacent to the Wadden Sea experience a greater number of fatalities than turbines on uplands (Winkelman, 1995). Large numbers of migrants, including waterfowl, shorebirds, and some songbirds are thought to use these areas during migrations and also with low altitude flights among feeding locations. Estimated fatality rates were 0.04-0.14 birds/turbine/day.

At a small coastal wind farm in northeastern England (Blythe Harbour), monitoring that began in 1991 (pre-construction) and continues post-construction has included regular beach surveys for dead birds. Only approximately 3% of the mortalities (86 of a total of 2,586) found on the beaches over six years were attributed to the wind farm, and a majority of those were gulls.

Results from the radar studies conducted by Cape Wind and from existing literature show that most night migrants fly at altitudes well above the turbine rotors (1,500 to 2,500 feet (457 to 762 meters) asl) (Appendix 5.7-E; Kerlinger, 1995; Kerlinger and Moore, 1989; Griffin, 1974; Able, 1970). For songbirds migrating at night, the literature shows that the average height of migration is usually 1,000 feet (305 meters) asl (Appendix 5.7 E). Radar studies by Gauthreaux (1972) of migrant songbirds flying over the Gulf of Mexico and southern Louisiana during spring migration showed that fewer than 10% of all migrants flew below 1,000 feet (305 meters) asl, and more than 60-70% flew higher than 3,000 feet (915 meters) asl. Of the 491,306 total targets observed by VerCat, 127,697 (approximately 26%) were observed in the rotor swept zone. An estimated 83,083 out of 221,059 (38%) of daytime targets were within the rotor swept zone, and 44,614 out of 270,247 (17%) of night time targets were within the rotor swept zone. These data support the idea that most night migrants would fly above rotor height; however, those birds that do fly at rotor height would be at risk.

Daytime fliers at sites in the eastern United States are thought to be at lower risk than nighttime fliers (Kerns and Kerlinger, 2004; Nicholson, 2003). Erickson et al., (2001) also demonstrated that, at most newer onshore wind plants, night migrants experienced more fatality; daytime migrants make up only a very small proportion of the birds killed by wind turbines (Erickson et al., 2001, Kerns and Kerlinger, 2004 and Nicholson, 2003). It is possible that risk to daytime fliers would be lower because obstacles are more easily seen and avoided. However, the radar data show that nearly twice the number of birds--83,083 daytime migrants (38%)--were at rotor swept

height, compared with 44,614 (17%) of nighttime migrants. Ability to avoid obstacles during the day may offset the nearly double the number of birds at rotor height, but overall impacts resulting from the interaction of these variables are unknown.

Since it appears that over 600,000 birds could be flying at rotor height in any given year, there is a potential for mortality, perhaps most often when visibility is poor and birds have difficulty avoiding obstacles (Erickson et al., 2001). As discussed in Section 5.7.3.2.1, mortality estimates range from 0 to 2.8 fatalities/turbine/year, conservatively indicating that an estimated 364 birds could be killed each year. This potential mortality represents an unavoidable adverse impact of the Project but one which, as described in the collision risk evaluation above, has been lessened through siting and design and the incorporation of various mitigation measures as discussed in Section 5.7.4.

5.7.3.2.2 Disturbance/Displacement by Wind Park

Disturbance/displacement by turbines, and barrier effects of lines of turbines that exclude individuals from certain areas leading to loss of access to suitable habitat, are thought to have direct impacts on some birds, especially those species that inhabit open areas and tend to avoid tall vertical structures. During operation, the infrastructure of the Wind Park would include, for each WTG, a tubular tower 246 feet (75 meters) in height with a work/landing platform near the water surface, navigational lighting on or near the work platform, three rotors approximately 170 feet (52 meters) in length attached to a nacelle, and two FAA-compliant lights on top (see Section 5.7.6.5.3 for a discussion of potential impacts related to Project lighting).

The WTG array would add a new structural system to the surface of Nantucket Sound. It has been documented that the presence of novel objects, such as new wind turbine arrays, can deter birds from entering into areas that would normally be available to them while foraging and migrating (Kerlinger, per. Observation). Studies in Europe and in North America have demonstrated varying effects, ranging from reduction of nesting activity near turbines, avoidance of turbines by foraging waterfowl, and complete habituation by some raptors, shorebirds, and other birds (Painter et al., 1999; Still et al., 1995; Appendix 5.7-A).

The presence of the WTG array is not anticipated to affect bird nesting activity, since nesting activities would occur onshore and the Proposed Site is located more than 4 miles (6.4 km) from the shores of Cape Cod, more than 5.5 miles (8.9 km) from Martha's Vineyard, and more than 11 miles (17.7 km) from other islands. Similarly, shorebirds (including the Piping Plover) should not be disturbed or displaced by the presence of the WTG array because the array is located so far from shore; over 12 miles (19.3 km) to Monomoy and over 8 miles (12.9 km) to Muskeget Island.

Some species of birds that occur in the Project vicinity, such as various species of waterbirds and waterfowl, may avoid or refrain from activity near these structures. Avoidance behaviors may include reduced feeding near the WTGs and increased migration buffers around them. This avoidance behavior (i.e., the minimum distance to which birds would approach these structures) is likely to vary among species. Studies conducted in Europe have documented a variety of turbine avoidance behaviors by seaducks and some other species, ranging from no avoidance (Lowther, 2000) to not flying or feeding within a couple thousand feet (several hundred meters) of the turbines (Winkelman, 1995). It is likely that some seaducks, loons, grebes, alcids, pelagic birds, and some other species would not feed or rest within the area beneath or near the turbines. Studies of eiders at a 10-turbine offshore facility in Denmark showed that eiders were reluctant to feed within 328 feet (100 meters) of the turbines (Guillemette et al., 1998); however, a later study by Guillemette et al. (1999) determined that this eider distribution was a result of prey density. The towers are tubular, rather than lattice, which reduces perching opportunities. It is likely that birds may initially be attracted to the WTGs for perching, but effective deterrents will likely limit the number of times birds do this. Once they learn that they cannot perch, they will be unlikely to attempt to perch on turbines further.

In some European studies (e.g., Winkelman, 1992), birds have been documented to avoid flying between turbines, resulting in their flying around the last turbine spaced at 656 feet (200 meters) in a string rather than flying between turbines. The Project would consist of 130 WTGs spaced a minimum of 2,066 feet (629 meters) by 3,281 feet (1,000 meters) in a rectangular grid. The area that would potentially be impacted is the cumulative area within which birds would not fly or forage. Assuming that some waterfowl, such as Common Eiders and

other birds, may avoid the wind turbines altogether, as demonstrated in studies in Europe (Winkelman, 1992; Guillemette et al., 1998), the turbines proposed for the Project could, theoretically, exclude some foraging birds from the Project area. This is an unlikely worst-case scenario due to the wide spacing between turbine rotors (1,725 to 2,940 feet (526 to 896 meters)) and the general tolerance of such structures by the bird species found in the Sound. At Tuno Knob located in Denmark and other locations, birds regularly approached within 328 to 656 feet (100 to 200 meters) of operating turbines, again suggesting that WTGs towers spaced at 2,066 feet (629 meters) may not present a barrier to migrating birds or birds flying to and from foraging areas (Appendix 5.7-A).

It is likely that birds affected by Project operation would exhibit some habituation within a short time after construction. Many birds habituate readily to man-made objects, especially if humans are not present. For example, at Blythe Harbour (United Kingdom), eiders, gulls, and cormorants were found to habituate to wind turbines located on a jetty such that no long-term habitat displacement impacts were realized (Lowther, 2000).

A large variation in responses has been reported among the studies that have been conducted in terrestrial habitats. They range from avoidance to complete habituation, depending on the habitat in which a project is situated and the types of birds concerned. Results have not always been consistent and it is likely that habituation changes the response of individual birds to the presence of wind turbines, such that transient migrants may be affected in different ways than residents.

As discussed in Appendix 5.7-A, studies of waterbirds at several locations in Europe have shown varied results with respect to displacement and disturbance. At Blythe Harbour, where 9 modern turbines were constructed on a sea wall/jetty, species like Purple Sandpipers and Sanderlings were not impacted by the turbines and continued to feed on the jetty (Still et al., 2000). Cormorants, gulls, and eiders did not seem to avoid the turbine area at Blythe. In the Oosterbierum Wind Park in the Netherlands, in low-lying lands near the shore, disturbance to shorebirds and waterfowl was minimal (Winkelman, 1995). In the Netherlands diving ducks avoided the areas within 300 m of new turbines and in another study showed avoidance behavior at a distance of about 100 m. These same ducks were reluctant to fly between turbines spaced by about 200 m (Winkelman, 1995). Eiders studied at a 10-turbine off-shore wind power facility in the Kattegat of Denmark were reluctant to feed within 100 m of turbines. This avoidance was not deemed to be significant by the authors of the study and may have been a result of changing food availability (Guillemette et al., 1998).

Terns are most likely to spend time foraging close to their nesting sites on shore (Hatch, per. observation). During the periods following spring arrival and between breeding and fall migration, a limited amount of offshore foraging may however occur near the Project area. Field studies conducted by the Applicant and MAS showed that terns are most common on Horseshoe Shoal in May while migrating into and through the area (Perkins et al., 2003, Perkins et al., 2004, Appendix 5.7-F, Appendix 5.7-K and Appendix 5.7-L). Once breeding begins (outside Nantucket Sound) in June the number of individuals foraging and traveling through Horseshoe Shoal is significantly reduced.

For those terns that feed or forage in the vicinity of the WTG array, there will be ample areas in which to forage because of the wide spacing of the WTGs. In addition, there will be substantial undisturbed areas nearby both within Nantucket Sound and in the Atlantic Ocean, and so terns should not be substantially affected by the Project. Similarly, species such as Common Loons, seaducks, and grebes should also have ample area available for foraging and should not experience substantial displacement from foraging or resting areas. Aerial and boat survey results indicate that abundance of these bird species was typically less at Horseshoe Shoal than at the other studied shoal areas or in the balance of the study area, so disturbance/displacement to these species would be less significant than in other locations within the Sound. However, some of these species may attempt to use the ESP as a resting area from which to initiate foraging activities, which would be an attractant to foraging in the area.

Any potential displacement of birds from areas occupied by the WTGs is expected to be accommodated in nearby areas of Nantucket Sound. Observations during field studies show that other portions of the study area provide similar habitat characteristics and resources, are presently being utilized by the same species groups, and appear to have adequate capacity to accommodate the additional presence of displaced birds.

With respect to migration – especially use of areas by staging birds – habituation behavior varies by species and age classes. Although adults may have come into contact with wind turbines during a previous migration, birds of the year may not have been introduced to similar structures. In the case of flocking species, young birds may be reluctant to approach turbines even if adults in their flock fly or swim close to turbines. Therefore, some birds may choose to fly around WTGs. Such avoidance behavior is analogous to waterbirds avoiding flight over land. Such birds (e.g., scoters) simply follow coastlines or deviate around jetties and headlands.

For some birds, WTGs may provide an attraction because they appear to be places where birds can perch and rest. Songbirds and a few others that are desperate for places to land, may fly to the turbines and attempt to perch on them. However, the presence of moving rotors is likely to dissuade many birds from perching. For terns, the large, moving rotors are likely to dissuade them from flying beneath the turbines to the landing platforms. It is well known that terns and many other birds are reluctant to fly beneath objects such as bridges (Hatch and Kerlinger Pers. comm.). With respect to other birds, they are not likely to be attracted to novel structures, especially structures with moving parts. The experience in the Altamont Pass and elsewhere demonstrates that birds rarely, if ever, attempt to perch on wind turbines when the rotors are operating (Orloff and Flannery, 1996).

5.7.3.2.3 Lighting

Preliminary plans call for lighting the WTG towers with flashing lights to meet FAA and USCG safety requirements. Each of the individual WTGs would be lighted at night by two flashing red lights on the nacelle and two flashing amber lights on the lower access platform. Lights would differ in intensity depending on the specific location of the individual turbine, with perimeter WTGs lighted at a higher intensity than those located within the interior of the Wind Park.

It is widely known that some birds, principally night-migrating songbirds, are attracted by some lights, particularly in conditions of poor visibility (Erickson et al., 2001). Seabirds and shorebirds are sometimes attracted to the bright lights (spotlights, sodium vapor lamps, etc.) of lighthouses and oilrigs. The features of oilrigs that most attract birds are bright lights and flares (burning-off petroleum) providing a semi-continuous and directly visible attraction (Wiese et al., 2001; Montevecchi et al., 1999). The proposed WTG lighting does not possess the characteristics that are known to attract birds and includes some of the features recommended by the USFWS in Guidelines for Communications Towers (US Department of the Interior Fish and Wildlife Service, 2000) for reducing potential bird collisions on land. Seabirds, shorebirds, and waterfowl have not been demonstrated to be attracted to the lighting on communication towers (Shire et al., 2000), and songbirds have not been shown to be attracted to the blinking lights on wind turbines (Erickson et al., 2001). A complete description of the proposed lighting scheme for the WTGs is included in Sections 4.0 and 5.12.

Operational lighting for the ESP, including the helipad, would only be switched on when the platform or the landing pad are in use. All lighting, with the exception of navigational lights, would be used as little as possible and would be shielded from direct view from sky or ocean. This applies to lights in emergency quarters as well as in working areas. This provision is important, because seabirds are most attracted to point-sources of light rather than to diffusely-illuminated areas. The lighting design components of the Project that minimize and mitigate impacts to birds are discussed in Section 5.7.4.3

5.7.3.2.4 Disturbance from Vessel Traffic

Vessel traffic would increase in the Project area during the operation/maintenance phase. Maintenance trips are expected on about 250 days per year (see Section 4.4). This increased vessel traffic is expected to have negligible effects on most waterbirds and shorebirds, including loons, cormorants, gulls, terns and plovers, because they are either not disturbed by vessel traffic or they move from the immediate path of the vessel, remaining in close proximity and hence do not exhibit a disturbance response from the activity, or because they have limited presence in the area where vessel traffic would occur. There would likely be some disturbance to seaducks by causing them to fly away from Project vessels (based on observations during the boat surveys). Although seaducks may exhibit avoidance behavior in the vicinity of Project vessels, these behaviors would likely be no different from the avoidance behaviors exhibited toward ferry traffic or fishing activity in the area. In addition, operation/maintenance vessels would affect only small portions of the Project area at any one time.

Landbirds, including the transient migrants, would be unaffected by vessel traffic since these birds would be found at high altitudes above the construction activities. The ESP would have a helicopter-landing platform in addition to the boat access. This would allow for crews to be deployed to the ESP during periods when wind and wave conditions are unsuitable for boat transfers which is anticipated to occur relatively infrequently. As discussed previously, helicopters would have a temporary disturbance effect on birds in the Project area during approach, landing, and departure on the ESP helicopter platform. It is expected that any birds in the immediate vicinity of the ESP during helicopter take-off and landing would react by flying away from the area. However, this disturbance would be temporary and birds are expected to return to the area after the helicopter departs the area. Bird responses to helicopters in the Project area would likely be similar to those exhibited toward vessels, discussed above.

5.7.3.2.5 Effects on Bird Migration

The majority of bird migration in the Project area is thought to occur at night and at high elevations (Appendix 5.7-E). Also, the majority of night migrating songbirds fly further inland than out over the Atlantic Ocean (Nisbet and Drury, 1967). The study states that in the fall, migration was much more dense to the northwest of Boston and that migrants were "much more sparsely" found to the southeast of that city. In spring, the Nisbet and Drury radar data showed "much smaller numbers southeast of Boston," as opposed to inland from Boston. This again suggests that fewer songbird migrants fly out over the Atlantic or other oceans than fly overland, and that these birds seem to prefer migrating overland (reviewed in Berthold 2001). Because the majority of songbird migration takes place further inland, at high altitudes (Nisbet and Drury, 1967), and that the lighting used on the turbines will minimize attraction of birds (Kerlinger, 2004), collisions are expected to be infrequent for the landbird species that migrate through the area.

There may be limited effects on species, such as seaducks and shorebirds that perceive the turbines as barriers and avoid them. These individuals may be local and/or long distance migrants. In Europe, several studies show that species can be affected by flying around the entire windfarm or cut off from roosting or foraging sites (Exo et. al 2003, Guillemette et al. 1999, Tulp et al. 1999). In the study area, this may have particular effects on species that travel between the mainland and nearby islands (i.e. Martha's Vineyard, Nantucket and Monomoy Islands).

Certain conditions, including weather and visibility, could put migrating birds at increased risk of collision. Few migrants fly during stormy or foul weather conditions (fog, light rain, low ceiling) during daylight hours. Those birds that are flying tend to see objects and fly around them. Day migrants may fly extra miles (perhaps 5 to 10 miles (8 to 16 km)) to avoid flying amongst the wind turbines; however, this additional distance would likely constitute less than 1% of their entire migration distance (Kerlinger, personal communication 2003b).

5.7.3.2.6 Indirect Impacts

The monopile foundations for the WTGs and ESP would introduce new underwater structures to Nantucket Sound that may affect the prey of certain bird species, including benthic organisms and certain species of fish in the immediate vicinity of each WTG, but such effects are expected to be very small because the structures would be widely spaced as discussed below.

Although the towers would create additional attachment sites for benthic organisms that require fixed (non-sand) substrates, the additional amount of surface area being introduced is relatively small (approximately 1,200 square feet/0.03 acres (111 square meters) per tower assuming an average water depth of 30 feet (9.1 meters)) and the wide spacing (2,066 to 3,281 feet (629 to 1,000 meters) apart) of these monopile structures would not result in the creation of a concentrated area of vertical or hard substrate that may otherwise act as a larger reef. Therefore, it is likely that these isolated structures would generate a small amount of additional patch reef type habitat, common in the Sound, and would not substantially alter the ecology of Nantucket Sound. Other types of similar artificial hard substrate can be found throughout harbor and port areas within the Sound that have pilings associated with wharfs and breakwaters constructed over the decades for the protection of anchorages and harbors. Benthic organisms that may initially be supported by such structures are likely to include algae, barnacles, hydroids, and possibly mussels. Additional organisms such as polychaetes, oligochaetes, and nematodes may also utilize the structures once algal growth becomes established. Bottom-feeding seaducks,

which feed on mussels and other invertebrates, could be attracted to the WTG monopiles if colonized by mussels or other invertebrates.

It is possible that, once the monopile structures are colonized by benthic organisms, they may function as vertical habitat for certain species of fish. Such changes could benefit terns and some other fish-eating waterbirds if bait fish targeted by these species congregate around the monopiles. Attracting terns to the towers influences the amount of time they spend in the wind plant and thus increases risk of collision. However, sand eels, one of the primary prey items of terns, are not expected to be affected by the addition of vertical structures, since their habitat preference is generally in areas with high bottom current velocities over sandy substrates, and therefore the monopiles are not expected to attract terns to the Project area. As previously stated, since the monopile structures are not providing much additional fixed surface area and since they are spaced far enough apart to function similarly to other existing patch reefs of hard substrate, it is unlikely that these isolated structures would substantially alter the ecology of Nantucket Sound or the interaction between bird species and their prey (see section 5.3 for discussion of benthic invertebrates and section 5.4 for discussion of fish).

5.7.3.2.7 Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to avian resources would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from various potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

The vast majority of birds that fly through Nantucket Sound nest farther to the north and west and originate across an enormous geographic area. Populations of many of these birds exceed a million individuals (Blancher, 2003). As discussed in Appendices 5.7-D, 5.7-G, and 5.7-K, the actual numbers of birds likely to be impacted at Horseshoe Shoal represent only a small proportion of their global or regional populations and it is unlikely that any localized impacts that may occur in the Project area would add significantly to the normal mortality of the species concerned.

There are no known offshore wind projects proposed nearby that would cause cumulative effects during operation of the Wind Park. Potential impacts to birds from the operations of proposed smaller land-based wind projects would be far enough from the Wind Park so that the localized impacts resulting from the operations of those projects, and the other types of projects referenced above, are not likely to result in a significant cumulative effect when added to the potential project impacts at Horseshoe Shoal. In addition, as discussed throughout this section, land birds represent a separate group of bird species that are mostly absent from the Wind Park area, except during long and short distance migration and land-based wind project affects on these species would therefore not be cumulative with any affects on seabirds associated with the Cape Wind project. Discussion of cumulative impacts associated with human activities in the opposing seasonal habitat for migrants (i.e. loss of tropical forest habitat used as winter habitat by some songbirds) is beyond the scope of this document as they do not reasonably occur in time or location with the Cape Wind project.

Maintenance vessel activity (estimated at 1-2 vessels per day – see Section 4.0) should have no significant cumulative impacts because the increase in vessel traffic in the area will be minimal when compared to existing vessel traffic.

5.7.3.3 Potential Impacts during Onshore Construction and Operation

The Project's submarine cable system would make landfall in a densely developed area at the end of New Hampshire Avenue in the Town of Yarmouth. The techniques for bringing the cable ashore would minimize adverse effects on intertidal habitats (see Section 4.3.5). The landfall is not a documented area used by birds for nesting or foraging, and no adverse effects to birds or bird habitat is expected. Potential for mortality due to ground disturbing activities is low because in addition to not being an active nesting or foraging habitat, the landfall will be constructed using HDD which will be initiated from the upland entry pit to the offshore HDD exit pit avoiding any potential resources that may be used by birds at the shoreline.

Impacts to birds or bird habitat from installation and operation along the proposed onshore transmission line route would be minimal, as all of the onshore portion of the transmission line system would be located below grade within existing roadways, roadway shoulders, and maintained ROWs. The installation along the roadways to the NSTAR Electric ROW would require the excavation of approximately 4.9 acres/213,444 square feet (19,830 square meters) of paved roadway and roadway shoulders. Since this portion of the route would be located within existing paved roadways and removal of vegetation is not required, no impacts to potential bird habitat or bird species are anticipated. The proposed onshore transmission cable route within the NSTAR Electric ROW would require a total width of workspace disturbance of approximately 25 feet (7.6 meters), which includes construction access, laydown areas, and the 8-foot (2.4 meters) wide trench. This work would require the temporary disturbance of approximately 5.8 acres /252,648 square feet (23,471.6 square meters) of vegetation within the maintained ROW. Birds would avoid active construction areas and if clearing occurs during the nesting season nests or young would be lost in the ROW. This portion of the route is within a previously disturbed ROW that periodically undergoes vegetative maintenance. Areas disturbed by construction would be revegetated through seeding with an erosion control seed mixture and allowed to revegetate similar to the existing NSTAR ROW. Therefore, no long-term adverse impacts to potential bird habitat or bird species are anticipated during construction or operation along the onshore transmission line route.

5.7.3.4 Potential Impacts to Endangered/Threatened/Other Listed Species

In compliance with Section 7 of the Endangered Species Act, an evaluation was prepared for two species listed under the Federal Endangered Species Act (ESA), the threatened Piping Plover (*Charadrius melodus*) and the endangered Roseate Tern (*Sterna dougallii*). The evaluation is presented in the DEIS-DEIR, Evaluation of the Roseate Tern and Piping Plover, which is included as Appendix 5.7-H. A formal Biological Assessment will be prepared and submitted separately from this DEIS to the USFWS to continue the consultation process under the Endangered Species Act. A Biological Review (Appendix 5.7-I) was also prepared as requested in the MEPA ENF Certificate to address the Common Tern (*Sterna hirundo*), listed as a State Species of Special Concern under the Massachusetts Endangered Species Act (MESA). In addition to the Section 7 ESA assessment, all avian resources within the Project area were evaluated under the Migratory Bird Treaty Act as provided in Section 7.2.2.1.

Biological Review of Common Tern

The Biological Review was prepared to determine if the proposed action is likely to result in adverse effects to the Common Tern (*Sterna hirundo*), a state-listed Species of Special Concern. This review (Appendix 5.7-I) summarizes information about the species, including population status and trends, seasonal distribution, preferred food and feeding habits, flight behavior, known disturbances and mortality factors, of Nantucket Sound and the Project area. A summary of the current use of the Project area by the Common Tern and general spatial and temporal patterns was provided in Section 5.7.2.3, above. A summary of potential impacts to this species from Project construction, operation/maintenance, and decommissioning is provided in Section 5.7.3, and a detailed evaluation of impacts is included in Appendix 5.7-I.

Roseate Tern and Piping Plover

Two federally-listed bird species (the endangered Roseate Tern and the threatened Piping Plover) were evaluated to determine if the Project is likely to result in adverse impacts to these species as required by Section 7 of the Endangered Species Act. A summary of the potential impacts to these protected species is included below. More detailed information on potential effects on these species is included in the Evaluation of the Roseate Tern and Piping Plover (Appendix 5.7-H).

The Roseate Tern uses the Project area differently from the Piping Plover. The Piping Plover is a shorebird species that nests at coastal sites around Nantucket Sound, and may fly across the Project area before and after nesting and during migration. The Roseate Tern forages in and around the Project area and also nest at coastal sites.

In order to estimate the potential collision mortality and possible effects on roseate tern and piping plover populations, a mortality estimate was calculated for each species and then used as input in population viability models. The mortality estimates are discussed in Section 4.2.5 of Appendix 5.7-H and the population viability models are presented in detail in Attachment 1 of Appendix 5.7-H. The following is a summary of the results.

The Roseate Tern model incorporates, in addition to the usual demographic parameters, features that address the female-biased sex ratio (unusual in a monogamous species) and the occasional catastrophic mortality-events (such as Hurricane Bob in August 1991). As expected for a long-lived species, the model shows that population growth is most sensitive to Adult Survival (Proportional Sensitivity = 0.607). Under existing conditions, the median projected time to recovery of the population is 17 years. This predicted outcome is almost unaffected by extra deaths of as many as 5 females per year and there is zero probability of extinction. Above that rate the effects increase relatively slowly.

The viability model was based on the New England Piping Plover population, which had stabilized above the subgoal of 600 pairs in the late 1990s. The model is complicated by a change in demographic parameters (decline in productivity in recent years not attributable to habitat saturation) at about that time (after the 1994 PVA in the Recovery Plan). Population growth is sensitive to Adult Survival (Proportional Sensitivity = 0.49), but to a lesser extent than the Roseate Tern (as discussed above). Possible impacts of additional fatalities depend strongly on assumptions about growth rates. The No Growth scenario (current conditions), even with zero take, yields substantial risk of the population declining below 600 pairs. Additional mortality of one Female (= 2 takes/yr) does not increase this risk significantly (3% by 20 years). The Intermediate Growth scenario (average performance since 1989) yields predictions of negligible chances of decline below the recovery threshold even with additional mortalities of as many as 10 females per year, and non-zero chances of extinction only at 50 deaths or more per year.

For the Roseate Tern, the potential fatality rate attributable to collisions in the proposed Wind Park, estimated in Appendix 5.7-H, is an average of 0.0002 individuals per year, and the highest rate in the range of possibilities identified, is 0.5 per year. These are well below the level of 5 females per year at which effects become important.

While plovers were not observed in the Project area during field studies, there remains some uncertainty whether they would make flights in the rotor-swept zone. Therefore the mortality estimate for plovers has been approached more conservatively than the Roseate Tern model. For the Piping Plover, the potential fatality rate attributable to collisions in the Wind Park, estimated in Appendix 5.7-H, is an average of 0.08 individuals per year. A take of ten birds per year (= five females) is unlikely to affect the New England population.

Based upon the analysis of potential impacts, as presented in more detail and depth in the Evaluation of the Roseate Tern and Piping Plover (Appendix 5.7-H) it is unlikely that biologically significant risks to these avian species could result from the construction/decommissioning or operation/maintenance of this Project. Some infrequent collision mortality is possible and would represent an adverse impact but this very small risk will not adversely affect overall population levels of either species. Analysis of potential impacts to these species revealed the following:

- The proposed cable landfall and vicinity is not reported to be used by the Roseate Tern, Common Tern, or Piping Plover for nesting or roosting, and therefore no adverse impacts from construction or operation are anticipated that would affect nesting or roosting behaviors. Neither noise nor visible activities from construction at reasonable distances are likely to affect the Roseate Terns or Piping Plover. Other terns (e.g. Least, Arctic) and plovers (Killdeer) are known to nest successfully in close proximity to airports. In areas managed for plovers, buffer zones of 150 ft (46 m) have been used successfully around birds nesting on beaches (Blodget and Melvin, 1996). Plover are likely to be present within the Nantucket Sound shoreline areas from April to September, but are not expected to be disturbed by Project construction activities.
- Construction and decommissioning activities are expected to result in only temporary and localized increases in TSS, and therefore would have minimal impacts to the foraging behavior of these listed species. Avian species that may be present in the vicinity of the Project area during construction are not expected to be adversely affected by temporary increases in TSS because they can move to other areas. The exception is the Piping Plover that feeds within a restricted territory and cannot shift to new areas while it is nesting. The plover feeds along the waterline, which includes wave disturbed sediments so some additional TSS is unlikely to substantially alter foraging activity. Regardless, sediment suspension during construction and decommissioning activities is expected to last no longer than a few tidal cycles and would not result in long-term elevations in water column TSS. In addition, the submarine cable system, at its closest point, is located

approximately 820 feet (250 meters) from the nearest Piping Plover nesting areas at Kalmus Beach/Dunbar Point. Therefore, any potential impacts to these nesting sites are expected to be very small (as discussed above) and confined in occurrence to a single breeding season. Terns could be temporarily impacted by temporary increases in TSS if access to their food supply is impaired due to turbid water conditions. This is unlikely to pose a significant problem due to terns' wide range of foraging areas and the limited area and/or duration of any sediment plumes. The jet plow technology proposed for this Project would minimize the thickness of sediment deposition, the amount of sediment that enters the water column and the duration of elevated sediment levels.

- The WTG access platforms may provide opportunities for terns to perch or rest, thus putting them at greater risk for collision with rotors. However, the platforms have been designed to minimize perching (see Section 5.7.4.2). Piping Plovers are unlikely to be affected by the WTG platforms and ESP, because they appear to cross the Project area only rarely, would not perch on WTG structures, and are not known to frequent offshore construction sites.
- If terns are able to perch at the ESP, they may be at increased risk for colliding with turbines when they fly high in the air during their courtship flights. However, these impacts would be minimized and mitigated by designing and equipping the ESP to minimize perching areas (Section 5.7.4.2).
- The presence of workboats during installation or operation/maintenance would be for a relatively short duration and would represent a small and temporary increase from the current boat traffic in and outside of the navigational channels. Although vessel traffic would increase slightly during construction and operation, it would have a negligible effect on foraging terns or plovers. The use of helicopters is expected to have similar effects as vessel traffic by causing temporary disturbance during landing and take-off. Plovers should not be affected at their nesting sites, since the helicopter landing area would be located offshore on the ESP within the WTG array and onshore at existing authorized landing locations.
- Localized habitat changes resulting from the presence of the turbines are not expected to have net adverse effects on the food supply of terns, and the turbines are not expected to exclude terns from a substantial amount of foraging area. Plovers would not be affected by localized habitat changes, because they do not spend significant time offshore, except during localized and long-distance migrations.
- The risk of mortality from bird-turbine collisions is anticipated to be very low, because the listed species that utilize the Project area are rarely reported to fly over the ocean at the height of the rotors nor were a substantial number of terns observed in the Horseshoe Shoal area during project surveys. Furthermore, no plovers were observed in the proposed Wind Park area. Please refer to Appendix 5.7-H for more detailed information.

5.7.4 Mitigation

The Project has been planned, sited, and designed to avoid or minimize impacts to avian species and habitat within Nantucket Sound, including protected avian species. While localized impacts, including some displacement and mortality, are anticipated during Project construction and operation, measures would be implemented to prevent and minimize these impacts and none would result in a significant adverse impact affecting population sizes of any bird species. The following sections address some of the features of the Project that have been adopted as potential mitigation or prevention of potential impacts to birds.

5.7.4.1 Location

Nantucket Sound is a diverse and productive ecosystem through which millions of migratory birds pass each year. Results of Cape Wind's field studies (Section 5.7.2.3) indicate that Horseshoe Shoal involves only a subset of the general population of avian species present in Nantucket Sound. In addition, studies conducted by the Applicant and MAS (Perkins et al., 2003 and 2004) found that areas near Monomoy Island and the southwestern part of the study area (see Figure 5.7-1) have higher densities of birds present throughout the year as compared to Horseshoe Shoal. These trends were typical for many species, suggesting that, of the three shoal areas examined within Nantucket Sound, the selection of Horseshoe Shoal minimizes potential impacts to bird species. Although for some species such as loons, gulls and razorbills, bird numbers observed in Horseshoe Shoal compared to other areas suggest little differential use of alternative areas.

5.7.4.2 Turbine Tower Design

The turbines would be supported by single, large diameter tubular towers, rather than lattice towers, which reduces perching opportunities for birds. Turbine access platforms and the ESP could offer a convenient resting places for terns, gulls, cormorants, and other species. This could be beneficial to some species by offering a resting area, but may increase the risk of collision with the WTGs for birds taking off and landing within the wind park. To reduce perching opportunities, perimeter fence on the WTG platforms would be equipped with thin wire to deter terns and other birds from perching and/or the ability to nest. The ESP would also be constructed with similar deterrents so as to be unsuitable for use by birds. The deterrent methods would be tested by field experiments on the existing Cape Wind Scientific Measurement Devices Station (SMDS). Existing literature and recommendations by the USFWS and USDA would also be considered in developing the design. Turbine spacing has been considered relative to risk to bird species, allowing them more open space to fly between each WTG. Although this relationship (wide versus narrow spacing) has yet to be empirically tested and there is no related data for waterbirds or waterfowl, it is likely that the wide spacing between turbines would reduce the potential for collisions.

5.7.4.3 Lighting

Currently, the Project design plans call for lighting the WTG towers with flashing red lights and flashing amber lights to meet FAA and USCG safety requirements, respectively. The proposed WTG lighting does not possess the characteristics that are known to attract birds and includes some of the features recommended by the USFWS in Guidelines for Communications Towers for reducing potential bird problems on land (USFWS, 2003); such as, only white (preferable) or red strobe lights should be used at night, and these should be the minimum number, minimum intensity, and minimum number of flashes per minute (longest duration between flashes) allowable by the FAA. Night migrants have not been shown to be attracted to the type of lights used on wind turbines (flashing red lights at night), which are very different from light houses, tall communication towers (which have steady burning red lights), brightly lit buildings, and other brightly lit structures (such as offshore oil platforms and bright lights on ships). Operational lighting of the ESP, including the helipad, and other lighting would only be switched on when the platform or the landing pad are in use. All lighting, with the exception of the FAA and USCG navigational lights, would be used as little as possible and shielded from direct view from sky or ocean. These provisions apply to lights in emergency quarters as well as in working areas. Daytime and nighttime lighting has been designed to use the lowest intensity lighting considered safe for navigation by the FAA and USCG. The USCG flashing amber lights on each perimeter turbine should not be visible to viewers at distances beyond 2 nautical miles (3.7 km). USCG lights on interior turbines should not be visible to viewers at distances greater than 0.5 nautical mile (0.9 km). For further detail on the lighting design for this Project, see Sections 4.0 and 5.12.

5.7.4.4 Height of Turbines in Relation to Avian Flight

The proposed turbines for the Project would be less than 500 feet (152 meters) in height and would not have guy wires. As discussed previously, towers less than 500 feet (152 meters) in height without guy wires have been infrequently documented to kill night migrating or other types of birds. Therefore, the proposed Project is not likely to pose a large collision risk to migrating bird species and would pose less risk than multiple guyed communication towers in excess of 500 feet (152 meters) that are located onshore throughout the country. Eiders and scoters have been shown to detect and avoid offshore turbines at night in both the Netherlands (Winkelman, 1995) and at offshore towers at Tuno Knob in Denmark (Tulp et al., 1999).

In addition, the turbine rotors would not come within approximately 75 feet (23 meters) of the ocean surface. Given that most waterbirds have been observed to fly close to the water or below 20 feet (6.1 meters) asl, impacts to many waterbirds (pelagic species and seaducks) that fly close to the water would be minimized.

5.7.4.5 Rotor Characteristics

Rotor speed and rotational rate vary among turbines. The recent trend in turbine design has been toward larger rotor blades with fewer revolutions per minute. Larger, slower-turning rotors, especially if they are variable speed or have two-speed gearing, are recommended over faster turning and constant rotation rate rotors for

reducing the potential for collision by birds. With larger and slower rotating rotors, they are more visible and move through less airspace per unit time than smaller, faster revolving rotors. The Project would utilize larger, slower-turning, variable speed rotors which would help reduce blade impacts to bird species. The Project design calls for rotor blades that are approximately 170 feet (52 meters) long and have a variable rotation rate between 8.5 and 15.3 rpm, relatively similar in size and speed to other state-of-the-art turbines in use at offshore facilities in Europe.

5.7.4.6 Monitoring

Plans and methodology for post-construction monitoring will be developed in consultation with the USFWS and other agencies to ensure that the Project is in compliance with regulations created to protect avian species. The principal purposes of this monitoring would be to assess any impacts resulting from habitat loss or mortality and to investigate methods for measuring and mitigating any such effects.

5.8 Coastal and Freshwater Wetland Resources

5.8.1 Introduction

This section describes the coastal and freshwater wetland resources and potential wetland impacts in the Project area. Regulatory authorities and consistency are discussed below and in Section 7.0. The information contained in this section was obtained from literature review, agency consultations, site investigations, and review of existing site investigation data. This section includes identification of the amount of land under ocean/salt marsh and upland/inland wetland to be disturbed; mapping of wetland boundaries and buffer zones; an explanation of the significance of each wetland area to the interests enumerated in the WPA; and a demonstration that the proposed routing avoids or minimizes impacts to eelgrass beds and other submerged aquatic vegetation.

Wetlands have been identified in the vicinity of the Project area seaward and within the state territorial limit of Nantucket Sound and Lewis Bay, and along the onshore transmission cable route. Portions of the submarine and onshore transmission route fall within the town boundaries of Barnstable and Yarmouth. Wetlands in the Project area are generally defined and regulated according to the following federal, state, and local wetland regulations:

- Section 10 of the Rivers and Harbors Act of 1899 (U.S.C. 403)
- Section 404 of the Clean Water Act (33 U.S.C. 1344)
- Endangered Species Act of 1973 (16 U.S.C. 1531-1543)
- Massachusetts Wetlands Protection Act (M.G.L. c. 131, §40), Rivers Protection Act (Ch. 258 of the Acts of 1996), and regulations (310 CMR 10.00)
- Section 401 Water Quality Certification (33 U.S.C. 1251, *et seq.*) and regulations (314 CMR 9.00)
- Coastal Wetlands Restriction Act (M.G.L. c. 131, §105)
- Coastal Zone Management Act of 1972 (16 U.S.C. §1451 to 1465), and regulations (301 CMR 20.00-21.00)
- Chapter 91 Waterways License (310 CMR 9.00)
- Massachusetts Endangered Species Act (M.G.L. c. 131 §40) and regulations (321 CMR 10.00).
- Cape Cod Commission Act (Ch. 716 of the Acts of 1989 and Ch. 2 of the Acts of 1990)
- Cape Cod Atlas of Tidally Restricted Salt Marshes, Cape Cod, Massachusetts (December 2001)
- Yarmouth Wetlands Protection By-law and Regulations (Chapter 143)
- Barnstable Wetlands Protection Ordinance (Article 27)

Wetland permits required for this Project would include, but may not be limited to, the following: Orders of Conditions from the Yarmouth and Barnstable Conservation Commissions or Superceding Order(s) from the MADEP upon appeal; a Chapter 91 License from MADEP; a Federal Consistency Certification from the Massachusetts Office of Coastal Zone Management and a Section 10 Permit from the USACE.

In general, projects involving a discharge of dredged or fill material to a waterbody or wetland require a permit from the Department of the Army under Section 404 of the Clean Water Act (33 U.S.C. 1344) and state Water Quality Certification from the MADEP (314 CMR 9.00; and M.G.L. c. 21, §§ 26-53). Section 404 jurisdiction extends to the 3-nautical mile (5.6 km) state territorial limit. The only Project activity proposed within this 3-nautical mile (5.6 km) limit is the installation of a portion of the submarine transmission cable interconnection

between the electrical service platform and the Barnstable Switching Station. The Project would involve no activities subject to Section 404 as these activities are not considered discharges of dredged or fill material. The Project would however be subject to state water quality jurisdiction due to the volume of sediment to be excavated for the HDD offshore exit pit (see Section 5.8.4.2.1).

No activities subject to Section 404 jurisdiction are proposed within the onshore portion of the proposed cable route. Within the marine portion of the cable route, the proposed method of cable installation is via hydraulic jet plow, considered a non-jurisdictional activity under Sections 401 and 404 because it is not a discharge of dredge or fill material (MADEP and USACE-NED, 2002). In the nearshore area at the proposed cable landfall, the cable is proposed to be placed in a conduit to be installed using HDD installation technology. As discussed in detail in Section 4.0, HDD would require excavation of an offshore exit pit (approximately 65 feet (19.8 meters) wide by 45 feet (13.7 meters) long) and the placement of a temporary cofferdam within Lewis Bay to facilitate the HDD operation. Because all excavated sediments from the pit would be removed from waters of the U.S. rather than sidecast and involve no discharge of dredge or fill material, the HDD activities would not be regulated under Section 404 (USACE-NED and MADEP, 2002). The excavation of sediments, although not jurisdictional under Section 404, are regulated as dredged material under state water quality certification regulations.

In addition, although not subject to review under Section 404, installation of the conduit by HDD, cable installation via hydraulic jet plow, and construction of the wind turbines are subject to the jurisdiction of Section 10 of the Rivers and Harbors Act of 1899 (U.S.C. 403). Installation of the transmission line within the 3-nautical mile (5.6 km) limit would also require permits under the WPA and local wetland bylaws.

Section 5.8.2 provides a listing of studies completed for this Project. In Section 5.8.3, existing wetland conditions are addressed. Potential impacts and mitigation measures related to construction, operation, and maintenance of the Project are discussed in Section 5.8.4. Mitigation measures proposed for the Project are outlined in Section 5.8.5. References utilized for this section are provided in Section 5.8.6.

5.8.2 Studies Completed

Wetlands in the Project area were characterized based on review of mapped resources, wetland field investigations, and related studies completed as part of the Project siting and permitting process. The following sources were reviewed as part of this characterization:

- USGS Topographic Map, Dennis and Hyannis Quadrangles
- USGS Aerial Photos dated March 5, 1995 and April 3, 1995
- MassGIS data on mapped wetland resources
- Lake and Pond Recharge Areas Map, prepared for Town of Yarmouth by IEP, Inc. (August 1988)
- MADEP SAV Mapping Inventory for 1995
- SAV Diver Survey, Woods Hole Group, Inc. July 2003
- Ocean Surveys, Inc. (OSI) Plan Drawing 01ES047.2, Sheet 1 of 7
- Massachusetts Natural Heritage and Endangered Species Program records
- Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps, Town of Yarmouth, Barnstable County, Community Panel Numbers 250015 003C (June 17, 1986) and 250015 005D (July 2, 1992)
- FEMA Flood Insurance Rate Map, Town of Barnstable, Barnstable County, Community Panel Number 250001 0005C (August 19, 1985).
- NRCS (formerly SCS) Soil Survey of Barnstable County, Massachusetts (March 1993)
- NOAA Published Bench Mark Data, Hyannis Harbor, Massachusetts (September 29, 1989)
- Coastal Watersheds Map, prepared for Town of Yarmouth by IEP, Inc. (August 1988)
- Town of Yarmouth GIS database
- Town of Yarmouth Comprehensive Plan, Chapter 7 Coastal Resources (March 20, 1997)

Information contained in Section 4.0 (Project Description of Applicant's Proposed Action), Section 5.1 (Geology and Sediment Conditions), Section 5.2 (Physical Oceanographic Conditions), Section 5.3 (Benthic and Shellfish Resources), Section 5.4 (Finfish Resources and Commercial/Recreational Fisheries), Section 5.5 (Protected Marine Species), Section 5.6 (Terrestrial Ecology, Wildlife, and Protected Species), Section 5.9 (Water Quality), and

Section 6.0 (Comprehensive Environmental Monitoring Program) of this report augments the discussion of wetlands in this section.

Areas potentially subject to federal, state, or local jurisdiction within 200 feet of the onshore transmission route were field investigated in October 2001, August 2002, and December 2002. Wetlands were delineated in December 2002, in accordance with criteria established by the USACE (Environmental Laboratory, 1987), MADEP (MADEP, 1995), and the Yarmouth Wetlands Protection Regulations (Town of Yarmouth Conservation Commission, 1997). It should be noted that there are no wetland resource areas located along the onshore transmission route within Barnstable. The data transect documentation for the wetland delineations was completed during the summer 2003 growing season and would be appended to federal, state, and local permit applications. Vegetated wetland boundaries were surveyed using Global Positioning System (GPS). Figures 5.8-1 and 5.8-2 show the location and extent of vegetated wetlands and other jurisdictional zones. These boundaries are subject to approval by federal, state, or local agencies.

5.8.3 Existing Conditions

Wetland resources present in or near the locations sited for the construction of the Project are described according to their characteristics and jurisdiction under federal, state, and local wetland regulations. The significant interests provided by each wetland resource area in the Project area are enumerated in the WPA and summarized in Tables 5.8-1 and 5.8-2.

5.8.3.1 Coastal Resources

5.8.3.1.1 Conditions Outside of Massachusetts Waters

The following jurisdictional coastal wetland resource area occurs outside the state 3-nautical mile (5.6-km) territorial limit, within Nantucket Sound and Horseshoe Shoal:

- **Navigable Waters of the U.S.** (federal jurisdiction) are defined as waters seaward of the mean high water line of navigable waters under Section 10 of the Rivers and Harbors Act of 1899. Jurisdictional limits of Navigable Waters of the U.S. extend seaward to the Outer Continental Shelf. Descriptions of ocean depths, substrate types, and benthic community in Horseshoe Shoal, Nantucket Sound, and Lewis Bay are provided in Sections 5.1, 5.2, and 5.3. Mapping indicates that two potential areas of submerged aquatic vegetation occur within the Project area, beyond the Massachusetts 3-nautical mile (5.6-km) limit.

5.8.3.1.2 Conditions Inside of Massachusetts Waters

Coastal wetlands were identified along the sections of the proposed submarine transmission cable route inside the state territorial limit in Lewis Bay to the proposed landfall location at New Hampshire Avenue in Yarmouth, and the coastal portions of the onshore transmission line route abutting Lewis Bay. The proposed landfall location is a rectangular embayment beach surrounded by a concrete headwall. Residences with associated yards are located directly adjacent (east and west) to the rectangular embayment, and their ocean frontage is fortified by concrete retaining walls and riprap.

Jurisdictional and coastal wetland resource areas observed to occur between the 3-nautical mile (5.6-km) limit and the proposed landfall location, see Table 5.8-1, include the following:

- **Navigable Waters of the U.S.** (federal jurisdiction) are defined as waters seaward of the mean high water line of navigable waters under Section 10 of the Rivers and Harbors Act of 1899. Within the 3-nautical mile (5.6-km) limit, Navigable Waters of the U.S. encompass the state-regulated Land Under the Ocean. Since the landward boundary extends to the mean high water line, this resource area partially overlaps with the federally-regulated Waters of the U.S. and state-regulated Land Subject to Tidal Action, Land Containing Shellfish, and Coastal Beach.
- **Waters of the U.S.** (federal jurisdiction) are defined as waters seaward of the highest annual tide line in tidal waters. The seaward limit of jurisdiction extends to the Massachusetts 3-nautical mile (5.6-km) limit. When adjacent wetlands are present, such as salt marshes, the limit of jurisdiction extends to the boundary

of the wetland. Waters of the U.S. overlap with the federally-regulated Navigable Waters of the U.S. and the state-regulated Land Under the Ocean, Land Subject to Tidal Action, Land Containing Shellfish, Coastal Bank and Coastal Beach. This resource area also includes Salt Marsh 1 and 2, described below. It should be noted that although Salt Marsh is identified herein there are no direct impacts to Salt Marsh from the Project, as presented below.

- **Land Under the Ocean** (state and local jurisdiction) is defined under the Massachusetts WPA as the land extending from the mean low water line seaward to the boundary of the municipality's jurisdiction, and includes land under estuaries. Land Under the Ocean along the route consists of Lewis Bay and portions of Nantucket Sound within the 3-nautical mile (5.6-km) state territorial limit. Based on recent surveys, rocks have been identified (beyond the presently recognized 3-mile state territorial line) which may call into question the need for bindary chages at some future date. All work proposed in Land Under the Ocean includes Nearshore Areas, which extend to the municipality's jurisdiction but not beyond the point where the land is 80 feet (24.4 meters) below the level of the ocean at mean low water. The proposed work in Land Under the Ocean would be within the Town of Yarmouth; however, a small portion of the work would occur within the Town of Barnstable. The Yarmouth Wetlands Protection Regulations establish a 100-foot (30.5-meter) Buffer Zone to Land Under the Ocean. The Barnstable Wetlands Protection Ordinance provides no additional regulations for Land Under the Ocean beyond the WPA.
- **Submerged Aquatic Vegetation** (federal, state, and local jurisdiction) is located within the federally-regulated Navigable Waters of the U.S. and Waters of the U.S. and state-regulated Land Under the Ocean. The MADEP Wetlands Conservancy Program has mapped submerged aquatic vegetation (SAV) beds one quarter acre or larger in size along the coast using aerial photography, GPS, and a digital base map. Mapping was completed in 1995 and 2000; the 1995 data is available from MassGIS (MassGIS, 1999). One SAV bed has been mapped within Lewis Bay, located to the west of Egg Island in the Town of Barnstable. A December 2002 telephone conversation with Mr. Charles Costello of the MADEP Wetlands Conservancy Program indicates that the mapped SAV bed has not changed much in size between 1995 and 2000. In addition to the mapped SAV in Lewis Bay, MADEP has mapped areas of SAV in Hyannis Harbor in the Town of Barnstable and to the west of Great Island in the Town of Yarmouth. Field investigations have been conducted to determine the extent of mapped SAV beds in the vicinity of the proposed submarine cable route. The submarine cable system would be no closer than 70 feet (21.3 meters) from the edge of the eelgrass bed located near Egg Island.
- **Coastal Bank** (state and local jurisdiction) is defined as the seaward face or side of any elevated landform, other than a coastal dune, which lies at the landward edge of a coastal beach, land subject to tidal action, or other wetland. The Coastal Bank at the New Hampshire Avenue landfall is a concrete revetment. Coastal Bank at the landfall does not serve as a sediment source for coastal beaches or coastal dunes; however, it provides a vertical buffer that is significant to storm damage prevention and flood control. The WPA and the Yarmouth Wetlands Protection Regulations establish a 100-foot (30.5-meter) Buffer Zone to Coastal Bank. In addition, the Yarmouth Wetlands Protection Regulations prohibit structures within 50 feet (15.2 meters) of Coastal Bank and establish a 35-foot (10.7-meter) Vegetated Buffer. Furthermore, the riprap wall associated with Coastal Bank adjacent to the rectangular embayment may qualify as Rocky Intertidal Shore under the WPA.
- **Land Subject to Tidal Action** (state and local jurisdiction) is defined as land subject to the periodic rise and fall of a coastal waterbody, including spring tides. The Yarmouth Wetlands Protection Regulations establish a 100-foot (30.5-meter) Buffer Zone to Land Subject to Tidal Action.
- **Land Subject to Coastal Storm Flowage** (state and local jurisdiction) is defined as an area that extends upgradient or landward from the ocean and the ocean's estuaries to a point where the maximum lateral extent of flood water would theoretically terminate based upon the 100-year storm elevation referenced in the latest Flood Insurance Rate Map (FIRM). Land Subject to Coastal Storm Flowage (LSCSF) extends approximately 1,100 linear feet (335.3 meters) from the shoreline, along the route from the proposed landfall. The 100-year flood elevation varies from 13 feet (4 meters) NGVD at the landfall location to 11 feet (3.4 meters) NGVD just beyond the intersection of Berry Avenue and Broadway. The limit of the 100-year floodplain is shown on Figure 5.8-2, Sheet 2 (Wetland Resources Map).

  Portions of the Project area below elevation 13 feet (4 meters) NGVD are also within the "V-zone." The V-zone is an area subject to flooding with wave action during a 100-year storm event. In the vicinity of the proposed landfall, the V-zone extends to approximately 300 feet (91.4 meters) north of the Coastal Bank.

- **Salt Marsh 1** (state and local jurisdiction) is located approximately 200 feet (61 meters) west of the proposed landfall location, between Lewis Bay and Shore Road in Yarmouth. This salt marsh is vegetated by poison ivy (*Toxicodendron radicans*), salt meadow cordgrass (*Spartina patens*), rushes (*Juncus* spp.), and seaside goldenrod (*Solidago sempervirens*). This salt marsh is positioned between the residences at 43 and 37 Shore Drive. The WPA and the Yarmouth Wetlands Protection Regulations establish a 100-foot (30.5-meter) Buffer Zone to Salt Marsh. In addition, the Yarmouth Wetlands Protection Regulations prohibit structures within 50 feet (15.2 meters) of Salt Marsh and establish a 35-foot (10.7-meter) Vegetated Buffer.
- **Salt Marsh 2** (state and local jurisdiction) is located approximately 85 to 120 feet (26 to 36.6 meters) west of the proposed transmission line route on New Hampshire Avenue. It is bordered by residences to the east and west, Shore Road to the south, and Broadway to the north. According to the Cape Cod Atlas of Tidally Restricted Salt Marshes (2001), a 12-inch (30.5 cm) wide culvert connecting this salt marsh to Lewis Bay is consistently clogged, causing regular tidal flooding over Shore Road between Salt Marsh 1 and Salt Marsh 2 (Cape Cod Commission, 2001). Salt Marsh 2 is vegetated by high tide bush (*Iva frutescens)*, bayberry (*Morella caroliniensis*), poison ivy, salt meadow cordgrass, rushes, and seaside goldenrod. A defined channel is visible in the center of the salt marsh. The WPA and the Yarmouth Wetlands Protection Regulations establish a 100-foot (30.5-meter) Buffer Zone to Salt Marsh. In addition, the Yarmouth Wetlands Protection Regulations prohibit structures within 50 feet (15.2 meters) of Salt Marsh and establish a 35-foot (10.7-meter) Vegetated Buffer.
- **Coastal Beach 1** (state and local jurisdiction) is defined under the WPA as unconsolidated sediment subject to wave action, tidal and coastal storm action that forms the gently sloping shore of a body of water. Coastal Beach extends from the mean low water line landward to the coastal bankline or seaward edge of existing manmade structures. Coastal Beach 1 is a gently sloping, sandy area that extends from mean low water line to the concrete revetment that comprises Coastal Bank at the proposed landfall location. The WPA and the Yarmouth Wetlands Protection Regulations establish a 100-foot (30.5-meter) Buffer Zone to Coastal Beach. In addition, the Yarmouth Wetlands Protection Regulations prohibit structures within 50 feet (15.2 meters) of Coastal Beach and establish a 35-foot (10.7-meter) Vegetated Buffer.
- **Coastal Beach 2** (state and local jurisdiction) is Englewood Public Beach, located approximately 60 feet (18.3 meters) east of New Hampshire Avenue. The beach extends from the mean low water line west to the edge of a paved parking lot adjacent to New Hampshire Avenue. The WPA and the Yarmouth Wetlands Protection Regulations establish a 100-foot (30.5-meter) Buffer Zone to Coastal Beach. In addition, the Yarmouth Wetlands Protection Regulations prohibit structures within 50 feet (15.2 meters) of Coastal Beach and establish a 35-foot (10.7-meter) Vegetated Buffer.
- **Land Containing Shellfish** (state and local jurisdiction) is located within Land Under the Ocean and Waters of the U.S. and may be located in Coastal Beach and Salt Marsh. Research and discussions with the Yarmouth Shellfish Constable (Caia, 2002) indicate that Lewis Bay contains quahogs (*Mercenaria mercenaria*) and soft shell clams (*Mya arenaria*), with some scallops (*Placopectin magellanicus*) and Eastern oysters (*Crassostrea virginica*). Shellfish resources within Lewis Bay are utilized for commercial and recreational shellfishing. The proposed submarine cable route in Lewis Bay crosses a designated recreational shellfish area, but would not cross any privately licensed shellfish areas or grants (Town of Yarmouth Natural Resource Commission's Aquaculture Lease Site Maps and Recreational Shellfish Area Maps dated June 1, 1998 and December 2, 1999). Refer to Figures 5.3-6 through 5.3-8 in Section 5.3 for locations of these designated commercial and recreational shellfish areas. Additional information on shellfish resources in Lewis Bay is provided in Section 5.3 (Benthic and Shellfish Resources).
- **Coastal Watershed Areas** (local jurisdiction) are defined in the Yarmouth Wetlands Protection Regulations as wetland and upland landforms that contribute surface and sub-surface water to the estuaries within the town. These areas are mapped and delineated within a "Water Resources Protection Study" prepared for the Town of Yarmouth (Figure 5.8-3). Conservation Commission jurisdiction is restricted to mapped areas within 300 feet (91.4 meter) of a major estuary. Portions of the proposed route are in a mapped Coastal Watershed Area within 300 feet (91.4 meters) of Lewis Bay, defined as a major estuary under Section 1.04 of the local regulations.

5.8.3.2 Freshwater Wetlands

The proposed onshore transmission line route runs north from the landfall at New Hampshire Avenue in Yarmouth for approximately four miles along Berry Avenue, Higgins Crowell Road, and Willow Street. The route leaves the roadways and for approximately two miles then heads west and then south along the existing NSTAR

Electric ROW to the Barnstable Switching Station. The land along this route is predominantly upland, consisting of roadways and roadway shoulders, and maintained utility ROW. The route was sited to utilize existing developed or disturbed landscapes, thereby eliminating or reducing temporary and permanent impacts to wetlands and associated state and local buffer zones. Terrestrial ecology, wildlife, and protected species issues along this corridor are discussed in Section 5.6.

Six freshwater wetland systems, as shown on Figure 5.8-1 and detailed in Table 5.8-2, were identified within approximately 100 feet (30.5 meters) of the proposed transmission cable route. A locally-regulated isolated wetland north of Water Street and east of Berry Avenue was also identified during field investigations. Because this wetland area is slightly more than 100 feet (30.5 meters) from the transmission cable route (see Figure 5.8-2, Sheet 3), it is not within the jurisdiction for this Project. The following provides a description of those six wetland resource areas, as shown on Figure 5.8-1 and detailed in Table 5.8-2, within 100 feet (30.5 meters) of the onshore transmission cable route[81].

- **Wetland 1 – Bordering Vegetated Wetland (BVW), Bank, Waters of the U.S.** (local, state, and federal jurisdiction) is an Atlantic white cedar (*Chamaecyparis thyoides*) swamp located on the east and west sides of Higgins Crowell Road in Yarmouth. The wetland is within approximately 60 feet (18.3 meters) of the road, and is located at a well-defined break in slope. A 12-inch (30.5 cm) concrete culvert beneath the road appears to connect the east and west wetland areas, and this wetland is therefore regulated as Bank and Waters of the U.S. On the east side of the road, the wetland is relatively undisturbed and consists of a mixed cedar, tupelo (*Nyssa sylvatica*), and red maple (*Acer rubrum*) canopy, and a shrub layer with highbush blueberry (*Vaccinium corymbosum*), sweet pepperbush (*Clethra alnifolia*), green briar (*Smilax rotundifolia*), fetterbush (*Leucothoe racemosa*), and swamp azalea (*Rhododendron viscosum*). On the west side of the road, the majority of the mature Atlantic white cedars are dead or in decline. Vegetation includes live sapling Atlantic white cedars, red maple, tupelo, inkberry (*Ilex glabra*), sweet pepperbush, green briar, highbush blueberry, water willow (*Decodon verticillatus*), and wool grass (*Scirpus cyperinus*). This wetland is regulated as Bordering Vegetated Wetland (BVW) and Bank, and has a 100-foot (30.5-meter) Buffer Zone under the WPA, and a 50-foot (15.2-meter) No-Build Zone and 35-foot (10.7-meter) Vegetated Buffer under the Yarmouth Wetlands Protection Regulations. Wetland 1 is regulated as Waters of the U.S. by the USACE.
- **Wetland 2 – BVW, Bank, Land Under Waterbodies and Waterways (LUWW), Riverfront Area, Waters of the U.S.** (local, state, and federal jurisdiction) consists of Jabinettes Pond, on the east side of Higgins Crowell Road, and Thornton Brook, located on both the east and west side of the road. A vegetated wetland abutting Jabinettes Pond is located within 100 feet (30.5 meters) of the proposed onshore transmission cable route. It is dominated by red maple, tupelo, highbush blueberry, sweet pepperbush, spicebush (*Lindera benzoin*), green briar, and sensitive fern (*Onoclea sensibilis*). Jabinettes Pond discharges into Thornton Brook, which appears to flow west and crosses beneath Higgins Crowell Road via a buried culvert. Road runoff is also channeled via paved swales on both sides of Higgins Crowell Road into Thorton's Brook. The stream briefly appears aboveground on the west side of the road, where it receives additional direct roadway runoff, and is then culverted beneath an old vegetated road. An unused concrete flow control structure with a slot for flashboards was observed on the east end of the west side culvert. The stream finally appears aboveground into a defined channel with steep man-altered banks and flows southwest.

  Thornton Brook is mapped as a perennial stream on the current USGS map, and it is presumed to be perennial under 310 CMR 10.58(2)(a)(1)(a). However, the stream channel was observed completely dry during the field reviews in October 2001 and December 2002, and additional documentation may be collected to rebut the perennial presumption.

  Wetland 2 is regulated as BVW, Land Under Waterbodies and Waterways (LUWW), and Bank. A 100-foot (30.5-meter) Buffer Zone and 200-foot (61-meter) Riverfront Area from Bank is jurisdictional under the WPA. The Yarmouth Wetlands Protection Regulations regulate Wetland 2 as Vegetated Wetland, LUWW, and Bank with a 50-foot (15.2-meter) No-Build Zone and 35-foot (10.7-meter) Vegetated Buffer. Portions of Higgins Crowell Road are mapped within the recharge area of Jabinettes Pond and are regulated under the local by-law as a Lake and Pond Recharge Area (Figure 5.8-4). Wetland 2 is regulated as Waters of the U.S. by the USACE.

[81] Please note that the wetland identification numbers referenced in this document may not correspond with those utilized in previous filings.

- **Wetland 3 – BVW, Bank, Waters of the U.S.** (local, state, and federal jurisdiction) is a forested wetland located approximately 50 feet (15.2 meters) west of Higgins Crowell Road in Yarmouth. The wetland is dominated by red maple, sweet pepperbush, highbush blueberry, inkberry, swamp azalea, fetterbush, cinnamon fern (*Osmunda cinnamomea*), and *Sphagnum* mosses. An intermittent stream channel flows west through the wetland and into Little Sandy Pond, located approximately 700 feet (213.4 meters) west of Higgins Crowell Road. The intermittent stream channel was observed dry in areas in the vicinity of the wetland delineation in December 2002. Wetland 3 is regulated as BVW and Bank with a 100-foot (30.5-meter) Buffer Zone under the WPA, and a 50-foot (15.2-meter) No-Build Zone and 35-foot (10.7-meter) Vegetated Buffer under the Yarmouth Wetlands Protection Regulations. This wetland is regulated as Waters of the U.S. by the USACE.
- **Wetland 4 – BVW, Waters of the U.S.** (local, state, and federal jurisdiction) is a large forested swamp located approximately 30 feet (9.1 meters) east of Higgins Crowell Road in Yarmouth. The wetland has an open understory and canopy and is dominated by red maple, sweet pepperbush, highbush blueberry and *Sphagnum* mosses. The wetland is defined by an obvious topographic break in slope. A headwall with a partially-buried culvert is located on the wetland's edge, adjacent to the roadway, but does not appear to be functioning. Wetland 4 is regulated as BVW and has a 100-foot (30.5-meter) Buffer Zone under the WPA, and a 50-foot (15.2-meter) No-Build Zone and 35-foot (10.7-meter) Vegetated Buffer under the Yarmouth Wetlands Protection Regulations. This wetland is regulated as Waters of the U.S. by the USACE.
- **Wetland 5 – BVW, Bank, Waters of the U.S.** (local, state, and federal jurisdiction) is located on the west side of Higgins Crowell Road in Yarmouth and is separated from the road by a strip of upland dominated by pitch pine and sheep laurel (*Kalmia angustifolia*). The wetland consists of a roughly circular wet meadow dominated by asters, little bluestem (*Schizachyrium scoparium*), rushes (*Juncus* spp.), umbrella-sedges (*Cyperus* spp.), St. John's wort (*Hypericum* spp.), cranberry (*Vaccinuium oxycoccos*), spike rush (*Eleocharis spp.*), and sundews (*Drosera* spp.). The east side of the wet meadow area abuts a 30-foot (9.1-meter) wide shrub swamp, densely vegetated with green briar, inkberry, highbush blueberry, pitch pine, and fetterbush. A manmade intermittent channel on the west side of the wetland flows west into Hawes Run. Both the wetland and intermittent channel were dry at the time of inspection in December 2002. The USGS map shows the wet meadow as an open waterbody meeting the 10,000-square foot (929-square meter) size requirements for a Pond under the WPA. However, observations of the area dry during non-drought periods indicates that it does not meet the definition of Pond under the WPA (310 CMR 10.04) or the Yarmouth Wetlands Protection Regulations (Section 1.04). Wetland 5 is regulated as BVW and Bank with a 100-foot (30.5-meter) Buffer Zone under the WPA. Under the Yarmouth Wetlands Protection Regulations, a 50-foot (15.2-meter) No-Build Zone and 35-foot (10.7-meter) Vegetated Buffer is established from the wetland boundary. Wetland 5 is regulated as Waters of the U.S. by the USACE.

From Willow Street in Yarmouth, the onshore transmission line route leaves the roadway and extends west and south for approximately 2 miles (3.2 km) along the NSTAR Electric ROW to the Barnstable Switching Station. One freshwater vegetated wetland area bordering the south shore of Long Pond in Yarmouth is present along the existing ROW immediately west of Willow Street. No wetland resource areas were identified within 100 feet (30.5 meters) of the ROW transmission route in the Town of Barnstable.

- **Wetland 6 – BVW, Bank, LUWW, Waters of the U.S.** (local, state, and federal jurisdiction) consists of Long Pond, which is situated on the northern edge of the ROW just west of Willow Street. The pond contains open water, surrounded by a fringe of emergent marsh and shrub swamp dominated by highbush blueberry, sweet pepperbush, swamp azalea, and leatherleaf (*Chamaedaphne calyculata*). The wetland is located at the base of a steep slope; however, many of the wetland plants, including swamp azalea and sweet pepperbush, are growing significantly upslope. Therefore, the boundary of the wetland was delineated using evidence of hydrology and hydric soils, under criteria established by the MADEP. Wetland 6 is regulated as BVW, Bank, and LUWW and has a 100-foot (30.5-meter) Buffer Zone under the WPA, and a 50-foot (15.2-meter) No-Build Zone and 35-foot (10.7-meter) Vegetated Buffer under the Yarmouth Wetlands Protection Regulations. This wetland is regulated as Waters of the U.S. by the USACE.

5.8.4 Analysis of Impacts

The Project is designed to avoid wetlands, minimize potential impacts, and provide mitigation where impacts occur. While limited localized impacts to jurisdictional wetlands and buffer zones are anticipated during Project

construction, measures would be implemented to prevent and minimize these impacts. For coastal wetlands, these measures include using HDD in the intertidal zone in Lewis Bay, state-of-the-art hydraulic jet plow for offshore cable embedment that minimizes sediment disturbance, and monopile foundations for WTG towers which minimize seafloor occupation and sediment disturbance.

The installation of WTG foundations and inner-array and submarine cables would physically displace sediment at specific locations through sediment suspension, transport, and deposition. In sandy sediments such as those in the Project area, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Appendix 5.2-C). As with other projects involving submarine cable embedment in the seabed using jet plow technology, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Appendix 5.2-C).

For coastal and freshwater wetlands, measures to prevent and minimize impacts would include the location of the transmission line system below grade within existing roadways and maintained ROW, and installing sediment and erosion controls prior to construction. Post-construction monitoring is proposed to document habitat disturbance and recovery (see Section 6.0). This section describes potential wetland impacts and anticipated mitigation measures for the Project.

5.8.4.1 Potential Impacts Outside of Massachusetts Waters

Seaward of the 3-nautical mile (5.6 km) limit, Nantucket Sound is regulated as "Navigable Waters of the United States" under Section 10 of the Rivers and Harbors Act. Temporary and permanent impacts to the seafloor within this area are summarized below and in Table 5.3-3.

The seafloor would be altered by the installation of pilings needed to support the WTGs and the ESP. The number of pilings to be constructed would include 130 for the WTGs and 6 to support the ESP. The diameter of the WTG pilings would be approximately 16.75 feet (5.1 meters) (in shallower waters) and 18 feet (5.5 meters) (in deeper waters) at the seafloor, while the ESP pilings would have a diameter of 3.5 feet (1.1 meters) at the seafloor. This results in a total area of impact equal for all pilings of approximately 29,637 square feet/0.68 acre (2,753 square meters). By mechanical pile-driving the pilings into place, seabed disturbance and turbidity associated with the foundation installation would be minimized.

Each of the pilings would be protected from scour and undermining through the use of scour mats, which would alter approximately 0.02 acre/810 square feet (75 square meters) at each piling. Total area of impact from the installation of the scour mats is 110,160 square feet/2.53 acres (10,234 square meters). Please refer to Appendix 4.0-A for additional information on the proposed scour mats.

In addition to the impacts from the pilings and scour mats, the seafloor would be temporarily disrupted to install the cables necessary to link the WTGs to the ESP, and to connect the ESP to the mainland. As previously discussed in detail in Section 4.0, the installation of the inner array cables and the submarine cable would be accomplished using jet plow embedment.

The total length of inner-array cables necessary to link the WTGs to the ESP is approximately 411,840 linear feet (78 miles/125.5 km). In order to install the cables to a target depth of 6 feet (1.8 meters) below present bottom, the width of the zone of disturbance for cable installation is estimated to be between 4 and 6 feet (1.2 to 1.8 meters) wide and 8 feet (2.4 meters) deep. As the jet plow progresses along the route the water pressure at the jet plow nozzles will be adjusted as sediment types and/or densities change to achieve the required minimum burial depth of 6 feet of cover. In the unlikely event that the minimum burial depth of 6 feet (1.8 meters) below present bottom is not met during jet plow embedment, additional passes with the jet plow device or the use of diver-assisted water jet probes will be utilized to achieve the required depth. Therefore, the upper range of temporary seafloor disturbance during inner-array cable installation is estimated to be 2,471,040 square feet/56.73 acres (229,567 square meters). In addition, two 3-foot (0.9-meter) wide skid pontoons would ride along the surface of the sediment on either side of the jet plow. Pontoon impacts resulting from the installation of the inner-array cables are also estimated to be approximately 2,471,040 square feet/56.73 acres (229,567 square meters).

Of the approximately 12.2 miles (19.6 km) of submarine cable required to join the ESP to the mainland, approximately 5.6 miles (9 km) of this lies outside the state's 3-nautical mile (5.6 km) territorial limit. The connection between the ESP and the mainland would consist of two circuits located approximately 20 feet (6.1 meters) apart. These cables would be installed to a target depth of 6 feet (1.8 meters) below present bottom (as described above) and would require temporary disturbance of between 4 feet (1.2 meters) and 6 feet (1.8 meters) of seafloor width per circuit. Therefore, the upper range of temporary seafloor disturbance during cable installation is estimated to be 354,816 square feet/8.15 acres (32,963 square meters). Pontoon impacts associated with this portion of the submarine cable installation would also be approximately 354,816 square feet/8.15 acres (32,963 square meters). The installation of the two circuits via jet plow embedment is anticipated to take approximately two to four weeks to complete.

The seafloor would also be temporarily impacted by the anchoring, positioning, and movement of the vessels associated with erecting the wind turbine towers, constructing the ESP platform, installing the scour protection mats, and installing the inner-array cables and submarine cable system (see Table 5.3-3). These impact areas are estimates, and may vary depending on sediment composition, water depth, and sea and weather conditions. Section 5.3 includes additional information on the calculation of these impact numbers.

Installation of the monopile foundation systems within the WTG array and the submarine cable system by jet plow embedment would result in temporary and localized sediment resuspension (see Section 5.1). Potential indirect impacts to benthic organisms and finfish from sediment resuspension are discussed in Sections 5.3 and 5.4, respectively. Due to the predominance of sand in the Project area, turbidity associated with construction activities is anticipated to be relatively low, and confined to the area immediately surrounding tower foundations and cable trenches. Resuspended sediments are expected to settle back to the seafloor within a short period of time (one to two tidal cycles). Based on the lack of chemical constituents of concern in the Project area sediments, sediment resuspension during foundation placement and cable embedment is not anticipated to have a long-term adverse effect on marine water quality or aquatic biota.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to "Navigable Waters of the United States" would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable has been proposed by National Grid that involves the installation of a second electric transmission cable between Cape Cod and Nantucket. Its proposed route would only cross the Project's submarine cable route in the vicinity of Hyannis Harbor, well within the Massachusetts 3-mile limit (as discussed below in Section 5.8.4.2). Outside of Massachusetts waters, at its closest point the proposed route of the Nantucket Cable would be approximately 2 miles (3.2 km) from the Wind Park and its inner array cables in Nantucket Sound. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and of short duration, these temporary impacts are not likely to occur at the same time. Thus any areas where both projects may result in impacts as a result of jet plow cable embedment would likely have assimilated the deposited sediment from the first project installation by the time the second project is constructed. As such, there are no significant cumulative impacts to "Navigable Waters of the United States" expected to result from the installation of both projects.

The submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance dredging. Therefore, no significant cumulative effects to wetland resources are expected in the area of the North Channel crossing.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts to wetland resources expected since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

Secondary Impacts

There are no potential onshore secondary impacts to wetlands associated with construction staging/laydown activities at Quonset. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy and no significant land alteration would be necessary to accommodate the Project's staging activities.

5.8.4.2 Potential Impacts Inside of Massachusetts Waters

5.8.4.2.1 Lewis Bay

The following section primarily discusses the general vicinity of Lewis Bay. The cable route in Nantucket Sound between the 3 mile limit and the mouth of Lewis Bay is similar in nature to the cable route outside of Massachusetts waters, as discussed above (see Section 5.8.4.1).

Within the 3-nautical mile (5.6 km) state territorial limit, Nantucket Sound and Lewis Bay are regulated as Land Under the Ocean under the WPA, Waters of the United States under Section 404 of the Clean Water Act, and Navigable Waters of the United States under Section 10 of the Rivers and Harbors Act. Approximately 6.6 miles of the submarine cable system route would be within the state's 3-nautical mile (5.6 km) territorial limit. Once the route crosses the 3-nautical mile (5.6 km) state jurisdictional limit, it enters Town of Yarmouth waters, then Town of Barnstable waters in the outer portion of Lewis Bay, continuing through the inner portions of Lewis Bay where it reenters Yarmouth waters to the proposed landfall at New Hampshire Avenue. Jet plow cable embedment and HDD at the transition zone from land to sea would minimize impacts to Lewis Bay wetland resources during installation of the transmission line. Anticipated impacts to the seafloor from jet plowing and HDD are summarized in Table 5.3-3.

Submarine Cable System Route

Approximately 6.6 miles (10.6 km) of the 12.2-mile (19.6-km) submarine cable system route would be within the Massachusetts 3-nautical mile (5.6 km) limit. Jet plow embedment would be utilized to bury the two cable circuits (as described above) approximately 6 feet (1.8 meters) beneath the surface of the ocean floor (see Figure 4-20). Cable installation is anticipated to disturb between 4 and 6 feet (1.2 and 1.8 meters) of seafloor per circuit. Therefore, the upper range of temporary seafloor disturbance during installation of the two circuits is estimated to be 418,176 square feet/9.6 acres (38,850 square meters) of Land Under the Ocean. In addition, the skid pontoons would temporarily impact approximately 418,176 square feet/9.6 acres (38,850 square meters) of Land Under the Ocean, and barge anchoring would temporarily impact an estimated 4,212,252 square feet/96.7 acres (391,331 square meters) of Land Under the Ocean within the Massachusetts 3-nautical mile (5.6 km) limit.

As discussed in Section 5.2, because the submarine cable system would be buried, the route would not significantly affect water depths, sediment transport regime, tidal or freshwater circulation patterns, or wave current regime. In addition, the proposed submarine cable system would not divert, restrict, or otherwise interfere with the flow of either fresh or salt water and would not change existing salinity gradients or sediment transport functions of the waters of Lewis Bay. Temporary and localized impacts to the physical characteristics of Land Under the Ocean within Lewis Bay as a result of jet plowing are further characterized in Sections 5.1 and 5.2.

Lewis Bay contains shellfish resources that are utilized for both commercial and recreational shellfishing. Therefore, state-regulated Land Containing Shellfish is located within Land Under the Ocean and may also be located in Coastal Beach and Salt Marsh. Shellfish resources that occur either naturally or through management and propagation measures primarily include quahogs, soft shell clams, scallops, and oysters. Potential impacts to Land Containing Shellfish from submarine cable installation activities are anticipated to be localized and short-term, resulting primarily from direct sediment disturbance. The only shellfish beds that would be impacted are recreational. No commercial beds will be directly impacted. The Applicant would work with the Shellfish

Constables of Yarmouth and Barnstable to mitigate for any short-term impacts to shellfish productivity. Mitigation may include reseeding or relocation of shellfish to a suitable location approved by the shellfish constable(s) and the Department of Marine Fisheries. Therefore, the installation of the submarine cable will not result in any permanent exclusion of shellfishing in the area.

Additional information on impacts to shellfish and other benthic resources is provided in Section 5.3 of this report.

Field investigation has been conducted to determine the extent of SAV beds in the vicinity of the proposed submarine cable route and to modify the proposed route accordingly to avoid direct impacts to SAV. Potential indirect impacts to SAV during cable embedment related to sediment resuspension would be minimized by maintaining an appropriate distance between the jet plow and mapped SAV beds. The submarine cable system would be no closer than 70 feet (21.3 meters) from the edge of the eelgrass bed located near Egg Island.

Landfall Transition

The proposed submarine cable system would be installed beneath Coastal Bank and Coastal Beach by HDD, in order to avoid open excavation that would expose the Coastal Bank and Beach to wave action and potential erosion. As described in Section 4.0, HDD would be staged at the onshore landfall area.

The landfall transition to offshore would involve HDD cable installation for approximately 200 feet (61 meters) (seaward of mean low water) from the onshore transition vaults to a temporary offshore excavated pit approximately 65 feet (19.8 meters) wide by 45 feet (13.7 meters) long (0.07 acre/2,925 square feet (272 square meters) of Land Under the Ocean). Four 18-inch (45.7 cm) HDPE conduit pipes (one for each of the three-conductor 115 kV cables) would be installed between the vaults and the pit. The conduit would be installed a minimum of 6 feet (1.8 meters) below the present bottom. The transition of the cables from the conduits to subsurface sediments would involve construction of a temporary cofferdam at the end of the conduit boreholes. Once the cofferdam is installed, the offshore pit would be excavated by dredging approximately 840 cubic yards (642.2 cubic meters) of sediment to an elevation of -10 feet (-3 meters) MLLW. All of the excavated sediment would be removed and disposed at an approved upland location, so no discharge is proposed. From the pit to the ESP, cables would be installed using the hydraulic jet plow.

After the submarine cable system has been installed, the cofferdam would be removed. When the temporary cofferdam sheeting is removed, the sediment on the outside of the sheeting would shift into the cofferdam excavation as a result of gravity. This would result in a depression in the sediment surface that could be several feet deep. This depression would be allowed to naturally fill in over time through natural sediment resuspension, deposition, movement, and consolidation. It is anticipated that the installation of the borehole and conduit by HDD techniques would take approximately two to four weeks to complete. For a more detailed discussion of the HDD installation, see Section 4.3.5.

To minimize the release of the bentonite drilling fluid into Lewis Bay during HDD, freshwater would be used as a drilling fluid to the extent practicable prior to the drill bit or the reamer emerging in the pre-excavated pit. This would be accomplished by pumping the bentonite slurry out of the hole, and replacing it with freshwater as the drill bit nears the pre-excavated pit. It is possible that some minor residual volume of bentonite slurry may be released into the pre-excavated pit. The depth of the pit and the temporary cofferdam perimeter are expected to contain any bentonite slurry that may be released. Prior to drill exit and while the potential for bentonite release exists, diver teams would install a water-filled temporary dam around the exit point to act as an underwater "silt fence." This dam would contain the bentonite fluid as it escapes and sinks to the bottom of the pre-excavated pit to allow easy clean-up using high-capacity vacuum systems.

Once the submarine cable system makes landfall at the proposed location, the transmission lines would be transitioned to the onshore transmission cable system in two below-grade transition vaults. The transition vaults would be located at the land boreholes with the dimensions of approximately 7 feet (2.1 meters) wide by 34 feet (10.4 meters) long by 7.6 feet (2.3 meters) high (Figure 4-15). The transmission line transition vault would be installed within the pavement using conventional excavation equipment (e.g., backhoe).

The proposed submarine cable system would be pulled beneath Coastal Bank, Coastal Beach, and Land Subject to Tidal Action, and would not adversely affect these resource areas with respect to wave action, the movement

of sediment, storm damage prevention, flood control, post-construction shellfish productivity, or marine fisheries. The use of HDD at the landfall would also minimize direct impacts to the designated recreational shellfish area located along the shoreline, as described in Section 5.8.3.1.2. Construction-related impacts to Land Under the Ocean would primarily be a result of the pre-excavation of the offshore exit point. The construction activities for the HDD would be temporary and localized as described in Section 4.0. Potential impacts from the HDD excavation pit to benthic biota are discussed in Section 5.3 (Benthic and Shellfish Resources).

Operation of the Wind Park and cable system is not anticipated to impact wetland resource areas. The Spill Prevention Control and Countermeasure (SPCC) Plan would be in place during Project construction/decommissioning and operation to prevent/control potential impacts to wetlands and water quality that could result from spills of fuel, lubricating oils, or other substances associated with the use of marine vessels and machinery (see Section 5.9).

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to wetland resources inside of Massachusetts waters would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent, cumulative sediment suspension and deposition. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on recent experience it could be needed in the next 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. Future USACE maintenance dredging in Hyannis Harbor would be the subject of an additional NEPA document. In any event, as discussed in Appendix 5.2-C, sediment deposition resulting from the cable installation would be minimal and localized, and would not substantially contribute to any significant cumulative impact to the waters within the 3-nautical mile (5.6 km) limit.

A new submarine transmission cable between the south shore of Cape Cod and Nantucket has been proposed by National Grid, and its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and of short duration, these temporary impacts are not likely to occur at the same time. Thus, any areas where both projects may result in impacts as a result of jet plow cable embedment would likely have assimilated the deposited sediment from the first project installation by the time the second project is constructed. As such, there are no significant cumulative impacts expected to the waters within the 3-nautical mile (5.6 km) limit that would result from the installation of both projects.

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the Project area. However, these marina dredging projects, if they were to occur, are very localized and not likely to result in sediment suspension and deposition that would be coincident with the cable installation (the closest point of which would be a minimum of .5 miles (805 meters) from the closest marina). Additionally those dredging and disposal activities would be subject to their own regulatory permit processes. Thus, no significant cumulative impacts to waters within the 3-nautical mile (5.6-km) limit are anticipated from these activities.

5.8.4.2.2 Potential Onshore Impacts

This section describes the three components of the onshore transmission cable route: 1) the landfall, 2) the transmission line route in roadways from the landfall to the NSTAR Electric ROW, and 3) the transmission line

route along the ROW to the Barnstable Switching Station. Impacts to wetland resource areas and Buffer Zones from onshore transmission cable installation are summarized in Table 5.8-3 and discussed below.

Landfall

As described previously, HDD would be staged in upland at the landfall area within the excavation pit that would contain the transition vaults and would involve the drilling of boreholes from land toward the offshore exit point. The transition vaults would be located on New Hampshire Avenue, approximately 50 feet (15.2 meters) landward of the Coastal Bank. Additional information on the landfall transition is provided in Section 4.3.5.

Drilling of the land boreholes and installation of the transition vaults would result in temporary impacts to existing paved portions of state- and locally-regulated Land Subject to Coastal Storm Flowage, the locally-regulated Coastal Watershed Area, and the 100-foot (30.5-meters) Buffer Zone of Coastal Bank and Coastal Beach, all of which are discussed in greater detail below.

Road Route

As described in Section 4.0, construction of the onshore transmission line would occur in two phases. The first phase consists of installing the ductbanks, conduits, and manholes, and is anticipated to take approximately 5 months to complete. The second phase consists of the installation of the onshore 115 kV transmission lines, including splices and termination, and is also anticipated to take approximately 5 months.

The onshore transmission cable system would be installed within existing paved roadways in Yarmouth from the landfall location to the NSTAR Electric ROW over a distance of approximately 4 miles (6.4 km). As described in Section 4.0, the onshore transmission line system would utilize 12 single-conductor 115 kV cables. These cables would be encased in a 2-foot (0.6-meter) high by 5-foot (1.5-meter) 8-inch (20.3-cm) wide concrete-encased ductbank (see Figure 4-14). In addition to the transition vault at the landfall, the proposed transmission facility would include approximately 15 underground vaults along the street portion of the proposed route. Each underground vault containing a manhole would be constructed of reinforced concrete and would be approximately 7 feet (2.1 meters) wide by 33 feet (10 meters) 6 inches (15.2 cm) long. The manholes would be located along the route, approximately 9 to 10 feet (2.7 to 3 meters) below the surface of the roadway, generally at intervals between 500 to 1,700 feet (152.4 to 518.2 meters).

The installation of the manholes, ductbanks, and transmission lines would require trenching within existing paved roadways. Figure 5.8-1 shows the onshore transmission line route from the landfall to the Barnstable Switching Station. All excavation would be performed with standard machinery, including excavators and backhoes. The trench opening for the ductbanks and transmission lines would be a minimum of 10 feet (3 meters) wide. Burial depth to the top row of transmission lines would be approximately 56 inches (142.2 cm) within the roadways to allow passage under existing water and gas lines. Two known culverts are located along the proposed route on Higgins Crowell Road, at Wetland 1 and Wetland 2. During final design, it would be determined whether the ductbanks and transmission lines would pass above or beneath these culverts. No impacts to the culverts or adjacent waterways or wetlands are proposed.

Excavated soil from the trench and vaults would be temporarily stored adjacent to the worksite or transported off-site, if on-site storage is not possible. Where soil is stored at the site, it would be stabilized with erosion and sedimentation controls. Following the completion of the installation of the transmission line, the excavation would be backfilled and repaved. Stormwater erosion and sedimentation controls would be in place prior to the initiation of construction activities. Once construction is completed, all equipment and construction debris would be removed from the site and the area would be returned to its original condition.

In addition to the standard excavation methods described above, trenchless technologies (e.g., HDD, horizontal boring, or pipe jacking; refer to Section 4.3.6) would be used in certain locations to minimize impacts to roadway traffic. The use of trenchless technology is required at the intersection of the onshore transmission line with Route 28 and at the Willow Street/Route 6 interchange.

The total estimated land area to be temporarily disturbed along the proposed onshore transmission line route from the landfall location to the NSTAR Electric ROW is approximately 4.9 acres/213,444 square feet (19,830 square meters). This work has been designed to minimize impacts to wetland resource areas. No work is

proposed within a freshwater wetland, salt marsh, or culvert. From the landfall to the NSTAR Electric ROW, work would be required within existing paved portions of state- and locally-regulated Land Subject to Coastal Storm Flowage, Riverfront Area, and 100-foot (30.5-meter) Buffer Zone of freshwater and coastal wetland resource areas (see Table 5.8-3 for estimated areas of impact). No permanent aboveground structures are proposed within Yarmouth's 50-foot (15.2-meter) No-Build Zone, and no vegetation would be disturbed within the local 35-foot (10.7-meter) Vegetated Buffer.

ROW Route

The proposed onshore transmission cable route within the NSTAR Electric ROW from Willow Street to the Barnstable Switching Station would be installed with the same general methods used for the road route described above over a distance of approximately 1.9 miles (3 km). The excavated trench would be approximately 8 feet (2.4 meters) wide, and the ductbank would be buried approximately 24 inches (61 cm) from the top of the transmission line to the surface of the ground. Approximately 9 underground vaults would be required within the ROW. The vaults' manhole covers would be flush with the surface of the ground, to allow access for maintenance and repairs. After the installation of the transmission line is complete, the excavation would be backfilled to the original grade, and the area would be seeded with an erosion control seed mixture for stabilization. Trenchless technology would be required where the transmission line intersects with an existing railroad ROW near Willow Street and where the ROW crosses Route 6 to the Barnstable Switching Station.

The total width of workspace disturbance would be approximately 25 feet (7.6 meters), including construction access, laydown areas, and the 8-foot (2.4-meter) wide trench. This work would require the temporary disturbance of approximately 5.8 acres/252,648 square feet (23,471.6 square meters) of vegetation within the maintained ROW and minor permanent alteration of upland as a result of the manhole covers. This work would result in no impacts to wetland resource areas. Work may be required within the 100-foot (30.5-meter) Buffer Zone of Wetland 6 in Yarmouth. No work is proposed in wetland jurisdictional areas in Barnstable.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to upland wetland resources would include other upland cable or pipeline installations, excavation activities, and other wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative). The cumulative impacts from two potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

There are no significant cumulative impacts expected to wetlands that would result from the installation of the onshore transmission line. Based on discussions with the Town of Yarmouth DPW and the MHD there are no other major transportation projects scheduled for the vicinity and estimated construction timeframe for the onshore cable route. There are also no significant cumulative impacts to wetlands expected should the onshore portion of National Grid's Nantucket Cable be installed at the same time of the onshore portion of the Project's cable system. The proposed Nantucket Cable's onshore route is more than a mile (1.6 km) distant from the Project's proposed route and would pass through the central portion of Hyannis, while the Project's onshore route bypasses the center of town to the east.

5.8.5 Mitigation

The proposed submarine and onshore transmission cable route would be designed to fully comply with all applicable local, state and federal wetland performance standards. Avoidance, minimization, and mitigation would be employed to protect wetland resource areas. Assuming the Project is water-dependent (which will be determined through the applicable state agencies), avoidance of coastal resources, and in particular Land Under the Ocean and Land Containing Shellfish, is not possible. Direct wetland impacts would be minimized through the use of hydraulic jet plowing, HDD, and installation of the onshore transmission line within existing paved roadways or disturbed electric ROWs. As a result, the proposed work within wetland resource areas and buffer zones would not significantly affect the applicable interests protected by Section 10 of the Rivers and Harbors Act, the WPA, the Yarmouth Wetlands Protection Regulations, and the Barnstable Wetlands Protection By-law.

This section reviews the Project's compliance with local, state and federal wetland regulations. A discussion of mitigation measures for the Project, particularly the use of erosion and sedimentation controls to minimize indirect construction-related impacts to downgradient wetlands, is also discussed.

5.8.5.1 Coastal Resources

The use of hydraulic jet plowing within Nantucket Sound and Lewis Bay and HDD at the landfall would minimize sediment disturbance and avoid direct impacts to shoreline and coastal wetland resource areas at the submarine cable landfall. Staging areas and the transitional cable vault would be located in the upland. This section describes regulatory compliance and proposed mitigation for impacts to the coastal wetland resources under local, state and federal jurisdiction.

5.8.5.1.1 Federal Jurisdiction

Under Section 10 of the Rivers and Harbors Act of 1899, the USACE regulates the coastal resources of Nantucket Sound and Lewis Bay as Navigable Waters of the United States. For tidal waters, Section 10 defines the seaward limit of jurisdiction as the Outer Continental Shelf and the landward limit of jurisdiction as the mean high water line. An application for a Section 10 individual permit was filed with the USACE on November 21, 2001. Revisions to the original application were submitted on June 3, 2004. Mitigation measures proposed for work within Navigable Waters of the United States are identical to those proposed under the WPA, as discussed below.

5.8.5.1.2 State Jurisdiction

The Notice of Intent (NOI) for the submarine transmission line route would request Limited Project status under the WPA, as the Project is anticipated to result in temporary alterations to the following state-regulated resource areas: Land Under the Ocean, Land Containing Shellfish, and Land Subject to Coastal Storm Flowage. In addition, temporary work is proposed within paved portions of the 100-foot (30.5-meter) Buffer Zone to Land Under the Ocean, Coastal Bank, Coastal Beach, and Salt Marsh, as established under the WPA. Direct impacts to Coastal Bank, Coastal Beach, and Land Subject to Tidal Action would be avoided by the use of HDD at the landfall. Pursuant to the WPA, the NOI for this Project would be submitted to MADEP and the Barnstable and Yarmouth Conservation Commissions. The proposed work would require Orders of Conditions from the Towns of Barnstable and Yarmouth. The NOI would also be submitted to the Natural Heritage and Endangered Species Program (NHESP) for review, pursuant to 310 CMR 10.59, because portions of the onshore transmission line route are within mapped rare species habitat (see Section 5.6, Terrestrial Ecology, Wildlife, and Protected Species).

This section addresses the Project's compliance with the Performance Standards for Limited Project status and work within Land Under the Ocean, Land Containing Shellfish, and Land Subject to Coastal Storm Flowage (LSCSF) as regulated under the WPA. Work within the state-regulated Land Subject to Tidal Action and 100-foot (30.5-meter) Buffer Zone is not governed by specific regulatory performance standards. The applicability of the Coastal Wetlands Restriction Act (M.G.L. c. 130 §105) and Massachusetts Water Quality Certification (314 CMR 9.00) is also discussed.

Limited Project

The Applicant would request Limited Project status under the WPA for the proposed work within coastal resource areas. Pursuant to 310 CMR 10.24(7)(b), the construction of underground or overhead public utilities, including electrical distribution or transmission lines, may be permitted within coastal resource areas provided that it meets the following performance standards:

(1) For local distribution or connecting lines not reviewed by the Energy Facilities Siting Council, the issuing authority determines that alternative routes with fewer adverse effects are not physically or legally feasible.

This standard is not applicable. The Applicant submitted a petition to the Energy Facilities Siting Board on September 17, 2002, and the Project is currently under review.

(2) Adverse effects during construction are minimized using the best available measures, which may include such equipment as Bailey Bridges and helicopters.

The installation of the submarine transmission line route would be accomplished using the environmentally sensitive (low impact) and well-accepted methodology of water-powered installation known as "jet plowing." Jet plow embedment technology involves the use of pressurized water jets to fluidize seabed sediments along a very narrowly defined path, while the cable is laid directly into the fluidized trench as the jet plowing tool advances along the route. The cable settles through the fluidized sediments to the proposed burial depth of approximately 6 feet (1.8 meters) beneath the ocean floor. The majority of resuspended sediments settle back in place after the jet plow advances along the cable (see Appendix 5.2-C).

The use of HDD would minimize sediment disturbance from the landfall location on New Hampshire Road to the conduit exit hole in Lewis Bay. The use of HDD installation technology would also avoid direct disturbance of shoreline and coastal wetland resource areas, including Coastal Bank and Coastal Beach as described in Section 4.0.

(3) The surface vegetation and contours of the area are substantially restored.

As described above, the submarine cable system would be installed by hydraulic jet plowing, which is not anticipated to substantially alter the contours of the area. The submarine cable system would be routed to avoid areas of submerged aquatic vegetation mapped as part of the MADEP Eelgrass Mapping Inventory (1995). The transmission line at the landfall would be installed via HDD beneath the surface of the Coastal Bank and Coastal Beach, and would therefore result in no impacts to the surface vegetation or contours of these resource areas. Beyond the landfall, the transmission line would be installed within LSCSF within an existing paved roadway. Therefore, no vegetation would be altered in this area. The trench would be backfilled and repaved to restore existing contours.

(4) When a trench is made in a salt marsh, all spoil is removed from the salt marsh upon excavation. Clean sand or other appropriate material shall be used to restore the level of the trench to that of the surrounding undisturbed salt marsh. The surface vegetation shall be restored substantially to its original condition by immediately transplanting appropriate marsh plant nursery stock once construction is completed. Baffles of concrete, clay or other non-porous material shall be placed in the trench, if necessary, to prevent groundwater excursion. During the first growing season, periodic maintenance of the marsh restoration area shall be required and shall include at least the replacement of non-surviving transplants and the removal of all deposits of debris and organic litter. During construction, equipment such as Bailey bridges and helicopters shall be used to minimize, using best available measures, the adverse effects of construction of the salt marsh. All vehicles shall be used only on swamp mats or in such a way as to prevent tire marks, trenches, or ruts.

This standard is not applicable. No work is proposed within a salt marsh.

(5) No utility shall traverse a salt marsh unless the applicant has shown that any thermal influence on the salt marsh of such line subsequent to the project being completed would not alter the natural freezing and thawing patterns of the top 24 inches of the salt marsh surface. Thermal sand, concrete or other suitable material may be used to backfill the trench to a point no less than 24 inches below grade. Above this level, clean sand shall be used to restore the level of the trench to that of the surrounding undisturbed salt marsh.

This standard is not applicable because no work is proposed within a salt marsh.

(6) No permanent access roads shall be permitted except in designated port areas.

This standard is not applicable. No permanent or temporary access roads would be constructed as part of the Project within Designated Port Areas.

(7) All sewer lines shall be constructed so as to be watertight so as to prevent inflow and leakage.

This standard is not applicable. No sewer lines are proposed as part of the Project.

Land Under the Ocean

Hydraulic jet plowing and HDD to install the proposed transmission line would occur within Land Under the Ocean, including Nearshore Areas of Land Under the Ocean. Under the WPA, when Land Under the Ocean or Nearshore Areas of Land Under the Ocean are found to be significant to the protection of marine fisheries, protection of wildlife habitat, storm damage prevention or flood control, 310 CMR 10.25(3) through (7) shall apply:

(3) Improvement dredging for navigational purposes affecting land under the ocean shall be designed and carried out using best available measures so as to minimize adverse effects on such interests…

This standard is not applicable because improvement dredging for navigational purposes is not proposed as part of the Project.

(4) Maintenance dredging for navigational purposes affecting land under the ocean shall be designed and carried out using best available measures so as to minimize adverse effects on such interests caused by changes in marine productivity which would result from the suspension or transport of pollutants, increases in turbidity, the smothering of bottom organisms, the accumulation of pollutants by organisms, or the destruction of marine fisheries or wildlife habitat.

This standard is not applicable because maintenance dredging for navigational purposes is not proposed as part of the Project.

(5) Projects not included in 310 CMR 10.25(3) or 10.25(4) which affect nearshore areas of land under the ocean shall not cause adverse affects by altering the bottom topography so as to increase storm damage or erosion of coastal beaches, coastal banks, coastal dunes, or salt marshes.

The proposed submarine cable system would be installed by hydraulic jet plowing, a process that would not alter the bottom topography of the ocean. The excavation of the HDD offshore exit pit would temporarily alter bottom topography, but the pit is expected to naturally fill with sediments as a result of natural tidal processes.

(6) Projects not included in 310 CMR 10.25(3) which affect land under the ocean shall if water-dependent be designed and constructed, using best available measures, so as to minimize adverse effects, and if non-water-dependent, have no adverse effects on marine fisheries habitat caused by:

(a) alterations in water circulation;

As discussed in Section 5.2 (Physical Oceanographic Conditions), the submarine cable system would be buried by jet plow embedment and would therefore not significantly affect tidal or freshwater circulation patterns.

(b) destruction of eelgrass (Zostera marina) or widgeon grass (Rupia maritina) beds;

Field investigation has been conducted to determine the extent of SAV beds in the vicinity of the proposed submarine cable system route within state waters and to modify the proposed route accordingly to avoid direct impacts. Potential indirect impacts to SAV as a result of sediment resuspension would be minimized by maintaining an appropriate distance between the proposed jet plow embedment and the mapped SAV beds. The submarine cable system would be no closer than 70 feet (21.3 meters) from the edge of the eelgrass bed located near Egg Island.

(c) alterations in the distribution of sediment grain size;

As discussed in Section 5.1 (Geology and Sediment Conditions), the submarine cable system would be buried by jet plow embedment, and sediments would naturally resettle back in place after the jet plow advances along the cable route. This natural resettling of sediments is not anticipated to substantially alter the distribution of

sediment grain size, as coarser particles would settle out more quickly than fines as they would during storms and other natural sediment disturbances (see Appendix 5.2-C).

(d) changes in water quality, including, but not limited to, other than natural fluctuations in the level of dissolved oxygen, temperature or turbidity, or the addition of pollutants; or

Based on the lack of chemical constituents of concern in the marine sediments collected and analyzed from the submarine cable route area, the temporary and localized resuspension of sediments during cable installation is not anticipated to adversely affect marine water quality conditions (see Section 5.1, Geology and Sediment Conditions).

(e) alterations of shallow submerged lands with high densities of polychaetes, mollusks or macrophytic algae.

Potential impacts to shallow submerged lands containing macrophytic algae, shellfish, and benthic resources from submarine cable system installation activities would be localized and short-term (see Section 5.3, Benthic and Shellfish Resources). The cable would be routed to avoid potential direct impacts to these resources, and use of jet plow and HDD technologies would minimize potential indirect impacts due to sediment resuspension.

(7) Notwithstanding the provisions of 310 CMR 10.25(3) through (6), no project may be permitted which would have any adverse effect on specified habitat sites of rare vertebrate or invertebrate species, as identified by procedures established under 310 CMR 10.37.

Based on the 2003 Natural Heritage Atlas (NHESP, 2003), portions of the proposed submarine cable system route are located within state-listed rare species habitat (see Figure 5.6-1). Additional information on potential impacts to state- and federally-listed species in the Project area is provided in Section 5.5 (Protected Marine Species) and Section 5.7 (Avian).

Land Containing Shellfish

Potential impacts to shellfish resources from submarine cable system installation activities would be localized, temporary and short-term resulting primarily from direct sediment disturbance. The Applicant would work with the Barnstable and Yarmouth Town Shellfish Constables to appropriately avoid and minimize impacts to designated shellfish areas from installation of the submarine cable. Land Containing Shellfish has been identified within the resource areas Land Under the Ocean and may be present within Coastal Beach and Salt Marsh. Under the WPA, when a resource area is determined to be significant to the protection of Land Containing Shellfish and therefore to the protection of marine fisheries, 310 CMR 10.34(4) through (8) shall apply:

(4) Except as provided in 310 CMR 10.34(5), any project on land containing shellfish shall not adversely affect such land or marine fisheries by a change in the productivity of such land caused by:

(a) alterations of water circulation,

As discussed in Section 5.2 (Physical Oceanographic Conditions), the submarine cable system would be buried by hydraulic jet plowing and would therefore not significantly affect tidal or freshwater circulation patterns in Nantucket Sound and Lewis Bay.

(b) alterations in relief elevation,

The submarine cable system would be buried beneath the surface by jet plowing and horizontal directional drilling and would therefore not affect the surface contours of the resource areas. As described in Section 6.0 (CEMP), a limited bathymetric survey along representative transects would assess post-construction seabed elevations and surface conditions. If the results of this survey indicate long-term impacts to seabed relief, appropriate mitigation measures would be employed.

(c) the compacting of sediment by vehicular traffic,

No vehicular traffic is anticipated on Land Containing Shellfish. Although not a vehicle, the jet plow vessel would maintain contact with the seafloor during submarine cable embedment. The proposed jet plow embedment tool has two pontoons that are each 3 feet (0.9 meter) wide. These pontoons are filled with varying amounts of water and air to adjust the buoyancy of the vessel during cable installation. The cable installer's experience has shown that only a shallow mark is left on the bottom by the vessel in fine sediment conditions (silts and clays). Because the sediment in the Project area is largely fine- and coarse-grained sands, sediment compaction and long-term shellfish habitat degradation are not anticipated.

(d) alterations in the distribution of sediment grain size,

As discussed in Section 5.1 (Geology and Sediment Conditions), the jet plow trench is naturally filled as resuspended sediments settle back in place after the jet plow advances along the cable route. This natural resettling of sediments is not anticipated to substantially alter the distribution of sediment grain size, as coarser particles would settle out more quickly than fines as they would during storms and other natural sediment disturbances (see Appendix 5.2-C).

(e) alterations in natural drainage from adjacent land,

The Project is not anticipated to alter drainage patterns in adjacent lands. All work on adjacent lands would be located beneath existing roadway surfaces, which would be restored to their original contours and repaved after installation of the onshore transmission line.

(f) changes in water quality, including, but not limited to, other than natural fluctuations of salinity, dissolved oxygen, nutrients, temperature or turbidity, or the addition of pollutants.

The proposed transmission line would not divert, restrict, or otherwise interfere with the flow of either fresh or salt water and it would not change existing salinity gradients or sediment transport functions of the waters of Nantucket Sound and Lewis Bay. The proposed transmission lines are not anticipated to alter levels of dissolved oxygen or nutrients within Land Containing Shellfish. Thermal inputs to surrounding sediments would be minimized through cable design and burial.

Due to the predominance of fine- to coarse-grained sand in this area, localized turbidity associated with these activities is anticipated to be relatively low and confined to the area immediately surrounding the submarine cable trench. Resuspended sediments are expected to settle back to the seafloor within a relatively short period of time (one to two tidal cycles). Based on the lack of chemical constituents of concern in the Project area sediments, sediment resuspension during foundation placement and cable installation are not anticipated to adversely affect marine water quality or aquatic biota.

(5) Notwithstanding the provisions of 310 CMR 10.34(4), projects which temporarily have an adverse effect on shellfish productivity but which do not permanently destroy the habitat may be permitted if the land containing shellfish can and would be returned substantially to its former productivity in less than one year from the commencement of work, unless an extension of the Order of Conditions is granted, in which case such restoration shall be completed within one year of such extension.

Potential impacts to shellfish beds and other benthic resources from submarine cable installation activities would be localized and short-term (see Section 5.3, Benthic and Shellfish Resources). The cable would be routed to avoid potential direct impacts to these resources, and use of jet plow and HDD technologies would minimize potential indirect impacts due to sediment resuspension. Therefore, shellfish productivity is expected to return to its pre-construction productivity within one year of the commencement of work.

(6) In the case of land containing shellfish defined as significant in 310 CMR 10.34(3)(b) (i.e., those areas identified on the basis of maps and designations of the Shellfish Constable), except in Areas of Critical Environmental Concern, the issuing authority may, after consultation with the Shellfish Constable, permit the shellfish to be moved from such area under the guidelines of, and to a suitable location approved by, DMF in order to permit a proposed project on such land. Any such project shall not be commenced until after the moving and replanting of the shellfish have been commenced.

The Applicant would work the Shellfish Constables of Yarmouth and Barnstable to mitigate for any short-term impacts to shellfish productivity. Mitigation may include reseeding or relocation of shellfish to a suitable location approved by the shellfish constable(s) and the Department of Marine Fisheries.

(7) Notwithstanding 310 CMR 10.34(4) through 10.34(6), projects approved by DMF that are specifically intended to increase the productivity of land containing shellfish may be permitted. Aquaculture projects approved by the appropriate authority may also be permitted.

This standard is not applicable. The Project is not an aquaculture project, nor is its purpose to increase shellfish productivity.

(8) Not withstanding the provisions of 310 CMR 10.34(4) through (7),no project may be permitted which would have any adverse effect on specified habitat of rare vertebrate or invertebrate species, as identified by procedures established in 310 CMR 10.37.

Based on the 2003 Natural Heritage Atlas (NHESP, 2003), portions of the proposed submarine cable system route within Land Containing Shellfish are located within state-listed rare species habitat (see Figure 5.6-1). Additional information on potential impacts to state- and federally-listed species in the Project area is provided in Section 5.5 (Protected Marine Species) and Section 5.7 (Avian).

Land Subject to Coastal Storm Flowage

Although LSCSF is not governed by specific performance standards under the WPA, the regulations at 310 CMR 10.24(1) allow the issuing authority to impose conditions necessary for the protection of any significant interests of the resource area. At the proposed landfall, LSCSF is likely to be significant to storm damage prevention and the prevention of pollution. Work in this area is temporary and would not alter existing elevations or structures; therefore, no impacts to these interests are anticipated.

In addition to the provisions in 310 CMR 10.24(1), performance standards for building in LSCSF can be satisfied by the construction provisions of FEMA as incorporated in the state building code (780 CMR 2102.00). As described in Section 5.8.3.1 above, portions of the Project area at the landfall location are within a V-zone, which is the zone in which wave action is expected during a 100-year storm event. FEMA standards do not allow fill in a V-zone for the purpose of elevating structures. Furthermore, Title 5 of the State Sanitary Code prohibits new septic systems in these areas. These standards are not applicable, as no elevation changes or septic systems are proposed as part of the Project.

Coastal Wetlands Restriction Act

The MADEP lists the Towns of Yarmouth and Barnstable as communities with previously registered wetlands with restriction orders under the Coastal Wetlands Restriction Act (M.G.L. c. 131, §105). Further investigations at the Registry of Deeds would be conducted to determine whether portions of Lewis Bay in the vicinity of the proposed submarine cable route or wetlands in the vicinity of the onshore transmission landfall are subject to a coastal wetlands restriction order.

Massachusetts Water Quality Certification

The landfall transition to offshore would involve HDD cable installation for approximately 200 feet (61 meters) (seaward of mean low water) from the onshore transition vaults to a temporary offshore excavated pit approximately 65 feet (19.8 meters) wide by 45 feet (13.7 meters) long (2,925 square feet (271.7 square meters)). Four 18-inch (45.7-cm) HDPE conduit pipes (one for each of the three-conductor 115 kV cables) would be installed between the vaults and the pit. The conduit would be buried a minimum of 6 feet (1.8 meters) below the present bottom. The transition of the cables from the conduits to subsurface sediments would involve construction of a temporary cofferdam at the end of the conduit boreholes. Approximately 840 cubic yards (642.2 cubic meters) of sediment would be excavated from the cofferdam. All of the excavated sediment would be removed, so no discharge is proposed. From the pit to the ESP, cables would be installed using the hydraulic jet plow. After the submarine cable system has been installed, the cofferdam would be removed and natural tidal processes would resettle sediment into the pit normalizing the seafloor.

Due to the excavation of greater than 100 cubic yards (76.5 cubic meters) of sediment for the temporary excavation pit, the Project would be subject to state water quality certification (see Section 5.8.4.2.1).

5.8.5.1.3 Local Jurisdiction

The submarine cable system route would pass through the Towns of Yarmouth and Barnstable. Because both communities have local wetland bylaws, the proposed work would require an Order of Conditions from each town under its bylaw and the WPA. For each town, the NOI would be filed jointly under the local bylaw and the WPA. Work within Barnstable would be limited to within Lewis Bay, regulated as Land Under the Ocean. For this resource area, the Barnstable Wetlands Protection Ordinance offers no additional regulations beyond the WPA and no specific performance standards are given.

Work within the Town of Yarmouth would result in temporary alterations of the locally regulated Land Under the Ocean, Land Containing Shellfish, Land Subject to Coastal Storm Flowage, and a Coastal Watershed Area. In addition, the Yarmouth Wetlands Protection Regulations establish a 35-foot (10.7-m) Vegetated Buffer, 50-foot (15.2-meter) No-Structure Zone, and 100-foot (30.5-meter) Buffer Zone to Coastal Bank, Coastal Beach, Salt Marsh, and Land Subject to Tidal Action. Direct impacts to Coastal Bank, Coastal Beach, and Land Subject to Tidal Action would be avoided by the use of HDD at the landfall.

This section reviews the Project's compliance with the Performance Standards for work within Land Subject to Coastal Storm Flowage, Coastal Watershed Areas, the 35-foot (10.7-meter) Vegetated Buffer, the 50-foot (15.2-meter) No-Structure Zone, and the 100-foot (30.5-meter) Buffer Zones of Coastal Bank, Coastal Beach, and Salt Marsh. Work within the 100-foot (30.5-meter) Buffer Zone of Land Subject to Tidal Action is not governed by specific regulatory performance standards. The performance standards of the WPA and Yarmouth Wetlands Protection Regulations for Land Under the Ocean and Land Containing Shellfish are very similar and are therefore not discussed in this section (refer to Section 5.8.5.1.2 above).

Land Subject to Coastal Storm Flowage

Work is proposed within paved portions of LSCSF. Work within LSCSF is temporary in nature and would not alter any elevations or the ability of the land to provide storm damage prevention or flood control. Once the work is complete, the roadway would be returned to pre-existing conditions. Under the WPA, LSCSF is not governed by specific performance standards. However, the Yarmouth Wetlands Protection Regulations require that any alterations of LSCSF within 300 feet (91.4 meters) of a major estuary meet certain requirements (Section 2.10). These performance standards relate to septic system repairs, test holes, leaching components, and decks, sheds, or similar structures. Because none of these are proposed as part of the Project, the performance standards for LSCSF under the local bylaw are not applicable.

Coastal Watershed Areas

Coastal Watershed Areas within 300 feet (91.4 meters) of a major estuary are regulated by the Yarmouth Wetlands Protection Regulations. The regulations at Section 2.11(3) prohibit land use practices that "present serious threats to the quality of Coastal Watershed areas" including: outdated underground storage tanks, landfills, stump dumps, road salt storage, package treatment plants, and automotive and construction equipment repairs. The proposed transmission line is not a land use that is specifically prohibited under these regulations and is not anticipated to pose a serious threat to the quality of the Coastal Watershed Area.

Wetland Setbacks

Under the Yarmouth Wetlands Protection Regulations, a 35-foot (10.7-meter) undisturbed natural vegetative buffer shall be maintained between all projects and certain resource areas, including Coastal Bank, Coastal Beach and Salt Marsh. For this Project, work within this 35-foot (10.7-meter) Vegetated Buffer would be located entirely within paved roadway surfaces; therefore, no vegetation would be disturbed.

In addition, the Yarmouth Wetlands Protection Regulations prohibit new structures (defined as "any building, shed, dock, driveway, road, septic component, dock, pier, bulkhead, revetment, groin, float, pipeline, fence guard rail, pool, tennis court or other playing surface, drainage component, storage tank, etc.") within 50 feet (15.2 meters) of certain resource areas, including Coastal Bank, Coastal Beach and Salt Marsh. The proposed transmission line and vaults most likely do not qualify as “structures” under the local definition because they are

components to a linear project that generally cannot avoid this 50-foot (15.2-meter) wetland setback (Pers. Comm., Brad Hall, Yarmouth Conservation Agent, February 24, 2003). However, the qualification of the transmission line and associated components as a "structure" under the local definition is subject to the discretion of the Yarmouth Conservation Commission.

100-foot (30.5-meter) Buffer Zone of Coastal Bank

Under the Yarmouth Wetlands Protection Regulations, any project within 100 feet (30.5 meters) of the top of a coastal bank shall not have an adverse effect due to wave action on the movement of sediment from the Coastal Bank to Coastal Beaches or Land Subject to Tidal Action or flooding, and shall not have an adverse effect on the stability of a Coastal Bank. Work within 100 feet (30.5 meters) of Coastal Bank is limited to the installation of a below-ground transition vault approximately 50 feet (15.2 meters) landward of the Coastal Bank, HDD of a borehole from the transition vault toward the offshore exit point, and the installation of a portion of the onshore transmission line and associated ductbanks beneath New Hampshire Avenue, as described in Section 4.0. Coastal Bank as it currently exists at the proposed landfall consists of a concrete revetment and does not serve as a sediment source for coastal beaches or coastal dunes. The HDD borehole would be constructed to avoid impacts to the structural stability of the Coastal Bank and its ability to provide storm damage prevention and flood control.

100-foot (30.5-meter) Buffer Zone of Coastal Beach

Under the Yarmouth Wetlands Protection Regulations, any activity allowed within 100 feet (30.5 meters) of a Coastal Beach shall not have an adverse effect on the Coastal Beach by:

(a) affecting the ability of waves to remove sand from the beach;
(b) disturbing the vegetative cover, if any, so as to destabilize the beach;
(c) causing any modification of the beach or down drift beach that would increase the potential for storm or flood damage;
(d) interfering with the natural movement of the beach;
(e) causing artificial removal of sand from the beach or down drift beach.

Work within 100 feet (30.5 meters) of Coastal Beach is limited to the installation of a transition vault and a portion of the onshore transmission line and ductbanks beneath New Hampshire Avenue and HDD of a borehole from the transition vault toward the offshore exit point. The proposed transition vault and onshore transmission line are not anticipated to result in any of the above-described adverse impacts to the down drift coastal beaches for the following reasons: (1) the proposed work would be entirely beneath existing paved roadway surfaces; (2) the work would be separated from Coastal Beach 1 by a concrete revetment wall and from Coastal Beach 2 by a parking lot; and (3) the proposed work is temporary in nature, and all areas disturbed by construction would be restored to their original conditions.

100-foot (30.5-meter) Buffer Zone of Salt Marsh

Work within 100 feet (30.5 meters) of Salt Marsh (specifically, Salt Marsh 2) includes the installation of portions of the transmission line and associated ductbanks beneath New Hampshire Avenue. Under the Yarmouth Wetlands Protection Regulations, a proposed project within 100 feet (30.5 meters) of a salt marsh "shall not destroy any portion of the salt marsh and shall not have an adverse effect on the productivity of the salt marsh. Alterations in growth, distribution and composition of salt marsh vegetation shall be considered in evaluating adverse effects on productivity." The proposed work would be located entirely beneath New Hampshire Avenue and would be separated from Salt Marsh 2 by residential homes. No alterations in the roadway's drainage, changes in impervious area, or other permanent alterations upgradient of the salt marsh are proposed. Prior to construction, an erosion and sedimentation control barrier would be installed to protect the adjacent salt marshes during the construction phase of the Project.

5.8.5.2 Freshwater Resources

The proposed transmission line route from the landfall location to the Barnstable Switching Station includes work within existing paved roadways and the existing maintained NSTAR Electric ROW. No inland wetlands would be impacted by the proposed onshore transmission line. This section describes the mitigation and regulatory compliance involving the freshwater wetland resources under local, state and federal jurisdiction.

5.8.5.2.1 Federal Jurisdiction

The proposed onshore transmission line route would not alter any federally-regulated freshwater wetlands and would be designed to avoid impacts to the two culverts regulated as Waters of the U.S. , located beneath Higgins Crowell Road. The onshore transmission line route is not subject to federal jurisdiction under Section 404 of the Clean Water Act, since there is no discharge of dredged or fill material to any Waters of the U.S.

5.8.5.2.2 State Jurisdiction

The Project would not alter any freshwater wetlands or regulated culverts that would trigger Section 401 review. However, the Project would result in minor impacts to paved Riverfront Area and Buffer Zones, as regulated under the Massachusetts Wetlands Protection Act and would, therefore, require an Order of Conditions. Work within Riverfront Area and the 100-foot (30.5-meter) Buffer Zone is limited to temporary construction on paved roadway surfaces for the installation of the proposed transmission line route.

To minimize the potential for erosion during construction, mitigation measures such as hay bales and silt fences would be placed as appropriate around disturbed areas and any stockpiled soils. Prior to commencing construction activities, erosion control devices would be installed between the work areas and down-slope waterbodies and wetlands to reduce the risk of soil erosion and siltation. Erosion control measures would also be installed down-slope of any temporarily stockpiled soils in the vicinity of waterbodies and wetlands. These mitigation measures would be fully described in an Erosion and Sedimentation Control and Storm Water Management Plan, which would incorporate applicable BMPs for erosion control and storm water management during construction. It is possible that dewatering of the excavated trench or vault locations close to the transition point would be required because of flooding and high groundwater. A dewatering plan, if necessary, would be prepared to address the procedures for handling of any water encountered during excavation.

This section addresses the Project's compliance with the Performance Standards for Limited Project status and work within previously developed Riverfront Area. Work within the state-regulated 100-foot (30.5-meter) Buffer Zone is not governed by specific regulatory performance standards.

Limited Project

The Applicant would be requesting Limited Project status under the WPA for the proposed onshore transmission line route. Under the Massachusetts Wetlands Protection Act [310 CMR 10.53(3)(d)], the construction of underground or overhead public utilities, including electrical distribution or transmission lines, may be permitted within freshwater resource areas provided that it meets the following performance standards:

(1) The issuing authority may require a reasonable alternative route with fewer adverse effects for a local distribution or connecting line not reviewed by the Energy Facilities Siting Council.

This standard is not applicable. The Applicant submitted a Petition to the Energy Facilities Siting Board on September 17, 2002, which is currently under review. A tentative decision was issued on July 2, 2004.

(2) Best available measures shall be used to minimize adverse effects during construction.

The onshore transmission line route has been designed to minimize adverse effects by utilizing existing paved roadways and existing maintained electric ROWs. The transmission line would not alter any culverts regulated as Bank or Waters of the United States. Impacts to previously developed Riverfront Area cannot be avoided because Thornton Brook flows beneath Higgins Crowell Road, within which the proposed transmission line would be located.

(3) The surface vegetation and contours would be substantially restored.

The proposed work would result in temporary impacts during cable installation. Measures would be taken to restore vegetation and contours to pre-existing conditions. Trenches within paved roadways would be backfilled and repaved, and trenches within the maintained electric ROW would be backfilled and seeded.

(4) All sewer lines shall be constructed to minimize inflow and leakage.

This standard is not applicable. No sewer lines would be constructed as part of the Project.

Riverfront Area

The proposed onshore transmission line route would temporarily alter approximately 0.08 acre/3,360 square feet (312.2 square meters) of Higgins Crowell Road within the 200-foot (61-meter) Riverfront Area of Thornton Brook. Work within Riverfront Area is proposed as a Limited Project, but would meet the performance standards for Riverfront Area to the extent practicable. Proof of compliance with these standards is provided below.

(a) Protection of other Resource Areas

No additional state-regulated resource areas are located within that portion of Riverfront Area impacted by the proposed onshore transmission line. Work within the 100-foot (30.5-meter) Buffer Zone of Bank and BVW that is also within Riverfront Area would protect the interests of the WPA by keeping construction entirely beneath paved roadway surfaces and installing and maintaining erosion and sedimentation controls during construction to prevent indirect impacts to downgradient wetlands.

(b) Protection of Rare Species

As described in detail in Section 5.6, the proposed work in the Riverfront Area of Thornton Brook is within a mapped habitat of state-listed rare species (PH 1622/WH 7288). However, the rare wildlife species mapped within this area (see Figure 5.6-1) are wetland-dependent insects that are not anticipated to use the Project area within Higgins Crowell Road as nesting, breeding, feeding, or over-wintering habitat.

(c) Practicable and Substantially Equivalent Economic Alternatives

Please refer to Section 3.0 for a comprehensive Alternatives Analysis.

(d) No Significant Adverse Impact

The proposed Limited Project electric transmission line would have no significant impact on Riverfront Area. Work would be limited to ±0.08 acre/3,360 square feet (312.2 square meters) of paved Riverfront Area associated with Thornton Brook. The proposed alterations are allowable under the WPA for the following reasons: the proposed work alters less than 5,000 square feet/0.11 acre (464.5 square meters) of Riverfront Area on the site; no changes to the roadway's stormwater management system are proposed; the work would be located within a roadway that provides no important wildlife habitat functions; and groundwater and surface water quality would be protected through the use of a comprehensive erosion and sedimentation control plan. Land within 100 feet (30.5 meters) of Thornton Brook is currently developed and consists of Higgins Crowell Road, disturbed roadway sideslopes, and residential areas; therefore, a 100-foot (30.5-meter) wide area of undisturbed vegetation is not available.

5.8.5.2.3 Local Jurisdiction

The onshore transmission line route would pass through the Towns of Yarmouth and Barnstable. The entire onshore transmission line route along the paved roadways and approximately 950 linear feet (289.6 meter) of the eastern portion of the ROW route would be located within Yarmouth. The remaining 1.8 miles (2.9 km) of the ROW route to the Barnstable Switching Station is within Barnstable. Although both communities have local wetland bylaws, no work associated with the onshore transmission line route is proposed within a resource area or Buffer Zone in Barnstable.

Proposed work in Yarmouth would result in temporary alterations of locally-regulated Lake and Pond Recharge Areas. In addition, the Yarmouth Wetlands Protection Regulations establish a 35-foot (10.7-meter) Vegetated Buffer, 50-foot (15.2-meter) No-Structure Zone, and 100-foot (30.5-meter) Buffer Zone to certain resource areas, including any Bank or Vegetated Wetland. Direct impacts to these resource areas would be avoided by installing the transmission line beneath existing paved roadways and onshore portions of the NSTAR Electric ROW.

This section reviews the Project's compliance with the Performance Standards for work within Lake and Pond Recharge Areas, the wetland setback areas, and the 100-foot (30.5-meter) Buffer Zones of Bank and Vegetated Wetlands.

Lake and Pond Recharge Areas

In addition to establishing wetland setbacks, the Yarmouth Wetlands Protection Regulations regulate work within Lake and Pond Recharge Areas. These areas are defined under Section 3.05 as wetland and upland landforms that contribute surface and subsurface water to the lakes and ponds of the towns and are mapped within a "Water Resources Protection Study" prepared for the Town of Yarmouth (Figure 5.8-4). Conservation Commission jurisdiction is restricted to mapped areas within 300 feet (91.4 meters) of a lake or pond. The proposed onshore transmission line route would be located within the mapped recharge areas of Jabinettes Pond (Wetland 2) and Long Pond (Wetland 6). The regulations at Section 3.05(3) prohibit land use practices that present serious threats to the quality of lake and pond recharge areas, including: outdated underground storage tanks, landfills, stump dumps, road salt storage, package treatment plants, and automotive and construction equipment repairs. The proposed transmission line is not a land use that is specifically prohibited under these regulations, and is not anticipated to pose a serious threat to the quality of these recharge areas.

Wetland Setbacks

The Yarmouth Wetlands Protection Regulations prohibit structures within 50 feet (15.2 meters) of certain wetland resource areas and prohibit the alteration of vegetation within 35 feet (10.7 meters) of these resource areas. The entire route from proposed landfall to the Barnstable Switching Station is not located within 35 feet (10.7 meters) of a wetland; therefore, no vegetation clearing is proposed within the local 35-foot (10.7-meters) Vegetated Buffer. Although subject to the discretion of the Yarmouth Conservation Commission, the proposed transmission line and associated ductbanks and underground vaults do not appear to qualify as "structures" under the local definition (see Section 5.8.5.1.3.3).

100-foot (30.5–meter) Buffer Zone of Bank

Under the Yarmouth Wetlands Protection Regulations, any proposed work within 100 feet (30.5 meters) of the upper boundary of a bank shall not impair the following:

(a) *the physical stability of the bank;*
(b) *the water carrying capacity of the existing channel within the bank;*
(c) *ground water and surface water quality;*
(d) *the capacity of the bank to provide breeding habitat, escape cover and food for fisheries and wildlife.*

Within 100 feet (30.5 meters) of Bank, the proposed onshore transmission line would be located beneath paved roadway surfaces. Roadway drainage and impervious area would not be altered, and the route would be designed to avoid direct impacts to culverts regulated as Bank. Therefore, no impacts are anticipated to the bank's physical stability, water carrying capacity, or wildlife value.

In addition, no impacts are anticipated to groundwater or surface water associated with the installation or future maintenance of the transmission line or associated infrastructure. The transmission line would be installed using typical open trench methods, and it is anticipated that the transmission line would be located above the groundwater table along the majority of the route. The transmission line would not contain any fluids, petroleums, oils, or lubricants. As such, there is no threat to groundwater or surface water from the installation, presence, or future maintenance of the transmission line and/or associated infrastructure. Water quality would be protected during the construction phase of the Project through the installation and maintenance of erosion and sedimentation control barriers. These mitigation measures would be fully described in an Erosion and Sedimentation Control and Storm Water Management Plan, which would incorporate applicable best management practices (BMPs) for erosion control and storm water management during construction.

100-foot (30.5-meter) Buffer Zone of Vegetated Wetland

Under the Yarmouth Wetlands Protection Regulations, any proposed work within 100 feet (30.5 meters) of a vegetated wetland "shall not destroy any portions of said vegetated wetland, nor shall the proposed work impair in any way the vegetated wetland's ability to perform any of the functions in section 3.02(1)." Within 100 feet

(30.5 meters) of vegetated wetlands, the proposed work would be located entirely within existing paved roadways. No alterations in the roadway's drainage, changes in impervious area, or other permanent alterations upgradient of the wetlands are proposed. Prior to construction, an erosion and sedimentation control barrier would be installed to protect the adjacent wetlands during the construction phase of the Project.

5.9 Water Quality

5.9.1 Introduction

This section describes the existing surface waters and associated water quality in the portions of Nantucket Sound and Lewis Bay that are within the Project area (see Section 4.0 for Project Plan/locus), as well as any water resources in the onshore portion of the Project area. The information contained in this section was obtained from literature review, agency consultations, and review of existing site investigation data. Further information on wetlands and regulatory authorities and consistency are discussed in Sections 5.8 and 7.0, respectively. A discussion of potential impacts related to oceanographic resources and shellfish are discussed in Sections 5.2 and 5.3, respectively.

In general, projects involving a discharge of dredged or fill material to a waterbody or wetland require a permit from the Department of the Army under Section 404 of the Clean Water Act (33 U.S.C. 1344) and state Water Quality Certification from the MADEP (314 CMR 9.00; and M.G.L. c. 21, §§ 26-53). This Project would be subject to state water quality certification due to the volume of sediment to be excavated for the HDD offshore exit pit (see Section 5.8.4.2.1). This Project would involve no discharge of dredged or fill material and therefore Sections 404 and 401 do not apply to the action. Section 401 and 404 jurisdiction extends to the 3-nautical mile state territorial limit. The only Project activity proposed within this 3-nautical mile limit is installation of a portion of the electric transmission cable interconnection between the ESP and the Barnstable Switching Station. Within the marine portion of the cable route, the proposed method of cable installation is via hydraulic jet plow, considered a non-jurisdictional activity under Sections 401 and 404 (MADEP and USACE, 2002). In the nearshore area at the proposed transmission line landfall, the cable system is proposed to be placed in a conduit to be installed using HDD installation techniques. As discussed in detail in Section 4.0, HDD would require excavation of an offshore exit pit and the placement of a temporary cofferdam within Lewis Bay to facilitate the HDD operation. Because all excavated sediments from the pit would be removed from waters of the U.S. rather than sidecast and involve no discharge of dredge or fill material, the USACE would not regulate the HDD activities under Section 404 (USACE-NED and MADEP, 2002). No activities subject to 404 jurisdiction are proposed within the onshore portion of the proposed cable route.

Although not subject to review under Section 404, installation of the conduit by HDD and cable installation via hydraulic jet plow are subject to the jurisdiction of Section 10 of the Rivers and Harbors Act of 1899 (U.S.C. 403). Installation of the submarine cable system within the 3-nautical mile limit would also require permits under the WPA and local wetland bylaws. Each of these programs involves consideration of water quality issues.

Under Massachusetts Surface Water Quality Standards (314 CMR 4.06(3)), Lewis Bay and surface waters adjacent to Nantucket Island are categorized as Class SA coastal and marine waterbodies. (Other waters of Nantucket Sound in the Project area are not classified.) According to the MADEP standards, Class SA waters are designated as "an excellent source of habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation." In approved areas, Class SA waters are suitable for shellfish harvesting without the need for depuration (that is, removal of contaminants) (Open Shellfish Areas). The antidegradation provisions of the Clean Water Act and the Massachusetts Clean Waters Act and accompanying regulations require that "existing uses and the level of water quality necessary to protect the existing uses shall be maintained and protected" (314 CMR 4.04(1)). This section, therefore, evaluates the Project's potential water quality affect.

In addition, the proposed Project would require the issuance of a National Pollutant Discharge Elimination System (NPDES) stormwater permit for construction activities. The USEPA has issued a National Construction General Permit (CGP) applicable to projects taking place within Region I. To comply with requirements of the CGP, stormwater from construction and operation of the Project would be managed under an approved Stormwater Pollution Prevention Plan (SWPPP). Notices of Intent to approve stormwater discharges under the CGP and/or the General Permit for Stormwater Discharges from Industrial Activities would be filed as applicable or required.

Finally, federal actions pertaining to the Project would also be reviewed by the Massachusetts Office of Coastal Zone Management for consistency with its policies, including those related to water quality. The extent to which the Project has been designed to be consistent with these policies is discussed in Section 7.0

Section 5.9.2 provides a summary of literature reviewed to complete this section. Existing water quality conditions are profiled in Section 5.9.3. Potential impacts to water quality, and proposed mitigation measures, are discussed in Sections 5.9.4 and 5.9.5, respectively.

5.9.2 Studies Completed

No primary data collection was undertaken with regard to water quality issues. Water quality information pertaining to the Project was obtained from literature review, agency consultations, and review of existing site investigation data. The following information on water quality in the Project area was reviewed to develop this section:

- MADEP water quality classification maps and narratives for Lewis Bay and Nantucket Sound;
- MADEP regulatory criteria for existing water quality classifications;
- Scientific literature, agency publications, and website postings for Lewis Bay and Nantucket Sound, as available; and
- Local studies of water quality in the vicinity of Lewis Bay by municipalities, Barnstable County Department of Health and Environment, watershed associations, and the University of Massachusetts School for Marine Science and Technology (as part of *The Estuaries Project: Southeastern Massachusetts Embayment Restoration*).

5.9.3 Existing Conditions

Nantucket Sound and Lewis Bay

The primary surface waterbodies in the Project area are Nantucket Sound, Hyannis Harbor, and Lewis Bay. As mentioned above, these waterbodies are categorized as Class SA by MADEP. Lewis Bay and Hyannis Harbor are listed on the Massachusetts Section 303(d) List of Waters as impaired due to the presence of pathogens in water quality samples. However, no specific sources of pathogen pollution were reported by the state in its 304(b) report to EPA (USEPA, 2002).

The Barnstable County Department of Health and Environment and the Towns of Yarmouth and Barnstable collect additional information on the water quality of Lewis Bay and Hyannis Harbor. The waters offshore of Cape Cod's bathing beaches are sampled during the summer for the bacterial indicator organisms *E. coli* and enterococci. The beaches sampled as part of this program that are closest to the Project landfall are Englewood Beach in Yarmouth; and Veterans Beach, Keys Beaches and Kalmus Beach in Barnstable (see Figure 5.8-1). Waters at these sites were sampled, from early June to late August, a total of 14 times in 2002 for Englewood Beach and 13 times for Veterans, Keys, and Kalmus Beaches (Barnstable County, 2002). None of the results of these samples exceeded established local and Massachusetts Surface Water Quality Standards at 314 CMR 4.06(2)(b) (Barnstable County, 2002).

Only one other coastal water quality data set was identified for waters in or near the Project area. The MADEP, in conjunction with the University of Massachusetts School for Marine Science and Technology (SMAST), has been collecting coastal water quality data as part of *The Estuaries Project: Southeastern Massachusetts Embayment Restoration* (MADEP, 2002a). SMAST typically teams with municipalities and watershed associations to evaluate estuarine eutrophication and other water quality issues.

The Estuaries Project sampling program location that is closest to the Project area is in Barnstable, at the Three Bays Estuary in Osterville, Cotuit, and Marstons Mills. SMAST and Three Bays Preservation, Inc., a local watershed association, has been collecting water quality data since 1999 in this estuary. Although this area is located several miles west of the Project area, the findings are typical of other southeastern Massachusetts estuaries evaluated as part of *The Estuaries Project*. In general, the estuary is exhibiting "poor nutrient related health" largely due to an overabundance of nitrogen inputs (Howes and Hampson, 2000). This is consistent with

the findings of other water quality studies on Cape Cod, which found that nitrogen is the key contaminant causing the degradation of water quality within Cape Cod's coastal embayments (Cape Cod Commission, 2002). Fecal coliform exceedences were also found in several areas of the Three Bays Estuary (Howes and Hampson, 2000).

Onshore

Water resources associated with the onshore cable route are described in detail in Section 5.8. Under Massachusetts Surface Water Quality Standards (314 CMR 4.06(2)(b)), the water resources located along the onshore route are classified as Class B, High Quality Water by MADEP. According to the MADEP standards, Class B waters are designated as "habitat for fish, other aquatic life and wildlife, and for primary and secondary contact recreation." In approved areas, Class B waters are suitable as a source of public water supply with appropriate treatment.

Portions of the transmission line route would be located within a zone of contribution to the town water supply wells and aquifer protection district (Figure 5.9-1). The proposed transmission line route to the intersection with the NSTAR Electric ROW crosses through the Zone I wellhead areas of three public water supply wells. These wells are Yarmouth Water Department (YWD) Numbers 1, 2 and 17 (see Figure 5.9-2). The Zone I area for these wells is defined as the area within a 400-foot (122-meter) radius from the public water supply wells, for wells with a greater than 100,000 gallons per day approved yield. The onshore transmission line is approximately 42 feet (12.8 meters) inside the Zone I boundary of YWD 1; approximately 170 feet (51.8 meters) inside the Zone I boundary of YWD 2; and approximately 25 feet (7.6 meters) inside the Zone I boundary of YWD 17. The proposed transmission line route within the NSTAR Electric ROW would not be located within a MADEP-approved Zone I. The proposed onshore transmission line route, including the portion in the NSTAR Electric ROW, also crosses through MADEP-approved Zone II boundaries for several public water supply wells (see Figure 5.9-3).

MADEP regulations (310 CMR 22.21(1)(b)(5)) state that current and future land uses within the Zone I shall be limited to land uses directly related to the public water system or to other land uses which the public water system has demonstrated would have no adverse impact on water quality. The regulations also state that no new underground storage tanks for petroleum products shall be located within Zone I. According to the MADEP regulations, Zone II is defined as that area of an aquifer that contributes water to a well under the most severe pumping and recharge conditions that can be realistically anticipated (180 days of pumping at the approved yield, with no recharge from precipitation).

Readily available groundwater elevation information from MassGIS (see Figure 5.9-4) was reviewed relative to topographic elevations along the proposed route and also reviewed readily available information from the U.S. Geological Survey (USGS). Based on the proposed depth of installation (6 to 8 feet (1.8 to 2.4 meters) below grade), shallow groundwater may be encountered along the proposed route to the south of Route 28. It has been determined that groundwater levels between the landfall location and Route 28 are generally below elevation 10 feet (3 meters), and the topographic elevations are generally less than 20 feet (6.1 meters). Therefore, there is the potential to encounter groundwater during this part of the onshore cable installation.

5.9.4 Analysis of Impacts

Potential impacts to water quality associated with construction and operation of the Wind Park and the submarine cable system across Lewis Bay and within Nantucket Sound would be short-term and localized. The submarine cables would be installed using low impact hydraulic jet plow equipment, and disturbance associated with submarine foundation structures would be minimized through use of a monopile system (see Section 4.3). Potential marine water quality impacts would be limited to temporary and localized sediment disturbance along the cable corridors and at monopile locations from construction vessel anchoring, anchor line sweep, and installation of the scour protection, foundation and cables. Chemical analysis results indicate that constituents of concern were present in sediment samples from Lewis Bay and Nantucket Sound and were determined to be at concentrations below the levels that would cause either chronic or long-term biological impacts and should pose little or no risk to water quality (see Section 5.1.3 for details, Tables 5.1-4 through 5.1-6 and Figure 5.1-1 for locations of the vibracores).

The installation of WTG foundations and inner-array and submarine cables would physically displace sediment at specific locations through sediment suspension, transport, and deposition. In sandy sediments, such as those in

the Project area, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Appendix 5.2-C). A small depression may remain over the cables after installation, depending on localized sediment depositional processes. As with other projects involving submarine cable embedment in the seabed using jet plow technology, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (Connecticut Light & Power Company, 2002; Bohlen, pers. comm., 2002).

Water quality impacts related to sediment disturbance from installation would be comparable to disturbance already occurring within Nantucket Sound from natural events and fishing gear (see Sections 5.2.3.7 and 5.2.4). The volume and extent of sediment disturbance as well as the biological impacts associated with the jet plow are less than those associated with both one tidal cycle and one commercial trawling event. In addition, it is important to note that use of the jet plow is an isolated event whereas commercial trawling takes place routinely over large areas during the fishing season and two tidal cycles generally occur each and every day. The near bottom suspended sediment concentrations associated with the jet plow are within the range of natural variability resulting from tidal currents, waves, storms, trawling, and vessel propulsion, and as a result are low compared to concentration associated with other natural and man-made occurrences in Nantucket Sound (CWA, 2003a). Potential impacts to surface water resources would be minimized to the greatest extent practicable through the use of appropriate cable installation techniques, and by limiting the area of seabed disturbance. Therefore, minimal short-term and no long-term impacts are anticipated.

The Project has also been sited and designed to avoid impacts to wetlands and other inland surface waters in the vicinity of the Project Site (see Sections 4.3 and 5.8). In onshore areas, proper measures would be taken to avoid wetlands and prevent erosion and sedimentation, as discussed in Section 5.9.4.2.2.

The nature of potential impacts to surface waterbodies associated with Wind Park operation is limited to minor changes in magnetic fields and thermal conditions that may be associated with submarine transmission cable operation (see Section 5.13). The cable system would generate a limited amount of heat that is absorbed by, and dissipated into, the surrounding subsurface environment. This loss of heat to the sediments is essential for proper operation of cables. Any increase in sediment temperatures resulting from operations of the submarine cables are expected to be on the order of fractions of a degree, which may not be measurable and is not expected to impact water quality (CWA, 2003b). Because the cable would be buried to a depth of approximately 6 feet (1.8 meters) of cover, this small level of heat dissipation should not result in impacts to surface waters or biota in the vicinity of the Project.

The only components of the Project that would come into regular contact with seawater and be subject to potential interactions between water, encrusting organisms, and sediment are the welded steel monopile foundations. The transition piece of the WTGs, which will be located on top of the monopile at the water line / splash zone, will be coated with a product equal or similar to Interzone® 954[82]. The portions of the structural steel and steel surfaces not directly exposed to seawater, such as the tower (above the transition piece), will be coated with an epoxy-polyamide. In addition, cathodic protection utilizing sacrificial anodes made of pure aluminum would be utilized on the piles. The limited area of contact between the coated transition piece and seawater, and the protective anodes on the monopile, would minimize the potential for undesirable interactions between water, encrusting organisms, and sediment. The selected coating is not anticipated to degrade substantially or leach materials into the water column over the life of the Project, as evidenced by its wide spread use in marine applications (i.e., hulls, bridge structures, etc.). Therefore, no measurable change in these interactions is expected after Project installation.

Several preventative/contingency plans would be in place during Project construction/decommissioning and operation to prevent erosion and sedimentation, respond if a release to the environment occurs, and ensure proper operation and maintenance of equipment. These plans would include:

[82] A two component, low VOC, modified epoxy barrier coat designed to give long-term protection in seawater. Continues to cure when immersed in water, and has been used extensively in the offshore sector for over 25 years. (International Protective Coatings/ Akzo Nobel) www.international-pc.com

- **Spill Prevention Control and Countermeasure (SPCC) Plan** – The Applicant would prepare a SPCC Plan that would detail the means to prevent, control, and mitigate releases to the environment. The SPCC Plan would be implemented during Project construction/decommissioning and operation to prevent potential impacts to water quality that could result from spills of fuel, lubricating oils, or other substances associated with the use of construction vehicles/vessels and other equipment and machinery. In the event of a release, clean up measures would be employed to minimize impacts to the environment and to assure the protection of any people and wildlife in the immediate area.
- **Storm Water Pollution Prevention Plan (SWPPP)** – The Applicant would prepare a SWPPP which describes erosion and sedimentation controls to be used during Project construction/decommissioning and incorporates applicable best management practices (BMPs) for erosion control and stormwater management during construction.
- **Operation and Maintenance (O&M) Plan –** The Applicant would prepare an O&M Plan that would detail standard operating and maintenance protocols to ensure proper operation of wind park facilities. The O&M Plan would specify operating guidelines, maintenance schedules, and materials approved for maintenance activities. The maintenance program would include preventive and emergency maintenance functions including shore-based predictive maintenance analysis of the WTGs and ESP.

5.9.4.1 Potential Impacts Outside of Massachusetts Waters

As discussed in Section 4.1, the WTG array would be located outside of the Massachusetts 3-nautical mile (5.6 km) state jurisdictional limit and exclusively within the waters of Nantucket Sound subject to federal oversight and control. The installation of transmission cables and foundations for towers to support WTG components would be the only construction activities within this area with the potential to impact water quality. Submarine cables would be installed using low impact hydraulic jet plow equipment, and submarine foundation structures would be minimized through use of a monopile system.

The installation of WTG foundations and inner-array cables would physically displace sediment at specific locations. In sandy sediments such as those in the Project area, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Appendix 5.2-C). A small depression may remain over the cables after installation depending on localized sediment depositional processes. As with other projects involving submarine cable embedment in the seabed using jet plow technology, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Section 5.2 and Appendix 5.2-C).

The WTG components would be mounted on a manufactured steel tower supported by a monopile foundation system. The monopile foundation system results in the least amount of seabed disturbance among the available alternatives. Minimal disturbance of sand and sediment would take place as a result of pile driving activities. The piles are hollow, and would enclose bottom material that is displaced in the pile. After installation, some localized scour around monopile foundations may occur, depending on the location of the WTG on Horseshoe Shoal and local sediment transport conditions. Scour protection, in the form of artificial frond scour control mats, would be installed (see Appendix 4.0-A, Scour Analysis).

The inner-array submarine cable system interconnecting the WTGs with the ESP would be of solid dielectric AC construction, using a three-conductor cable with all phases under a common jacket. From the centrally located ESP within the Wind Park, the wind-generated energy from each of the WTGs would be transformed to a voltage of 115 kV. Two 115 kV AC submarine transmission circuits would bring the electric energy from the ESP to the mainland (see Section 5.9.4.2). Potential water quality impacts associated with the cable system in this area would be limited to temporary, localized sediment disturbance along proposed cable corridors during installation. Chemical analysis results indicate that constituents of concern present in sediment samples from Lewis Bay and Nantucket Sound are at concentrations below the levels that would cause either chronic or long-term biological impacts, and should pose little or no risk to water quality (see Section 5.1.3).

Operation of the Wind Park and cable system is not anticipated to impact hydrodynamics or water quality. Dielectric (insulating) fluid would be used in ESP transformers and stored on the ESP. Although the specific dielectric fluid to be used in the ESP transformers has not yet been selected, the typical fluids available for this

application provide good dielectric properties and low potential for environmental effects. Due to its relatively low volatility (compared to most industrial solvents) and low toxicity, potential impacts to water quality and aquatic life from dielectric fluid are anticipated to be minimal. The SPCC Plan would describe measures to prevent, control, and mitigate releases to the environment.

As discussed in Section 4.0, temporary living accommodations would also be provided on the ESP, intended for use during emergency periods, when crews cannot be removed due to weather issues. These accommodations would utilize waste storage holding tanks for domestic waste that would be pumped to the service vessel for proper disposal. All equipment would be contained within an enclosed weather-protected service area. The ESP would not require a NPDES permit for the discharge of storm water because rainfall runoff from the ESP would not be considered a storm water discharge associated with industrial activity as defined in 40 CFR 122.26(14). The SPCC Plan would be in place during Project construction/decommissioning and operation to prevent/control potential impacts to water quality that could result from spills of fuel, lubricating oils, or other substances associated with the use of marine vessels and machinery.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to water quality would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable has been proposed by National Grid between Cape Cod and Nantucket. Its proposed route would only cross the Project's submarine cable route in the vicinity of Hyannis Harbor, well within the Massachusetts 3-mile limit (as discussed below in Section 5.9.4.2). Outside of Massachusetts waters, at its closest point the proposed route of the Nantucket Cable would be approximately 2 miles (3.2 km) from the Wind Park and its inner array cables in Nantucket Sound. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and are of short duration, these temporary impacts are not likely to occur at the same time. Thus, any areas where both projects may result in impacts as a result of jet plow cable embedment would likely have assimilated the deposited sediment from the first project installation by the time the second project is constructed. As such, there are no significant cumulative impacts expected to water quality that would result from the installation of both projects

The submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance dredging. Therefore, no significant cumulative effects to water quality are expected in the area of the North Channel crossing.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts expected to water quality since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

Secondary Impacts

The only potential impact associated with construction staging/laydown activities at Quonset would be potential pier improvements. This would have a potential for limited temporary sediment disturbance and water quality impairment. No specific plans for pier improvements have been identified as necessary at this time.

5.9.4.2 Potential Impacts Inside of Massachusetts Waters

As described in Section 4.3, two 115 kV AC submarine transmission circuits would bring electric energy from the ESP to the mainland. This submarine cable system would make landfall at the proposed location in the Town of

Yarmouth, and extend overland to the Barnstable Switching Station. The installation and operation of these cables would be the only Project activities conducted within the 3-nautical mile (5.6 km) state territorial limit. The following section primarily discusses the general vicinity of Lewis Bay. The cable route in Nantucket Sound between the 3 mile limit and the mouth of Lewis Bay is similar in nature to the cable route outside of Massachusetts waters, as discussed above (see Section 5.9.4.1).

Lewis Bay

Potential water quality impacts would be limited to temporary, localized sediment disturbance along the proposed submarine cable system route during cable installation. Installation of transmission cables by jet plow embedment would result in temporary and localized impacts to water quality through sediment suspension, transport, and deposition. In sandy sediments such as those in Lewis Bay, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation (see Appendix 5.2-C). A small depression may remain over the cables after installation depending on localized sediment depositional processes. As with other projects involving submarine cable embedment in the seabed using jet plow technology, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation. Chemical analysis results indicate that constituents of concern present in sediment samples from Lewis Bay and Nantucket Sound are at concentrations below the levels that would cause either chronic or long-term biological impacts and should pose little or no risk to water quality (see Section 5.1.3).

The transition of the interconnecting 115 kV submarine transmission lines from water to land would be accomplished through the use of HDD installation methodology in order to minimize disturbance within the intertidal zone and near shore area. The HDD is anticipated to span approximately 200 feet (61 meters) from the onshore transition vaults to a temporary offshore excavated pit approximately 65 feet 19.8 meters) wide by 45 feet 13.7 meters) long (0.067 acres/2,925 square feet (272 square meters)). Four 18-inch (45.7 cm) HDPE conduit pipes (one for each of the three-conductor 115 kV cables) would be installed via HDD between the vaults and the pit. The transition of the cables from the conduits to subsurface sediments would involve construction of a temporary cofferdam at the end of the conduit boreholes. Approximately 840 cubic yards (642.2 cubic meters) of sediment would be excavated from the cofferdam. All of the excavated sediment would be removed and disposed of at an approved onshore site, so no discharge is proposed. From the pit to the ESP, cables would be installed using the hydraulic jet plow. After the cable installation is complete, the cofferdam would be removed and the sediment surface would be allowed to normalize through natural tidal processes. A small depression may remain over the pit area after installation depending on localized sediment depositional processes.

To minimize the potential for release of the bentonite drilling fluid into Lewis Bay during HDD activities, freshwater would be used as a drilling fluid to the extent practicable prior to the drill bit or the reamer emerging in the pre-excavated pit. This would be accomplished by pumping the bentonite slurry out of the hole, and replacing it with freshwater as the drill bit nears the pre-excavated pit. It is possible that some minor residual volume of bentonite slurry may be released into the pre-excavated pit. The depth of the pit and the temporary cofferdam perimeter are expected to contain any bentonite slurry that may be released. Prior to drill exit and while the potential for bentonite release exists, diver teams would install a water-filled temporary dam around the exit point to act as an underwater "silt fence." This dam would contain any bentonite fluid that may inadvertently escape when it sinks to the bottom of the pre-excavated pit to allow easy clean-up using high-capacity vacuum systems.

Operation of the Wind Park and cable system is not anticipated to impact water quality. The SPCC Plan would be in place during Project construction/decommissioning and operation to prevent/control potential impacts to water quality that could result from unanticipated spills of fuel, lubricating oils, or other substances associated with the use of marine vessels and machinery.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to water quality inside of Massachusetts waters would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of

Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable has been proposed by National Grid. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment are minimal and of short duration, these temporary impacts are not likely to occur at the same time. Thus, any areas where both projects may result in impacts as a result of jet plow cable embedment would likely have assimilated the deposited sediment from the first project installation by the time the second project is constructed and any temporary or localized changes in water quality would not overlap in their occurrence. As such, there are no significant cumulative impacts to water quality expected to result from the installation of both projects.

The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent, cumulative sediment suspension and deposition. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on recent experience it could be needed in the next 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. If however the Projects were to be concident, time of year reistrictions likely to be placed on marine construction activities to protect fisheries resources could result in increased cumulative impacts to marine navigation. Future USACE maintenance dredging in Hyannis Harbor would be the subject of an additional NEPA document. In any event, as discussed in Appendix 5.2-C, sediment deposition resulting from the cable installation would be minimal and localized, and would not substantially contribute to any significant cumulative impact.

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the Project area. However, these marina dredging projects, if they were to occur, are very localized and not likely to result in sediment suspension and deposition that would be coincident with the cable installation (the closest point of which would be a minimum of .5 miles (805 meters) from the closest marina). Thus, no significant cumulative impacts are anticipated from these activities.

Onshore

In the onshore cable corridor, the use of sedimentation and erosion controls during cable installation would further protect surface waterbodies (see Section 4.3.6). A SWPPP would be prepared and submitted for approval prior to commencement of construction activities. The SWPPP would specify erosion and sedimentation controls and incorporate applicable BMPs for stormwater management during construction/decommissioning. In addition, an SPCC Plan would be in place during Project construction/decommissioning and operation to prevent/control potential impacts to water quality that could result from unanticipated spills of fuel, lubricating oils, or other substances associated with the use of marine vessels and machinery.

Excavated soil from the trench and vaults would be temporarily stored adjacent to the worksite or transported off-site, if on-site storage is not possible. Where soil is stored at the site, it would be stabilized with erosion and sedimentation controls. Following the completion of the installation of the transmission line, the excavation would be backfilled and repaved. Stormwater erosion and sedimentation controls would be in place prior to the initiation of construction activities. Once construction is completed, all equipment and construction debris would be removed from the site and the area would be returned to its original condition.

It is possible that dewatering of the excavated trench or vault locations close to the transition point would be required because of high groundwater. A dewatering plan would be prepared to address the procedures for handling of any water encountered during excavation. In all cases, dewatering would be conducted outside of wetland resource areas and in a manner protective of water quality.

Should groundwater be encountered, dewatering procedures would be developed. These procedures would include the use of multiple drums (placed as necessary within the excavation) and a 1,000-gallon sediment tank.

The portable sediment tank would be designed and constructed in accordance with the Massachusetts State Guidelines for Erosion and Sediment Control. Water would be pumped into the drums and then into the sediment tank. To facilitate dewatering of the sediment tank, it would be equipped with an appropriately sized outlet pipe that would discharge water onto a hay bale splash pad to dissipate water velocity. Pre-treatment of the discharge water is not required due to the absence of contamination in groundwater.

Portions of the proposed cable route would be located near public water supply wells and within Zone I and II wellhead protection areas. Based on conversations with MADEP staff regarding the proposed installation of subsurface utilities along the proposed cable route (MADEP, 2002b; MADEP, 2003), MADEP would typically prefer that the utilities were installed outside of the Zone I areas. However, the MADEP staff stated that they would allow the installation of utilities along existing roadways as long as alternative routes have been evaluated and the areas affected were minimized to the extent practicable. It is also important to note that the cable installation within Zone I areas would be installed using conventional open trench excavation and installation techniques, and that the transmission line would not contain any fluids, petroleums, oils, or lubricants. The trenchless technology proposed for the Route 6 area would not be located within a Zone I area. MADEP Drinking Water Program staff indicated that the MADEP would allow the installation of the proposed transmission lines within the Zone I area (MADEP, 2002b; MADEP, 2003).

There are no disadvantages to siting within the aquifer protection district. The proposed transmission line would not result in changes to surface or groundwater hydrology. The Project would not result in the addition of impervious surface areas, nor would it change the infiltration of surface water. The MADEP regulations (310 CMR 22.21(2)(a) and (b)) outline the restrictions for the siting of various land uses within the delineated Zone II area. None of these restrictions would affect the Project along the preferred route. Based on these findings, it does not appear that the MADEP Zone I and Zone II regulations would affect the Project along the preferred route.

There are no projected impacts to groundwater associated with the intended installation or future maintenance of the transmission line or associated infrastructure. As such, there is no threat to groundwater from the installation, presence, or future maintenance of the transmission line and/or associated infrastructure.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to upland water quality would include other upland cable or pipeline installations, excavation activities, and other wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative). The cumulative impacts from two potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

There are no significant cumulative impacts expected to water quality that would result from the installation of the onshore transmission line. Based on discussions with the Town of Yarmouth DPW and the MHD there are no other major transportation projects scheduled for the vicinity and estimated construction timeframe for the onshore cable route. There are also no significant cumulative impacts to wetlands expected should the onshore portion of National Grid's Nantucket Cable be installed at the same time of the onshore portion of the Project's cable system. The proposed Nantucket Cable's onshore route is more than a mile (1.6 km) distant from the Project's proposed route and would pass through the central portion of Hyannis, while the Project's onshore route bypasses the center of town to the east.

5.9.5 Mitigation

As discussed above, the Project has been planned, sited, and designed to avoid and / or minimize impacts to water quality within the Project area. No adverse impact to water quality is anticipated as a result of the Project, and the Project would involve no activities subject to review under Section 404. This Project would be subject to a Massachusetts Water Quality Certification due to the volume of sediment to be excavated for the HDD offshore exit pit (see Section 5.8.4.2.1). SPCC, SWPPP, and O&M Plans would be implemented during Project construction/decommissioning and operation to prevent potential impacts to water quality from spills and erosion/sedimentation. These plans would include specific guidance for contractors and operators in the prevention of and response to erosion/sedimentation and releases of contaminants to waterbodies and resource

areas. The O&M Plan would detail standard operating and maintenance protocols to ensure proper operation of wind park facilities. These plans would be prepared and submitted to the appropriate review agencies prior to the start of construction.

5.10 Cultural and Recreational Resources and Visual Studies

5.10.1 Introduction

This section describes historic properties, including archaeological sites, and recreational resources identified within and in the vicinity of the Project area, and describes the Project's potential effects, including visual effects, on these resources. Consistency with applicable regulations is discussed in this section and in Section 7.0. The information in this section was obtained from literature review, agency consultations, marine and terrestrial archaeological background review and field investigations, and visual studies.

The visual studies include field investigations and computer simulations of representative views of the visible components of the offshore Wind Park from historic properties on Cape Cod, Martha's Vineyard, and Nantucket. Project impacts on local character and culture, tradition, and heritage, as well as visual effects on recreational resources, are also discussed in this section. Potential Project effects on offshore recreational fishing are described in Section 5.4.2.4, potential effects from noise generated by the Project on recreational areas are described in Section 5.11, and potential effects on navigation (which would pertain to recreational boating) are described in Section 5.12. Impacts to recreational resources not listed or eligible for inclusion on the National Register are not subject to Section 106 of the National Historic Preservation Act (NHPA) (see Section 5.10.1.2).

The following subsections provide additional context for the review of cultural, recreational and visual issues. Section 5.10.1.1 defines the Area of Potential Effect (APE) for the Project; Section 5.10.1.2 outlines the regulatory requirements under which these issues are evaluated and the agencies and other participants involved in reviewing such issues.

5.10.1.1 Area of Potential Effect

An APE for a project is defined as that geographic area or areas within which construction/decommissioning, operation or maintenance of a project may directly or indirectly cause alterations in the character or use of historic properties [36 CFR Part 800 Section 16(d)]. There are different types of potential effects a project may have on historic properties, including physical effects (such as ground disturbance or destruction), noise effects, or visual effects of aboveground structures on the setting of historic properties.

The APE for the Cape Wind Project is the marine and onshore geographic area within which the Project may cause potential physical, noise and visual effects on historic properties (as described below). Each potential effect has been assessed and characterized as temporary or permanent, and determined both individually and cumulatively to have either no effect, no adverse effect or an adverse effect on specific historic properties, if present, using criteria in regulations implementing NHPA and NEPA

The Project's APE for archaeological sites includes areas of physical ground disturbance during construction/decommissioning, operation and maintenance. These marine and onshore areas include the footprints of the WTG structures on the sea bottom; the work area around each WTG where marine sediments may be disturbed; the jet plowed trenches for installation of the inner array cables connecting the WTGs to the ESP; the jet plowed trenches for the transmission cable system from the ESP to the landfall; associated marine work areas such as anchor drop areas; and the construction areas along the overland route to the tie-in at the Barnstable Switching Station. The lateral extent of physical marine effects associated with each of these Project components is described in Section 5.3 and summarized on Table 5.3-3. The lateral areal extent of physical onshore effects is summarized in Section 5.6.4.2.1.1 (along the paved roadway) and Section 5.6.4.2.1.2 (along the NSTAR ROW).

The Project's APE for visual effects includes those historic properties on Cape Cod, Martha's Vineyard, and Nantucket from which open views of the visible components of the Wind Park (aboveground or above water) would be available. Due to the generally level topography, mature wooded vegetation, and intervening

structures found on the Cape and Islands, it was found during field reconnaissance that open views were generally limited to historic properties in the immediate vicinity (within approximately 300 feet (91 m)) of the shoreline). Given the proposed location of the onshore electric transmission line underground beneath existing public roads and the NSTAR ROW, the APE for visual effects focused on potential views of the offshore wind farm. The Project would have no long-term visual or physical effects on inland recreational resources.

Both existing and proposed daytime views and nighttime lighting effects as seen from representative properties were modeled as part of the visual studies. Anticipated visual effects are described in Section 5.10.4, and are based upon the Visual Simulation Methodology report in Appendix 5.10-A and the Visual Impact Assessment (VIA) report in Appendix 5.10-F. The VIA was completed under the direction of the USACE for specific onshore historic properties within open unobstructed views of the visible offshore components of the Project. Based upon the findings of the VIA, a draft Programmatic Agreement has been prepared and will be finalized in consultation with signatories USACE, the SHPO, the Advisory Council on Historic Preservation and consulting parties Cape Wind LLC and the Wampanoag Tribe of Gay Head (Aquinnah). The Programmatic Agreement details methods for the Applicant to implement in order to minimize or mitigate adverse effects. The minimization and mitigation measures are summarized in Section 5.10.5; a copy of the draft Programmatic Agreement is included in Appendix 5.10-G.

The APE for noise effects includes those historic properties proximal to the Project that may experience noise during construction, operation and maintenance. A noise study, including modeling of noise expected from Project construction and operation, has been completed and is presented in Section 5.11.

5.10.1.2 Statutes, Regulations and Regulatory Agency Roles

Federal

The identification of historic properties in the Project's APE and assessment of potential Project effects is being conducted in accordance with NEPA (see Section 7.2.1) and Section 106 of the National Historic Preservation Act (NHPA). Section 106 of the NHPA of 1966, as amended through 2000, requires that federal or federally permitted projects "take into account the effect of the undertaking on any district, site, building, structure or object that is included in or eligible for inclusion in the National Register [of Historic Places]." According to regulations implementing the NHPA, these cultural resources are called historic properties [36 CFR Part 800, Section 800.16 (l) 1] or designated historic properties [33 CFR Part 325, Appendix C 1(a)]. Cultural resources may be prehistoric (pre-European Contact Period) or historic (more than 50 years old), and can include archaeological sites and historic structures and districts. Section 106 compliance is required under the federal Advisory Council on Historic Preservation's (ACHP) implementing regulations 36 CFR Part 800 entitled "Protection of Historic Properties" (effective January 11, 2001) and USACE's implementing regulations 33 CFR Part 325, *Processing of Department of the Army Permits*, Appendix C, *Procedures for the Protection of Historic Properties.*

Potential Project effects are assessed on historic properties, and occur when the undertaking's effect(s) may alter the characteristics or use of the property that qualified the property for inclusion in the National Register [36 CFR Part 800, Section 800.16(i) and 33 CFR Part 325, Appendix C Paragraph 15 (a)]. Under these regulations, if an adverse effect on a historic property is found, measures to avoid, minimize or mitigate the effects would be sought.

The USACE is the lead federal regulatory agency responsible for approving the Project. USACE has defined the permit area for the Project as the polygon (shown on Figure 4-1 and Figure 5.10-1) encompassing the WTGs and the marine cable installation area landward to high water, as well as any upland fill areas associated with inland wetlands regulated under Section 404 of the Clean Water Act.

State

Terrestrial (onshore) archaeological field surveys have been completed in the Project's APE for ground disturbance, in accordance with Section 27C of the Massachusetts General Laws (MGL) Chapter 9, and implementing regulations outlined in 950 CMR 70.00, entitled "*Massachusetts Historical Commission.*" In portions of the Project's APE under state jurisdiction, identification and assessment of potential Project visual impacts to properties included in the State (and National) Register(s) of Historic Places, as well as properties included in MHC's Inventory of Historic and Archaeological Assets of the Commonwealth which have previously been found

eligible for the NRHP with the concurrence of MHC, would continue to be conducted in accordance with 950 CMR 71.00, entitled "*Protection of Properties Included in the State Register of Historic Places.*"

The SHPO and State Archaeologist at MHC and the Massachusetts Board of Underwater Archaeologists (MBUAR) have been and would continue to be consulted regarding the Project during the permit processing, in accordance with 36 CFR Part 800; 33 CFR Part 325, Appendix C; and EIS scoping requirements.

Massachusetts Historical Commission

State jurisdiction over historic properties generally applies to resources located within the Commonwealth of Massachusetts, including its territorial waters to 3 nautical miles (5.6 km) seaward of the low water mark of shore. Therefore, jurisdiction over potential physical effects on cultural resources located outside of state jurisdiction, such as potential submerged archaeological resources on Horseshoe Shoal, which is in federal waters, does not extend to state agencies such as MHC. For example, state jurisdiction does not extend to potential submerged cultural resources on Horseshoe Shoal that are within the APE. Nonetheless, MHC was asked to be a cooperating agency during the permitting process for the entire Project. For archaeological field studies within MHC's jurisdiction, permits are required and have been obtained from the State Archaeologist (terrestrial) or MBUAR (marine), as necessary.

With respect to potential visual or noise effects on historic properties located within the Commonwealth, the APE for these effects extends into state jurisdiction in order to determine if the project may create an effect on historic properties (per Section 27C of the MGL Chapter 9, and implementing regulations outlined in 950 CMR 70.00 and 71.00).

Massachusetts Board of Underwater Archaeology Resources

The MBUAR is part of the Massachusetts Executive Office of Environmental Affairs. According to the Massachusetts Office of Coastal Zone Management (MCZM, 2002), "The Board's jurisdiction extends over the inland and coastal waters of the state." For certain marine archaeological field studies within MBUAR's jurisdiction, permits are required. Results of a marine archaeological reconnaissance survey found no potential archaeological resources in the Project's APE in state waters which would warrant archaeological investigation under a MBUAR permit (see Sections 5.10.2.1, 5.10.2.3, 5.10.3.1, and 5.10.3.2 and reports in Appendix 5.10-C).

Massachusetts Coastal Zone Management

With respect to historic properties, federal consistency review by MCZM is conducted under Protected Areas Policy #3. No portion of the Project area has been identified within or near an historic area or historic site in the Coastal Zone. However, offshore components of the Project are expected to be visible at specific onshore historic properties listed or eligible for listing on the National Register. A Visual Impact Assessment (VIA) has been completed, and a Programmatic Agreement is under development which will contain stipulations to minimize or mitigate adverse visual effects at two National Historic Landmarks, four historic districts and 10 individual properties (see Sections 5.10.4.3.2 and 5.10.5, and Appendices 5.10-F and 5.10-G).

Other Cooperating Agencies and Interested Parties

The Cape Cod Commission and the Tribal Historic Preservation Officer (THPO) of the federally-recognized Wampanoag Tribe of Gay Head (Aquinnah) have been offered opportunities to comment on the Project during permit processing. A complete list of cooperating agencies is provided in Section 10.0. The Wampanoag Tribe of Gay Head (Aquinnah) is a consulting party in the Section 106 process.

The Wampanoag Tribe of Mashpee, the Massachusetts Commission on Indian Affairs and the Alliance to Protect Nantucket Sound are interested parties with respect to Section 106.

5.10.2 Cultural, Recreational and Visual Studies

This section describes studies completed to identify offshore and onshore historic properties and recreational resources that may be affected by the Project. Since potential Project effects include visual effects of the Wind Park upon onshore historic properties (historic structures and districts sites), this section also summarizes visual studies undertaken to simulate views of the offshore built Project. A Visual Impact Assessment of Multiple Historic Properties, prepared by PAL, Inc. under the direction of USACE, has also been completed in accordance

with Section 106 of the NHPA and implementing regulations, based upon information described in applicable portions of this Section 5.10.2. The assessment is summarized in Section 5.10.4.3.2, and presented in Appendix 5.10-F. Impacts to recreational resources not listed or eligible for inclusion on the National Register are not subject to Section 106 of the NHPA.

Public Archaeology Laboratory, Inc. (PAL) was retained to identify onshore and offshore historic properties and archaeological sites within the Project's APE, and to prepare the Visual Impact Assessment. PAL's Project cultural resources personnel are qualified in accordance with professional standards for management of cultural resources set by the Secretary of the Interior's Standards and Guidelines for Archaeology and Historic Preservation [48 FR 44716, September 29, 1983], MHC, and the MBUAR.

Visual simulations of the most unobstructed publicly available views of the visible components of the Project from within or adjacent to 12 onshore historic districts and structures were developed by EDR, PC of Syracuse, New York. EDR, PC is a firm specializing in computerized visual simulations and assessment for large commercial and industrial projects. The 12 simulation locations were selected by USACE, following consultation with MEPA and MHC.

5.10.2.1 Marine Archaeological Sensitivity Assessment

A marine sensitivity assessment of approximately 669,081,600 square feet (62,159,710 square meters) of Nantucket Sound seafloor comprising the Wind Park study area, as well as along the 115 kV transmission line route to the Yarmouth landfall, was conducted between January and February 2003. The goal of the study was to assess the archaeological sensitivity of the Project's offshore study area, and to prepare a research design and methodology for conducting a marine archaeological remote sensing reconnaissance survey of the offshore Project area (also completed in 2003). The marine sensitivity assessment report is included in Appendix 5.10-C.

Known and potential submerged historic properties within the Project's marine APE could potentially include now-submerged prehistoric (pre-European Contact Native American) sites, historic shipwrecks, and/or inundated built historic resources along the coast. As the first step in identifying known and potential sites, PAL reviewed existing data. These data included review of previously documented offshore archaeological resources, including compilations of known shipwrecks within and in the vicinity of the offshore study area; the geomorphologic history and sedimentary environments of the Nantucket Sound area; onshore Native American prehistoric and historic settlement and subsistence patterns; and Euro-American historic settlement and maritime activity patterns.

The research design and methodology are presented in Appendix 5.10-C. The research indicated that the offshore study area has potential for containing both submerged prehistoric and historic cultural resources. PAL therefore recommended that a marine archaeological reconnaissance survey, comprised of further geophysical and geological field studies, be conducted in the offshore study area. The field study was conducted from June through October 2003. The scope and methodology of the survey are described in Section 5.10.2.3; results are presented in Section 5.10.3.1.1 and in the marine archaeological reconnaissance survey report provided in Appendix 5.10-C.

5.10.2.2 Marine Reconnaissance Survey of SMDS Area

A detailed geophysical survey was conducted in August 2002 within the southern portion of the Project area in the vicinity of the Cape Wind SMDS, to confirm the presence or absence of potentially significant submerged archaeological resources prior to issuance of final permits for that structure. Additional geophysical transects were surveyed in the southern portion of the Project area in the immediate vicinity of the proposed SMDS, to supplement the existing geophysical datasets and a deep boring collected in the area during the 2001 field program. A marine archaeologist at PAL reviewed the information and concluded that the surveyed area did not contain potentially significant historic or archaeological resources, and recommended no further archaeological study for the SMDS area. MHC was consulted and concurred with the findings. Final permits were issued and the SMDS has been constructed and is operational. Geophysical and geological data collected to assess the SMDS area within the Wind Park was also used as part of the overall cultural resources assessment for the offshore Project Area.

5.10.2.3 Marine Archaeological Reconnaissance Survey

Based upon the results of the marine archaeological sensitivity assessment, and because the preliminary turbine array layout was revised subsequent to the original geophysical field surveys in 2001, PAL recommended additional marine geophysical field work to determine the presence or absence of potentially significant submerged historic cultural resources (e.g., shipwrecks) within the Project's marine APE. PAL recommended that the survey be performed using differential GPS, side scan sonar, sub-bottom profiler, a marine magnetometer and a recording fathometer. A survey track line interval of 50 feet (15.2 meters) was recommended for those portions of the Project area in which sub-surface impacts during construction are anticipated, such as where installations of the WTGs, ESP, inner-array and submarine cable transmission lines are proposed. This geophysical survey program, which also collected data to be used for geotechnical and engineering design purposes, was conducted in the summer of 2003 (see Section 5.1).

In addition to the geophysical survey, PAL recommended additional vibracores to characterize the origin, nature and extent of organic sediments observed in three vibratory coring samples previously recovered from the eastern edge of the marine Project area. The advancement and analysis of nine additional vibracores was recommended by the marine archaeologist following review of additional geophysical survey data collected during the summer of 2003. The purpose of the vibracore program was to assess whether intact shallow submerged terrestrial paleosols (former soil surfaces) may be present within limited areas of the Project's eastern portion. If a paleosol was found and identified as terrestrial in origin, it may have the potential for containing submerged prehistoric resources. Its significance would then be assessed in consultations between USACE and the appropriate regulatory agencies. Vibracores additional to the nine recommended by the marine archaeologist were also collected during the 2003 field program, for geotechnical and engineering design purposes (see Section 5.1). The entire suite of data was reviewed by PAL.

The scope of this marine archaeological reconnaissance survey was developed following consultations with MBUAR and MHC. The field portion of the marine geophysical survey was conducted by OSI over a three-week period during Summer 2003. The survey collected over 300 linear miles (483 km) of geophysical information within the Wind Park and along the proposed 115 kV transmission cable route into Lewis Bay. In addition to OSI personnel and other scientists, a marine archaeologist from PAL was on board the geophysical survey boat during each field day, to identify targets and note other areas of interest for potential submerged cultural resources.

Figure 5.1-1 shows the locations of the 2001 and 2003 geophysical tracklines. See Section 5.1.2.1 for a description of the marine geophysical/hydrographic surveys. Study results are described in Section 5.10.3.1 and Appendix 5.10-C.

5.10.2.4 Terrestrial Archaeological Reconnaissance and Intensive Surveys

An onshore (terrestrial) reconnaissance archaeological survey of the Proposed Site (Yarmouth landfall) and alternative (Mashpee landfall) onshore transmission line routes was completed by PAL in spring 2003. The survey was conducted under archaeological Permit No. 2246, issued on March 28, 2003 by the State Archaeologist's office at MHC (see Appendix 5.10-E), and included a review of background information and a walkover survey of both routes. The purpose of the survey was to classify the onshore routes into zones of low, moderate, and high archaeological sensitivity based upon known and suspected resource locations and any previous ground disturbances. Findings are presented in Appendix 5.10-D, and are summarized in Sections 5.10.3.2.5 and 5.10.3.2.6. The results of the reconnaissance survey were used to determine the scope of the intensive (locational) archaeological survey, which has also been completed under MHC permit (see Section 5.10.2.4).

The terrestrial intensive archaeological survey was designed to locate and identify previously unrecorded historic or archaeological resources that may be affected by onshore Project construction/decommissioning and operation, based upon the results of the reconnaissance survey described above and a review of detailed roadway plans. The survey was conducted along the proposed Yarmouth-Barnstable onshore cable route during October 2003 under Permit No. 2595 from the State Archaeologist (see Appendix 5.10-E). Subsurface testing locations were selected in the field based on detailed Project plans, the results of the reconnaissance survey,

existing road construction and utility plans, and proposed temporary work areas along the onshore route. Results are described in Sections 5.10.3.3.1 and 5.10.3.3.2.

5.10.2.5 Identification of Onshore Historic Properties

Known historic properties in communities within potential visual range of the offshore turbines were compiled by PAL based upon a review of available databases and records at MHC, including MHC's *Inventory of Historic and Archaeological Assets of the Commonwealth (Inventory)*. Historic structures and districts were identified in the Towns of Barnstable, Falmouth, Yarmouth, Dennis, Harwich, Chatham, Nantucket, Oak Bluffs, Tisbury and Edgartown that meet the following criteria:

- Properties listed or formally determined eligible for inclusion on the NRHP;
- Properties in the *Inventory* for which MHC has concurred with an eligibility recommendation;
- Properties on the State Register of Historic Places (SRHP), including local historic districts, which MHC has found are eligible for the NRHP.

The properties are listed in Appendix 5.10-B; locations are shown on Figure 5.10-1.

USACE regulations pertaining to assessment of potential Project impacts on potentially eligible historic properties are set forth in 33 CFR Part 325 - C Paragraph 5(f) as:

> *The Corps of Engineers' responsibilities to seek eligibility determinations for potentially eligible historic properties is limited to resources located within waters of the U.S. that are directly affected by the undertaking. The Corps responsibilities to identify potentially eligible historic properties are limited to resources located within the permit area that are directly affected by related upland activities. The Corps is not responsible for identifying or assessing potentially eligible historic properties outside the permit area, but would consider the effects of undertakings on any known historic properties that may occur outside the permit area.*

Therefore, an architectural inventory of previously unidentified but potentially eligible historic properties within the Project's viewshed is not required.

5.10.2.6 Identification of Recreational Resources

The EIS scope for Project studies noted "recreational impacts may be addressed within other sections such as the fisheries, navigation and aesthetics." Recreational resources are not regulated under the Section 106 statute, but are addressed under NEPA of 1969, as amended, and implementing regulations. Onshore recreational resources within the viewshed of the Wind Park were identified using MassGIS databases and a review of available maps, atlases and web sites (listed in Section 5.10.6), as well as field reconnaissance. As is the case for historic properties, due to the generally level topography, mature wooded vegetation, and intervening structures found on the Cape and Islands, open views were generally limited to recreational areas in the immediate vicinity (within approximately 300 feet (91 m)) of the shoreline. In addition, given the proposed location of the onshore electric transmission line underground beneath existing public roads and the NSTAR ROW, the Project would not have long-term visual or physical effects on inland recreational resources.

The recreational resources subject to potential visual impacts from construction/decommissioning, operation and maintenance of the Project are compiled on Table 5.10-4 and shown on Figure 5.10-5. Identification numbers on the table and figure pertain to those resources identified by the MassGIS databases; resources identified by other information sources were placed on Table 5.10-4 in the rows between the nearest GIS-listed resources. On Figure 5.10-5, these resources are located between the nearest reported GIS-listed locations. Also included are the viewpoint(s) closest to each recreational area, which were prepared to represent the overall change in the viewed seascape at each location.

The nearshore and offshore waters of Nantucket Sound were also identified as important recreational resources. Identification and discussion of related marine recreational activities are included in Sections 5.4 (recreational fishing), Section 5.11 (noise) and 5.12 (navigation).

5.10.2.7 Visibility Study

In accordance with scoping requirements, and as discussed during the July 31, 2002 meeting with MHC staff and in subsequent correspondence, visual simulations of the proposed Wind Park were done from 12 agreed-upon historic properties on Cape Cod, Nantucket, and Martha's Vineyard. The locations were selected to assess potential visual impacts to known historic properties, and to provide a sense of the anticipated change in the seascape at other sensitive locations, such as nearby recreational resources (primarily beaches) in the viewshed. Both daytime and nighttime simulations were prepared for each location, with the exception of Monomoy, where only daytime simulations were completed, as discussed in Section 5.10.2.7.2.

The visual simulations modeled representative views of the 130 proposed WTGs and the ESP at the Wind Park to illustrate the potential change in views of the seascape. The most open, publicly available, view toward the Wind Park, based upon field reconnaissance, was selected as the visual simulation location within each historic district or property location, and therefore each simulation represents a "worst case" view of the built Project.

The daytime simulations were developed to show the range of daytime lighting conditions (with the WTGs front lit, side lit and back lit) that may be experienced by onshore viewers, based upon the time of day and position of the sun relative to the viewer at each location and the visible WTGs.

Fieldwork, the viewpoint selection process, and simulation methodology are described in the report entitled Visual Simulation Methodology prepared by EDR, included in Appendix 5.10-A is summarized below. Photographs of the historic structure or district at each viewpoint, as well as photographs to capture the character of the area or district, are included in the Figure 5.10-2 (Sheets 1 through 64). Locations of the photographs are shown on the aerial photographs in Figure 5.10-2 (Sheets 1-64), and are labeled either "C" or "CE". The "C" series photographs were taken by EDR during a number of field visits in 2003. The "CE" series character photographs along the south Cape were taken by ESS on October 28, 2002. Locations of the viewpoints and the historic properties are shown on Figure 5.10-1.

Existing views and proposed views (simulations) from the selected viewpoints are included in the Figures 5.10-3 (Sheets 1 through 12) and 5.10-4 (Sheets 1 through 11), which show daytime and nighttime conditions.

5.10.2.7.1 Viewshed Reconnaissance

From the list of historic properties listed or eligible for inclusion on the National Register and/or locally designated historic properties approved by MHC in communities within potential visual range of the offshore turbines (Appendix 5.10-B), field viewshed reconnaissance was conducted in the winter and spring 2003 along the south side of Cape Cod from Woods Hole to Chatham, the north and east sides of Martha's Vineyard, and the north side of Nantucket. The ground-level exteriors of known historic properties were visited and photo-documented to determine whether open views of the Project would be available. Due to the generally level topography and the presence of mature wooded vegetation and intervening structures, it was found that open views toward the Project were largely limited to areas in the immediate vicinity of the shoreline. The properties visited are listed on Table 5.10-1 and are shown as viewpoints (VPs) on Figure 5.10-1.

Color photographs were taken of both the structure(s) and area of interest, and of the most open publicly available view at each location toward the estimated center of the Project. The photographs of structures at each viewpoint, as well as photographs taken to illustrate the character and setting of the area, are included in Figure 5.10-2 (Sheets 1-64).

5.10.2.7.2 Selection of Viewpoints for Visual Simulations

Based upon the findings of the viewshed reconnaissance, 12 representative viewpoints were recommended for visual simulations of the Project structures that are anticipated to be visible. Six locations along the south shore of Cape Cod were recommended, along with three locations each on Martha's Vineyard and Nantucket. Locations were selected to obtain the most open, publicly available views toward the proposed Wind Park, based upon field observations. Within historic districts, representative locations were selected to obtain unobstructed publicly

available views relative to other areas of the district, in accordance with the MEPA ENF Certificate. In cases where the historic district extended to the waterfront, shoreline locations were typically recommended for simulations.

The information, including the photo documentation of the structures on the Cape and the listing of historic properties on the Cape and Islands, was submitted to MHC and MEPA for review and comment. It was determined that the preparation of simulations from these 12 viewpoints would adequately illustrate Project visibility and visual impact from Cape Cod, Nantucket, and Martha's Vineyard. The visual simulation locations are listed on Table 5.10-2 and shown on Figure 5.10-1.

After the start of fieldwork, it was learned that public access to Monomoy Island, a National Wildlife Refuge, is restricted during the nighttime hours. Therefore, potential nighttime viewers are not anticipated at Monomoy. Nighttime photographs were obtained from two other similar locations with remote undeveloped shorelines (Great Point, on Nantucket, and Cape Poge, on Martha's Vineyard, each closer to the Project than Monomoy), and nighttime simulations were prepared from those locations, as described in the following sections. Because 11 other nighttime simulations were prepared, as well as daytime photographs at various times throughout the day and under various conditions, it was determined that nighttime photos from Monomoy were not necessary.

5.10.2.7.3 Viewpoint Photos

Daytime and nighttime field photos were obtained from each of the 12 selected viewpoints (Monomoy, daytime only) during the winter and spring of 2003. The field methodology is fully described in Appendix 5.10-A, and is briefly summarized here. On multiple field visits scheduled to coincide with clear weather, a two-person crew (one photographer and one surveyor) visited each of the selected viewpoints listed in Table 5.10-2. At each viewpoint, locations of the tripod-mounted camera, the Project's center point, foreground reference features, and correct bearings were determined using GPS survey equipment, Project layout plans, and the built SMDS tower (where visible), as detailed in Appendix 5.10-A. Field information pertaining to photographs taken at each of the visual simulation locations is presented on Table 5.10-3.

Photographs were obtained under a variety of daytime lighting conditions to accurately represent the range of views that would be available. Offshore visibility to the proposed Project from each onshore location was clear in all cases. Shoreline views and those more interior within the historic districts were included, although in most places open views toward the Project quickly diminish as one moves inland. Midday and afternoon photos were obtained from most of the viewpoints, as sun location and low clouds hindered visibility during the morning hours. Night photographs were also taken at the same locations from 11 of the 12 viewpoints.

In accordance with scoping requirements for the Project, the selected viewpoints were the most open, unobstructed, publicly-accessible views toward the offshore Wind Park at each viewpoint locations. For example, the selected viewpoint at Cotuit was from Loop Beach at the southeastern end of Ocean View Avenue, immediately south and outside of the historic district. If no unobstructed publicly-accessible views were available within the district, an open shoreline view immediately adjacent to the district was selected. At Craigville, it was found that the Craigville Historic District contains no open views toward Nantucket Sound; the Craigville simulation was prepared from a bluff overlooking Nantucket Sound, and represent worst-case (elevated) views from the popular Craigville Beaches.

5.10.2.7.4 Visual Character and Setting

At each of the viewpoints, the area's aesthetic character and the availability of other open views toward the Wind Park was documented. Other than on Nantucket, which is located entirely within a historic district, this generally involved walking and driving within a one-mile radius of the selected viewpoint location or the boundaries of the historic district (whichever was smaller) to determine if the selected viewpoint offered the most open view available.

Character photos were taken of the historic structures and setting at each viewpoint, along with representative structures or distinctive built and/or natural features within each district. These are included in Figure 5.10-2, and are described in the narrative for each viewpoint.

The visual simulations were then prepared, using the methodology summarized below and detailed in Appendix 5.10-A.

5.10.2.7.5 Visual Simulation Methodology

The visual simulation methodology is fully described in Appendix 5.10-A. In brief, a three-dimensional (3D) computer model of the proposed Wind Park was developed by EDR using data from the 130-turbine layout plan, GE Wind Energy's turbine and tower specifications, and drawings of the ESP. To-scale computer models of the individual visible Project components were modeled in the proper geographic location and elevation using 3D Studio Max 5.0® software. Appropriate structural materials, colors and finishes were also applied.

Data on the proposed lighting system was incorporated into the nighttime simulations. The proposed nighttime lighting system was designed in consultation with the USCG and FAA (see Section 5.12). The objective of the proposed lighting system is to make the proposed WTG structures sufficiently conspicuous to pilots and mariners in order to ensure aeronautical and marine safety, while minimizing visual impacts to land-based viewsheds and potential attraction impacts to avian communities. The nighttime lighting design is described in Section 5.12.2. Nighttime simulations were prepared using the nighttime photos obtained at each viewpoint (except Monomoy) as detailed in Appendix 5.10-A.

Because the FAA warning lights would be flashing, the proposed flashing rate (20 FPM) was used to animate the simulations, with each interior turbine flashing randomly (rather than synchronized). Each simulation is essentially a snapshot that shows the Project at one moment in time (i.e., 1/30th of a second) with some portion (in the range of 50 to 65%) of the interior lights on. All of the perimeter lights are illuminated, as the flashing of these lights is proposed to be synchronized. No visible lighting from the Coast Guard navigation warning lights was shown in the nighttime simulations, as the proposed lights have a range of approximately 2 nautical miles (3.7 km), and the nearest shoreline viewpoint is approximately 5.4 miles (8.7 km) from the nearest proposed WTG.

5.10.3 Existing Conditions

This section presents a brief historical context of the Cape and Islands, and identifies known marine and terrestrial prehistoric and historic archaeological resources and historic properties in the vicinity of the Project's APE. The section also describes recreational activities and resources in the Project vicinity in federal waters, state waters and onshore areas. The existing setting of the historic districts and properties selected for visual simulation, as well as recreational resources in the vicinity of those locations, are also described.

Overview of the Cultural Context

This overview is a summary from research conducted by PAL (see Appendices 5.10-B, -C and -D); information on NRHP Nomination Forms, including the regional history in the Barnstable Multiple Resource Area Nomination Form, on file at MHC; and web sites, as listed in Section 5.10-6.

Nearly 12,000 years of Native American settlement has been documented in the de-glaciated terrestrial terrain of southern New England. Following the retreat of glacial ice from Cape Cod and the Islands, much of Nantucket Sound was exposed and may have been used by small bands of migratory people referred to as Paleo Indians. Over time as the glacial ice melted during climatic warming, sea level rose, inundating the shoreline. Evidence of Native American use of shoreline areas may have been destroyed by wave and tidal action associated with rising sea levels.

Sea level had generally stabilized by approximately 4,500 years ago, and by 3,500 years ago many of the coastal marshes had been formed. These coastal areas were favorable for shellfishing and fishing. Archaeological sites from the Middle and Late Archaic Periods (7,500 to 3,000 BP) found on the Cape and Islands indicate growing use of coastal and freshwater resources. During the Woodland Period (3,000 to 450 BP), a foraging way of life transformed to a more sedentary life with a greater emphasis on plant domestication.

The first European explorers, in the early 1600s, found Native American villages along river drainages linked by an extensive system of trails. The introduction of European diseases during the Contact Period caused a disastrous and sudden decline in the Native American population in the region. Today, descendants of these coastal peoples are among the members of the Wampanoag Tribe of Gay Head (Aquinnah), federally recognized in 1987, and the Mashpee Wampanoag Tribe, which awaits a decision on federal recognition.

Permanent Colonial settlement of Cape Cod began in the mid-1600s, with the first communities located north of the present day Route 6, along Cape Cod Bay, on lands obtained from the Wampanoag Tribe. Early Colonial life focused largely on agriculture, fishing and religious activities. The Great Marshes of Cape Cod Bay provided salt hay for livestock, as well as plentiful fish and shellfish. The glacial till north of the Sandwich glacial moraine was more fertile than the outwash sands and gravels south of the moraine, and the north side of the Cape also offered better access to Boston.

Early colonial life on Nantucket centered on fishing, whaling, farming and religion. Nantucket began a long-term economic decline in the 19th century, as the nation grew to depend on petroleum over whale oil. This economic decline saved many of the early buildings from demolition and redevelopment. Architectural styles of historic village structures range from the simple lines of the houses of sailors and ministers to the grand federal-style mansions of ship captains and owners. These structures are linked by narrow cobblestone streets and large shade trees.

The economy of Martha's Vineyard, and particularly Edgartown, was centered on agriculture and the maritime trade. During the 1700s, wind-powered gristmills were established on Martha's Vineyard and Cape Cod.

Starting in the early 1700s, seafaring activities grew more prevalent, as coastal trading, whaling, ship building and salt making joined the traditional farming, fishing and shellfishing economies. The southern part of the Cape, with its deeper harbors and proximity to the Nantucket, Martha's Vineyard and New York trade routes, experienced rapid growth that continued into the mid-1800s. Maritime interests and prosperity increased, defining part of the historic character of the Cape and Islands that continues to be recognized today.

From the mid-1800s through the Great Depression in the 1930s, the Cape and Islands entered a period of gradual economic decline and population loss. Traditional maritime industries such as fishing, whaling, salt making and coastal trading declined. The railroad, which was brought to Hyannis in 1854 to provide reliable service for the maritime industries, started to replace regional coastal shipping. The railroad also provided the means for city dwellers to escape the summer heat and reach the Cape and finally the Islands. A number of Christian camp meeting areas were established in the late 19th century, including those at Craigville and Oak Bluffs. These gatherings were attended by both laypersons and ministers, who often arrived by train or boat. By the late 1800s, several hotels had been built on the shores of Nantucket Sound. Summer estates and resort communities were developed. The era of the summer resort, which continues today, had begun.

Cultural and recreational resources within the APE of the Project are described below, by area. In areas that may be affected by Project visibility, the existing visual character and setting of the area or historic property is described.

5.10.3.1 Conditions Outside of Massachusetts Waters

5.10.3.1.1 Submerged Prehistoric Archaeological Resources

Review of the preliminary geophysical and geotechnical data and a literature and database review obtained as part of the marine archaeological sensitivity assessment indicate that a majority of the offshore study area has a low probability for containing submerged prehistoric cultural resources. This conclusion was made because of the extensive disturbance of the formerly exposed and habitable, pre-inundation landscape that resulted from the post-glacial marine transgression (see Appendix 5.10-C).

No submerged prehistoric archaeological sites have been previously reported in the offshore Project area. Application of published rates of sea level rise since the end of glaciation to the present elevations of the sea floor suggest that much of the offshore Horseshoe Shoal area may have been exposed and available for human

occupation and use from about 12,500 to 7,000 years BP. The marine archaeological sensitivity assessment (Section 5.10.2.1 and Appendix 5.10-C) found that prehistoric archaeological deposits with contextual integrity might be present within limited parts of the eastern offshore study area where former natural soil strata (paleosols) may be present.

Review of the geophysical and geological field data collected in 2001 through 2003, and referenced published studies, also indicates that a majority of the offshore Project area has a low probability for containing submerged prehistoric cultural resources; again, due to extensive disturbance to the pre-inundation landscape that resulted from wave and storm action during the post-glacial marine transgression.

However, based upon descriptions of a 1- to 3-foot (0.3 to 0.9 m) thick organic zone encountered in sediments in three vibratory cores, and what appears to be a correlative discontinuous seismic signature on the shallow sub-bottom profiler data, several small zones of shallow submerged sediments in the eastern portion of the Project area may contain intact paleosols and, thus, the potential for submerged prehistoric cultural resources. The three core samples (shown in Figure 5.1-1) are Project vibracores collected in 2001 (VC01-G4 and VC01-G7) and a core specimen collected in the 1970s by the USGS (USGS VC-4939). The sediments described as containing organic material were collected within the east-facing embayment of Horseshoe Shoal, roughly along the present 45- to 55-foot (13.7 to 16.7 m) bathymetric depth contours. The embayment may have provided comparatively sheltered conditions during transgressive marine processes that allowed limited areas of former land surfaces to escape destruction by waves and storm action.

Organic material recovered from USGS VC-4939 was radiocarbon dated by USGS, and reported to have an age of 6,470 +/- 200 BP (O'Hara and Oldale, 1987). Recent calibration of this date by PAL provided a date range of 7,513 to 7,233 CalBP (see Appendix 5.10-C). Reconstruction of Horseshoe Shoal at approximately 7,250 BP, generated by applying published sea level rise curves to existing bathymetry and seafloor topography, suggests that the locations of the three core samples may generally rim a bathymetric low which could once have been a fresh-water kettle pond (see Figure 4.3 in the reconnaissance survey report provided in Appendix 5.10-C). This low was eventually transgressed by rising sea level sometime before 6,000 BP. Lakes, ponds and coastal embayments are known to have been attractive locations for prehistoric use. Archaeological evidence exists in southern New England for coastal adaptation and fish harvesting by the Middle Archaic Period (7,500 to 5,000 BP).

The origin, nature and extent of possible organic sediments were further investigated during vibracoring, as part of the marine archaeological reconnaissance survey conducted in the summer and fall of 2003. This field program was part of a comprehensive geophysical and geotechnical field program described in Sections 5.1 and 5.10.2.3. Results pertaining to potential prehistoric archaeological resources are presented below; results pertaining to potential historic archaeological resources are presented in Section 5.10.3.1.2.

Geophysical and geotechnical field survey data collected in 2003 provided additional evidence of extensive disturbance of the sea floor sediments, and confirmed the earlier sensitivity assessment that a majority of the offshore study area had a low archaeological sensitivity for containing contextually intact prehistoric cultural deposits.

However, the additional vibracores, advanced during the 2003 survey at locations recommended by the marine archaeologist to delineate the relatively small zone identified as potentially sensitive on the eastern side of the WTG array area, confirmed that the origin of the organic deposits observed in several vibratory samples were terrestrial in nature and contextually intact. These paleosol deposits were examined microscopically by a marine geologist/limnologist at the University of Rhode Island Graduate School of Oceanography and the depositional environment interpreted as a preserved forest floor (VC03-05), fresh water wetlands (VC01-G4), and a shallow fresh water pond (VC03-04) (see the reconnaissance survey report in Appendix 5.10-C and the report's Appendix D).

As discussed further in Sections 5.10.4 and 5.10.5, PAL recommended avoidance of ground disturbing activities in areas where sub bottom profiler reflectors correlating to the intermittent paleosols were identified. If avoidance is not possible, then additional survey was recommended, in consultation with SHPO (MHC and MBUAR). MBUAR and MHC concurred with these recommendations (see letters dated May 11, 2004 and May 19, 2004,

respectively, in Appendix 5.10-E). A Programmatic Agreement containing stipulations to ensure avoidance or additional investigation of submerged archaeologically sensitive areas is under development (see Section 5.10-5 and Appendix 5.10-G).

5.10.3.1.2 Submerged Historic Archaeological Resources

Review of available literature and databases indicate the offshore Project area is within a region of extensive historic maritime activity in the post-European Contact (historic) period. Review of shipwreck databases indicate that 45 vessels may have been reported lost in the vicinity of the Project area (see Appendix 5.10-C). Specific locations for most of these shipwrecks, as well as details of size, type and age, were not reported. No evidence of shipwrecks was apparent in the preliminary geophysical or geotechnical data obtained in 2001, according to the marine archaeologist at PAL who reviewed the data.

Dates for the reported wrecks range from the sloop *Platina*, lost off Half Moon Shoal in 1841, to the U.S. Navy oil-screw *P.C. 1203*, lost off Horseshoe Shoal in 1963. The temporal distribution of reported shipwrecks correlates with the post-1850 expansion of settlement and commercial activity on the mid-Cape's southern shore. Reported vessel losses per century are:

- 1600s and 1700s - no vessels reported lost;
- 1800s - 19 vessels reported lost;
- 1900s - 7 vessels reported; and,
- 19 vessels reported lost without associated dates.

The schooner is the most common vessel type reported lost, although barges, motorboats, oil-screws, ships and sloops are also reported. Additional unreported wrecks, including scuttled or abandoned vessels, may also be within the Project area.

Based upon the potential for the offshore study area to contain submerged historic cultural resources such as shipwrecks, a marine remote sensing (geophysical) archaeological survey was recommended within the Project area and along the proposed cable route to Lewis Bay. The field survey was completed during the summer and fall of 2003.

Preliminary review of geophysical survey data as it was acquired in the field during the June to July 2003 deployment in waters deeper than 3 feet in the offshore Project area and in Lewis Bay in September 2003 recorded 461 anomalies (109 side-scan sonar, 154 magnetic, and 198-plus Chirp sub bottom profiler anomalies). Of the 430 anomalies inventoried during the June-July 2003 offshore field survey, all but 29 (6.7%) were determined to have a source that was non-cultural in nature or was interpreted as isolated debris, and, therefore, were eliminated from further consideration. Survey data for the remaining 29 anomalies, as well as for the anomalies detected in Lewis Bay in September 2003, were post-processed and additional analyses were completed.

Analyses of the post-processed data associated with the 29 anomalies of interest and the data collected during September 2003 produced three targets with moderate probability of representing submerged Euro-American (historic) cultural resources. All are in the vicinity of Horseshoe Shoal. Locations have been provided to MHC and MBUAR, but are not publicly distributed to protect the integrity of these potentially significant sites. The targets are named PAL Targets 03-01 through 03-03.

As discussed further in Sections 5.10.4 and 5.10.5, PAL recommended avoidance of ground disturbing activities around the detectable limits of each of these three potentially archaeologically sensitive targets. If avoidance is not possible, then additional survey was recommended, in consultation with SHPO (MBUAR and MHC). MBUAR and MHC concurred with these recommendations (see letters dated May 11, 2004 and May 19, 2004, respectively, in Appendix 5.10-E). A Programmatic Agreement containing stipulations to ensure avoidance or additional investigation of submerged archaeologically sensitive areas is under development (see Section 5.10-5 and Appendix 5.10-G).

5.10.3.1.3 Recreational Resources in Federal Waters

The offshore waters of Nantucket Sound are used by recreational boaters and fishermen, as well as commercial vessels engaged in waterborne commerce. Peak usage by recreational vessels is during the warmer months of the year (typically April through October). As presented in Section 3.2 of the Navigational Risk Assessment in Appendix 5.12-B, the charted shallow water depths across Horseshoe Shoal physically limit the sizes of recreational vessels that can transit the shoal.

Changes in water depths over short distances, and strong tidal currents (with peak currents often exceeding two knots), tend to create steep waves that break on the shoal, causing many boaters to avoid the area. In addition, the distance from shore and the wave and tidal action also limit use by very small recreational vessels, such as open runabouts, day sailors, wind surfers, and jet skiers. Project staff performing other field investigations in the vicinity of the shoals have reported seeing few vessels operating on Horseshoe Shoal, which has been corroborated by field surveys specifically designed to document recreational boating activities during peak summer weekend days (as discussed in Section 5.16).

There are two main shipping lanes, the Main Channel and the North Channel, used for safe navigation by larger vessels in Nantucket Sound (see Figure 5.12-1). The Main Channel in Nantucket Sound is located south of Horseshoe Shoal, and is used by most vessels with a draft up to approximately 24 feet transiting through Nantucket Sound. The North Channel runs along the north side of Nantucket Sound, northward of Horseshoe Shoal, and is used mostly by vessels bound for the south shore of Cape Cod, and by vessels transiting the Sound during northerly winds. The shallowest depth in the channel is approximately 16 feet at MLLW. The area between the Main Channel and the Cape Cod shoreline, including Horseshoe Shoal, is designated as an anchorage ground, known as "Anchorage I." Floats or buoys for marking anchors or moorings in place are allowed in this area. Fixed mooring piles or stakes are prohibited.

The Figawi Race from Hyannis to Nantucket and back is held every year over Memorial Day weekend, and includes sailboats with overall lengths of 20 feet and greater. The course varies every year, but typically starts to the north of Horseshoe Shoal and proceeds around or over portions of the shoal. Special marine events such as the Figawi must be registered in advance with the USCG local office. A review of partial records of marine events at the USCG Marine Safety Office in Providence indicates most of the events in the Nantucket Sound area have been located nearer to shore than Horseshoe Shoals, with the exception of the Figawi Race (see Section 3.4 of Appendix 5.12-B).

Recreational fishing is described in Section 5.4. Navigation and transportation are described in Section 5.12.

5.10.3.1.4 Visual Character and Setting in Federal Waters

In federal waters within Nantucket Sound, the existing seascape contains a large expanse of open water, rimmed by the low-lying landforms of the Cape and the Islands. The character of the viewscape is not fragmented, and is consistent with a natural unified nearshore southern New England seascape. Activity is limited to recreational and fishing boats, ferries, navigational aids, and aircraft flying overhead. Tankers, freighters and other large commercial ships typically avoid the shallow drafts and shoals of the Sound.

5.10.3.2 Conditions Inside of Massachusetts Waters

5.10.3.2.1 Submerged Prehistoric Archaeological Resources

Review of the preliminary geophysical and geotechnical data as part of the marine archaeological sensitivity assessment described in Section 5.10.2.3 indicates that a majority of the offshore study area, including state coastal waters, has a low probability for containing submerged prehistoric cultural resources, because of extensive disturbance to formerly exposed and inhabitable pre-inundation landscape that is the result of marine transgression (see Appendix 5.10-C). No potential archaeological resources were identified and no additional archaeological investigations were recommended by PAL within the Project Area in these waters, based upon results of the background review and marine archaeological reconnaissance survey.

5.10.3.2.2 Submerged Historic Archaeological Resources

Three shipwrecks have been reported in the vicinity of Bishops and Clerks shoals. One is reported to be a wooden barge. No information about the remaining two was found in the databases other than approximate location.

No archaeological investigations were recommended by PAL within the Project area in these waters, based upon results of the background review and marine archaeological reconnaissance survey.

5.10.3.2.3 Recreational Resources in State Waters

Fishing, water skiing, wind surfing, jet skiing, power and sailboat cruising and racing are common pastimes among boaters in state waters of Nantucket Sound. Scuba diving is limited in the area because the soft sediment habitat is generally uninteresting. Local yacht clubs provide opportunities for sailing instruction and fleet racing in state waters, often using traditional locally designed day sailors, including Beetle Cats, Wianno Juniors and Wianno Seniors. Public access to state waters is provided at various boat ramps located in harbors and sheltered inlets.

A review of partial records of marine events (such as regattas and fireworks displays), which must be registered in advance with the USCG District Office, indicate a powerboat race was held in June 2002 off Yarmouth near Parkers River. The course was located approximately 5.4 nautical miles (10 km) northeast of the nearest proposed WTG location. The race was not held in 2003.

Recreational fishing is described in Section 5.4. Navigation and transportation are described in Section 5.12.

5.10.3.2.4 Visual Character and Setting in State Waters

The existing seascape in state waters of Nantucket Sound contains an expanse of open but sheltered water, rimmed by the generally low landforms of the Cape and Islands. Within state waters, existing structures and development along the nearest shoreline are more noticeable than in federal waters. The enhancement of summer tourism is a major economic force. The character of the seascape remains unified and is consistent with a natural nearshore marine environment in southern New England. Visible in the summer months are many recreational and fishing boats and ferries using state waters, as well as navigational aids and aircraft flying overhead. The aircraft include small airplanes towing large advertising banners over area beaches on sunny days. Tankers, freighters and other large commercial ships typically avoid the shallow drafts and shoals of the Sound.

5.10.3.3 Onshore

5.10.3.3.1 Onshore Prehistoric Archaeological Resources

Two archaeological surveys have been completed along the onshore cable route under MHC permits, as described in Section 5.10.2.4. The first, a terrestrial (onshore) reconnaissance survey to assess the archaeological sensitivity of two alternative upland routes, was completed in the Spring of 2003. The second, an intensive (locational) archaeological field survey of the Yarmouth upland route to assess the presence or absence of archaeological sites, was completed in November 2003. Findings are summarized below and in the following section; a copy of the technical report presenting both surveys is presented in Appendix 5.10-D. In summary, no archaeological sites meeting the criteria for eligibility for listing on the NRHP were found along the proposed upland route; no further archaeological investigations were recommended. By requesting copies of the report as final, MHC accepted these recommendations (see letter dated April 22, 2004 in Appendix 5.10-E).

The surveys were conducted along the proposed Yarmouth – Barnstable onshore cable route. The proposed electric transmission line is approximately 5.9 miles (9.5 km) long and is situated partly beneath paved roadways and partly beneath existing vegetated utility easements.

Ten recorded prehistoric archaeological sites have been reported within 1.5 miles (2.4 km) of the Yarmouth route, although none of these is located directly within the Project corridor. A number of these sites have been recorded by avocational archaeologists; little information regarding their size, content or significance is available. MHC files indicated six Native American burials were located east of the proposed route in Yarmouth; no further information was available. This area would not be within the cable route's APE. Locations of archaeological sites are considered confidential to protect the integrity of the sites, and are not shown in this document or the report in Appendix 5.10-D.

Following a driveover survey and review of existing roadway and utility plans, PAL determined that the existing belowground utilities located to either side of the proposed trench, combined with the grading and filling associated with roadway construction and maintenance, affected the likelihood that intact archaeological deposits could be located in these areas. PAL assigned the 18,000-foot (5.5 km) paved roadway portion of the onshore Project area a low archaeological sensitivity, since the cable would be trenched beneath the existing pavement in areas already disturbed by the construction and maintenance of the roadways and existing in-road utilities.

The majority of the onshore cable route within the existing NSTAR easement was assigned a moderate archaeological sensitivity, based on existing environmental conditions and the proximity to known sites.

An intensive (locational) survey of the onshore transmission line route was recommended by PAL and was conducted during the fall of 2003, under Permit No. 2595 from the State Archaeologist (see Appendix 5.10-E). The purpose of the survey was to identify previously unrecorded prehistoric or historic archaeological sites within the Project's APE. Design plans for onshore cable installation within the paved 18,000 linear feet (5.5 km) of paved public roadways (Berry Avenue, Higgins Crowell Road and Willow Street in Yarmouth) call for the proposed cable trench to be placed beneath the center of the roads to avoid existing belowground utilities along both sides of the road.

One low-density prehistoric site that appears to have been heavily disturbed was identified along the NSTAR ROW during the intensive survey. While the recovered materials (four pieces of stone chipping debris) provide documentation of prehistoric use of the general area, the archaeological deposits were not considered by PAL to represent potentially significant cultural resources. No further archaeological investigation of this site or within the onshore cable route was recommended by PAL. MHC concurred with these recommendations (see Appendix 5.10-E). PAL's technical report presenting the intensive survey results is included in Appendix 5.10-D, without locational information pertaining to archaeological sites (which has been provided to MHC).

5.10.3.3.2 Onshore Historic Archaeological Resources

No known historic archaeological sites are located within 1.5 miles (2.4 km) of the proposed onshore cable route. As noted above, an intensive (locational) survey to identify previously unknown archaeological sites within the APE along the cable route was conducted during the fall of 2003. No evidence of historic structures was identified in the Project's APE through the documentary research or subsurface testing. The tested portion of the Project corridor along what is now the NSTAR ROW appears to have functioned historically as open or wooded house lots. The limited historic cultural materials collected during the testing represent field trash and/or refuse deposited in low to moderate densities over the past century. No historic archaeological sites were identified during the survey, and PAL recommended no additional archaeological investigation along the onshore cable route. The technical report is included in Appendix 5.10-D; by acceptance of the report as final, MHC concurred with the recommendation for no further archaeological investigation of the onshore cable route (see letter dated April 22, 2004 in Appendix 5.10-E).

5.10.3.3.3 Onshore Historic Structures and Districts, Visual Character and Setting

Since the cable route would be located beneath public roadways or within the existing NSTAR easement, no historic properties listed or eligible for listing on the National Register are located within the Project's APE for ground disturbance along the onshore route. There are over 30 recorded buildings in the hamlets of West Yarmouth and Englewood in the vicinity of the landfall, which are included in MHC's Inventory. While not considered a historic district, a number of these buildings date from the early 1700s to late 1800s and are documented as belonging to sea captains or other wealthy residents of Yarmouth. The buildings are arranged in

three clusters in Englewood. There are no other historic structures recorded along the route northward to the NSTAR ROW.

Two historic buildings and an historic cemetery are located in Barnstable, approximately 0.25 to 0.75 miles (0.4 to 1.2 km) north of the cable route along the NSTAR ROW. Both historic buildings are off Marstons Lane; the cemetery is located on Mary Dunn Road.

Onshore Historic Structures and Districts Within Viewshed

According to the National Park Service web site (www.cr.nps.gov/nr/listing.htm), accessed September 2, 2003), the:

> *"quality of significance in American history, architecture, archeology, engineering, and culture is present in districts, sites, buildings, structures and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:*
> *A. That are associated with events that have made a significant contribution to the broad patterns of our history; or*
> *B. That are associated with the lives of persons significant in our past; or*
> *C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or*
> *D. That have yielded, or may be likely to yield, information important in prehistory or history."*

A through D, above, are the NR criteria for eligibility.

The 12 existing historic structures and districts listed or eligible for listing on the National Register that may potentially be visually affected by the built Wind Park are described below. The National Register eligibility criteria that each possesses is noted, if an MHC determination has been made. A description of the visual character and setting at each of the 12 visual simulation locations is presented, based upon field reconnaissance, background research, and review of NRHP Inventory Nomination Forms, where available, and other documentation in MHC files. These 12 locations are listed on Table 5.10-2.

Potential Project effects would be assessed in Section 5.10.4, and occur if the undertaking's effect(s) may alter the characteristic or use of the property that qualified the property for inclusion in the National Register [36 CFR Part 800, Section 800.16(d) and 33 CFR Part 325, Appendix C Paragraph 15(a)]. Descriptions of the visual simulations showing the built Project from each location are provided in Section 5.10.4.3.1.

Recreational resources in the vicinity of each simulated viewpoint are also identified. Photographs showing the historic structure, the existing daytime view toward the proposed Wind Park, and the character of the surrounding area at each simulated viewpoint are described below, and are shown on specified sheets within the 64-sheet Figure 5.10-2.

It is important to note that many other locations were visited and photographed as part of the documentation of historic properties in the APE. Also included below are summaries of viewpoints at other nearby historic properties which were visited and found to have no views or limited views of the Project, and therefore were not recommended for visual simulation. These visited locations are included in Table 5.10-1.

Daytime and night time views of the proposed Project from each of the 12 simulated viewpoints are shown on Figures 5.10-3 (Sheets 1-12) and 5.10-4 (Sheets 1-11) respectively. These simulated views are discussed in Sections 5.10.4.3.2 (onshore historic structures and districts) and 5.10.4.3.3 (recreational resources).

Sheet numbers referenced below are included in Figure 5.10-2. Locations of each viewpoint (VP) are shown on Figure 5.10-1, as well as on aerial photographs on sheets specified below within Figure 5.10-2.

South Side of Cape Cod

- *Nobska Point Light Station, Woods Hole, Falmouth (VP-1 on Figure 5.10-1; Character photos on Figure 5.10-2, Sheets 1-7)*

The Nobska Point Light Station complex dates from 1876, when the existing white cylindrical tower was constructed to replace a navigational light atop a keeper's dwelling that had operated since 1828. The light is a major navigational aid located on a rocky headland near the entrance to Woods Hole Harbor. A photograph of the structure and the existing view toward the proposed Wind Park is shown on Sheet 1; locations of these photographs are shown on Sheet 2. The complex consists of the 40-foot-high light tower with entry porch (1876), two keeper's dwellings (1876, 1990) connected by a porch, a brick oil house (1876), paint lockers (1876), garage (1931) and a radio beacon building (1937). The light has been unmanned and automated since 1985.

The Light Station complex is listed on the National Register as part of the Lighthouses of Massachusetts Thematic Group. The 2.11-acre (0.009 km^2) site is largely bare of vegetation and the white tower can be seen clearly from all directions. According to MHC's Lighthouse Information Form (MHC, 1981) "the Light possesses integrity of location, design, setting, materials and workmanship as well as significant associations with the development of aids of navigation in Massachusetts. It is important for its scenic qualities, sited on a bluff overlooking Vineyard Sound, and for its strategic location. The complex meets criteria A and C of the National Register on the state level."

Visitors to the historic lighthouse are presented with open views of Nantucket Sound (see Sheet 1) from the southeast to the southwest, including views of Martha's Vineyard. The base of the light is publicly accessible, and a plaque provides historic information to visitors that park at a small adjacent lot.

Character photos of the area around the Nobska Light are shown in Viewpoint 1 photographs on Sheets 4-6. Locations are shown on Sheet 2. The area is generally characterized by low to medium-density residential land use, with commercial use in the village of Woods Hole to the northwest. Large homes are generally scattered along winding roads among low wooded hills. Views toward the water from most roads and residences are generally well screened by trees. Open views easterly toward the Project site are available from Fay Road, and are expected from the easterly and southeasterly-facing upper stories of area homes. Open views of the proposed Wind Park were not found in Woods Hole village.

- *Other nearby viewpoints not selected for simulation*

A representative historic structure and the view toward the Wind Park from the southern end of Viewpoint 2, the locally-designated Woods Hole Historic District, are shown on Sheet 6. The location of Viewpoint 2 is shown on Sheet 2, and was the only ground-level location found within this district with some view of Nantucket Sound toward the proposed Wind Park. The view is partially blocked by the point of land at Nobska Light and by Martha's Vineyard.

Viewpoint 3 at the Woods Hole School on 24 School Street is shown on Sheet 6. Photograph Viewpoint 3-CE-4 on Sheet 7 shows no view of Nantucket Sound at this interior historic property.

A representative photograph of Viewpoint 4 in the locally designated East Falmouth Historic District is shown on Sheet 7; the location is shown on Sheet 3. No ground-level views of Nantucket Sound toward the Wind Park were found in this historic district.

- *Cotuit (See Figure 5.10-1 for VP 5; Character photos in Figure 5.10-2, Sheets 8-11), Town of Barnstable*

The Village of Cotuit Historic District is included in the Town of Barnstable Multiple Resource Area (MRA), which was listed on the National Register on November 10, 1987. Other Barnstable MRAs in the vicinity of the Project viewshed and described in this section include historic districts in Wianno, Craigville, Centerville, and Hyannis Port.

The Cotuit Historic District, westernmost of the villages in Barnstable, occupies a neck of land surrounded by Popponesset Bay to the west, Nantucket Sound to the south, and Osterville Harbor to the east. Most of the 107 buildings in the district are residential, although some commercial and institutional buildings have also been designated in the village colonial center. A representative historic structure is shown on Sheet 8.

Character photos of the district are presented on Sheets 10-11; locations are shown on Sheet 9. Public access and views to the shoreline and south-southeasterly toward the proposed Wind Park are limited. Street level

views toward the water are generally broken/partially screened by vegetation and structures. However, views are likely available from many of the large shoreline homes, especially from the upper stories.

The National Register Criteria Statement found the Cotuit Historic District significant as a major collection of 19th and early 20th century buildings related to the maritime industries and summer resort activities. The district was determined to possess integrity of location, design, setting, materials, workmanship, feeling and association, and to meet criteria A, B, and C of the NRHP (MHC, Village Summary Sheet: Cotuit, 1987).

Cotuit was first settled in the early 1700s in the interior Santuit area, near what is now Route 28, to utilize fertile lands and early transportation corridors. As local economies shifted from land-based activities to the maritime industries in the early 19th century, the settlement shifted to the shore along the west side of Cotuit Bay. Key maritime activities included oystering, fishing, shipbuilding, coastal trade, and salt making. Many of the houses in the district were built by ship captains, and reflected their wealth. As the maritime trades ebbed in the late 19th century, summer residents discovered the village. Federal and Greek Revival architectural styles represent the district's early seafaring heritage, while later Italianate, Second Empire, Gothic Revival, Queen Anne and Colonial Revival structures reflect the area's later evolution into a quiet summer resort.

Most buildings are framed by mature wooded vegetation. Cotuit has retained a quiet, settled atmosphere due to its location several miles from busy main routes. Its small harbor offers moorings for many boats, and the village has an active local sailing program. The village is traditionally known for its oysters, which continue to be harvested in Cotuit Bay. Oyster Harbors, a gated community of large seasonal homes, is located across Cotuit Bay to the east and is not included in the Barnstable MRAs.

- *Wianno (See Figure 5.10-1 for location of VP 6; Character photos in Figure 5.10-2, Sheets 12-16)*

The Wianno Historic District in the Village of Osterville is comprised of 28 main buildings and 13 outbuildings on approximately 40 acres (0.16 km^2) along Sea View Avenue and Wianno Avenue. The lands were originally assembled in the late 19th century by a consortium of businessmen and developed as a summer colony. The large well-kept lots on either side of Sea View Avenue along Nantucket Sound contain grand Shingle Style and Colonial Revival style summer houses, most of which were constructed between the late 19th century and World War I.

The focal point of the Wianno Historic District is the Wianno Club on Sea View Avenue, a massive three-story shingled main building and two-story rear ell, both with mansard roofs. The Wianno Club is shown on Sheet 14, photograph Viewpoint 6-CE-10. The structure was designed by architect Horace Frazer of Boston (who also designed a number of private residences in the district). The Club overlooks Nantucket Sound on almost 1,000 feet (304 meters) of beach frontage. The building is described as architecturally extremely significant, as much of its original and interior detailing survives. The structure was individually listed in the National Register in 1979, and was listed as a Barnstable MRA in 1987.

On the Sound side of Sea View Avenue, which runs parallel to the shore, the structures are regularly spaced with open well-maintained lawns and unobscured views toward the Wind Park site to the south. Across Sea View Avenue, views toward the Wind Park site are limited to areas between intervening structures. Mature trees and large hedges also effectively screen views.

The National Register Criteria Statement found the Wianno Historic District in excellent condition, and possessing integrity of location, design, setting, materials, workmanship, feeling and association. It is significant as one of three well-preserved summer resort colonies developed in Barnstable in the late 19th century, and contains an extraordinary collection of Colonial Revival and Shingle Style architecture. The district is also significant for its association with a notable Boston architect and many prominent seasonal residents. The district meets criteria A, B, and C of the NRHC (MHC, Wianno Historic District Form B, 1986).

- *Other nearby areas visited but not selected for simulation*

No views toward the water to the south were found in the Village of Osterville.

- *Craigville, Town of Barnstable (See Figure 5.10-1 for location of VP 7; Character photos in Figure 5.10-2, Sheets 17-20)*

Craigville is located at the center of a large crescent-shaped sandy beach system bordered by headlands at Wianno in Osterville on the west and Squaw Island in Hyannis Port on the east. Open views of Nantucket Sound to the south are available from this large beach system. The busy shorefront area contains popular public, semi-private and private beaches and associated parking areas, as described in Section 5.10.3.3.4. The most open and extensive southerly views toward the water and the Wind Park are from Craigville Beach, the bluff above the apex of Craigville Beach, and shorefront homes on Long Beach Road in Centerville.

The Craigville Historic District includes 33 buildings and one park within the larger village of Craigville. The southernmost boundary of the historic district is 0.25 mile (0.4 km) north and topographically low compared to the bluff overlooking Nantucket Sound, from which VP 7 was taken (see Sheet 17; for locations see Sheet 18.) The district is limited to the core of the original development of the earliest buildings associated with a camp meeting ground developed by the New England Convention of Christian Churches in the 1870s. Although most of the structures in the district are now privately owned summer homes, the Craigville Conference Center owns the Craigville Inn and runs religious retreats. The district is within the interior portions of Craigville, does not extend to the bluff above Craigville Beach, is well vegetated and has no open views of Nantucket Sound. Representative historic structures within the district are shown on Sheet 20 (Viewpoint 7 CE-7 and CE-8). The structures on the bluff at VP 7 have not been determined eligible for listing on the National Register.

The focus of the Craigville camp meeting ground was the Tabernacle, a simple wooden church constructed in 1887, at the head of a triangular shaped park. The Tabernacle is shown on Sheet 20, Viewpoint 7-CE-8. The Craigville Historic District was determined to possess integrity of location, design, materials, workmanship and feeling, and meets criteria A and C of the National Register. It was found to be significant for its association with the Christian camp meeting movement the 19th century, and contains a well-preserved collection of associated buildings (MHC, 1985).

The religious campground settlement was similar to other earlier Methodist camp meetings in Eastham, Yarmouth and Martha's Vineyard, and drew lay people and ministers who journeyed by train then carriage or barge for summer services. The architecture is very similar to the Yarmouth Camp Ground Historic District (MHC No. YAR.B), which is located in an interior wooded location just south of the mid-Cape Highway (Route 6) at Exit 7 and several miles north of Nantucket Sound. The Yarmouth Camp Ground Historic District also has no open views of Nantucket Sound.

- *Other nearby areas visited but not selected for simulation*

The Centerville Historic District, which contains 49 buildings and one object along Main Street, does not offer ground-level views of Nantucket Sound toward the Wind Park; representative character photographs of Centerville are provided on Sheet 19.

- *Hyannis Port, Town of Barnstable (See Figure 5.10-1 for location of VP 8; Character photos in Figure 5.10-2, Sheets 21-28)*

The summer community in the Hyannis Port Historic District is characterized by large, well-maintained colonial and shingled Victorian beach homes. The district contains 127 buildings on 1,000 acres (4.0 km^2), and is roughly bounded by Massachusetts Avenue and Edgehill Road, Hyannis Avenue, Hyannis Harbor and Scudder Avenue. A representative historic structure is shown on Sheet 21. Character photographs are shown on Sheets 25-28; locations of the photographs are shown on Sheets 22-24. Open views of the water to the south-southwest are available along the shorefront (see Sheet 21, bottom photograph), and intervening structures and vegetation provide broken views from the road and near shore locations. Public access to the shoreline is very limited.

The Kennedy Compound is located along the shore within the Hyannis Port Historic District and is also represented by VP 8. The Compound was listed as a National Historic Landmark in 1972. The Compound contains approximately 6 acres (0.02 km^2) of waterfront property on Nantucket Sound, and includes the white clapboard residences that formerly housed Kennedy family patriarch Joseph P. Kennedy and his sons Robert F. Kennedy and John F. Kennedy (U.S. Department of the Interior, 1972). The largest is the Joseph P. Kennedy house, where the family summered starting in 1926, and where Rose Kennedy lived until her death in 1995. The smaller houses were purchased by the sons for their families, and together comprise the Kennedy Compound. The Compound was the base of John F. Kennedy's presidential campaign in 1960, and served as the Summer White House in 1961. Subsequent presidential summer stays were nearby at Squaw Island, which provided

better security and privacy. Although the Compound itself was not visited during the field reconnaissance, observations from adjacent locations indicate that open views of the proposed Wind Park would be available from the Kennedy Compound.

- *Other nearby areas visited but not selected for simulation*

Other historic districts and properties visited during field reconnaissance in Hyannis, Yarmouth, Dennis, Harwich and Chatham are listed on Table 5.10-1. Locations are shown on Figure 5.10-1, and on the appropriate sheets in Figure 5.10-2. These locations either did not have open views of Nantucket Sound, or were not designated historic properties, and were therefore not selected for simulation.

- *Monomoy Point Lighthouse, Town of Chatham (See Figure 5.10-1 for location of VP 26, Character photo in Figure 5.10-2, Sheets 31-33)*

The Monomoy Point Lighthouse is located at the southern end of Monomoy Island, a coastal barrier beach island extending approximately 10 miles (16.1 km) south of the Cape's elbow at Chatham. The island is an uninhabited coastal dune and marsh complex, and comprises most of the Monomoy National Wildlife Refuge managed by the U.S. Fish and Wildlife Service. The island is accessible only by boat, and little human disturbance or development is evident except for footpaths and the historic lighthouse and its associated buildings. The land form is characterized by rolling dunes and bluffs, with beach grass and sparse, scattered woody vegetation. Marshes and open water dominate views near the shoreline.

Wildlife such as gulls, terns and seals are abundant and add to the remote and undeveloped character of the island. The island is a National Wilderness Area, although the parcel that contains the lighthouse is not included in that designation. The Massachusetts Audubon Society has owned the parcel since 1977. A lighthouse has occupied the site since 1823. The present light was constructed around 1871. The lighthouse complex is unmanned, and includes a brick light tower and a two-story keeper's house, both of which have deteriorated. The complex was determined significant in the areas of engineering, exploration and settlement, and transportation.

North and East Sides of Martha's Vineyard

- *Oak Bluffs, Martha's Vineyard (See Figure 5.10-1 for location of VP 21, Character photographs Figure 5.10-2, Sheets 45-50)*

This island village area is characterized by fairly high-density residential and commercial land use. Topography is relatively flat, except for a steep shoreline bluff. The lack of topographic relief and abundant structures tend to screen views toward the water from the interior of the area. The most open easterly-northeasterly views toward the Project are available along East Chop Avenue, Sea View Avenue and Ocean Avenue, as well as from residences along these roads, and from the East Chop Lighthouse. Ocean Park on Ocean Avenue (the selected viewpoint) also offers unobscured views toward the Project.

VP 21 is representative of open views from East Chop Light and the Dr. Harrison A. Tucker Cottage at 65 (formerly 42) Ocean Avenue in Oak Bluffs, which are both listed on the National Register.

The Tucker Cottage was originally built in the American Stick Style in 1872, and then was substantially altered into a large Queen Anne summer house in 1877. The house and carriage house is part of the Ocean Park neighborhood of large, late 19th century summer homes, near the Methodist camp meeting ground at Wesleyan Grove (see Martha's Vineyard Campground Historic District, below).

The street pattern of Ocean Park is a curvilinear series of narrow streets around Ocean Park, a 7-acre (0.03 km^2) semi-circular green space that faces Sea View Avenue and the Sound beyond. The Tucker Cottage overlooks the bandstand at Ocean Park on Ocean Avenue, the innermost crescent along the Park. The Dr. Harrison A. Tucker Cottage was determined to retain integrity of location, design, materials, workmanship, feeling, and association, and meets Criteria B and C of the National Register of Historic Places (U.S. Department of the Interior, 1990).

The East Chop Lighthouse is located on the highest bluff on East Chop, on the east side of Vineyard Haven Harbor. The cast-iron lighthouse was constructed in 1878, to replace a private lighthouse that was destroyed by fire. Open views toward the Wind Park are available from this structure.

The West Chop Lighthouse, on the western side of Vineyard Haven Harbor, was originally constructed in 1817, replaced with the present brick tower in 1838, and was moved back from the sea in 1848 and 1891. Views toward the Wind Park are screened by a line of white pines from roadside by the West Chop light, which is posted private property. Ground level views from the property itself are expected to be screened by the trees, although open views from atop the light are anticipated. Both East Chop and West Chop lighthouses have protected mariners entering Vineyard Haven Harbor since Colonial times, and both are listed on the National Register's multiple listing of lighthouses on Martha's Vineyard.

- *Other nearby areas visited but not selected for simulation*

Several other historic properties or districts in Oak Bluffs have more limited views of Nantucket Sound toward the Project area, due to screening provided by mature vegetation such as shade trees and intervening structures. These include the Martha's Vineyard Campground Historic District in Oak Bluffs (also called Wesleyan Grove), which contains 306 19th century cottages and 6 public buildings on 34 acres. The district is located close to, but does not border, Nantucket Sound. No ground level views of Nantucket Sound were found within this district. The campground was founded in 1835 as a summer Methodist meeting area; the first participants stayed in tents that were later replaced by small cottages. The focal points of the camp are the iron Tabernacle and the Trinity Methodist Church, both located on Trinity Park near the center of the campground. The typical campground cottage is a simple 1.5-story rectangular structure, approximately 15 feet wide by 20 feet deep. Porches, typically late 19th century additions, are heavily ornamented with trim. Much of the historic district is shaded with mature trees and other vegetation. The Martha's Vineyard Campground is significant for its unique architecture, state of preservation, and its association with 19th century religious practices (U.S. Department of the Interior, 1978).

Religious activity in the 19th century caused the campground to grow rapidly. The original week-long religious meeting in August evolved as people began arriving earlier in the summer, sparking the resort development of the adjacent area. The resulting town of Cottage City was created in 1880, and was renamed Oak Bluffs in 1907.

The Oak Bluffs Christian Union Chapel (known as Union Chapel) is west of Ocean Park and close to the Methodist campground of Wesleyan Grove. The chapel was built in 1870 in the American Stick Style. The mature vegetation around the church partially obscures the chapel from contiguous streets, and fully screens the chapel from views of Nantucket Sound. The chapel exhibits integrity of location, design, materials, workmanship, feeling and association, and meets Criteria A and C of the National Register (U.S. Department of the Interior, 1990).

The Flying Horses Carousel at 33 Oak Bluffs Avenue is located in the business district of Oak Bluffs. It is listed on the National Register, and has also been listed as a National Historic Landmark since 1987. The carousel of 20 prancing horses and four chariots has operated at this location since 1889, and is indicative of the late 19th century interest in amusements and recreation at summer resorts such as Oak Bluffs. The Flying Horses Carousel possesses integrity of location (since 1889), design, material, workmanship and association, and is significant as the oldest platform carousel operating in the United States (U.S. Department of the Interior, 1979). No open views were available from this structure.

The Arcade at 31 (formerly 134) Circuit Avenue is a commercial building listed on the National Register. No ground level views of the Wind Park are available from this building, which is surrounded by other commercial buildings and shops along this busy street in downtown Oak Bluffs.

Limited views to the north-northeast are available from West Chop, a residential area in Tisbury. Views toward the Wind Park site are not generally available from the center of Vineyard Haven.

- *Edgartown, Martha's Vineyard (See Figure 5.10-1 for location of VP 20; Character photos Figure 5.10-2 , Sheets 38-44)*

This island colonial village area has relatively high-density residential and commercial land use, with well-maintained large homes, small shops, inns and restaurants connected by narrow streets. Public views toward the water from the village area are generally partially or fully screened by intervening structures and vegetation. Views toward the Wind Park to the northeast are available from shoreline residences and associated private beaches. The only publicly accessible open northeasterly views are from Water Street and Lighthouse Beach. The selected viewpoint VP 20 is the most open view from a historic site (the Edgartown Lighthouse at the

entrance to Edgartown Harbor). Almost all other views toward the Wind Park site from Edgartown are partially blocked by Chappaquiddick Island.

The Edgartown Village Historic District comprises approximately 150 acres (0.61 km^2) along the west side of Edgartown Harbor. The district contains approximately 500 contributing buildings (constructed pre-1933), mostly wood frame houses of the 19th and early 20th centuries. A smaller, locally designated district (the Edgartown Local Historic District) is contained within the National Register District. The village's two major periods of significance relate to late 18th to 19th century whaling activities, and late 19th century to present day summer tourism. Architectural styles vary from First Period Colonial (circa 1650's to 1750), late Georgian and Federal sea captains homes, Greek Revival, Victorian and Colonial Revival. The boundaries of the historic district do not extend to Nantucket Sound except at Edgartown Light (also called the Harbor Light Lighthouse), but views of the Sound to the east and northeast are available from easternmost structures within the district.

The Edgartown Lighthouse is located on a rock breakwater off a spit along the northeastern side of Edgartown Harbor. The original lighthouse at the eastern end of the Harbor was built in 1828 and destroyed following the Hurricane of 1938. This structure was replaced by a cast-iron lighthouse that originally stood at Crane's Beach in Ipswich, and was disassembled and moved by barge to Edgartown in 1939. The structure is part of the Lighthouses of Massachusetts multiple listing on the National Register, and is one of five lighthouses included on the listing within Martha's Vineyard.

- *Cape Poge, Edgartown, Martha's Vineyard (See Figure 5.10-2 for location of VP 19; Character photos in Figure 5.10-2, Sheets 34-37)*

This largely natural area on the north side of Chappaquiddick Island is protected by the Massachusetts Trustees of Reservations. The area contains dunes and low coastal vegetation, bordered in places by a steep 20- to 30-foot (6.1 to 9.1 m) high sandy bluff at the ocean shoreline. The area is undeveloped other than perhaps 5 to 10 large homes and several unimproved sand roads. Cape Poge offers expansive views at and near the shoreline. Once away from the shoreline, including at the base of the lighthouse discussed below, the dunes and dune vegetation effectively screen most views toward the water.

The Cape Poge Lighthouse at VP 19 is one of the five lighthouses on Martha's Vineyard listed on the National Register. Built in 1922 on the northeastern tip of Chappaquiddick, the present wood-shingled lighthouse replaced several earlier decaying towers, the earliest of which was constructed in 1802. Encircling the top of the tower is a simple cast iron balustrade. The windows and doorway are pedimented.

North Side of Nantucket

Nantucket Village is a densely settled classic colonial New England maritime community on the western side of Nantucket Harbor. The entire island, including Muskeget and Tuckernuck Islands to the west, comprises a National Register Historic District and was also designated as a National Historic Landmark in 1966. Muskeget Island was designated as a National Natural Landmark in 1980, as the only known locality where the Muskeget vole is found and the southernmost area where the gray seal breeds (National Registry of Natural Landmarks, 1999).

The historic character of the village is defined by the clean pious lines of the houses of former sailors, fishermen and clergy as well as the grand federal-style mansions of former ship captains and owners. These varied structures are linked by cobblestone streets and shaded with large street trees. Views of the northwest toward the Project site are not available at ground level within Nantucket village itself (although views may be available from the upper stories of some buildings) or from the docks and wharfs along the western side of Nantucket Harbor. Representative photographs of Nantucket Village and locations are provided on Sheets 52-58. The simulation location is discussed below.

- *Nantucket Cliffs along Cliff Road, North of Nantucket Village Center (See Figure 5.10-1 for location of VP 22; Character photos in Figure 5.10-2, Sheets 51-52)*

Upon leaving the village area and heading to the northwest, narrow roads traverse a landscape of rolling dunes and low-density residential development. The dunes and vegetation tend to block views toward the water. An open area atop the shore-facing bluff along Cliff Road (the selected Viewpoint 22) offers the first open views toward the Wind Park. The beach below also offers unobscured views. The beach continues to the west to the

Eel Point conservation area at Madaket. Homes along the north shore and associated private beaches also have open views toward the Wind Park, as does the shorefront area off Cliff Road to the east to Jetties Beach at West Jetty. Public access to the north-facing beaches is generally limited, and as one moves inland, views of the water toward the Wind Park quickly disappear.

- *Great Point, Nantucket (See Figure 5.10-1 for location of VP 23, Character photos in Figure 5.10-2, Sheets 59-61)*

Great Point is a unique undeveloped beach area that forms the northeastern most part of Nantucket, and separates the Atlantic Ocean to the east from Nantucket Sound to the west. Characterized by crashing surf, rolling sand dunes, low beach grass and tidal marsh, the area is a remote and wild setting. The point is managed by the Trustees of Reservations, and is accessible only by four-wheel drive along a sand track. The Nantucket Light (also called Great Point Light or Sandy Point Light) and the immediately surrounding land constitute the historic property. Lighthouses have operated at Great Point since 1789. The existing unmanned masonry structure was constructed in 1818, and is one of the oldest existing lighthouse structures in the state.

Great Point Light was determined to possess integrity of location, design, setting, materials and workmanship, as well as significant associations with the development of aids to Massachusetts navigation. The tower is the first landfall on Nantucket seen from the Atlantic Ocean, and meets criteria A and C of the NRHP.

The Nantucket Conservation Foundation protects barrier beach south of the Great Point area. The area is remote and is characterized by ocean surf on the east, sand dunes and salt marshes. The area is largely undeveloped with only one or two private homes, a sand road, and the Great Point lighthouse, which is a visual focal point. Panoramic open views in all directions are available from many locations on Great Point, as well as along the sand access road, where not screened by sand dunes. The viewpoint from Great Point is representative of open views toward the Wind Park from the Wauwinet area of Nantucket.

- *Tuckernuck Island (See Figure 5.10-1 for location of VP 24, Character photos in Figure 5.10-2, Sheets 62-64)*

Tuckernuck Island is roughly 2 miles (3.2 km) long and 1 mile (1.6 km) wide, and is located approximately 1 mile (1.6 km) west of Nantucket Island and 8 miles (12.9 km) east of Martha's Vineyard. This sparsely settled island off the western tip of Nantucket is accessible by boat only. The island is composed of moraine deposits (in the rocky northwestern portion of the island), sandy outwash plains along the south, and sand dunes.

The island contains about 30 to 40 seasonal cottages and larger homes, and a network of sand roads. The historic houses on Tuckernuck are clustered within two groupings, one around North Pond (on the northwest side of the island) and one around East Pond, and consist of wood-frame shingle-clad structures that generally reflect early fishing, hunting and livestock grazing economies. Topography is generally flat and vegetation consists of low to medium height shoreline scrub. Vegetation is taller and denser in the interior of the island, and more open and sparse near the shoreline. As a result of the level topography and scrub vegetation, views toward the Project are concentrated near the shoreline and from private residences.

5.10.3.3.4 Onshore Recreational Resources

Onshore Cape Cod, Nantucket, Martha's Vineyard (and the state waters of Nantucket Sound) are well known for coastal recreational and summer tourism activities including beach going, swimming, boating, fishing, hiking, biking, picnicking, golfing and bird watching. Marinas, yachts clubs and public boat ramps line most of the harbors and inlets with sufficient water depths.

Sandy beaches nearly continuously rim the Cape and Islands landforms, supplied with sediments deposited by receding glaciers and reworked since then by fluvial processes (see Section 5.1). The shorelines around Nantucket Sound are generally developed with large seasonal shorefront homes or shorefront resorts and associated private beaches, most constructed during the 20th century. The public beaches attract thousands of recreational users in the summer months. Public and semi-private beaches (such as association and resident-only beaches) with expected open views toward the Project are listed on Table 5.10-4, as are conservation areas and other recreational resources such as golf courses and bike paths with expected open views toward the Project. Simulation locations from representative historic sites are provided in the tables for each resource, to capture a sense of the overall anticipated visual change at the recreational area due to the Project. Due to the

generally level topography, mature wooded vegetation, and intervening structures found on the Cape and Islands, open views were generally limited to recreational areas in the immediate vicinity (i.e., within approximately 300 feet (91 m)) of the shoreline. Recreational resources identified from the MassGIS database are shown on Figure 5.10-5.

Large areas of undeveloped protected shoreline are found along Monomoy Island south of Chatham, Cape Poge on Chappaquiddick Island on Martha's Vineyard, and Tuckernuck Island and Great Point in Nantucket. Representative simulations were prepared for each of these three locations, as well. Onshore recreational resources in the vicinity of each of the simulations are identified below.

South Side of Cape Cod

- *Nobska Point Light Station, Woods Hole, Falmouth (See Figure 5.10-1 for location of VP 1; Character photos in 5.10-2, Sheets 1-7)*

Visitors to the historic lighthouse are presented with open views of Nantucket Sound from the southeast to the southwest, including views of Martha's Vineyard. The base of the light is publicly accessible, and a plaque provides historic information to visitors that park at a small adjacent lot. The surrounding area is residential, with large homes scattered along winding roads among low wooded hills. The popular Shining Sea Bike Path meanders through woods and along the shore near this area.

Heading easterly from Woods Hole to Cotuit (described below) are popular shorefront areas in Falmouth, and Falmouth Heights, as well as a number of small parks (see Table 5.10-4). The shoreline is nearly continuously rimmed with wide sandy beaches and contains large waterfront resorts, public beaches, and many seasonal homes with associated private beaches. These areas have open views of Nantucket Sound to the south.

- *Cotuit, Town of Barnstable (See Figure 5.10-1 for location of VP 5; Character photos in Figure 5.10-2, Sheets 8-11)*

Recreational resources in the vicinity of VP 5 are the Mashpee beaches, including South Beach State Park, the New Seabury beach, and Popponesset Beach, as well as Loop Beach in Cotuit. The New Seabury Country Club and golf course are also located in the vicinity of this viewpoint. The Waquoit Bay National Estuarine Research Reserve, a 3,000-acre (12.1 km^2) Area of Critical Environmental Concern (ACEC), bordering Falmouth and Mashpee, offers opportunities for passive recreation such as bird watching. Sampson Island, a 15-acre (0.06 km^2) Massachusetts Audubon Sanctuary and barrier island at the mouth of Cotuit Harbor between Cotuit and Oyster Harbors, and many local sailing and boating programs are located within Cotuit and Osterville Harbors.

- *Wianno (See Figure 5.10-1 for location of VP 6; Character photos in Figure 5.10-2, Sheets 12-16)*

A small Town Beach with limited parking is located on Wianno Avenue at the eastern end of Sea View Avenue. Open views of the Wind Park would be available from this location. Wianno Beach and the larger Dowses Beach in Osterville are also located in the vicinity of VP 6. Boating is a popular activity in the Osterville area, which includes a number of marinas.

- *Craigville, Town of Barnstable (See Figure 5.10-1 for location of VP 7; Character photos in Figure 5.10-2 , Sheets 17-20)*

Craigville is located at the center of a large crescent-shaped sandy beach system bordered by headlands at Wianno on the west and Squaw Island in Hyannis Port on the east. Open views of Nantucket Sound to the south are available from this large beach system. The popular public beaches of Craigville Beach, the Association Beach, and Covell Beach are located in the vicinity of this viewpoint, as well as associated beach parking areas. Several summer rental cottage communities are located on the opposite side of Craigville Beach Road, with a popular snack bar servicing beach-goers in the summer months.

The private Beach Club on Long Beach Road in Centerville abuts the western end of the large Craigville Public Beach. Private beaches are located adjacent to large shorefront homes down Long Beach Road. The Long Beach Conservation Area, a 3.5-acre (0.01 km^2) protected barrier beach at the west end of Long Beach Road, offers passive recreation with limited parking.

- *Hyannis Port, Town of Barnstable (See Figure 5.10-1 for location of VP 8; Character photos in Figure 5.10-2, Sheets 21-30)*

Private recreational resources near this viewpoint include the Hyannis Port Golf Club and the Hyannis Port Yacht Club, which have open views of the water to the south. Public access to the shorefront is extremely limited.

Heading easterly along the shore from Hyannis Port to Chatham are the communities of Hyannis around Lewis Bay, including the boat and ferry docks of Hyannis, the Hyannis beaches of Keyes, Sea Street and Kalmus Park, the private residential Point Gammon area, and the beaches and recreational areas in West Yarmouth, Yarmouth, Bass River, West Dennis, Dennis, Dennisport, Harwich, Harwich Port, Wychmere Harbor, and Chatham. These are listed in Tables 5.10-4 and 5.10-5, along with the distances and directions of the resource from the nearest viewpoints.

Open views of Nantucket Sound to the south-southwest are available from immediate shorelines of these areas, which include resorts and other accommodations, as well large seasonal homes and associated private beaches. Intervening topography, structures and vegetation typically screens views to the south and southwest from within Hyannis Inner Harbor and other smaller harbors to the east, such as Wychmere Harbor in Harwich Port.

- *Monomoy Point Lighthouse, Town of Chatham (See Figure 5.10-1 for location of VP 24, Character photo in Figure 5.10-2, Sheets 31-33)*

The 2,750-acre (11 km^2) island comprises most of the Monomoy National Wildlife Refuge managed by the U.S. Fish and Wildlife Service and is a National Wilderness Area, although the parcel that contains the lighthouse is not included in the designation. Monomoy is only accessible by boat, and visitation at night is prohibited. The island offers opportunities for swimming and boating, as well as passive recreation, such as bird and wildlife watching.

VP 24 is also representative of the views from the beaches of Harwich and Chatham, and from Harding Beach boat landing.

North and East Sides of Martha's Vineyard

- *Oak Bluffs , Martha's Vineyard (See Figure 5.10-1 for location of VP 21, Character photographs Figure 5.10-2, Sheets 45-50)*

VP 21 at Ocean Park is also representative of open views from East Chop Light in Oak Bluffs. Ocean Park is a 7-acre (0.03 km^2) park overlooking Nantucket Sound, with a bandstand that offers musical and other outside entertainment. The East Chop Lighthouse is both a scenic and historic attraction.

The Flying Horses Carousel at 33 Oak Bluffs Avenue is located in the business district of Oak Bluffs. The carousel of 20 prancing horses and four chariots has operated at this location since 1889, and is a popular tourist attraction. No open views of Nantucket Sound are available from this structure.

VP 21 and VP 20 (below) are indicative of views from the bike path from Edgartown Beach Road between Oak Bluffs and Edgartown, and from beaches along this roadway. The viewpoints are also representative of views from Felix Neck Wildlife Sanctuary and Sarson's Island Bird Sanctuary, and the Farm Neck Golf Course.

- *Edgartown , Martha's Vineyard (See Figure 5.10-1 for location of VP 20; Character photos Figure 5.10-2, Sheets 38-44)*

Views at VP 20 are indicative of views at Lighthouse Beach and the Harbor Light Lighthouse, as well as recreational resources south of Oak Bluffs, as identified above.

- *Cape Poge, Edgartown, Martha's Vineyard (See Figure 5.10-1 for location of VP 19; Character photos in Figure 5.10-2, Sheets 34-37)*

This largely undeveloped area on the north side of Chappaquiddick Island is protected by the Massachusetts Trustees of Reservations. The area contains dunes and low coastal vegetation, bordered in places by a steep 20- to 30-foot (6.1 to 9.1 m) high sandy bluff at the shoreline. The Cape Poge Lighthouse is one of the five lighthouses on Martha's Vineyard listed on the National Register. Built in 1922 on the northeastern tip of Chappaquiddick, the present wood-shingled lighthouse replaced several earlier decaying towers, the earliest of which was constructed in 1802.

A wide barrier beach open to the public extends to the south from Cape Poge Lighthouse. Several sand roads and a small number of large homes comprise the limited development. The Reservation offers expansive views

across Nantucket Sound to the northeast, although once away from the shoreline (including at the base of the lighthouse), the dunes and association vegetation effectively limit most views of the water. Fishing is popular along the barrier beach at Cape Poge.

North Side of Nantucket

- *Nantucket Cliffs along Cliff Road, North of Nantucket Village Center (See Figure 5.10-1 for location of VP 22; Character photos in Figure 5.10-2, Sheets 51-58)*

An open area atop the shore-facing bluff along Cliff Road (the selected Viewpoint 22) offers the first open views toward the Wind Park when coming from Nantucket Village. Cliff Beach below also offers unobscured views, and is representative of views continuing westerly to Dionis Beach, Capaum Beach and to the Eel Point conservation area at Madaket. Homes along the north shore and associated private beaches also have open views toward the Wind Park, as does the shorefront area off Cliff Road to the east to Jetties Beach at West Jetty. Public access to the north-facing beaches is generally limited.

- *Great Point, Nantucket (See Figure 5.10-1 for location of VP 23, Character photos in Figure 5.10-2, Sheets 59-61)*

Great Point is a unique nearly pristine beach area that forms the northeastern most part of Nantucket, and separates the Atlantic Ocean to the east from Nantucket Sound to the west. The point is managed by the Trustees of Reservations, and is accessible only by four-wheel drive along a sand track out to Nantucket Light.

The Nantucket Conservation Foundation protects barrier beach south of the Great Point area. The area is remote, and is characterized by ocean surf on the east, sand dunes and salt marshes. The area is largely undeveloped, with only one or two private homes, a sand road, and the Great Point lighthouse, which is a visual focal point. Panoramic open views in all directions are available from many locations on Great Point, as well as along the sand access road, where not screened by sand dunes. Beaches include Coskata Beach and Coatue Beach. The area offers opportunities for passive recreation.

- *Tuckernuck Island (See Figure 5.10-1 for location of VP 24, Character photos in Figure 5.10-2, Sheets 62-64)*

This island has several colonies of seasonal houses. No recreational resources available to the public were identified on the island itself.

5.10.4 Analysis of Impacts

Project impacts addressed in this section include those that may result in physical disturbance or alteration of cultural resources by Project construction/decommissioning, operation, or maintenance activities in marine or onshore areas and potential physical impacts on onshore recreational resources. Potential visual or noise impacts on historic properties which may affect the specific characteristic(s) of the property, such as location, setting or use, that resulted in a determination of eligibility for listing on the National Register [36 CFR Part 800, Section 800.16 (d) and 33 CFR Part 325, Appendix C, Paragraph 15 (a)] and visual impacts on recreational uses are also described.

The Project is not considered to have potential visual impacts on submerged prehistoric or historic resources. The visual simulation and impact evaluation methods described in this section were applied conservatively, generally providing a "worst case" portrayal of potential Project impacts. For example, the simulations were conducted using clear sky conditions that maximize visual contrast, at locations with little or no visual screening from topography or intervening vegetation available, and do not take into account factors such as the blocking effect of the curvature of the earth (because the degree of the effect could not be accurately determined at the time of this report, each turbine was "set" on the horizon, not in front or behind it) or haze on the horizon. Therefore, development of the Project is likely to result in somewhat less visual impact than indicated by the study results presented below.

5.10.4.1 Impacts Outside of Massachusetts Waters

Potential Project impacts to submerged prehistoric and historic archaeological resources in federal waters are limited to physical impacts to archaeological sites from Project construction/decommissioning, operation and maintenance, as discussed below.

5.10.4.1.1 Submerged Prehistoric Archaeological Resources

Physical Impacts

Results of the marine archaeological survey identified organic material interpreted as paleosols (ancient land surfaces) in limited areas within the easternmost portion of the WTG array. The extent of the paleosols and associated seismic signature on shallow geophysical data are highly intermittent, which is consistent with the destruction of former land surfaces that likely occurred during the Holocene marine transgression. Avoidance of ground disturbing activities was recommended in these limited areas where sub bottom profiler reflectors correlating to the intermittent paleosols were identified within the current APE. The Project APE for the inner array cables extends to a maximum depth of 8 feet (2.4 meters) below the seafloor. The APE for the WTGs and ESP pilings extends to depths well below the 12–foot (3.7 meter) depth considered the maximum for archaeological investigation (Appendix 5.10-C). Avoidance of areas along seismic reflectors with specific characteristics which appear to correlate with the paleosols would require adjustment of locations for WTGs G3, G4, H9, I4, I5, and L4 and seven limited portions of the inner array cable grid (see Figure 6-1 in Appendix 5.10-C). If avoidance is not possible, then additional survey was recommended, in consultation with SHPO (MHC and MBUAR).

In accordance with the recommendations, the WTGs and portions of the inner array cable specified will be addressed in one of three ways: 1) move the WTG or portion of inner array cable out of the potential paleosol area; 2) eliminate the WTG or portion of the inner array cable within the potential paleosol area; or 3) undertake additional studies to determine the presence/absence of archaeologically sensitive materials at the specified locations.

5.10.4.1.2 Submerged Historic Archaeological Resources

Physical Impacts

Based upon a review of available databases, 45 targets that may be shipwrecks have been identified within the overall study area within Nantucket Sound. None of these targets was specifically identified within the Project area, although locational information for many was not complete in the databases. No submerged historic cultural resources (e.g., shipwrecks) were identified within the Project's APE, based upon a review of geophysical and geotechnical information collected in 2001 by the Applicant's consulting marine archaeologist.

Review of geophysical survey results identified three targets with moderate probability of representing submerged Euro-American (historic) cultural resources. All are in the vicinity of Horseshoe Shoal. Locations have been provided to MHC and MBUAR, but are not publicly distributed to protect the integrity of these possible sites. The targets are named PAL Targets 03-01 through 03-03. A recommendation was made that construction activities be avoided within a minimum buffer of 100 feet (30.5 m) in all directions around the detectable limits of each of these three potentially archaeologically sensitive targets. If avoidance is not possible, then an intensive marine archaeological survey, consisting of visual inspection and limited subsurface probing and testing by archaeological divers was recommended to determine the source of each target and preliminarily evaluate its potential historic significance as necessary. MBUAR and MHC concurred with the report's recommendations (see letters dated May 11, 2004 and May 19, 2004, respectively, in Appendix 5.10-E). The recommendations for avoidance or additional survey would be evaluated in consultation with appropriate regulatory agencies.

5.10.4.1.3 Recreational Resources in Federal Waters

Visual Impacts

Recreational users in federal waters of Nantucket Sound would experience open views of the above water components of the Wind Park during clear days and nights. No topographic or vegetative screening is feasible or available. The size and perspective of the turbine array would be a function of the viewer's location and orientation at sea level.

In a boat during clear daytime conditions, the full horizon is in view. Generally, within 8 miles (12.9 km) the entire Project (130 turbines and rotors, ESP, and SMDS tower) would be visible within the field of view. The grid pattern of the turbine layout would also be visible. Turbines would appear darker or lighter against the sky,

based upon the position of the sun and shadows cast at different times of the day, as shown in the daytime simulations in Figure 5.10-3 (Sheets 1-12).

The Project would add a built element to existing daytime views of the seascape, and would cause a change in daytime views of the Horseshoe Shoals area as presently experienced by recreational boaters. However, it should be noted that the visual renderings are based on clear sky conditions, which during the high tourism and recreation time of the year in Nantucket Sound do not always occur (see Section 5.10.4.3.2). More commonly, some degree of haze due to atmospheric moisture is present which can reduce visibility to less than a mile or two on occasions. The presence and degree of haze can substantially lessen the visibility of the WTGs during daylight, thereby lessening the impact to some degree compared to those portrayed by the renderings.

At night under clear sky conditions from a boat in federal waters, FAA-required aviation warning lights mounted on each turbine would be visible. These include two medium-intensity red flashing lights mounted on the nacelle of every other perimeter turbine, and two low-intensity red lights on each of the remaining turbines. Amber Coast Guard-required navigation lights would be installed on each turbine at about 35 feet (10.7 m) above the water. The amber lights on perimeter WTGs are designed to only be visible to viewers within two nautical miles (3.7 km); the amber lights on interior WTGs are designed to be visible to viewers within 0.5 nautical mile (0.9 km). The flashing lights would create a visual change to the existing relatively unbroken nighttime view under clear sky conditions.

Greatest visibility and visual contrast would occur from undeveloped or lightly developed sites with dark skies, such as in federal offshore waters, on Cape Poge or Tuckernuck Island (see Figure 5.10-4, Sheets 9 and 12). As illustrated in Figure 5.10-4, Sheets 7 and 11, ambient light in developed areas significantly reduces the visibility and contrast of WTG lighting against the night sky.

5.10.4.1.4 Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to cultural and recreational resources would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable has been proposed by National Grid between Cape Cod and Nantucket. Its proposed route may be in the vicinity of the Wind Park and its inner array cables in Nantucket Sound. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, as discussed above, the potential to encounter submerged archaeological resources is low. No submerged prehistoric cultural resources have been identified to date within the Project's APE. The findings of the marine archaeological remote sensing reconnaissance survey of the offshore area, including the Wind Park and 115 kV transmission line route, indicate little likelihood that there would be any significant cumulative impacts to cultural resources that would result from the installation of both projects. Any other proposed project, including potential dredging, would be required to conduct cultural resource investigation and would be responsible for its own impact potential.

The submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance dredging. Therefore, no significant cumulative effects to cultural resources or the viewshed are expected in the area of the North Channel crossing.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts expected to cultural resources since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

5.10.4.1.5 Secondary Impacts

There are no potential onshore secondary impacts to cultural resources associated with construction staging/laydown activities at Quonset. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy, and no significant land alteration would be necessary to accommodate the Project's staging activities.

5.10.4.2 Impacts Inside of Massachusetts Waters

Potential Project impacts to submerged cultural resources in state waters are limited to physical impacts to archaeological sites from Project construction/decommissioning, operation or maintenance.

5.10.4.2.1 Submerged Prehistoric and Historic Archaeological Resources

Physical Impacts
Findings of the marine archaeological sensitivity assessment (see Sections 5.10.2.3 and 5.10.3.2.1) indicate that a majority of the offshore study area, including all of the cable route in state coastal waters, has a low probability for containing submerged prehistoric cultural resources due to the extensive disturbance of formerly exposed and potentially inhabitable pre-inundation landscape resulting from marine transgression.

With respect to historic archaeological resources, the 115 kV transmission line route has been re-routed to avoid Bishops and Clerks Shoal, since three shipwrecks have been reported in the vicinity of these shoals. A marine archaeological geophysical reconnaissance survey along the revised 115 kV cable route was conducted during 2003. No targets that may be potential submerged historic cultural resources such as shipwrecks were identified along the revised 115 kV route.

Based upon results of the background review, the marine archaeological sensitivity assessment and marine archaeological reconnaissance survey, no submerged potential prehistoric or historic archaeological resources were identified and no additional archaeological investigations were recommended in these waters. This recommendation for no further studies includes the area proposed for the 115 kV transmission line, at the HDD tie-in at Lewis Bay, and shoreward to the Yarmouth landfall.

5.10.4.2.2 Recreational Resources

Visual Impacts
Recreational users in the state waters of Nantucket Sound would experience open views of the visible components of the Wind Park during clear days and nights. No topographic or vegetative screening is feasible or available.

In a boat during clear daytime conditions, the full horizon is in view. Generally, within 8 miles (12.9 km) the entire Project (130 turbines and rotors, ESP, and SMDS tower) would be visible within the field of view. The grid pattern of the turbine layout would also be visible. Turbines would appear darker or lighter against the sky, based upon the position of the sun and shadows cast at different times of the day, and the viewer's orientation, as shown in the daytime simulations in Figure 5.10-3 (Sheets 1-12).

The Project would add a built element to existing day time views of the seascape, and would cause a change in daytime views of the Horseshoe Shoals area as presently experienced by recreational boaters. However, it should be noted that the visual renderings are based on clear sky conditions, which during the high tourism and recreation time of the year in Nantucket Sound do not always occur (see Section 5.10.4.3.2). More commonly, some degree of haze due to atmospheric moisture is present which can reduce visibility to less than a mile or two on occasions. The presence and degree of haze can substantially lessen the visibility of the WTGs during daylight, thereby lessening the impact to some degree compared to those portrayed by the renderings.

At night under clear sky conditions from a boat in state waters, flashing red FAA- medium and low intensity navigation lighting on the turbines would be visible. Since the FAA-required aircraft navigation lights are designed to be most visible from the air, the lights would be visible to boaters from a distance but less visible as boaters get closer to the turbine array due to limited ground scatter. The USCG flashing amber lights mounted 35 feet (10.7 m) above sea level on each perimeter turbine are designed to be visible at distances up to 2 nautical miles (3.7 km), and therefore would be seen by boaters within that distance of the Wind Park. The Coast Guard lights on interior turbines are designed to be visible at distances up to 0.5 nautical mile (0.9 km), and therefore would only be seen by boaters within that distance of a turbine. The Coast Guard lights should not be seen by boaters in state waters at distances greater than 2 nautical miles (3.7 km) from the WTGs.

Under clear sky conditions, navigation lights on the turbines would be visible over a large portion of the field of view to recreational boaters in the vicinity of the Wind Park site. Greatest visibility would occur from undeveloped or lightly developed areas such as the state waters near the 3-nautical mile limit. The lighting would add a built element to existing nighttime views. As with the daytime simulations, the lights would be much less visible under low visibility conditions such as fog.

5.10.4.2.3 Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to cultural and recreational resources inside of Massachusetts waters would include other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impact from one potential activity that may occur within the location and timeframe of the proposed Project is discussed below.

A new submarine transmission cable has been proposed by National Grid between Cape Cod and Nantucket. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, as discussed above, the potential to encounter submerged archaeological resources is low. No submerged prehistoric cultural resources have been identified to date within the Project's APE. The findings of the marine archaeological remote sensing reconnaissance survey of the offshore area, including the Wind Park and 115 kV transmission line route, indicate little likelihood that there would be significant cumulative impacts to cultural resources that would result from the installation of both projects. Any other proposed project, including potential dredging, would be required to conduct cultural resource investigation and would be responsible for its own impact potential.

5.10.4.3 Onshore

5.10.4.3.1 Onshore Prehistoric and Historic Archaeological Resources

Based on the results of the terrestrial archaeological intensive survey, no significant prehistoric or historic archaeological resources have been identified within the Project's APE for ground disturbance along the onshore transmission line route. No further archaeological investigations of the onshore transmission line route were recommended. By acceptance of PAL's report in Appendix 5.10-D as final, MHC concurred with these recommendations (see letter dated April 22, 2004 in Appendix 5.10-E).

5.10.4.3.2 Onshore Historic Structures and Districts

Physical Impacts

No known or designated historic structures or districts have been identified within the Project's APE for ground disturbance on land, which consists of paved roadway and cleared NSTAR ROW. There would be no temporary, permanent or cumulative physical impacts to onshore historic structures and districts due to construction/decommissioning, operation and maintenance of the Project.

Noise Impacts

There would be temporary noise impacts in the immediate vicinity of the onshore cable installation during construction, but no designated historic structures or districts should be affected, given the distances of these resources from the cable route. See Section 5.11 for additional information regarding noise.

Visual Impacts

Before visual impacts at each viewpoint are described, several general observations can be made based upon the visual study. First, viewpoint locations selected for visual simulations were the most open, unobstructed, publicly available view within each historic district or at each structure, and therefore the simulations represent "worst case" visibility. Most locations within these districts generally have more limited/screened views of the Project area. The simulations also illustrate the Project under clear sky conditions, again a "worst case" portrayal of visual impacts.

During fog, storms, and other periods of limited visibility, the Project would be less visible. NOAA's climatological data collected on Nantucket indicate that over the 22-year period of record, an average of 98 days per year had visibility measured at or less than 0.25 mile (0.4 km) at some point during the day (NOAA, 1994). The months during which visibility was most frequently measured at less than 0.25 mile (0.4 km) were June (an average of 12 days), July (15) and August (13). These summer months coincide with the times of highest visitation to the historic and recreational resources on the Cape and Islands.

Visibility observations recorded by ships in passage near coastal areas off Nantucket report that the annual frequency when visibility was less than 2 nautical miles (3.7 km) was 8.5 percent, based upon 27,287 observations prior to 1994 (NOAA, 1994). The months that experienced the highest frequency of low visibility conditions are May (15.4 percent), June (17.7 percent), and July (16.1 percent), again times that coincide with high visitation to the Cape and Islands.

As previously discussed the simulations also do not take into account the blocking effect of the curvature of the Earth, because the degree of the effect could not be accurately determined at the time of this report, therefore each turbine was "set" on the horizon, not in front or behind it. The actual effect of the curvature of the Earth will result in small portions of the tower bases being blocked from each of the selected viewpoints (with the possible exception of Cape Poge), and from all shoreline locations on Cape Cod, Martha's Vineyard, and Nantucket.

The daytime simulations were constructed to incorporate a variety of lighting conditions. As a result, it was observed that sun location and angle have an effect on Project visibility. Visibility is heightened when the structures are directly front lit or backlit and appear very light or very dark against the surrounding sea and sky in these conditions, respectively. For an example of a backlit condition, see VP 5, Figure 5.10-3, Sheet 2. For a front lit simulation, see VP 21 on Figure 5.10-3, Sheet 7. However, when the structures are sunlit from the side, turbine color blends well with the surrounding seascape. The proposed blue-gray color for the visible structures appears to minimize structure visibility.

The greatest Project visibility and visual contrast occur at distances of less than 8 miles (12.9 km), such as from Cotuit, Wianno, Craigville and Hyannis Port on Cape Cod (Figure 5.10-3, Sheets 2, 3, 4 and 5, respectively), and Cape Poge on Martha's Vineyard (Figure 5.10-3, Sheet 9). Beyond this distance, Project structures become more obscure and certain components, such as rotor blades, become difficult to see, as shown at Nobska Lighthouse in Woods Hole (Figure 5.10-3, Sheet 1), and the Nantucket viewpoints (Figure 5.10-3, Sheets 10-12). This observation is consistent with European studies that indicate a distance of 15 km (9.3 miles) may be the maximum limit of visual significance along the coast and within a seascape (Hill et al., 2001).

Visual Impact Assessment on Multiple Historic Properties

The Project will be visible from a number of designated National Register listed or eligible historic districts and individual structures, and is therefore subject to an assessment of effects on these historic properties under Section 106 of the NHPA. The historic properties are located near or at the shorefront along the south side of Cape Cod, the northeast side of Martha's Vineyard, and the north side of Nantucket. A Visual Impact Assessment (VIA) was conducted by an architectural historian at PAL, to provide a professional assessment of the Project's effects on historic properties under Section 106 of the NHPA, the Advisory Council's regulations at 36 CFR 800

and the USACE regulations at 33 CFR Part 325 Appendix C. In accordance with Section 106 and the Advisory Council regulations, the effects findings consider the significant qualities of the historic property, regardless of ownership, and assess the overall effect of the proposed undertaking on the historic property. The specific type of adverse effect applicable to the Project's impact on aboveground historic properties is the introduction of visual elements that may diminish the integrity of a property's significant features that qualify the property for inclusion in the National Register. The eligibility criteria were listed in Section 5.10.3.3.3. A copy of the full VIA report, including methodology, is included in Appendix 5.10-F; findings are summarized in the following section.

The VIA addresses 10 of the 12 simulated viewpoints. The 10 viewpoints were taken within or are representative of views that would be experienced at all National Register eligible or listed historic properties (including districts and individually listed structures) on the Cape and Islands expected to have open unobstructed views of the WTGs. The Craigville Historic District (Viewpoint 5) was not found to have Project visibility and was not included in the VIA. Tuckernuck Island (Viewpoint 24) is a State Register historic property, but is not listed on the National Register, and is therefore not included in the VIA.

Based upon a review of information about the features, character, siting, history and significance of the historic properties in the visual APE of the Project (as summarized in Section 5.10.3.3.3 and presented in Appendix 5.10-F), the VIA found that within the overall historic context of Cape Cod, Martha's Vineyard and Nantucket, maritime associations are clear. Whether associated with early settlement, fishing, coastal trading, whaling, summer resort, or as a Summer White House, all the properties assessed in the VIA are linked to the proximity of coastal waters.

Daytime impacts at each simulation location are presented below, followed by nighttime impacts. An architectural historian's opinion on the visual effect of the Project on aboveground historic properties, as rendered by PAL, is presented for each of the properties below from the Section 106 Findings of Effect determinations presented in the VIA (see Appendix 5.10-F). Although presented with Daytime Visual Impacts, the findings are not limited to daytime conditions and are applicable to night time conditions as well. The resolution of adverse effects takes place through development of a Programmatic Agreement, in consultation between USACE, SHPO and other consulting parties. The Programmatic Agreement stipulates measures the Applicant will take to minimize and/or mitigate adverse effects to specified historic properties. A draft Programmatic Agreement to resolve adverse Project effects to historic properties is summarized in Section 5.10.5; a copy is included in Appendix 5.10-G.

In brief, the analysis of visual effects undertaken in the VIA resulted in recommended adverse effect findings for two NHL properties (the Kennedy Compound and the Nantucket Historic District), four historic districts and 10 individual historic properties. These are listed in Table 5.10.5. No Effect was recommended for one historic district (the Martha's Vineyard Campground Historic District), and three individual properties, all in Oak Bluffs (the Flying Horses Carousel, the Arcade and the Oak Bluffs Christian Union Chapel). These properties, also listed in Table 5.10.5, are generally within the visual APE defined as 300 feet from the shoreline (see Section 5.10.1.1), but are screened from water views by intervening structures, vegetation and/or topography.

Daytime Visual Impacts

A variety of lighting conditions were used in the simulations to approximate the visibility of the structures under variable daytime lighting.

- *Nobska Point Light Station, Woods Hole, Falmouth (VP 1; Figure 5.10-3, Sheet 1)*

The view from the base of Nobska Light is approximately 50 feet (15.2 m) above sea level. The full horizon is visible, and all Wind Park structures (130 turbines, ESP, and SMDS tower) are visible. Turbines range from 14.1 to 21.7 miles (22.7 to 35 km) from the viewer at this location. In this late morning view taken under a clear sky, the turbines are visible along the horizon, although they appear distant. The slender components, such as the rotor blades, are difficult to see.

The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the character, setting and viewshed of this historic aid-to-navigation property that make it eligible for inclusion in the National Register. The Project will have an adverse visual effect on the Nobska Point Light Station, according to the VIA.

- *Cotuit Historic District, Town of Barnstable (VP 5; Figure 5.10-3, Sheet 2)*

Public access and views toward the shoreline and the Project are limited from within the historic district. Because no publicly available open views were found within the historic district itself, VP 5 was located immediately to the south at Loop Beach. Open views would be available toward the Wind Park from some private properties within the district, which typically are at elevations higher than sea level.

The simulation at VP 5 shows approximately 95% of the proposed turbines visible within the field of view (the remaining structures are beyond the sides of the simulation). Turbine distances range from 6.1 to 14.2 miles (9.8 to 22.9 km) from the viewer. At this distance and from this location, the grid patterns of the turbine layout are recognizable. VP 5 was taken on a sunny winter afternoon that illustrate the turbines in a generally backlit condition. Under a sunny sky, this backlighting would create strong shadows that heighten turbine contrast with the sky.

The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic early settlement, maritime village and summer resort that make it eligible for inclusion in the National Register. The Project will have an adverse visual effect on the Cotuit Historic District, according to the VIA.

- *Colonel Charles Codman Estate, Town of Barnstable (VP 5; Figure 5.10-3, Sheet 2)*

The Codman Estate is located southeast of the Cotuit Historic District on a point of land extending into Cotuit Harbor. Although no access was available to the estate, which was posted as private property, Viewpoint 5 for the Cotuit Historic District is considered representative of expected open views at the historic property toward the proposed Project.

The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic summerhouse property that make it eligible for inclusion in the National Register. Therefore, the Project will have an adverse visual effect on the Colonel Charles Codman Estate, according to the VIA.

- *Wianno, Town of Barnstable (VP 6; Figure 5.10-3, Sheet 3)*

This view from Sea View Avenue is typical of the broken/partially obscured views available along the road, which parallels the shore. Approximately 91% of the turbines are visible in this simulation near the shorefront (the remaining structures are beyond the sides of the simulation). The turbines range from 5.7 to 12.6 miles (9.2 to 20.3 km) from the viewer at this location. Views just back from the shore along Sea View Avenue are typically broken or partially obscured by intervening structures or vegetation. The regular row pattern of the turbine layout is apparent, and the turbines look dark in this late afternoon view. The darkness contrasts with the early evening sky and illuminated clouds on the horizon.

VP 6 is representative of views toward the Project from the Wianno Historic District. The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic summer resort community that make it eligible for inclusion in the National Register. Therefore, the Project will have an adverse visual effect on the Wianno Historic District, according to the VIA.

- *Wianno Club, Town of Barnstable (VP 6; Figure 5.10-3, Sheet 3)*

The view from adjacent to the privately owned Club, which is individually listed on the National Register, is described above, and is represented by VP 6.

The VIA found that the significant visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic summer social and recreational property that make it eligible for inclusion in the National Register. Therefore, the Project will have an adverse visual effect on the Wianno Club, according to the VIA.

- *Craigville, Town of Barnstable (VP 7, Figure 5.10-3, Sheet 4)*

This midday view is from the bluff at the southern end of Craigville, approximately 34 feet (10.4 m) above sea level. In this simulation, the turbines are from 7.0 to 13.0 miles (11.3 to 20.9 km) away, and approximately 95% of the structures are visible (the remaining structures are beyond the sides of the simulation). They are backlit and appear dark against the light sky and reflective water surface. Turbine visibility and contrast decrease to the east (left) in this view, where one is not looking as directly into the sun.

The southern boundary of the Craigville Historic District is 0.25 mile (0.4 km) north of the viewpoint location. Nantucket Sound is not visible in the direction of the Project from within the historic district, which is screened from views of the Sound by mature shade trees and vegetation, as well as topography and intervening structures. There would be no visual impact to the Craigville Historic District from construction/decommissioning, operation or maintenance of the Project. The Craigville Historic District was not included in the VIA.

- *Hyannis Port, Town of Barnstable (VP 8; Figure 5.10-3, Sheet 5)*

This view on Scudder Avenue in the Hyannis Port Historic District just west of the Kennedy Compound is the most open, unobstructed public view found from this area toward the Project. This viewpoint is similar to what would be experienced at unobstructed locations within the Kennedy Compound. Approximately 97% of the structures are visible in this simulation (the remaining structures are beyond the sides of the simulation). The WTGs range in distance from 6.2 to 12.0 miles (10 to 19.3 km) from the viewer. Their arrangement in regular rows can be seen. This is a midday view looking into the sun, under lighting conditions similar to the simulated view from Craigville. As a result, the sky and water appear very light. Together with strong shadows created by backlighting the turbines, this results in heightened structural visibility and contrast.

VP 8 is representative of shoreline views toward the Project from the Hyannis Port Historic District. The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic early settlement, maritime village, and planned seaside resort that make it eligible for inclusion in the National Register. Therefore, the Project will have an adverse visual effect on the Hyannis Port Historic District, according to the VIA.

- *Kennedy Compound , Hyannis Port, Town of Barnstable (VP 8; Figure 5.10-3, Sheet 5)*

Although the Kennedy Compound itself was not visited during the visual studies as it is posted private property, observations from adjacent locations indicate that open views of the proposed Wind Park will be available from within the Compound, which is within the Hyannis Port Historic District. The expected view from the Compound, which is a NHL, is described above.

The VIA found that the significant visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of the Kennedy Compound, and features that make it nationally significant and designated as an NHL, as well as eligible for inclusion on the National Register. Therefore, the Project will have an adverse visual effect on the Kennedy Compound, according to the VIA.

- *Monomoy, Town of Chatham (VP 26, Figure 5.10-3, Sheet 6)*

This open, unobstructed view toward the Project site includes the historic lighthouse structures in the foreground, with a broad expanse of sparsely vegetated dunes and open water in the background. The elevated viewpoint is approximately 30 feet (9 m) up on a large dune, looking west toward the proposed Project. In this location the turbines range from 13.9 to 20.8 miles (22.4 to 33.5 km) from the viewer, and approximately 96% of the turbines are included in the simulation. The turbines are visible on the horizon, and those at the north end line up in rows, thus increasing their visibility. However, in this simulation, lack of strong backlighting or front lighting, along with haze and sky washout, reduce their visual contrast.

The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic aid-to-navigation property that make it eligible for inclusion on the National Register. Therefore, the Project will have an adverse visual effect on the Monomoy Point Lighthouse, according to the VIA.

- *Oak Bluffs , Martha's Vineyard (VP 21; Figure 5.10-3, Sheet 7)*

The viewpoint from Ocean Park is located about 54 feet (16 m) above sea level and 450 feet (137 m) back from the shore. All of the turbines are visible in this view, which lacks foreground structures or vegetation. This afternoon view under clear sky conditions illustrates the Project being front lit, with the sun at a low angle behind the viewer. The light's strong reflection off the turbines makes the structures appear whiter than their light gray color. The white color against the dark blue sky maximizes the Project's visibility, even though the turbines are 9.4 to 16.6 miles (15.1 to 26.7 km) away.

VP 21 is representative of views from the East Chop Lighthouse, along the shore to the north of Ocean Park. The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic aid-to-navigation property that make it eligible for inclusion on the National Register. Therefore, the Project will have an adverse visual effect on the East Chop Lighthouse, according to the VIA.

VP 21 is also representative of views from the Harrison A. Tucker Cottage on Ocean Park. The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic seaside summer house property that make it eligible for inclusion on the National Register. Therefore, the Project will have an adverse visual effect on the Dr. Harrison A. Tucker Cottage, according to the VIA.

- *Edgartown, Martha's Vineyard (VP 20; Figure 5.10-3, Sheet 8)*

This clear morning view of the Project from Lighthouse Beach shows all the Project structures, although the lower portions of many are screened by Chappaquiddick Island. This simulation is representative of views from the Edgartown (Harbor Light) Lighthouse and east facing structures within the historic district. The turbines range from 8.8 to 15.8 miles (14.2 to 25.4 km) from the viewer. Under these conditions, the turbines are lit from the side, which creates neither strong reflection nor shadows. As a result, and due to their distances from the viewer, the turbines are difficult to see relative to other viewpoints. The light gray color of the turbines blends well with the sky under these conditions.

VP 20 is representative of Project views from the Edgartown Harbor Lighthouse. The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic aid-to-navigation property that make it eligible for inclusion on the National Register. Therefore, the Project will have an adverse visual effect on the Edgartown Harbor Lighthouse, according to the VIA.

VP 20 is also representative of Project views from the Edgartown Village Historic District. The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic early settlement, maritime village and summer resort property that make it eligible for inclusion on the National Register. Therefore, the Project will have an adverse visual effect on the Edgartown Village Historic District, according to the VIA.

- *Cape Poge, Edgartown, Martha's Vineyard (VP 19; Figure 5.10-3, Sheet 9)*

This viewpoint on the northeastern tip of Cape Poge at the lighthouse is the closest one can get to the Project on Martha's Vineyard. The simulation of the open, elevated view at approximately 56 feet (17 m) above sea level shows 95% of the turbines (the remaining structures are beyond the sides of the simulation), at distances of 5.4 to 12.4 miles (8.7 to 20 km). Shown under similar lighting conditions to VP 21 at Oak Bluffs, strong afternoon sun behind the viewer front-lights the turbines, resulting in a reflective white color that contrasts with the dark blue ocean and sky.

VP 19 is representative of views from the Cape Poge Lighthouse. The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic aid-to-navigation property that make it eligible for inclusion on the National Register. Therefore, the Project will have an adverse visual effect on the Cape Poge Lighthouse, according to the VIA.

- *Nantucket Cliffs along Cliff Road, North of Nantucket Village Center (VP 22; Figure 5.10-3, Sheet 10)*

Views to the northwest toward the Project site are not available from publicly available ground level locations within Nantucket Village itself and from the docks and wharfs along the western side of Nantucket Harbor, although views from the upper stories of certain buildings are likely. This viewpoint on Cliff Road along the north shore is the nearest open view from the Village (with the exception of Jetties Beach, which is further from the Project). The entire Project can be seen at this location, due to the lack of screening. Strong sunlight and a dark blue sky heighten the reflection and visibility of Project structures. However, because of the distance from the viewer (13.6 to 21.4 miles (21.9 to 34.4 km)), the turbines appear very small on the horizon. Additionally, slender elements, such as the rotor blades, are difficult to perceive. This viewpoint is similar to what would be experienced at other locations along the north shore of Nantucket.

VP 22 is representative of Project views from those areas of the Nantucket Historic District with open unobstructed views of Nantucket Sound (generally the north and northwest facing shorelines and vicinity). The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic character, setting and viewshed of this historic early settlement, maritime and whaling village and summer resort that make Nantucket nationally significant and eligible for inclusion in the National Register and the NHL. Therefore, the Project will have an adverse visual effect on the Nantucket Historic District, according to the VIA.

- *Great Point, Nantucket (VP 23; Figure 5.10-3, Sheet 11))*

This view from the base of Great Point Lighthouse is typical of open views available from this exposed area. All of the turbines are visible, and afternoon lighting illuminates the sides of the turbines. Under these conditions, neither strong reflection nor strong shadows are created. The WTGs are far from the viewer (11.2 to 19.5 miles (18 to 31.4 km)), and slender components such as the rotor blades are difficult to see.

VP 23 is representative of Project views from Great Point Light and the Great Point portion of the Nantucket Historic District NHL. The VIA found that the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures will constitute an alteration of the historic aid-to-navigation property that make it eligible for inclusion in the National Register. Therefore, the Project will have an adverse visual effect on Great Point Light and the Great Point portion of the Nantucket Historic District NHL, according to the VIA.

- *Tuckernuck Island , Nantucket (VP 24; Figure 5.10-3, Sheet 12)*

This is the only simulation that was photographed under less than ideal visual conditions. The island is only accessible by boat, and during the day of the field visit a fog bank moved in during the early afternoon. The fog bank eventually lifted, but low clouds and overcast conditions persisted. Although the entire Project is visible at the horizon, the gray color of the ocean and sky, as well as the lack of direct sunlight, serves to obscure the WTGs. The proposed marine gray color is effective under these conditions, and minimizes the structures' contrast with the seascape. The distance of the Project from this viewpoint (10.4 to 16.4 miles (16.7 to 26.4 km)) also reduces Project visibility and visual impact.

Because Tuckernuck Island is not a NHL or within the National Register listed Nantucket Historic District, the island was not subject to a federal Section 106 Finding of Effect. Tuckernuck Island is included in the SRHP. It should be noted that this was the only SRHP-listed property found that will have open unobstructed views of the proposed Project.

Nighttime Visual Impacts

Nighttime field observations of a constructed wind power project in New York state by EDR during the summer of 2003 suggests that night time visibility of the FAA aviation warning lights (in particular the L864 medium intensity lights) is not greatly affected by distance under clear sky conditions. Consequently, there is a high degree of similarity between the various nighttime simulations (compare sheets within Figure 5.10-4). Thus, rather than reviewing the simulations individually, the following general observations/conclusions regarding the night time visibility and visual impact of the Project can be made.

The simulations represent a "worst case" assessment of potential night time visibility since they illustrate the Project from open, unscreened viewpoints; they show the Project under clear sky conditions; and they do not include any obscuring of visibility that may result from atmospheric effects such as high relative humidity, salt spray or low fog over the water, which are common night time conditions along the shore. As with the daytime

simulations, the lights would be much less visible from other more well-screened areas within the historic districts and under less ideal weather conditions (fog, low clouds, etc.).

Based on field review of the Fenner and Madison Wind Power Projects in New York, aviation warning lights do not significantly illuminate rotor blades or other turbine components. As shown in the simulations, nighttime views of wind power projects are essentially groupings of red points of light that do not indicate what the lighted feature is.

Under clear sky conditions, the FAA-required aviation warning lights on the turbines are visible along the horizon, and add a built element to views of the existing seascape. Lights would flash at 20 flashes per minute (FPM), with the perimeter lights flashing synchronously, and the interior lights flashing in a random pattern. The nighttime simulations are shown with approximately 50 to 65% of the interior FAA lights flashing on and all the perimeter FAA lights flashing on.

Greatest visibility and visual contrast would occur at undeveloped or lightly developed sites with dark skies, such as Cape Poge and Tuckernuck Island (see Figure 5.10-4, Sheets 8 and 11). As illustrated in Figure 5.10-4, Sheets 6 and 7 (Oak Bluffs and Edgartown, respectively), ambient light in the sky significantly reduces the visibility and contrast of the lights with the night sky.

The Project is on the horizon, uses the lowest allowable light intensities (per the FAA and Coast Guard) and, as a result, should not interfere with views or illuminate night skies to an extent that could hinder viewing of the moon or stars.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to onshore historic structures or districts would include other upland cable or pipeline installations, residential or commercial structures, pile supported marine structures, other upland wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative) and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island). The cumulative impact from one potential activity that may occur within the location and timeframe of the proposed Project is discussed below.

There are no significant cumulative impacts expected should the onshore portion of National Grid's Nantucket Cable be installed at the same time as the onshore portion of the Project's cable system. The proposed Nantucket Cable's onshore route is more than a mile distant from the Project's proposed route and would pass through the central portion of Hyannis, while the Project's onshore route bypasses the center of town to the east.

5.10.4.3.3 Onshore Recreational Resources

Physical Impacts

There would be no physical impact or change of use to existing onshore recreational resources such as beaches, parks, golf courses, freshwater fishing, and other onshore recreational facilities on the Cape and Islands. Construction/decommissioning might temporarily prevent some passive recreation such as walking or birdwatching along the NSTAR ROW in areas of active construction. Operation and maintenance of the Project would not physically affect the present day or continuing use of onshore recreational resources.

Visual Impacts

The visual impacts on onshore recreational resources from development of the Project would be essentially the same as those described for onshore historic sites. The same daytime and nighttime visual simulations are used to assess the degree of these impacts. The same general observations apply regarding the worst case nature and variability under different lighting conditions of the visual simulations of the Project. As previously noted, greatest visibility and visual contrast would occur at undeveloped or lightly developed sites with dark skies, such as Cape Poge and Tuckernuck Island (see Figure 5.10-4, Sheets 8 and 11). As illustrated in Figure 5.10-4, Sheets

6 and 7 (Oak Bluffs and Edgartown, respectively), ambient light in the sky significantly reduces the visibility and contrast of the lights with the night sky.

Nantucket Sound beaches along the southern shore of Cape Cod in the Towns of Falmouth, Mashpee, Barnstable, Yarmouth, Dennis, Harwich, and Chatham would have open views of the Project's visible structures. The visual simulations indicate the greatest Project visibility would be between Cotuit (VP 5 at 6.4 miles (10.3 km) distance) and Hyannis Port (VP 8 at 6.2 miles (10 km) distant), including Craigville (VP 7 at 7.0 miles (11.3 km) distant). Applying these distances to areas not simulated west of Cotuit and east of Hyannis Port, visual impacts on Cape Cod are expected to be greatest from Great Neck in Mashpee to the mouth of Bass River at the Yarmouth-Dennis town line.

Open views would be available from other recreational resources along the south side of Cape Cod, including the Shining Sea Bike Path in Falmouth, the New Seabury Golf Club's Ocean Course, the Hyannis Port Golf Club, and shorefront conservation areas (see Table 5.10-4 and Figure 5.10-5).

Falmouth beachgoers would experience views between those simulated at Nobska (VP 1) and Cotuit (VP 5), depending on their respective distances to the Project. VP 5 approximates views at Mashpee beaches, including New Seabury and Popponesset, east through Oyster Harbors. Users of the small Town Beach at the eastern end of Sea View Avenue would experience similar views to VP 6. No views toward the water and proposed Project were found in the Village of Osterville. The Craigville simulation (VP 7) approximates Project visibility from the Craigville beaches, Long Beach in Centerville, and West Hyannis Port. Because this viewpoint was taken on a bluff at approximate elevation 35 feet (10.7 m) above sea level, the simulation provides more visibility of the built Project than would be experienced at sea level on the beaches.

Views from VP 8 are similar to what would be experienced at Kalmus Park Beach, the large public beach in Hyannis, smaller area public beaches, and the outer areas of Hyannis Harbor. Views from points to the east out to Chatham (VP 26) would be similar, although the structures would be increasingly smaller and less noticeable in the field of view as one proceeds east along the south shore of the Cape and away from the Project.

On Martha's Vineyard, open views of the Project would be available along the beaches and in the immediate vicinity from East Chop at Oak Bluffs south to the Edgartown Lighthouse. VP 21 is similar to what would be experienced under similar conditions at east-facing beaches between Oak Bluffs and Edgartown, as well as portions of Felix Neck Wildlife Sanctuary in Edgartown. Open views would be available from the beaches at Cape Poge on Chappaquiddick Island (VP 19).

On Nantucket, open but distant views of the Wind Park would be available from beaches along the entire north shore of Nantucket Island east to Great Point. As described above for water recreation, visibility of the Wind Park would be affected during the high use season by the degree of haze that develops over the water. It is possible that for some days of the summer months, the WTGs would not be visible from any land areas due to the occurrence of haze or fog.

5.10.5 Mitigation Summary

Based on the results of technical studies, three areas (targets) have been identified on Horseshoe Shoal that, in the opinion of the marine archaeologist, have a moderate potential to be submerged historic cultural resources. Avoidance of these areas, including a buffer of a minimum of 100 feet (30.5 meters) is recommended. If avoidance is not feasible, additional archaeological investigation was recommended to preliminarily evaluate the potential historic significance of the area(s). Additionally, limited areas in the easternmost portion of the Project were found archaeologically sensitive for potential submerged prehistoric resources. These areas were also recommended for avoidance or, if not feasible, additional archaeological investigation.

Measures to avoid or, if avoidance is not feasible, to further investigate these archaeologically sensitive areas in order to assess whether they contain submerged National Register-eligible resources, are included in a draft Programmatic Agreement (see Appendix 5.10-G). The measures agreed upon in the Programmatic Agreement will be carried out by the Applicant. In addition, the Programmatic Agreement will contain an Unanticipated Discovery Plan, to ensure that previously unidentified cultural resources, which may be discovered during

construction of the Project are identified and assessed in accordance to the applicable regulations. The Programmatic Agreement is being developed in consultation with signatories USACE, the SHPO, the Advisory Council on Historic Preservation, and concurring parties Cape Wind LLC and the Wampanoag Tribe of Gay Head (Aquinnah).

The Project has been designed to take maximum advantage of wind energy with as few turbines and within as small a footprint as possible, while maintaining the Project's economic viability and minimizing environmental impacts. The number of turbines has been reduced from the originally proposed 170 to 130, and in doing so, the potential impact on cultural and recreational resources has been reduced. Previously proposed turbines closest to the south shore of Cape Cod (the closest land area to the Project) have been eliminated, moving the limit of the Project approximately 0.5 mile (0.8 km) further from this shoreline. The visible structures of the Project would be painted a marine gray color, to minimize contrast with the surrounding sea and sky. Daytime and nighttime lighting has been designed to use the lowest intensity lighting considered safe for navigation by the FAA and USCG. Although the FAA has required that perimeter turbines flash synchronously, a random flashing pattern for the interior turbine lights would minimize visual lighting impacts. The USCG flashing amber lights mounted at 35 feet (10.7 m) above sea level on each perimeter turbine should not be visible to viewers at distances beyond 2 nautical miles (3.7 km). USCG lights on interior turbines should not be visible to viewers at distances greater than 0.5 nautical mile (0.9 km).

An opinion on the extent of visual effect (no effect, no adverse effect) of the Wind Park on National Register listed or eligible historic properties/districts within the viewshed has been prepared by PAL at the direction of the USACE. The VIA found that the Project will have an adverse visual effect on two (of three) National Historic landmarks, four (of five) historic districts and 10 (of 12) individual historic properties identified and analyzed. A Programmatic Agreement is under development containing stipulations to minimize or mitigate adverse effects to historic properties with open unobstructed views of the Project. Stipulations may include documentation (photographic and narrative recordation) of existing conditions, settings and viewsheds of the affected properties and Project design measures to minimize visibility (summarized in the preceding paragraph). An executed and implemented Programmatic Agreement will satisfy USACE's Section 106 responsibilities. Any Section 10 permit issued by USACE for the Project will contain conditions to ensure that the mitigation measures contained in the implemented Programmatic Agreement are carried out by the Applicant.

The 115 kV marine transmission route has been shifted to the west to avoid several reported shipwrecks on Bishop and Clerk's Shoals. The onshore transmission route would be located entirely below ground within paved roads and existing utility ROWs, to avoid visual impacts and impacts to potential intact archaeological resources. Within the onshore cable route, no significant prehistoric or historic archaeological sites were identified within the Project's APE, based upon results of an intensive (locational) archaeological survey.

Adverse impacts to cultural resources determined to be significant (i.e., listed or eligible for listing on the National Register of Historic Places) would be avoided, minimized or mitigated in consultation with the SHPO. For those significant cultural resources for which adverse Project effects cannot be avoided, a draft Programmatic Agreement detailing methods to mitigate potential impacts has been prepared and is located in Appendix 5.10-G of this DEIS.

5.11 Noise

This section presents the potential noise effects from the Project and applicable regulatory requirements. The full technical analysis for noise is contained in Appendix 5.11-A and provides supporting details and calculations for the results and conclusions given in this section. The noise analysis discussed in this section includes an assessment of the magnitude and frequency of above ground sound as well as underwater noise and vibration. The potential for adversely affecting fish and marine mammal habitats and migration is discussed in detail in Sections 5.4 and 5.5 (Finfish Resources and Protected Marine Species), with a summary of those results provided in this section.

The information contained in this section was obtained from review of existing data available for the Project Area, including above water and underwater sound monitoring, and from acoustic modeling. Section 5.11.1 provides information regarding the above water sound analysis. A discussion of relevant acoustic concepts and regulatory

requirements for the above water analysis can be found in Sections 5.11.1.1 and 5.11.1.2, respectively. Baseline conditions at two offshore locations in Nantucket Sound; and representative, secluded locations on the south coast of Barnstable and Yarmouth and east coast of Martha's Vineyard are discussed in Section 5.11.1.3. The above water acoustic modeling methodology is described in Section 5.11.1.4. Projections of the above water impacts from Project operation and construction are presented in Sections 5.11.1.5 and 5.11.1.6, respectively. Mitigation measures adopted or proposed for potential above water noise impacts is summarized in Section 5.11.1.7.

Similarly, a discussion of relevant acoustic concepts and regulatory requirements for the below water analysis can be found in Sections 5.11.2.1 and 5.11.2.2, respectively; and existing noise levels at representative underwater locations is provided in Section 5.11.2.3. Below water acoustic modeling methodology is described in Section 5.11.2.4. Projections of the underwater impacts from Project operation and construction are presented in Sections 5.11.2.5 and 5.11.2.6, respectively; and mitigation for potential below water noise impacts is summarized in Section 5.11.1.7.

5.11.1 Above Water Sound Analysis

This section begins with an introduction to above water Acoustic Concepts and applicable Regulatory Requirements, followed by a presentation of Existing Conditions, Acoustic Modeling Methodology, Projects Impacts, Construction Impacts, and finally Mitigation.

5.11.1.1 Acoustic Concepts

All sounds originate with a source – a human voice, motor vehicles on a roadway, or an airplane overhead. The sound energy moves from the source to a person's ears as sound waves, which are minute variations in air pressure. The loudness of a sound depends on the sound pressure level, defined as the ratio of two pressures: the measured sound pressure from the source divided by a reference pressure (the quietest sound we can hear). The pressure ratio is expressed on a logarithmic scale in the units of decibels (dB). On this scale, the quietest sound we can hear is 0 dB, while the loudest sounds we hear are around 120 dB. Most sounds we encounter in our daily lives have sound pressure levels in the range from 30 to 100 dB.

Because decibels Are Logarithmic, they do not behave like other numbers. For example, if a sound of 70 dB is added to another sound of 70 dB, the total is only a 3-decibel increase (or 73 dB), not a doubling to 140 dB. Thus, every 3 dB increase represents a doubling of sound energy, and a 10 dB increase represents ten-times as much sound energy. A 3 dB change increase is the minimum change perceptible to the human ear, a 5-dB change is noticeable and a 10 dB increase sounds twice as loud. Going in the other direction, every 10 dB reduction on the decibel scale represents a ten-fold decrease in sound energy. Thus, compared to a baseline sound level of 50 dB, a 40 dB sound has 1/10 the energy, a 30 dB sound has 1/100 the energy, and a 20 dB has 1/1000 the energy of the baseline. In addition, if one source is much louder than another (say a difference of 10 dB or more), the two sources together produce the same sound level as if the louder source was operating alone. For example, a 50 dB source plus a 35 dB source (having only 3/100 of the sound energy of the first source) produce 50 dB when operating together. The louder source dominates the quieter one.

Frequency, or pitch, is an important characteristic of sound. An analysis of sound can include an examination of how much of the sound energy is in low, middle and high frequency ranges. The human ear can typically perceive sounds in a frequency range from about 20 to 20,000 Hertz (Hz),[83] with human hearing being most sensitive in the mid-range of 1,000 to 4,000 Hz. While the threshold of hearing is 0 dB in the sensitive mid-range, it rises rapidly for lower frequencies of sound, and very low frequency sounds below 20 Hz are essentially inaudible. Data from recent hearing threshold studies[84, 85] have been compiled to produce Table 5.11-1 which gives the hearing threshold for the human ear at frequencies from 16 to 16,000 Hz. In a sound study, the frequency range of human hearing is analyzed by looking at large slices of the spectrum (whole octave bands) or thin slices (1/3-octave bands).

[83] The frequency unit Hertz is equivalent to cycles per second.
[84] Bies, D. and Hansen, C., Engineering Noise Control, Theory and Practice, 2nd Ed., Chapman & Hall, New York, 1996, p. 55.
[85] Berglund, B., Hassmen, P., and Job, R., "Sources and effects of low-frequency noise," J. Acoust. Soc. Am., 99(5), May 1996, p. 2986.

To account for the human ear's sensitivities to certain frequencies, an A-weighting filter is commonly used for describing environmental sound levels. The A-weighting scale was developed and has been shown to provide good correlation with the human response to sound and is the most widely used descriptor for community noise assessments. The above water acoustic environment near the Project site is comprised of wind and wave sounds as well as sound from vessels, recreational boats and over-flying aircraft. Moving inland, many other sources associated with human activity are added in, principally motor vehicle traffic and commercial activity. Typical airborne sound levels are presented in Table 5.11-2.

When sound energy is concentrated at a single frequency, the peak in the spectrum may be audible as a "pure tone". Generally this condition occurs when a particular 1/3-octave band has a sound level higher than the average level of the two adjacent bands by 5 to 15 dB (with the 15 dB threshold used for low frequencies below 125 Hz).[86] This is the definition of a pure tone condition that was used in this analysis.

Sound levels are measured in many different ways. The most common sound metrics used in community assessments are the equivalent sound level (L_{eq}), the maximum sound level (L_{max}), and the background sound level (L_{90}). The L_{eq} is the energy averaged sound level that includes both steady background sounds and transient peak sounds. The L_{eq} provides a uniform method for comparing time-varying sound levels. The L_{max} is the near-instantaneous maximum sound level measured during a time period and is always higher than the L_{eq}. The L_{90} is the sound level that is exceeded for 90 percent of a given time period and is normally lower than the L_{eq}. The L_{90} can be thought of as the quietest ten percent of a time period, and since it generally excludes transient sound events, it is referred to as the background level.

5.11.1.2 Regulatory Requirements

There are no local or federal noise control regulations with decibel limits that apply to the Project. The Massachusetts Department of Environmental Protection (MADEP) regulates sound through Regulation 310 CMR 7.10 that prohibits "unnecessary emissions" of sound. MADEP Policy Statement No. 90-001 interprets a violation of the state noise regulation to have occurred if a source causes either:
(1) An increase in the broadband sound level of more than 10 dBA above the ambient background level (L_{90}); or
(2) A "pure tone" condition.

These are the MADEP Community Sound Level Criteria and apply to sources within the Massachusetts territorial limit (three nautical miles from shore). The Noise Policy does not apply to construction activities.

All Project operations and most construction would occur outside the three nautical mile limit. Some construction activity would occur on land in Yarmouth where the Submarine Cable System would come ashore and connect into the regional power grid. Neither the Town of Yarmouth nor the MADEP regulate sound from construction activities. The Cape Cod Commission does not regulate noise separate from the MADEP Noise Policy. While the MADEP Noise Policy does not apply to the Project, the Secretary of the EOEA included a requirement in the MEPA Certificate that: "For informational purposes, the EIR should address the ability of the project to meet the performance standards contained in the DEP Noise Policy (DAQC Policy 90-001)." The sections below provide the requested information and show that the Project would comply with the Noise Policy if it were subject to it.

5.11.1.3 Existing Conditions

5.11.1.3.1 Sound Levels at Two Offshore Sites

Existing daytime sound level measurements were made above water at two locations in the areas where recreational boaters travel: at Buoy G5 in the North Shipping Channel about one mile north of the edge of the Proposed Alternative location of the Wind Park, and at Buoy R20 at the edge of the Main Channel about 1/3 mile south of the Proposed Alternative location. These data were collected on October 22, 2002 between 10 a.m. and 12 Noon. The weather conditions were clear skies, light winds (4 mph average), and light seas (0.5-1.5 foot waves). The boat engine was shut-off during the measurements and the dominant sounds were wave interaction

[86] American National Standards Institute, ANSI S12.9-1996/Part 4, "Noise Assessment and Prediction of Long-Term Community Response," New York, 1996, page 15.

with the boat hull (the boat was allowed to drift), periodic over flying aircraft and distant boat traffic. Figure 5.11-1 is a map showing the locations of Buoys R5 and G20, as well as all onshore monitoring locations and modeling receptors.

The background (L_{90}) sound levels were 35 and 37 dBA, respectively, at Buoys G5 and R20. The corresponding average (L_{eq}) sound levels were 46 and 51 dBA. The wind speed during these measurements approximates the cut-in wind speed conditions for the WTGs (see the next section). To estimate existing average sound levels for the design wind speed condition of the proposed Wind Park, the measured levels were increased by 14 dBA, the average observed difference between the two wind conditions for long term monitoring done at three shoreline locations (see the next section). The frequency spectrum for existing condition sound levels at the two buoy locations are given in Figure 1 of Appendix 5.11-A.

5.11.1.3.2 Sound Levels at Three Representative Coastal Sites

Baseline sound monitoring locations were chosen to satisfy the MEPA Certificate that required monitoring at "the nearest representative locations along the south coast of Barnstable and Yarmouth and the east coast of the Vineyard". Along the coasts there is a wide variety of existing land use and population density. If representative locations were targeted at areas with the most people, then logical choices would be Hyannisport, the shore along Lewis Bay in Yarmouth and Edgartown harbor. These areas, however, have high levels of human activity and motor vehicle traffic, and baseline sound levels are higher than those found at uninhabited areas along the coast. To ensure the measured sound levels are a conservative (i.e., low) estimate of baseline conditions along the entire coast, secluded areas along the coast were sought out. In the same vein, measurements were taken in November and December 2002, a time of year with little or no beach traffic (cars, trucks and boats). Measurements made in the summer would have been higher. The three monitoring sites were located on the coast at **Point Gammon** in Yarmouth (4.7 miles from the closest WTG at the northeast corner of the Proposed Alternative location of the Wind Park), at **Oregon Beach**, Cotuit in Barnstable (5.5 miles from the closest WTG at the northwest corner of the Proposed Alternative location of the Wind Park), and at **Cape Poge Wildlife Refuge** at the tip of Cape Poge on Martha's Vineyard (5.4 miles from the closest WTG at the southwest corner of the Proposed Alternative location of the Wind Park).

Point Gammon is on a private peninsula (Great Island) in Yarmouth that sticks out into Nantucket Sound. The monitoring location was above a south-facing beach on the south tip of Great Island. The equipment was located 100 feet from the high water mark where the grade is 20 feet above the beach. The microphone (with wind screen) was mounted 7 feet above grade. The principal sounds at this site were the wind and ocean waves, periodic over-flying aircraft, and an occasional passing ferryboat. There was no vehicle or pedestrian access to this location during the measurement program that lasted seven days from November 15 to 22, 2002.

Oregon Beach is a public beach located off Main Street and Oregon Way, south of Cotuit Center in Barnstable. The coast generally faces southeast at this point on the Cape. The equipment was located 80 feet from the high water mark where the grade is a few feet above the beach. The microphone (with wind screen) was mounted 7 feet above grade. The principal sounds at this site were the wind and ocean waves, sea birds, periodic over-flying aircraft, and occasional motor vehicles and pedestrians accessing the beach area. Monitoring lasted more than four days from November 14 to 18, 2002.

Cape Poge Wildlife Refuge on Chappaquidick Island, Martha's Vineyard is a wildlife refuge and recreational area with facilities for swimming and shore fishing. It is a very isolated location, travel to which requires a four-wheel drive vehicle. The coast faces east towards the ocean at the monitoring location that was setup near the lighthouse above the beach. The equipment was located 40 feet from the high water mark on a sand dune where the grade is 20 feet above the ocean. The microphone (with wind screen) was mounted 8 feet above grade. The principal sounds at this site were the wind and ocean waves, and sea birds. Measurements were taken for seven days from November 25 through December 2, 2002.

The baseline measurements of existing sound conditions were examined in detail for the two wind conditions for which the Project's acoustic effects were quantified in Section 5.11.1.4: the **cut-in wind speed** of the WTGs (a

steady wind speed of 8 mph at hub height, equivalent to 5 mph at 3 meters above the ground)[87] and the **design wind speed** of the WTGs (a steady wind speed of 30 mph at hub height, equivalent to 16 mph at 3 meters above the ground). The WTGs would not operate under wind speeds below 8 mph.

Background (L_{90}) and average (L_{eq}) sound level measurements are summarized for three separate meteorological conditions in Table 5.11-3: 1) the cut-in wind speed for the turbines; 2) the design wind speed for the turbines (on-shore flow); and 3) the design wind speed for the turbines (off-shore flow). The distinction between on-and off-shore winds at the design wind speed condition is important for two reasons: (1) baseline sound levels are lower for off-shore winds as discussed below; and (2) sound from the Project would be reduced by 27 dBA under off-shore winds due to the wind shadow effect.[88] The frequency spectrums for these measurements are given in Figures 3 through 11 in Appendix 5.11-A.

The baseline measurements of existing sound conditions covered a full range of meteorological conditions from calm to high winds, with wind directions blowing both onshore and offshore and average wind speeds of 0 to 28 mph. The monitoring equipment was located on elevated land above and back from the high water mark to minimize the influence of surf sound yet still provide a quiet environment removed from highway and street noise. Surf sound is not an important factor except under high wind conditions, when surf sound can be heard anywhere along the coast. The baseline measurements, summarized in Table 5.11-3, reveal background (L_{90}) sound levels as low as 27 dBA (at Point Gammon) and in the 30s at the other two sites, which are representative of quiet rural areas. Since the measurements also covered periods of time when steady winds were up to 28 mph (wind gusts were higher), higher baseline sound levels are expected, and these higher levels would be measured at any location, whether it was along the shore where there might be surf sound in the background or inland where noise from wind flow around buildings and trees occurs.

At Point Gammon (November 15-22), measured background (L_{90}) levels ranged from 27 to 66 dBA, and average (L_{eq}) levels were 35 to 71 dBA. At Oregon Beach (November 14-18), measured background (L_{90}) levels ranged from 34 to 57 dBA, and average (L_{eq}) levels were 41 to 61 dBA. At Cape Poge (November 25-December 2), measured background (L_{90}) levels ranged from 37 to 70 dBA, and average (L_{eq}) levels were 40 to 73 dBA. At all three sites, existing sound levels are directly correlated to surface wind speed, and on-shore winds produce slightly higher sound levels than offshore winds, which is expected because offshore winds both suppress wave action at the shoreline and shield the coast from the sound of ocean waves by the wind shadow effect.

5.11.1.4 Acoustic Modeling Methodology

The analysis of sound effects for the Project utilized acoustic modeling (the methodology for which is described in this section) in conjunction with measured baseline sound levels (described in the previous section). Above water Project sound levels were calculated at two buoys (G5 and R20) in the shipping channels north and south of the Wind Park (to represent areas where recreational boaters travel), in Lewis Bay, and at 10 onshore locations along the south shore of the Cape and the east shore of Martha's Vineyard. These 13 modeling locations are listed in Table 5.11-4. Modeling locations 1, 2, 4, 9 and 13 are identical to the monitoring locations discussed in Section 5.11.1.3, and thus baseline sound level measurements exist for these five locations. For the other modeling locations, baseline sound level measurements were assigned as follows. The measurements made at Point Gammon (location 4) were used for both locations 3 and 4. The measurements made at Oregon Beach (location 9) were used for locations 5-10, and the measurements made at Cape Poge (location 13) were used for locations 11-13. As discussed in the previous section, actual baseline sound levels in inhabited areas of the coast would likely be higher than the baseline levels used in this analysis, which represent isolated uninhabited areas of the coast.

The above water acoustic modeling used standard methods. The sound level downwind of a source decreases with distance due to: 1) Geometric Wave Spreading, 2) air absorption, and 3) excess attenuation owing to wind and temperature gradients, atmospheric turbulence and ground characteristics.[89] To produce conservative results, the surface of the sea was assumed to be reflective plane (hemispherical wave spreading) excess

[87] The increase of wind speed with height above the ground is calculated in Appendix 5.11-A, section 3.2.
[88] Beranek, L., Noise and Vibration Control, Institute of Noise Control Engineering, 1988, pp. 187-190.
[89] "Sound Propagation Outdoors" in Beranek, L., Noise and Vibration Control, Institute of Noise Control Engineering, 1988, pp. 164-190 and American National Standards Institute, ANSI S1.26-1995, "Method for Calculation of the Absorption of Sound by the Atmosphere," 1995.

attenuation effects were assumed to be zero, consistent with downwind sound propagation and temperature inversion condition, and a high wind effect (discussed in the next paragraph) that can slow down wave spreading with distance was included. For construction impacts, modeling was performed only for calm to moderate winds (0 to 10 mph) when conditions are ideal for installation of the WTG foundation piles. Sound source data for installation of similar sized piles at the Utgrunden Wind Park were used in the acoustic modeling (see Section 2.3.1 in Appendix 5.11-A). For operational effects, acoustic modeling was performed for two wind conditions: (1) the WTG cut-in wind speed (8 mph at hub height); and (2) the WTG design wind speed (30 mph at hub height). Event (1) represents the operating condition when existing sound levels would be lowest, and Event (2) represents the maximum sound levels from the Project. GE Wind Energy provided WTG sound source data from recent tests performed at a GE 3.6 MW unit operating near Barrax, Spain. Simultaneous operation of all 130 WTGs was assumed in the acoustic modeling.

Under high wind conditions (20 mph and above), research has shown that changes in wind speed with height can cause very low frequency (below 20 Hz) sound waves to bend in the atmosphere in a way that slows down the process by which sound intensity diminishes with distance. This slower wave spreading effect ("cylindrical wave spreading") was included in the acoustic model to ensure conservative results. Research shows higher frequency sounds follow normal hemispherical wave spreading. Details are provided in section 4.1 of Appendix 5.11-A. Only the onshore wind condition was modeled because, under offshore winds, sound from the Project would be 27 dBA lower due to the wind shadow effect[90] and existing sound levels during offshore winds are only 1-14 dBA lower than during onshore winds (see Table 5.11-3). The above water acoustic modeling calculations are summarized at the end of Appendix 5.11-A.

As noted in the previous discussion of Acoustic Concepts (Section 5.11.1.1), a 3-dBA change in above water sound is the minimum perceptible to the human ear. Adding a new sound equal to an existing baseline level increases that level by exactly 3 dBA. Thus, if sounds from the Project are equal to or greater than the existing average baseline level (L_{eq}), it is assumed that a change would be perceived. Likewise, when broadband sound from the Project is less than the existing level, it is expected to be largely inaudible unless it creates a pure tone, as defined in Acoustic Concepts (Section 5.11.1.1).

5.11.1.5 Project Impacts

5.11.1.5.1 Impacts Outside of Massachusetts Waters

The two modeling locations that are seaward of the 3-mile limit are Buoys R5 and G20, which are along the edges of the North Channel and Main Channel closest to the Wind Park and represent the closest likely approach within a marked navigational channel by a recreational boater to the Wind Park. For the cut-in wind speed condition, predicted maximum continuous sound levels from Project operations are presented in Table 5.11-5. Existing sound levels are 46 to 51 dBA and represent daytime conditions for a non-motorized vessel (e.g., a sailboat) running downwind when the average surface wind speed is about 5 mph. (Occupants of a sailboat tacking upwind or a motorboat would experience higher baseline sound levels). For such boaters, the calculated Project operational sound levels of 30 to 34 dBA are well below existing sound levels of 46 to 51 dBA, and the Project would not create a pure tone (see Table 6 in Appendix 5.11-A); therefore the Project is expected to be largely inaudible to recreational boaters. The frequency-specific modeling results (Figures 12 and 13 in Appendix 5.11-A) also reveal that low-frequency sound from the Project is below the threshold of human hearing and would be inaudible regardless of the baseline sound levels.

For the design wind condition, predicted maximum continuous sound levels from Project operations are presented in Table 5.11-5. Existing sound levels are 60 to 65 dBA and represent daytime conditions for a non-motorized vessel (e.g., a sailboat) running downwind when the average surface wind speed is 16 mph. (Occupants of a sailboat tacking upwind or a motorboat would experience higher baseline sound levels). For such boaters, Project operational sound levels of 40 to 45 dBA are well below existing sound levels of 60 to 65 dBA, and the Project would not create a pure tone (see Table 6 in Appendix 5.11-A); therefore, again, the Project is expected to be largely inaudible to recreational boaters. As was the case with the cut-in wind speed condition, the frequency-specific modeling results (Figure 14 and 15 in Appendix 5.11-A) also reveal that low-frequency

[90] Beranek, L., Noise and Vibration Control, Institute of Noise Control Engineering, 1988, pp. 187-190.

sound from the Project is below the threshold of human hearing and would be inaudible regardless of the baseline sound levels. Accordingly, no noise impacts on recreational boaters are anticipated due to operation of the Project at either the cut-in or design wind speed conditions.

The Wind Park would be equipped with foghorns for boating safety. Several different devices would be deployed around the perimeter of the Wind Park, each with a different characteristic sound. The horns would operate only when fog is present, day or night, and would have a ½-mile audible range. Thus, boaters traveling near the Wind Park in dense fog would certainly hear these warning devices, just as they now hear various gongs and bells in Nantucket Sound from fixed buoy locations. Persons on land (5+ miles away) would not hear the foghorns.

5.11.1.5.2 Impacts Inside of Massachusetts Waters – Lewis Bay and Onshore Locations

For the cut-in wind speed condition, predicted maximum continuous sound levels from Project operations at Lewis Bay and onshore locations along the shore of Cape Cod and Martha's Vineyard are presented in Table 5.11-6. The calculated maximum operational sound levels of 11 to 18 dBA are well below existing sound levels for onshore winds (41 to 63 dBA), and the Project would not create a pure tone (see Tables 8 and 10 in Appendix 5.11-A); therefore the Project is also anticipated to be largely inaudible under these conditions. The frequency-specific modeling results (Figures 16, and 18 through 27 in Appendix 5.11-A) also reveal that low-frequency sound from the Project is below the threshold of human hearing and would be inaudible regardless of the baseline sound levels.

For the design wind speed condition, predicted maximum continuous sound levels from Project operations at Lewis Bay and onshore locations along the shore of Cape Cod and Martha's Vineyard are presented in Table 5.11-7. The calculated maximum operational sound levels of 19 to 26 dBA are well below existing sound levels for onshore winds (54 to 71 dBA), and the Project would not create a pure tone (see Tables 8 and 11 in Appendix 5.11-A). As before, the Project is anticipated to be largely inaudible. The frequency-specific modeling results (Figures 17, and 28 through 37 in Appendix 5.11-A) also reveal that low-frequency sound from the Project is below the threshold of human hearing and would be inaudible regardless of the baseline sound levels. Accordingly, no noise impacts are anticipated at any onshore locations due to Project operation for either the cut-in or design wind speed conditions.

The foghorns deployed around the Wind Park for boating safety would not be audible at Lewis Bay or onshore (see Section 5.11.1.5.1).

5.11.1.5.3 Compliance With the Massachusetts DEP Noise Policy

Table 5.11-8 illustrates that the Project would increase ambient background (L_{90}) sound levels by 0.5 to 2 dBA at Buoys G5 and R20 and by only 0.0 to 0.1 dBA at all other locations including Lewis Bay and all onshore areas of Cape Cod and Martha's Vineyard. In addition, the Project would not create a pure tone condition at any of the modeling locations (see Appendix 5.11-A). Thus, the Project would fully comply with the Community Sound Level Criteria in the DEP Noise Policy if it were applicable to the Project.

5.11.1.6 Construction Impacts

5.11.1.6.1 Construction Impacts Outside of Massachusetts Waters

The sound effects of construction would be temporary and are associated with the installation of 130 16-18 foot diameter monopiles (one for each WTG), installation of six smaller 4-foot diameter piles for the ESP, and vessel traffic for transporting equipment, piles, and workers to the site. The jet plow embedment process for laying submarine power cables with a cable barge produces no sound beyond typical vessel traffic in Nantucket Sound. The principal sound from construction would therefore be temporary pile driving of the WTG monopiles. The anticipated duration of installing all of the monopiles from start to finish is expected to be approximately eight months, plus any delays due to weather. It would take 4 to 6 hours to drive each monopile. The driving rate would be in the range of 2 to 36 impacts per minute. Sound data from installation of similar sized piles at the Utgrunden Wind Park were used in the acoustic modeling (see Section 2.3.1 in Appendix 5.11-A). The sound

levels from monopole driving would depend on the distance from the receiver to the particular point in the Wind Park array and whether the receiver is upwind or downwind of the location where the monopile is being driven. (In the former case, the wind shadow effect substantially reduces sound levels).

Table 5.11-9 summarizes the predicted range of maximum sound levels (L_{max}) at Buoys G5 and R20 (the receivers) from pile driving in the Wind Park. The lowest sound levels are associated with pile driving at the WTG location farthest away from the receiver, while highest sound levels are associated with pile driving at the WTG location closest to the receiver. The predicted construction impacts are 31 dBA to 76 dBA when the receiver is downwind of the pile driving activity and 8 dBA to 49 dBA when the receiver is upwind of the activity. Existing average sound levels (L_{eq}) at sea in the vicinity of the Project are approximately 46 to 51 dBA. These existing levels represent daytime conditions for a non-motorized vessel (e.g., a sailboat) running downwind in light wind conditions. For such boaters, the acoustic modeling results reveal that sometimes the temporary pile driving activity would be audible (i.e., above existing levels) and sometimes it would not, depending on a boater's distance from the monopile being driven and whether he is upwind or downwind of the activity. It should also be noted that occupants of sailboats tacking upwind or motorboats would experience higher baseline sound levels, and for these boaters it is less likely that temporary sound from Project construction would be audible.

5.11.1.6.2 Construction Impacts Inside Massachusetts Waters – Lewis Bay and Onshore Locations

As for the seaward analysis above, the principal sound from construction at sea would be temporary pile driving of the WTG monopiles. The same impact rates and sound data as above were utilized for this analysis. Table 5.11-10 summarizes the predicted range of maximum sound levels (L_{max}) at Lewis Bay and onshore locations from pile driving in the Wind Park. The lowest sound levels are associated with pile driving at the WTG location farthest away from the receiver, while the highest sound levels are associated with pile driving at the WTG location closest to the receiver. Table 5.11-10 also lists existing average sound levels (L_{eq}) for these near-shore and onshore locations for calm to moderate (0 to 10 mph) wind conditions and reveals that pile driving sound would be below existing sound levels at 9 of the 11 near-shore and onshore locations and is therefore expected to be largely inaudible along most of the coast. At Point Gammon in Yarmouth, the temporary sound of construction could be audible when pile driving is done for the monopiles in the northeast corner of the Wind Park closest to shore (sounds up to 43 dBA when winds are onshore) when existing sound levels are very low (possibly as low as 35 dBA). At Cape Poge on the northeast tip of Martha's Vineyard, the temporary sound of construction could be audible when pile driving is done for the monopiles in the southwest corner of the Wind Park closest to the Vineyard (sounds up to 40 dBA when winds are onshore) when existing sound levels are very low (possibly as low as 40 dBA). Even in these instances, however, the temporary short-term sound levels would be low and would not interfere with any activities.

The onshore construction activities include HDD for the boreholes containing the Submarine Cable System from Lewis Bay to the transition vault on nearby land and overland laying of cable from the transition vault to the Barnstable Switching Station using excavators and backhoes. Onshore construction activities would be temporary, lasting 4 to 6 weeks, and would be audible to persons near the cable corridor; sound levels would be similar to roadway construction equipment. The exact temporary sound levels experienced by residents for the HDD and cable laying would depend on their distance from the construction activity. For example, a person standing 50 feet from the equipment (HDD, excavator, backhoe) would hear sound levels (L_{eq}) in the range of 73 to 79 dBA, and at 200 feet they would hear 61 to 67 dBA. Houses along New Hampshire Avenue where this construction would occur are generally 50 or more feet from the trench that would be dug. The nearest houses to the HDD area are Nos. 32 and 49 New Hampshire Avenue. The closest edge of the house at No. 32 New Hampshire Avenue is 16 feet from the HDD pit and the closest edge of the house at No. 49 New Hampshire Avenue is 32' from the edge of the HDD pit. Noise barrier walls would be constructed at the edge of the HDD pit to shield these residences. The calculated Leq sound level at the nearest edge of the house, assuming a second-floor window exists at that point, would be 68 dBA at No. 32 and 61 dBA at No.49 New Hampshire Avenue.

To further facilitate the HDD operation, a temporary cofferdam would be constructed at the end of the boreholes. The cofferdam would be approximately 65 feet wide and 45 feet long and would be open at the seaward end to allow for manipulation of the HDD conduits. The cofferdam would be constructed using steel sheet piles driven from a barge-mounted crane. The installation of sheet steel for the cofferdam would be done using a low-noise vibratory method; the project would not use impact pile driving. The noise effects would be temporary and the

calculated maximum sound levels are 79 dBA at the two closest residences to the cofferdam, Nos. 32 and 49 New Hampshire Avenue. The installation of sheet steel for the cofferdam would utilize a low-noise vibratory method and would not use impact pile driving. Therefore underwater sound effects from the cofferdam installation would also be minimal and temporary.

5.11.1.7 Mitigation for Potential Impacts from Noise

The Project design has mitigated potential operational sound effects to the extent practicable through the selection of state-of-the-art, very low noise WTGs and their siting offshore, over 5 miles from any populated areas. Project operation is anticipated to be largely inaudible at all near-shore and onshore locations. Accordingly, no additional noise mitigation measures are necessary.

Construction noise impacts would be temporary, unavoidable, and are primarily associated with the laying of the Onshore Transmission Line from the transition vault at the shore of Lewis Bay along existing roadways to the Barnstable Switching Station using standard roadway construction equipment. Noise mitigation for this onshore activity would consist of scheduling activities during normal working hours and ensuring that all equipment has properly functioning noise mufflers. Sound levels from pile driving of the WTG monopiles in the Wind Park would generally be inaudible for the vast majority of the time at all near-shore and onshore locations.

5.11.2 Below Water Sound Analysis

This section begins with an introduction to underwater Acoustic Concepts and applicable Regulatory Requirements, followed by a presentation of Existing Conditions, Acoustic Modeling Methodology, Projects Impacts, Construction Impacts, and finally Mitigation.

5.11.2.1 Acoustic Concepts

In the underwater environment, acoustic energy (also referred to as vibration) moves through the water as sound waves, which are minute variations in water pressure. The underwater sound pressure level is defined on a decibel (dB) scale, similar to the familiar above water decibel scale, but the reference pressure is different. As a result, an identical sound pressure wave in air and underwater is recorded differently in the two fluids. For example, a sound pressure of 80 dB in air is equivalent to 106 dB underwater, i.e., the underwater scale is shifted 26 dB higher than the air scale. There are also substantial differences in ambient (background) sound levels in air and in the ocean, and in the frequency weighting that is used in water versus air. Thus, the reader should not try to equate dB levels reported for water with those in air, or vice-versa. A discussion of the logarithmic characteristics of the decibel scale is given in Section 5.11.1.1.

The existing sound in the sea comes from many sources, natural and man-made, including turbulence in ocean currents, tides, surface waves, cavitations (collapse of air bubbles) in near-surface waves, low-level seismic activity, sea animals, and ship traffic. The hearing capabilities of and the frequency responses of marine mammals vary widely. Therefore, underwater sound levels are presented as un-weighted or linear decibels, dBL (also as "L" in tables and graphs). As with airborne sound, the frequency component of the underwater sound is important in this analysis.

Underwater sound levels are commonly measured as either the equivalent sound level (L_{eq}) or the maximum sound level (L_{max}). The L_{eq} is the energy averaged sound level that includes both steady background sounds and transient peak sounds. The L_{eq} provides a uniform method for comparing time-varying sound levels. The L_{max} is the near-instantaneous maximum sound level measured during a time period and is always higher than the $L_{eq.}$ For underwater sound, the typical measurement range at sea is from 80 dBL (still water conditions) to 180 dBL. The ambient underwater sound level is highly variable in time and by location. For example, a one-knot current can produce turbulent pressure changes (sound waves) of 116 dBL.91 Typical ambient underwater sound levels in Nantucket Sound are L_{eq} 95-115 dBL for surface winds of five to 30 mph.

[91] Urick, R., Principles of Underwater Sound, 3rd Edition, McGraw-Hill, 1983, p. 206.

5.11.2.2 Regulatory Requirements

While there are no local, state or federal underwater noise control regulations with decibel limits that apply to the Project, the National Marine Fisheries Service (NMFS) has set a guideline limit of 180 dBL, generally thought to be the threshold level for preventing injury or harassment to marine mammals and sea turtles.[92] The 180 dBL limit is used in this analysis.

5.11.2.3 Existing Conditions

5.11.2.3.1 Sound Levels at Two Offshore Sites

Short-term existing daytime sound level measurements were made underwater at two locations in the areas where recreational boaters travel: at Buoy G5 in the North Shipping Channel about one mile north of the edge of the Proposed Alternative location of the Wind Park, and at Buoy R20 at the edge of the Main Channel about 1/3 mile south of the Proposed Alternative location. These data were collected on October 22, 2002 between 10 a.m. and 12 Noon. The weather conditions included clear skies, light winds (4 mph average), and light seas (0.5-1.5 foot waves). The boat engine was shut-off during the measurements and the dominant sounds were wave interaction with the boat hull (the boat was allowed to drift), periodic over flying aircraft and distant boat traffic.

The underwater L_{eq} levels were 90 and 93 dBL, respectively, at Buoys G5 and R20. The sound level at Buoy R20 is slightly higher due to the shallower water and greater current. The depth at Buoy R20 is more representative of the water depth on Horseshoe Shoal, and so the R20 measurements were used as the underwater baseline for the proposed Wind Park. To estimate existing underwater sound levels for the design wind speed condition of the proposed Wind Park, the measured levels were scaled by a factor of 7.2 dBL per doubling of wind speed, as has been observed in coastal water sound studies.[93] The estimated underwater L_{eq} level for the design wind speed condition therefore extrapolates to 107.2 dBL. The frequency spectrum for the existing condition is given in Figure 2 of Appendix 5.11-A.

5.11.2.3.2 Sound Level at Horseshoe Shoal

Underwater sound measurements were made on Horseshoe Shoals at the site of the Scientific Measurement Devices Station (SMDS) for the Project during the time when three support piles were driven into the seabed (see Section 2.1 in Appendix 5.11-A). The weather conditions were moderate winds (below 12 mph) and moderate seas (less than 5 feet). The measured existing underwater L_{max} level (no pile driving) was 123 dBL.

5.11.2.4 Acoustic Modeling Methodology

The analysis of underwater sound effects for the Project under the design wind condition utilized acoustic modeling (the methodology for which is described in this section) in conjunction with measured baseline underwater sound levels (described in the previous section). The design wind condition corresponds to the maximum underwater operational sound for the Project. Sound wave propagation and attenuation underwater is a very complex phenomena influenced by gradients of temperature, salinity, currents, sea surface turbulence, and bottom conditions. Underwater acoustic modeling used standard methods for representing how sound waves spread out and diminish in intensity and for seawater absorption effects[94]; research has shown this model provides a reasonable fit to measured underwater sound levels under a wide variety of conditions.[95] Sound source data for construction and operational effects underwater were provided by GE Wind Energy from recent tests at the Utgrunden and Gotland Wind Parks (see Sections 2.3.1 and 2.3.2 in Appendix 5.11-A) which have similar environmental conditions to Nantucket Sound and provide the best available data. Baseline underwater sound levels under the design wind condition are 107.2 dBL (see Section 5.11.2.3.1). The underwater acoustic modeling calculations are summarized at the end of Appendix 5.11-A.

[92] National Marine Fisheries Service, letter from Ms. Patricia Kurkal, Regional Administrator to Ms. Christine Godfrey, U.S. Army Corps of Engineers, June 27, 2002.
[93] Urick, R., Principles of Underwater Sound, 3rd Edition, McGraw-Hill, 1983, p. 213.
[94] Etter, P., Underwater Acoustic Modeling: Principles, Techniques and Applications, Elsevier Applied Science, New York, 1991, p. 65.
[95] Urick, R., Principles of Underwater Sound, 3rd Edition, McGraw Hill, New York, 1983, p. 110.

5.11.2.5 Project Impacts

5.11.2.5.1 Impacts Outside Massachusetts Waters

For the design wind condition, calculated continuous underwater sound levels from Project operations are presented in Table 5.11-11 as a function of the distance from a WTG monopile. (The frequency-specific modeling results are given in Figure 41 of Appendix 5.11-A). The underwater sound from the Project increases the baseline sound level only 1.9 dBL at 20 meters from the monopile, and this increment falls rapidly with increasing distance such that total sound levels with the Project return to the existing baseline level within only 120 meters of the monopile. Since 120 meters is far less than the spacing between WTG monopiles, there are no cumulative underwater acoustic effects from multiple WTGs and there would be no measurable underwater sound from the Project beyond the boundaries of the Wind Park.

5.11.2.5.2 Impacts Inside Massachusetts Waters

There would be no measurable underwater sound effects from Project operation in the coastal waters off Cape Cod and Martha's Vineyard (see the previous section).

5.11.2.6 Construction Impacts

The underwater sound effects of construction would be temporary and are associated with the installation of 130 16-18 foot diameter monopiles (one for each WTG), installation of six smaller 4-foot diameter piles for the ESP, vessel traffic for transporting equipment, piles, and workers to the site and vessel traffic associated with installation of submarine cables. According to divers experienced in jet plow installations, the jet plow itself produces no audible noises other than the sound of water exiting the nozzles, which is only audible when immediately adjacent to the nozzles. The principal sound from construction would therefore be temporary pile driving of the WTG monopiles using a drop hammer similar to an IHC S-600. Only one monopile will be driven at a time. The driving rate would be in the range of 2 to 36 impacts per minute. It is anticipated that the process of completing one string of WTGs (10 WTGs with associated inner-array cable and scour mats) will take up to approximately one month and installation of all 130 WTGs will occur over two construction seasons. Sound data from installation of similar sized piles at the Utgrunden Wind Park were used in the acoustic modeling (see Section 2.3.1 in Appendix 5.11-A). Sound levels would depend on the distance from the underwater receiver to the monopile being driven. For additional information on construction noise effects to finfish and protected marine species, please refer to Section 5.4 and 5.5.

The calculated maximum underwater sound levels (L_{max}) from pile driving in the Wind Park would range from 172 dBL at a distance of 500 meters to 170 dBL at a distance of 1,220 meters and down to 145 dBL at a distance of 21 kilometers. In the near-shore waters of Cape Cod and Martha's Vineyard, the L_{max} levels would range from 140 to 155 dBL. Levels would be lower in Lewis Bay due to the barrier attenuation provided by the land-mass of Great Island in Yarmouth. Figures 38 and 39 in Appendix 5.11-A show the temporary underwater L_{max} sound levels throughout Nantucket Sound for pile driving at the southwest and northeast corners of the Wind Park, respectively. The frequency spectrum of the underwater sound at a distance of 500 m from a monopile is given in Figure 40 of Appendix 5.11-A.

5.11.2.7 Cumulative Impacts

In addition to the proposed Project as discussed above, other activities in the past, present or future which may contribute to cumulative impacts to above water and below water sounds would include other submarine cable or pipeline installations, dredging activities, trawling, installation of pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY), as well as upland cable or pipeline installations, excavation activities, construction of new commercial and residential structures, and other upland wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative).

5.11.2.8 Secondary Impacts

The secondary noise impacts associated with construction staging/laydown activities at Quonset would involve sounds from the use of heavy industrial equipment such as trucks and cranes used in the loading and offloading of cargo ships. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy and no significant land alteration would be necessary to accommodate the Project's staging activities.

5.11.2.9 Mitigation for Potential Impacts from Noise

The use of state-of-the-art, very low noise WTGs would minimize operational sound effects. There would be no measurable underwater sound from Project operation beyond 120 meters from each monopile and Project operations would not adversely affect marine mammals, sea turtles or fish. See Sections 5.5 and 5.4 for further information on protected marine species and finfish.

Construction noise impacts would be temporary, unavoidable, and are primarily associated with pile driving the monopiles in the Wind Park. Predicted maximum underwater sound levels at the 500 meter Initial Safety Radius would be below the 180 dBL threshold set by the NMFS to prevent injury or harassment to marine mammals, sea turtles and fish. Underwater sound level monitoring will be performed during monopile construction identical to that done to protect marine mammals during the installation of the SMDS tower foundation piles, with measurements taken at 500 meters and further distances out. Noise mitigation would consist of having a NMFS approved observer present during initial pile driving activities to ensure no listed marine species are within the 500 meter Initial Safety Radius during construction, similar to the procedure used during the installation of the SMDS foundation piles. See Sections 5.5 and 5.4 for further information on protected marine species and finfish.

5.12 Transportation and Navigation

5.12.1 Introduction

This section provides an analysis of potential impacts of the Project on transportation and navigation, including aviation navigation in the airspace above the Project area, marine navigation, and land-based transportation along the onshore portions of the proposed transmission cable route.

The balance of this section discusses the regulatory context of transportation and navigation issues. Section 5.12.2 describes studies completed to address these issues. In Section 5.12.3, existing conditions are described, followed by a discussion of potential Project impacts and mitigation measures in Sections 5.12.4 and 5.12.5, respectively.

Federal Aviation Administration

The FAA's authority to promote the safe and efficient use of the navigable airspace, whether concerning existing or proposed structures, is predominantly derived from 49 United States Code, Section 44718. Title 14, Code of Federal Regulations, Part 77, Objects Affecting Navigable Airspace, was adopted to establish notice criteria for proposed construction or alteration that would protect aircraft from encountering unexpected structures. The regulations apply to structures located within any state, territory, or possession of the United States, within the District of Columbia, or within territorial waters (12NM) surrounding such states, territories, or possessions. The primary objective of an evaluation under Part 77 is to ensure the safety of air navigation and efficient utilization of navigable airspace by aircraft. The sponsor has the responsibility to notify the FAA of proposed construction of any structure with a height greater than 200 feet above ground (in this case above sea level) that may affect the protected areas/airspace around airports, commonly referred to as Part 77 surfaces. This notification is accomplished by the submission of an FAA Form 7460-1, Notice of Proposed Construction or Alteration.

The Applicant has coordinated with the FAA in the review of potential impacts to air navigation for structures greater than 200 feet in height above ground level. On September 25, 2002, the Applicant filed a *Notice of Proposed Construction or Alteration (FAA Form 7460-1)* with the FAA, pursuant to 14 CFR Part 77, Objects Affecting Navigable Airspace, for each proposed WTG location. The FAA's review has considered whether the Project would be a hazard to air navigation.

United States Coast Guard
The Applicant is coordinating with the USCG in the review of potential navigation impacts to commercial and recreational boating, including the impact on sailing vessels and commercial fishing vessels. The Project must file with the USCG for a *Permit to Establish and Operate a Fixed Aid-to-Navigation* pursuant to 33 CFR Part 66. The USCG grants authority for establishment, erection, or maintenance of any aid to maritime navigation in U.S. waters. The USCG has jurisdiction over projects located in navigable waters of the U.S., and the USCG Marine Safety Office for the Port of Providence, Rhode Island has coordinated a Navigational Risk Assessment for the Project.

Massachusetts Highway Department
The Project would be required to file a *Permit to Access State Highway* from the Massachusetts Highway Department (MHD). MHD has jurisdiction over installation of the cables within the portions of State Routes 28 and 6, located in Yarmouth and Barnstable. In addition, the Project would require MHD access agreements for maintenance access to the onshore transmission cable located within state highway ROWs.

Town of Yarmouth Department of Public Works
The Project would require a *Street Opening* approval from the Yarmouth Department of Public Works (YDPW). The YDPW has jurisdiction over the installation of the onshore transmission cable within Town-owned roadways, easements, and ROWs.

Town of Barnstable Department of Public Works
The Project would require a *Street Opening* approval from the Barnstable Department of Public Works (BDPW). The BDPW has jurisdiction over the installation of the onshore transmission cable within Town-owned roadways, easements, and ROWs.

5.12.2 Studies Completed

Existing conditions for the proposed Horseshoe Shoal location for the Wind Park and submarine transmission line route are described based on consultation with the FAA, on a review of NOAA navigation charts (#13237) and USACE publications, consultations with the USCG, and meetings with the Massachusetts Steamship Authority and private ferry operators transiting this area of Nantucket Sound. Additionally, the Applicant has completed detailed hydrographic studies of the area to confirm water depths and safe navigation conditions on Horseshoe Shoal, and has noted all field observations of vessel traffic in the Project area during aerial surveys, boat transits, and other operations related to Project development. The FAA assessed the effect of the proposed Wind Park location on existing established FAA Instrument Flight Rule (IFR) and Visual Flight Rules (VFR) routes, and navigational aids. Existing conditions along the onshore transmission line route are described based on a review of mapped resources and a field review. Mapped resources reviewed during this investigation include USGS topographic maps (Hyannis and Dennis Quadrangles); and USGS aerial photos dated March 5 and April 3, 1995.

A lighting design has been proposed to make the structures sufficiently conspicuous to pilots and mariners in order to ensure aeronautical and marine safety, while minimizing visual impacts to land-based viewsheds and potential avian impacts associated with attraction of birds. Each of the individual WTGs would be lighted by two flashing lights on the nacelle (for pilots) and two flashing lights on the lower access platform (for mariners). Lights would vary in intensity, depending on the specific location of the individual turbine, with perimeter WTGs generally lit at a higher intensity than those located within the interior of the Wind Park. Alternating WTGs on the Project perimeter would be illuminated with two flashing medium intensity white warning lights (FAA L865) during the day and two flashing medium intensity red lights (FAA L864) at night, mounted on the nacelle. The remaining perimeter WTGs would be marked day and night with two flashing low intensity red lights (comparable to a low intensity FAA-L810 fixture). All interior WTGs would each have two flashing low intensity red lights (L810) at night and during the daytime. All WTGs will have two flashing amber USCG ATON lights mounted on the access platform. The lighting design has been developed based on the following:

- Consultations with FAA New England Region staff;
- Review of FAA Advisory Circular 70/7460-1K, Obstruction Marking and Lighting;
- Consultations with USCG Private Aids to Navigation (PATON) – District One staff;

- Review of regulations for Private Aids to Navigation (PATON);
- Consultations with USACE;
- USFWS recommendations (September 14, 2000 memo: Service Guidance on the Siting, Construction, Operation and Decommissioning of Communications Towers);
- International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) recommendations for marking offshore wind parks;
- Cape Wind Associates Scientific Measurement Devices Station (SMDS) approved lighting design;
- Avian consultant (Dr. Paul Kerlinger);
- Lighting contractor (Automatic Power Inc.); and
- European wind park experience (Horns Rev).

The FAA has completed an aeronautical study of each of the 130 proposed WTG locations on Horseshoe Shoal, which included the distribution of public notices and a 30-day public comment period. The FAA aeronautical study included an evaluation of the proposed structures' effects:

- On existing and proposed public-use and military airports and/or aeronautical facilities.
- On existing and proposed visual flight rule (VFR) / instrument flight rule (IFR) aeronautical departure, arrival and en route operations, procedures, and minimum flight altitudes.
- Regarding physical, electromagnetic, or line of sight interference on existing or proposed air navigation, communications, radar, and control systems facilities.
- On airport capacity, as well as the cumulative impact resulting from the structure when combined with the impact of other existing or proposed structures.
- Whether marking and/or lighting is necessary.

The FAA issued a Determination of No Hazard to Air Navigation on April 9, 2003 (see Appendix 5.12-C). The Applicant would follow the recommendations of the FAA regarding lighting

A Navigational Risk Assessment has been prepared at the direction of, and in consultation with, the USCG Marine Safety Office at the Port of Providence, to provide a qualitative assessment of navigational risks related to the proposed Project. The analyses required by the USCG were outlined in a letter to the USACE dated February 10, 2003 (see Appendix 5.12-A). The Navigational Risk Assessment (dated August 18, 2003) has been reviewed by the USCG. The USCG determined that the assessment appeared to sufficiently address the key navigational issues identified in their letter of 2/10/2003 which outlined requirements for the Navigational Risk Assessment. The Navigational Risk Assessment is included as Appendix 5.12-B.

5.12.3 Existing Conditions

5.12.3.1 Marine

As shown in Figure 5.12-1, Nantucket Sound is bounded to the south by the islands of Martha's Vineyard and Nantucket, and to the north by Cape Cod. To the west of Nantucket Sound is Vineyard Sound, and to the east is the Atlantic Ocean. Horseshoe Shoal is located in the approximate middle of Nantucket Sound, with its geometric center at approximately 41°30'N; 70°20'W. The northeasterly tip of the shoal is known as "Broken Ground." The southeasterly tip of the shoal is known as "Halfmoon Shoal."

Nantucket Sound is used for navigation by recreational watercraft, commercial fishing vessels and commercial vessels engaged in waterborne commerce. Peak usage by recreational watercraft and commercial fishing vessels is during the warmer months of the year (typically April through October). (For additional information on commercial and recreational fishing conditions and impacts please refer to Sections 5.4 and 5.16 of this DEIS-DEIR). Pilotage is not typically required for vessels transiting through central and eastern Nantucket Sound. There are two main shipping lanes, the Main Channel and the North Channel, used for safe navigation by larger vessels in Nantucket Sound (see Figure 5.12-1). USCG marks both of these areas with aids-to-navigation (buoys, lights, etc.). These shipping lanes are described as follows:

- The Main Channel in Nantucket Sound is located south of Horseshoe Shoal. This channel is used by most of the vessels transiting through Nantucket Sound. It is reported that vessels using the channel seldom exceed a draft of 24 feet (7.3 meters) (NOAA, 1994).
- The North Channel runs along the north side of Nantucket Sound, on either side of Bishop and Clerks, northward of Horseshoe Shoal, between Wreck Shoal and Eldridge Shoal, northward of L'Hommedieu Shoal, and through one of the openings in the shoals westward of L'Hommedieu Shoal into Vineyard Sound. This channel is used mostly by vessels bound for the south shore of Cape Cod, and by vessels transiting the Sound during northerly winds. The shallowest depth in the channel is approximately 16 feet (4.9 meters) at Mean Low Low Water (MLLW).

In addition to these shipping channels, privately and federally maintained channels are located at the approaches to Cotuit Bay, Centerville Harbor, and Hyannis Harbor (see Figure 5.12-1).

The area between the Main Channel and the Cape Cod shoreline, including Horseshoe Shoal, is designated as an anchorage ground, known as "Anchorage I." Floats or buoys for marking anchors or moorings in place are allowed in this area. Fixed mooring piles or stakes are prohibited (NOAA, 1994).

Passenger and freight ferries (including high-speed ferries) bound for both Nantucket and Martha's Vineyard operate out of Hyannis Inner Harbor and transit the area near Horseshoe Shoal. Steamship Authority vessels do not transit over Horseshoe Shoal. Ferries bound for Nantucket transit to the east of Horseshoe Shoal, while ferries bound for Martha's Vineyard transit to the north and west of the shoal. According to USACE data for the 1998 through 2000 timeframe, an annual average of 1,305 vessel trips for vessels engaged in waterborne commerce were reported as passing Cross Rip Shoal, which is to the south of Horseshoe Shoal and the Main Channel.

There do not appear to be historical records on the frequency of sea ice events in Nantucket Sound. The National Weather Service in Taunton, MA stated they do not keep sea ice records, and are not aware of other agencies that maintain such records for Nantucket Sound (NWS, 2003). The *Coast Pilot* makes one passing reference to ice in Nantucket Sound, when it mentions that northerly winds keep the north shore of the Sound free from drift ice (NOAA, 1994); this further suggests that sea ice events in Nantucket Sound do not occur with any regular frequency. Anecdotal evidence suggests that large-scale sea ice events have occurred less frequently in Nantucket Sound during the past decade. However, sea ice was common in Nantucket Sound during the winters of 2002 to 2003, and 2003 to 2004. According to ferry operators and others interviewed, ice does not appear to affect navigation in Nantucket Sound with any regular frequency.

Along the proposed submarine cable system route from Nantucket Sound through Lewis Bay to the preferred landfall in Yarmouth, water depths reach a maximum of 35 feet (10.7 meters) MLLW near the seaward end of the route and gently slope upward to the landfall location. The entrance to Lewis Bay is sufficiently wide enough to allow access by cable-laying vessels, and there are no shoals or obstructions along the route that would hinder travel or maneuverability. For their own safety, other vessels would be asked to navigate around the installation barge's anchors, which will be marked by buoys. Given the relatively shallow water depths at the entrance to Lewis Bay and the cable route's location to the side of the Federal Channel, the presence of the anchors is not expected to adversely affect vessel traffic entering or leaving Lewis Bay

5.12.3.2 Aeronautical

The proposed WTG array is generally located approximately 9 miles (14.5 km) south of Barnstable Municipal Airport, approximately 17 miles (27.4 km) northwest of Nantucket Memorial Airport, and 13 miles (21 km) northeast of Martha's Vineyard Airport (see Figure 5.12-2). These three airports provide service connections from the mainland to the Islands of Nantucket and Martha's Vineyard. Other surrounding airports include Provincetown Municipal Airport on the Outer Cape, Otis Air Force Base in Sandwich, New Bedford Regional Airport, Logan International Airport in Boston, and T.F. Green Airport in Providence, Rhode Island. These airport facilities also have connecting flights to the Barnstable, Nantucket, and Martha's Vineyard airports.

In addition to commuter and general aviation aircraft, the airspace over Nantucket Sound is used by military aircraft for training, by USCG aircraft for Search and Rescue (SAR) and other operations, by commercial fish spotter planes, and by commuter helicopters.

5.12.3.3 Onshore

The proposed onshore transmission line route to its intersection with the NSTAR Electric ROW would be located entirely along existing paved ROWs where other underground utilities already exist. All of the roadways within Yarmouth and Barnstable in which the proposed transmission line would be placed are town owned and maintained roads with the exception of Routes 6 and 28, which are owned and maintained by MHD. A portion of the onshore transmission line route would also be located underground within the existing maintained NSTAR Electric ROW.

Installation of the proposed transmission cable includes constructing a utility easement within and along four roadways: New Hampshire Avenue, Berry Avenue, Higgins Crowell Road, and Willow Street. The easement would also include the crossing of Route 28 and Route 6. The transmission line would affect three intersections.

New Hampshire Avenue
New Hampshire Avenue is a two-lane residential road allowing vehicle access in a north-south direction. The roadway is a dead-end roadway with a concrete retaining wall at its southern end. There are no sidewalks on either side of the roadway. In addition, there is no on-street parking. During the summer of 2002, over the course of multiple site visits, observations were made of the relative traffic volumes at various points along the proposed route. Mid-day volumes along New Hampshire Avenue were observed to be very light. The transmission line would be installed within the east side of the roadway.

Berry Avenue
Berry Avenue is a two-lane residential road allowing vehicle access to travel in a north-south direction. There are sidewalks on both sides of the roadway. Mid-day volumes were observed to be light. The transmission line would cross to the west side of Berry Avenue off of New Hampshire Avenue. No on-street parking was observed on Berry Avenue. Berry Avenue is approximately 22 feet (6.7 meters) wide.

Intersection 1 - Route 28 Between Berry Avenue and Higgins Crowell Road
The intersection of Route 28 with Berry Avenue and Higgins Crowell Road is a two-lane roadway with a painted divider. Vehicle access on Route 28 travels in an east-west direction. The intersection of Route 28 with Berry Avenue and Higgins Crowell Road is signalized. There are sidewalks on both sides of Route 28. Mid-day volumes were observed to be moderate to heavy. The transmission line would be installed underneath Route 28 using trenchless technologies.

Higgins Crowell Road
Higgins Crowell Road is a two-lane road with a painted divider. Vehicle access travels in a north-south direction. There are no sidewalks on either side of the roadway; however, there are unpaved shoulders along either side. Mid-day volumes were observed to be moderate to heavy. The transmission line would be placed on the east side of Higgins Crowell Road. The street width for this road is approximately 24 feet (7.5 meters).

Intersection 2 - Buck Island Road
The intersection of Buck Island Road with Higgins Crowell Road is a two-lane roadway with a painted divider. Vehicle access on Buck Island Road travels in an east-west direction. The intersection of Buck Island Road with Higgins Crowell Road is signalized. Mid-day volumes were observed to be moderate to heavy. The transmission line would be installed beneath Buck Island Road using trenchless technologies.

Willow Street
Willow Street is a two-lane road with a painted divider. Vehicle access travels in a north-south direction. There are no sidewalks on either side of the roadway; however, there are unpaved shoulders along either side. Mid-day volumes were observed to be heavy. The transmission line would be placed on the west side of Willow Street. The street width for this road is approximately 30 feet (9.1 meters).

Intersection 3 – Route 6 Overpass
The transmission line would be installed using trenchless technologies as it passes underneath the Route 6 overpass. Approximately 0.5 mile (0.8 km) past the Route 6 overpass, the transmission line would cross to the west side and enter the NSTAR Electric ROW. The transmission line would also cross under Route 6 from the NSTAR Electric ROW from north to south to connect with the Barnstable Switching Station. This crossing would also be accomplished using trenchless techniques.

5.12.4 Analysis of Impacts

5.12.4.1 Impacts Outside of Massachusetts Waters

5.12.4.1.1 Marine

Construction and Decommissioning
There would be minimal temporary impacts to navigation in the immediate vicinity of ongoing construction operations. Any restrictions that are necessary to protect the safety of mariners would be implemented in coordination with the USCG. Anchors would have pennant buoys and mid-line anchor buoys to assist in identifying the extent of the anchor spread.

Details of the marine-based construction would be closely coordinated with the USCG and local Harbor Pilots. During construction, it is likely that temporary vessel access restrictions in the immediate vicinity of construction operations may be required to protect public safety. These restrictions, however, would be limited to small sections of the Wind Park as the cable embedment process is completed. Notice to Mariners would be posted and called on a daily basis or at intervals required by the USCG. The construction vessels would display the appropriate day shapes and/or lighting, and would monitor VHF Ch. 13 and Ch. 16 during operations.

Should decommissioning become necessary at any time, the same procedures and restrictions would apply. Like the construction impacts, these decommissioning impacts would be temporary in nature.

Operation and Maintenance
Detailed information on existing navigational uses in the Horseshoe Shoal area, the potential for impacts to navigation from the Wind Park, and on SAR in and around the Wind Park is found in the Navigational Risk Assessment provided in Appendix 5.12-B. The Navigational Risk Assessment (dated August 18, 2003) has been reviewed by the USCG. The USCG determined that the assessment appeared to sufficiently address the key navigational issues identified in their letter of 2/10/2003 which outlined requirements for the Navigational Risk Assessment.

The Navigational Risk Assessment was developed in accordance with the expressed requirements of the USCG, and provided a detailed analysis of all aspects of marine navigation safety issues related to development of the proposed Wind Park. The following paragraphs summarize the parameters and analysis of navigation safety and are largely excerpted from the Navigational Risk Assessment. This summary demonstrates that all reasonable measures would be taken in the design, construction, operation and maintenance of the Wind Park to provide for safe navigation. It is important to note, however, that it is not possible to identify the characteristics and routes of every vessel that uses, or could potentially use, the waters in and around the site because marine vessel traffic is not closely regulated and routes are generally not restricted to designated corridors. In addition, and as described in more detail under Navigation Rules below, the ability to safely navigate in and around the WTGs during any given set of weather and/or vessel conditions, must be determined by and is the responsibility of each vessel's captain.

Planned Configuration
The WTGs would be constructed in a grid pattern (minimum 0.34 nautical mile (NM) (629 meters) by 0.54 NM (1,000 meters) spacing), rather than randomly scattered throughout the Wind Park area. This would provide mariners with the ability to navigate through the area by maintaining an essentially straight course that passes easily between the WTGs. The large spacing would allow those vessels not restricted by depth to navigate between the WTGs with large spaces between the vessel and the WTGs. As an example, 14 M/V *Eagle*'s (the Massachusetts Steamship Authority's largest vessel, at 233 feet (71 meters) long) laid stem-to-stern could fit

between adjacent WTGs along the 0.54 NM (1,000 meters) spacing rows, and 8.8 M/V *Eagle*'s could fit between adjacent WTGs along the 0.34 NM (629 meters) spacing rows. When 45-foot (13.7 meters) length overall (LOA) long sailboats are laid stem-to-stern, 71.5 sailboats could fit between adjacent WTGs along the 0.54 NM (1,000 meters) spacing rows, and 45.2 sailboats could fit between adjacent WTGs along the 0.34 NM (629 meters) spacing rows.

After installation of the pile foundations and during Project operation, some localized scour around the monopile foundations could occur at the seabed-monopile interface around each WTG, depending on local sediment transport conditions. A scour analysis was conducted to predict sediment scour that may occur in seabed sediments around the WTG structures (see Section 4.0, Section 5.1, Section 5.2, and Appendix 4.0-A). In brief, results of the studies indicated that localized effects to sediment transport patterns are anticipated immediately around WTG foundation bases, due to localized turbulence adjacent to the structures. However, this localized scour will be mitigated as described in Section 5.2.5, and is not expected to produce any large-scale changes in bathymetry or shoaling of shipping channels outside of the Project area.

Ice

The large spacing between WTGs, combined with the natural tidal circulation in Nantucket Sound, will prevent rafting of ice between WTGs. Localized rafting of sea ice around individual WTGs may occur if weather conditions permit. However, such events are expected to be infrequent.

Although rotor blades will have a slick surface for aerodynamic efficiency, which will allow most ice to slide off prior to any significant buildup, ice may collect on the WTG structure and blades under certain meteorological conditions (i.e., a combination of high relative humidity, freezing temperatures, and overcast or nighttime sky). This ice usually takes the form of a thin sheet as it attaches to wind turbines (similar to how ice attaches to an airplane's wings during flight). Temporary icing of a rotor blade would activate vibration sensors causing turbine shutdown in order to prevent rotor damage or hazard to Project maintenance staff or others from falling ice. Conditions conducive to icing will be evaluated by continuous monitoring of meteorological conditions and by monitoring the WTGs remotely (via camera). If conditions warrant, manual shutdown of the WTG(s) experiencing icing conditions will be initiated. The ice will remain attached until meteorological conditions allow it to melt. If the WTG is no longer operating due to icing, the melting ice will break apart into fragments in the same manner as ice falls off buildings, trees, and power lines, and fall down to the water surface under the WTG. If the WTG is operating, it is possible that the ice sheet attached to the WTG blade could be thrown from the blade as it rotates. However, as the ice sheet pieces are thrown from the blade, wind resistance will work to break them into much smaller fragments as they fall.

The risk of ice fragments being thrown from a turning rotor and causing injury is relatively small when the following points are considered:

- Icing can only occur during the winter months when navigational activity within the wind park is reduced to few vessels other than Project maintenance vessels
- Specific meteorological conditions must exist simultaneously for icing conditions to occur and these conditions only occur periodically during the course of a winter
- Mechanisms are in place for automatic or manual shutdown of turbines during icing events or when meteorological conditions suggest icing is likely
- The most frequent navigation taking place during the winter months (i.e., ferry traffic and commercial vessels) occurs in the Main Channel and along the Steamship Authority's route to the east of Horseshoe Shoal. The Main Channel is located over 800 feet (244 meters) from the nearest WTG and the Steamship Authority's route is over 4,600 feet (1402 meters) feet from the nearest WTG. It is unlikely that the falling fragments of sheet ice will travel such distances before reaching the water surface.

Proposed Aids-to-Navigation

Installation of the Wind Park would result in the presence of additional aids-to-navigation (ATON) in Nantucket Sound that can be used by mariners in the area. Each WTG would essentially serve as an ATON simply by its presence in Nantucket Sound. The WTGs would be marked on NOAA navigation charts, and would serve as points of reference for mariners navigating in and around Nantucket Sound. Each WTG would be clearly marked

with an alphanumeric designation that would also assist mariners in determining their position within the Wind Park.

In addition, the Applicant has committed to providing private ATONs within the Wind Park to assist mariners when navigating in and around the Wind Park. These private ATONs would consist of light and sound signals, would add to the existing network of USCG maintained ATONs, and would provide more navigational references for mariners. The Applicant would apply for and receive a Permit to Establish and Operate a Fixed Aid-to-Navigation pursuant to 33 CFR 66.0 prior to constructing the ATONs.

In addition to the proposed private ATONs, each WTG would be equipped with lighting that meets FAA standards for aircraft avoidance. These lights may provide another point of reference for mariners.

GPS positioning systems used by many mariners for navigation are not expected to be affected by the presence of the Wind Park. Each WTG is a tall, slender object that will not block signals from multiple satellites. Tall and wide objects such as buildings or mountains can block signals from satellites depending on the location of the GPS antenna in relation to the object and the position of the satellite in the sky. Since each WTG is no wider than 18 feet (5.5 meters) at its base and the WTG are spaced in a 0.34 NM (629 meter) by 0.54 NM (1,000 meter) grid, even GPS antennas located next to a WTG should not experience degraded GPS information as a result of not acquiring sufficient satellite signals.

Collision Risk

The risk of a vessel colliding with a WTG is low, given the Wind Park's location away from typical vessel routes, the small diameter of the towers (approximately 16.75 feet and 18 feet (5.1-5.5 meters) as described in Section 4.0) and the large spacing between the WTGs. The small diameter of the WTGs would prevent all but the smallest vessels (those with LOA of approximately 16 – 18 feet (4.9 – 5.5 meters) or less) from being shielded from view of another vessel by a WTG. When the WTG blade is in its lowest position, it would be approximately 75 feet (22.9 meters) above the water surface, and approximately 22 feet (6.7 meters) from the WTG tower. Therefore, vessels with mast or structure heights less than 75 feet (22.9 meters) would pass under the WTG blade should they get within 22 feet (6.7 meters) of the WTG.

The location of the Wind Park relative to established vessel routes, physical water depth restrictions on Horseshoe Shoal, and the large WTG grid spacing combine to limit the potential for a vessel to collide with a WTG. Despite this, the Applicant has analyzed the possibility for damage to a WTG and to the impacting vessel in the unlikely event of a vessel-WTG collision. The analysis concluded that neither a drifting nor moving vessel of the size that frequents the Wind Park area, or would be used for construction, would result in collapse of a WTG after impact. A drifting vessel, if it were to collide with a WTG, would likely receive some level of structural damage, but would remain afloat. A vessel colliding while under power would sustain substantially greater damage.

Lastly, the potential for boat collisions with the WTGs has been reduced by incorporation of required USCG lighting. Two flashing amber lights would be located on the lower access platform about 35 feet (10.7 meters) above sea level. The amber lights on the perimeter WTGs are designed to be visible within distances of two miles; the amber lights on the interior WTGs are designed to be visible within distances up to 0.5 NM (0.9 km). Lights would flash at a frequency of 20 flashes per minute (FPM), with the perimeter lights flashing synchronously and the interior lights flashing in a random pattern. This design results in approximately 50 to 65 percent of the interior lights flashing on at any given moment, together with all the perimeter lights.

Search and Rescue

The proposed Wind Park is within an area between 41°27' N to 41°32' N and 70°14' W to 70°23' W (a "SAR Study Area" of approximately 35 square NM (116 km^2). Analysis of historical SAR data provided by the USCG indicates that there are 94 sortie records in the data within this USCG SAR Study Area. Multiple sorties occurred at the same date and time in many locations in the data, resulting in a total of 50 incidents in the Wind Park area. These incidents occurred between November 1991 and August 2002. The majority of the incidents occurred during daylight hours, with only 22% occurring between sunset and sunrise. The majority (81%) of the responses to SAR incidents in the SAR Study Area were made by sea. Aircraft were only used to respond to 4 incidents in the SAR Study Area during the 10-year study period. In some cases, multiple responders were required for an incident.

The Wind Park is not anticipated to have negative effects on SAR operations in the area of Horseshoe Shoal. The wide turbine spacing would allow those USCG vessels that are not restricted by the existing water depths to continue to operate within the Wind Park. A representative of USCG Air Station Cape Cod indicated to ESS that USCG aircraft would be able to operate in and around the Wind Park during periods of good visibility, including nighttime operations (USCG, 2003). The representative indicated that aircraft would not likely conduct operations in the area during times of very low cloud ceilings or dense fog, and a vessel-based response would be more appropriate during those times. USCG aircraft responding to incidents south of the Wind Park would either cruise over or around the Wind Park, depending on their destination, and this would not adversely affect USCG response times (USCG, 2003).

The presence of the WTGs within the Wind Park, as well as some of their design features, can benefit SAR operations in the area, as discussed below.

- Each WTG would be clearly marked with an alphanumeric designation on the tower, and the USCG, other local, states, and federal agencies, and commercial salvors would be provided with a plan showing designations for each WTG. This designation could be used by mariners in distress as a primary or additional positional reference to provide to the USCG when requesting assistance. By receiving these additional easily readable positional references from mariners in distress, the USCG would be able to focus its efforts on rescuing the mariner in distress rather than spending time in the search.
- Each WTG would have a safety line with a loop at the end from the platform to the water. While tying up to WTGs under normal circumstances would be prohibited, mariners in distress would be allowed to tie up to a WTG either by their own choice or by direction from the USCG, until assistance arrives. In addition, persons in the water could swim to the WTG and hold on to the safety line until assistance arrives.
- The Wind Park's grid pattern and WTG spacing would provide the USCG with the opportunity to establish air and sea search grids that align with the turbines if desired. The WTGs would provide points of reference to USCG personnel as SAR missions are performed.
- During Wind Park operations, Project work vessels in the Wind Park would be conducting routine monitoring and maintenance during daylight hours when the seas are less than 6 feet (1.8 meters). These work vessels would be able to assist vessels in distress within the Wind Park during these times, and would do so either upon receipt of a request for assistance from the vessel or from the USCG. Project personnel on these vessels would be trained in first aid, CPR, and marine survival skills.

Submarine Cable System

It is expected that the installation of the inner-array and submarine cable systems, which would be buried below the seabed to an approximate depth of 6 feet (1.8 meters), would have no permanent adverse impact to ferry operations or general commercial and recreational vessel navigation in this area of Nantucket Sound.

Construction impacts to navigation associated with the installation of the submarine cable system and inner-array cables are expected to be temporary and localized. The installation of the submarine cable system would be accomplished using a low-impact jet plow embedment process. In terms of marine access and maneuverability required by the cable-laying vessel, conditions along the proposed submarine cable system route are favorable with channel widths and depths along the route ample enough to allow access and maneuverability.

Once installed, the submarine cable system and inner-array cables would have no impact to navigation. This is based upon the following:

- The submarine cable system would be buried to a minimum 6 feet (1.8 meters) below the seabed, with minimum of 20 feet (6.1 meters) of horizontal separation between circuits.
- The submarine cable system and inner-array cable burial depth of 6 feet (1.8 meters) below the seabed would provide sufficient sediment overburden to avoid cable damage by vessel anchors or other mechanical impacts.
- The submarine cable system and inner-array cables are an alternating current (AC) system and, therefore, there would be no measurable compass deflection on vessels transiting over the transmission lines. Additionally, there is no electrical interference from the AC submarine and inner-array cable systems with radio, GPS, or radio-beacon navigational equipment.

- Once installed, it is expected that the National Ocean Services would, on the next version of the Nautical Chart, chart the submarine cable system area. It is also expected that this transmission cable area designation would be published in the Coast Pilot and Notice to Mariners for this area. These transmission line area designations do not restrict or preclude vessel traffic or general navigation within these areas.
- The submarine cable system and inner-array cables would not preclude, prevent, or disrupt commercial and recreational fishing, since the cables would be buried at a minimum of 6 feet (1.8 meters) below the seabed. Since large vessel operations in the Wind Park are naturally restricted by existing water depths, it is unlikely that anchors larger than those on the installation vessel (10,000 pound Danforth anchors with an estimated fluke-tip penetration of approximately 4 feet (1.2 meters)) would be used in the Wind Park area. The ability of smaller vessels to anchor within the Wind Park area would remain unchanged. Smaller vessels typically have smaller anchors that result in shallower fluke-tip penetration than large anchors. Therefore, anchors from smaller vessels would not penetrate to depths close to the cable burial depths. Mariners setting anchors within the Wind Park would need to take into account their position relative the WTGs, their desired anchor scope, and the boat's swing radius when determining appropriate locations to set anchor when in or around the Wind Park.

Navigation Rules

Vessels operating in Nantucket Sound operate under the International Regulations for Preventing Collisions at Sea 1972 (COLREGS) (IMO, 2003). Rule 1 of the COLREGS requires that all vessels operating in the area comply with the regulations, and duly regard all dangers of navigation and collision. In preparing this assessment of potential impacts to navigation, it was assumed that all mariners would adhere to the COLREGS, as required, and would operate their vessels in a safe and prudent manner. Risks and impacts associated with failure to comply with the COLREGS or unsafe vessel operation cannot be evaluated and are beyond the scope of this assessment.

The COLREGS apply to all vessels operating in the Atlantic Ocean, Buzzards Bay, and Nantucket Sound (including recreational vessels). The COLREGS have been implemented by the USCG as part of the International and Inland Navigation Rules (USCG, 1999). The USCG is also responsible for ensuring compliance with the International and Inland Navigation Rules. A summary of pertinent COLREGS requirements is provided below.

- Rule 1 of the COLREGS requires that all vessels operating in the area comply with the regulations, and duly regard all dangers of navigation and collision.
- Rule 2 states that nothing in the COLREGS exonerates any vessel, owner, master, or crew member from the consequences of failure to comply with the COLREGS or take the necessary precautions required by ordinary practice or special circumstances. In other words, the mariner is responsible for safe operation of the vessel regardless of the navigational situation.
- Rule 5, "Lookout," states that "Every vessel shall at all times maintain a proper lookout by sight and hearing as well as by all available means appropriate in the prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision."
- Rule 6 states, in part, that "every vessel shall at all times proceed at a safe speed so that she can take proper and effective action to avoid a collision and be stopped within a distance appropriate to the prevailing circumstances and conditions." The proximity of other vessels, structures, as well as other factors, must be taken into account when determining a safe speed. Therefore, vessels must operate at speeds within and around the Wind Park that allow the vessel to stop or avoid collision with another vessel or a WTG.
- Rule 7a states "every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt, such risk shall be deemed to exist." The vessel is therefore required to continually assess the potential for collision with another vessel or a WTG while navigating in the Wind Park.
- Rule 8e requires that, if more time is necessary to assess the situation or avoid collision, a vessel shall slow down or stop. As with Rule 7a, the vessel is therefore required to continually assess the potential for collision with another vessel or a WTG while navigating in the Wind Park.
- Rule 8a states "any action to avoid a collision shall, if the circumstances of the case admit, be positive, made in ample time, and with due regard to the observance of good seamanship." The vessel is required to take appropriate action to prevent collision with another vessel or a WTG.
- Rule 19b states that every vessel shall proceed at a safe speed adapted to the prevailing circumstances and conditions of restricted visibility. Even in clear daylight weather, the presence of the WTGs would present a momentary condition of restricted visibility by shielding small vessels as described in Section 4.3.1 of the

Navigational Risk Assessment. Under this rule, the vessels must take the presence of the WTGs into account as a momentary restricted visibility condition, and must adjust the vessel's safe speed and distance from the WTG accordingly.

These rules make it very clear that properly assessing the potential risk of collision, operating at safe speeds, and taking necessary action to avoid collision is the responsibility of the vessel's captain. The mariner must remain cognizant of the presence of the WTGs, and adjust operation of his or her vessel accordingly to be in compliance with the COLREGS. The presence of the WTGs would alter the watersheet by creating above surface structures that would require more diligence in navigating in the vicinity of Horseshoe Shoal than would exist in the absence of the wind park.

Marine Navigation Summary

After completion of initial investigations of potential Project effects on commercial and recreational navigation, discussions with commercial ferry operators and fisherman, as well as weeks of field observation of navigation on or near Horseshoe Shoal, it is expected that the construction and operation of the Wind Park and the installation of the inner-array and submarine cable systems would not substantially adversely impact general commercial/recreational vessel navigation or ferry operations in this area of Nantucket Sound. (For additional information on commercial and recreational fishing conditions and impacts please refer to Sections 5.4 and 5.16 of this DEIS-DEIR).

Based on the evaluations completed to date, it is evident that larger vessels with deeper drafts transit Nantucket Sound through either the Main Channel or the North Channel. These larger vessels avoid the shallow water depths of the shoals, including Horseshoe Shoal. Shallower draft recreational vessels are known to operate in the vicinity of Horseshoe Shoal, particularly during the summer season. Recreational vessels, including sailboats, traversing the area are not expected to require vertical clearance in excess of 65 feet (19.8 meters). The majority of sailboats of a size that would have mast(s) approaching these heights would avoid the shallow waters of the shoal, due to existing physical water depth limitations associated with keel depths. The spacing between the WTGs, in combination with NOAA chart revisions and establishment of private ATON, would provide adequate watersheet area for unrestricted and safe navigational access in and around the Wind Park by vessels that are currently able to safely navigate on the shoal. However, a vessel's ability to safely navigate in and around the WTGs must be determined by the vessel's captain.

Installation of the WTGs would result in structures being present where no structure has previously existed. As such, the presence of the Wind Park would require that all mariners (including recreational boaters) be more attentive to the types of navigational equipment needed onboard to safely operate in and around the Wind Park, their vessel's position, and the proximity of other vessels and WTGs to their own vessel as they navigate in and around the Wind Park. This would be especially important during foggy conditions or other times of reduced visibility, high winds or waves.

Cumulative Impacts

In addition to the proposed Project, other activities which may contribute to cumulative impacts to marine navigation would include other submarine cable or pipeline installations, dredging activities, trawling, installation of pile supported marine structures and other offshore wind installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

The submarine cable installation for the Cape Wind Project would cross Nantucket Sound's North Channel. North Channel is a naturally occurring and maintained passageway marked by USCG aids-to-navigation and is not designated as a Corps of Engineers Federal Navigation Project, and therefore is not subjected to maintenance dredging. Therefore, no significant cumulative effects to transportation are expected in the area of the North Channel crossing.

A new submarine transmission cable has been proposed by National Grid between Cape Cod and Nantucket. Its proposed route would only cross the Project's submarine cable route in the vicinity of Hyannis Harbor, well within the Massachusetts 3-mile limit (as discussed below in Section 5.12.4.2.1). Outside of Massachusetts waters, at its

closest point the proposed route of the Nantucket Cable would be approximately 2 miles (3.2 km) from the Wind Park and its inner array cables in Nantucket Sound. Where the two projects may be in the near vicinity of one another, the impacts of each project may be coincident in nature. However, because installation of submarine cables via jet plow embedment typically takes about 4 weeks for installation, the impacts from jet plow cable embedment would be minimal and of short duration, and these temporary impacts are not likely to occur at the same time. Thus, the area would not experience heavy marine traffic and boaters would be able to pass through freely.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts to navigation anticipated since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

Secondary Impacts

The potential navigational secondary impacts associated with construction staging/laydown activities at Quonset Point would be additional marine traffic. However, the pier and site is currently an active marine industrial site that houses several industrial businesses. There are currently two piers sufficient to conduct the necessary staging activities. The pier envisioned to be primarily utilized for construction is currently being used on an intermittent basis as a staging area for the Rhode Island Department of Transportation (RIDOT) bridgework, but is expected to be available at the time the Project requires it. Should it still be in use by RIDOT during the staging for the Project, the applicant would arrange for use of the second available pier at Quonset Point.

The potential onshore secondary impacts associated with construction staging/laydown activities at Quonset Point would be additional vehicle traffic. However, the Quonset site is currently an active industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy, and the existing road systems are expected have the capability to absorb delivery traffic resulting from the Project.

5.12.4.1.2 Aeronautical

Due to the significant distance between turbines, each turbine would be lighted. Based largely on FAA Advisory Circular 70/7460-1K and consultation with FAA New England Region staff, the Applicant is proposing a lighting scheme with the stated objective of ensuring safe aeronautical navigation for pilots, while minimizing visual impacts to land-based viewpoints and potential avian impacts from attraction of birds. Lights would vary in intensity depending on the specific location of each WTG, with perimeter structures generally lit at a higher intensity than those within the interior of the Wind Park, as described above. The FAA determined, during its Aeronautical Study 2002-ANE-804-OEfor the Cape Wind SMDS (8/01/02), that when lighting a structure in open waters, a lower intensity lighting fixture (such as the FA-249-155mm marine lantern) can be used to achieve the same safety effect as the higher intensity lighting that is normally recommended by the FAA for land based structures. Based on this determination the lighting proposed for the Project maximizes the use of the low intensity fixtures for the majority of WTGs.

The proposed turbine array is not located in the flight path of any low altitude IFR routes (US Government Flight Information Publication – IFR Enroute Low Altitude-US). These routes are used by aircraft flying at night, or on instrumentation for guidance in low visibility conditions. Three IFR routes are established for Nantucket Sound (see Figure 5-12.2); however, they are not in the vicinity of the Wind Park. As shown in US Government Flight Information Publication – IFR Enroute Low Altitude-US, IFR Route V167, connecting T.F. Green and Provincetown airports, makes a turn approximately 2 miles (3.2 km) northwest of the Wind Park WTG array at a minimum altitude of 1,600 feet (487.7 meters). Route V141 from Logan Airport to Nantucket passes approximately 3 miles (4.8 km) to the east of the Wind Park at a minimum altitude of 1,700 feet (518.2 meters). Route V146 connects Martha's Vineyard with Nantucket at a minimum altitude of 2,000 feet (609.6 meters), approximately 8.5 miles (13.7 km) south of the Wind Park. See Figure 5.12-2 for routes and approximate distances from the Wind Park.

In addition to the IFR routes discussed above, the airspace above Nantucket Sound is also used by aircraft flying on Visual Flight Rules (VFR). Low flying aircraft operating under VFR, over open water may not be any closer than 500 feet from any vessel or structure (14 CFR part 91.119). In the absence of any vessel or structure, there

is no minimum altitude restriction when flying over open water. In order to alert pilots to the presence of the structures in the area and assist in safe navigation the Wind Park will be charted and published in Special Notes to Pilots and noted on all applicable aeronautical charts.

The Aeronautical Studies conducted by the FAA (numbers 2002-ANE-982-OE through 2002-ANE-1111-OE) found that the WTGs at the Proposed Site would:

- Not have an adverse effect on physical, electromagnetic, or line of sight interference or existing or proposed air navigation, communications, radar, control system facilities;
- Not have an adverse effect on air traffic operations enroute through the Nantucket Sound airspace under VFR conditions;
- Not have an adverse effect on any air traffic operations either inbound to or outbound from any Nantucket Sound vicinity airport under VFR conditions;
- Not have an adverse effect on air traffic operations inbound, outbound, or enroute through the Nantucket Sound airspace under IFR conditions;
- Not have an adverse effect on any existing or planned runway length;
- Not have an adverse effect or derogation to any airport efficiency;
- Not have an adverse effect on any planned IFR and VFR airport operations indicated by plans on file; and
- Not be located within any airport traffic pattern and would not have an effect on traffic.

The FAA issued a Determination of No Hazard to Air Navigation on April 9, 2003 (see Appendix 5.12-C).

5.12.4.2 Impacts Inside of Massachusetts Waters and Onshore

The following discussion is limited to potential for marine and onshore impacts, as no structures with the potential for aviation interference are proposed within state territorial limits.

5.12.4.2.1 Lewis Bay

The installation of the submarine cable system would require work within Nantucket Sound and Lewis Bay, including shoreline landfall and submarine cable system installation activities. Construction impacts to navigation associated with the installation of the submarine cable system are expected to be temporary and localized. The installation of the submarine cable system would be accomplished using low-impact jet plow embedment process using an anchored barge and support vessels. Vessels not related to the cable installation would be asked to avoid the immediate vicinity of the installation vessel and its anchors, and to reduce speed as they pass the installation vessel. The vessel's anchors are expected to be set within approximately 200 feet of the vessel while in Lewis Bay as a result of the relatively shallow water depths, and will be marked at the surface with a buoy. Vessels will not be excluded from operating in this area, unless the USCG chooses to do so. However, mariners choosing to operate between the anchor buoy and the installation vessels will do so at their own risk. The HDD operation transitioning the transmission line from submarine to onshore would be conducted from the onshore area and is not expected to significantly impact marine navigation. A jack-up barge and support vessels would be situated and operating at the exit hole for at least several weeks All work within the waterway would be temporary, localized and short term. As is the case with installation of the submarine cable system in federal waters, once the submarine cable system is installed, there are no anticipated impacts to commercial or recreational navigation activities since the submarine cable system would be buried approximately six feet (1.8 meters) below the seafloor. Channel widths and depths along the submarine cable system route are sufficient to allow the cable-laying vessel to operate and maneuver.

The HDD operation would be conducted from the onshore with limited use of marine support vessels. Therefore, there would be only minor navigational impacts associated with the installation of the four boreholes from landside operations. The HDD operation would involve a marine construction component in order to construct the 18-inch (45.7 cm) conduit sections. It is expected that a marine work barge would be stationed near the temporary cofferdam. This marine-based operation would facilitate the HDD operation and conduit installation. The presence of this vessel in the Lewis Bay is not expected to impact the vessel traffic, since it would be located outside of the private channel located to the southeast of the Project area.

To facilitate the HDD operation, a temporary cofferdam would be constructed at the end of the boreholes. The cofferdam would be approximately 65 feet (19.8 meters) wide and 45 feet (13.7 meters) long and would be open at the seaward end to allow for manipulation of the HDD conduits. The area enclosed by the cofferdam would be approximately 0.067 acres/2,925 square feet (272 square meters). The cofferdam would be constructed using steel sheet piles driven from a barge-mounted crane. The top of the sheet piles would be cut-off approximately 2 feet (0.61 meters) above mean high water. This would serve to contain any turbidity associated with the dredging and subsequent jet plow embedment operations, and would provide a visual reference to its location for mariners. While the cofferdams would be located outside of areas normally subject to vessel traffic, the location of the cofferdam would be appropriately marked to warn vessels of the temporary cofferdam's presence. This temporary cofferdam would be installed prior to the beginning of the HDD borehole construction, and would remain in place until jet plow embedment installation of the submarine cable system is complete.

All in-water operations associated with the HDD operation, including the cofferdams, would be conducted by qualified and certified vessel and equipment operators. These operations would be closely coordinated on a day-to-day basis with the USCG.

Marine Navigation impacts associated with the installation of the submarine transmission line work would be temporary in nature. Installation of the submarine cable system from the ESP to the shoreline HDD would take approximately two to four weeks for jet plow embedment.

Cumulative Impacts

As discussed above, other activities in the past, present or future which may contribute to cumulative impacts to marine navigation would include other submarine cable or pipeline installations, dredging activities, trawling, installation of pile supported marine structures and other offshore wind installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY). The cumulative impacts from three potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Channel in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent, cumulative marine navigation traffic for the anticipated timeframe that the submarine cable would be installed. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on recent experience it could be needed in the next 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. Future USACE maintenance dredging in Hyannis Harbor would be the subject of an additional NEPA document.

A new submarine transmission cable has been proposed by National Grid. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor, outside of Lewis Bay. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. At this crossing, and in its near vicinity, the impacts of each project would be coincident in nature. However, because installation of submarine cables via jet plow embedment typically takes about 4 weeks for installation, the impacts from jet plow cable embedment would be minimal and of short duration, and these temporary impacts are not likely to occur at the same time. Thus, the area surrounding Hyannis Harbor and the federal channel would not experience heavy marine traffic and boaters would be able to pass through freely.

It is possible that additional dredging may occur at shore-based marinas supporting boating activities throughout the Project area. However, these marina dredging projects, if they were to occur, are very localized and not likely to result in marine navigation that would interrupt everyday marine transportation that would be coincident with the cable installation (the closest point of which would be a minimum of .5 miles (805 meters) from the closest marina). Thus, no significant cumulative impacts are anticipated from these activities.

5.12.4.2.2 Onshore

Transportation impacts associated with the installation of onshore transmission line facilities would be temporary in nature. Installation of the ductbanks for the onshore transmission line would require limiting the roadway width to approximately 18 to 22 feet (5.5 to 6.7 meters) and would progress along the route at a rate of approximately 150 feet (46 meters) per day. Some combination of road detours or lane closures would be required for cable installation within roadways. A detailed Traffic Management Plan will be prepared in coordination with the Town of Barnstable, Town of Yarmouth, and the Massachusetts Highway Department to address road detour and/or temporary closure procedures as well as maintenance of access to abutting businesses and residences. This Traffic Management Plan will also include provisions for coordination with planned municipal roadway maintenance and improvement projects. Steel road plates will be utilized to allow driveway access in construction areas. Surface restoration will be performed in accordance with Town of Barnstable, Town of Yarmouth, and Massachusetts Highway Departments as applicable. Crossing state-owned roadways and railways would require more space and longer duration of disturbance in these areas, since this work would require the use of trenchless technology. Use of trenchless technology in these areas will be outside of traveled areas, and will have minimal effect on traffic. The Applicant has met with the MHD to discuss installation and maintenance, and MHD has noted in its letter of December 14, 2001 to Secretary Durand that "We believe that the traffic impacts associated with maintenance activities would be minimal, and we recommend that no further environmental review be required based on traffic issues."

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to upland transportation would include other upland cable or pipeline installations, excavation activities, and other wind installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative). The cumulative impact from one potential activity that may occur within the location and timeframe of the proposed Project is discussed below.

There are no significant cumulative transportation impacts that would be expected to result from the installation of the onshore transmission line. Based on discussions with the Town of Yarmouth DPW and the MHD there are no other major transportation projects scheduled for the vicinity and estimated construction timeframe for the onshore cable route. There are also no significant cumulative impacts expected should the onshore portion of National Grid's Nantucket Cable be installed at the same time of the onshore portion of the Project's cable system. The proposed Nantucket Cable's onshore route is more than a mile distant from the Project's proposed route, and would pass through the central portion of Hyannis, while the Project's onshore route bypasses the center of town to the east.

5.12.5 Mitigation Summary

The Project has been sited and designed to minimize and / or avoid impacts to marine, aviation, and land based transportation to the greatest extent practicable. Specific measures associated with mitigation of marine, aeronautical, and onshore issues are addressed below.

5.12.5.1 Marine

WTGs have been spaced such that adequate watersheet area would exist between turbines (minimum of 0.34 NM (629 meters)x 0.54 NM (1,000 meters)) allowing for unrestricted and safe navigational access around and within the Wind Park. In addition, the WTGs would be equipped with private ATON as required by the USCG. Based on USCG requirements for ATON on fixed structures (33 CFR Part 66) and pre-application consultations with USCG First District staff, the following measures are proposed in order to ensure safe navigation for mariners:

- The location of the Project would be published in the Notice to Mariners and noted on all applicable NOAA marine charts. The steel composition of the turbine structures would make them clearly visible to radar during poor visibility conditions.
- Each WTG would be clearly marked with an alphanumeric designation on the tower, and the USCG, other local, states, and federal agencies, and commercial sailors would be provided with a plan showing

designations for each WTG. This designation could be used by mariners in distress as a primary or additional positional reference to provide to the USCG when requesting assistance.

- A USCG-approved lighting scheme is proposed to ensure safe passage in proximity to the turbine array (see Figure 5.12-3). The following preliminary lighting scheme is proposed:
  - Two flashing amber ATON lights, each with 360° lens, would be installed on opposite sides of each turbine tower.
  - Lights would be strobe or light emitting diode (LED) bulbs, where possible, and would flash at a rate of 20 FPM.
  - Those WTGs located on the perimeter of the Wind Park would be equipped with ATON lights of an intensity visible to approximately 2 NM (3.7 km) (155 mm amber lens with 0.77 amp bulb).
  - WTGs located within the perimeter of the Wind Park would be equipped with ATON lights of lower intensity, visible only to approximately 0.5 NM (0.9 km) (155 mm amber lens with 0.25 amp bulb). This lower intensity lighting is adequate to allow a vessel within the Wind Park to navigate from WTG to WTG, a maximum distance of 0.5 mile (0.8 km).
  - Lights would be installed on the WTG access platform at a height of approximately 35 feet (10.7 meters) above the Mean High Water (MHW) elevation.
- Sound signals which are audible to 0.5 NM (0.9 km) would be installed on the four WTGs located at the corners of the WTG array to assist mariners navigating in fog conditions. These would be controlled by fog sensors and only operational during periods of poor visibility.
- The submarine cable system would be buried a minimum of 6 feet (1.8 meters) below the present bottom in firm sand. The anchoring of recreational vessels on Horseshoe Shoal or within the Wind Park would not be restricted by the presence of the buried submarine cable system within the WTG array.
- Local fishing and lobstering interests will be provided with the coordinates of the proposed cable routes and anticipated installation schedules in advance of installation. Routine progress updates and radio broadcasts on marine channels will also be provided to them. This is standard practice for cable installations, and will allow them to adjust their operations and move their gear out of the way of the installation vessel. Once the cables have been installed, they will be allowed to place their gear back into the original position over the route.

5.12.5.2 Aeronautical

As previously discussed, the FAA has determined that the Project as proposed does not present a hazard to air navigation provided that the WTGs are lighted as described below. In order to assist USCG in air SAR, direct communication would be established between Air Station Cape Cod SAR personnel and the Cape Wind Associates Operations Center (manned 24 hours) in order to facilitate rapid remote WTG shut down, at the request of USCG, in the event of bad weather SAR by air. Each WTG would be lighted as follows:

- Each WTG would have two FAA approved obstruction lights located on the top of the generator housing, horizontally separated to ensure that at least one light is visible at all times (see Figure 5.12-4).
- Perimeter WTGs located at corners/turning points and no more than 1 mile (1.6 km) apart (every other perimeter WTG) would be lighted during the day with two flashing white FAA L-865 medium intensity lanterns (maximum 20,000 candela) and at night with two flashing red FAA L-864 medium intensity lanterns (maximum 2000 candela) on the nacelle. The balance of the perimeter WTGs and all interior WTGs would be lighted with two flashing red lanterns comparable to a low intensity FAA L-810 fixture (approximately 32 candela) on the nacelle.
- Lights would be strobe or LED bulbs, where possible, and would flash at a rate of 20 FPM.

5.12.5.3 Onshore

Impacts to land based transportation would be limited and temporary in nature. Installation of the onshore cable system would occur outside of the height of the summer tourist season to minimize any disruption. Trenchless technologies would be used at major intersections and railroad crossings in order to avoid major traffic disruptions.

A Construction Traffic Management Plan would be prepared in consultation with local and state officials to ensure that safe access is maintained for vehicular traffic during onshore cable system installation, once the final route has been determined. This plan would typically include the following mitigating measures:

- Construction zone signage;
- Police officer details to provide traffic control in work zones;
- Areas to maintain ingress to and egress from off-street facilities;
- Temporary pavement marking, barriers or other means, as may be required, to ensure safe traffic flow;
- Notice of construction schedules and locations to minimize local inconvenience;
- Coordination with the Town Department of Public Works for any roadway construction projects to minimize multiple construction periods in the same area; and
- Maintenance of safe pedestrian flow through construction zones.

5.13 Electrical and Magnetic Fields

5.13.1 Introduction

The EMF analysis discussed in this section includes an assessment of anticipated EMF from WTGs, the associated 33 kV cables, and the 115 kV transmission lines. This section also identifies populations that could be exposed to 60 hertz (Hz) EMF greater than 85 milliGauss (mG), including humans and ecological receptors. The information contained in this section was obtained from review of existing data available for the Project area, EMF monitoring and modeling and review of the scientific literature on EMF. This introduction provides an overview of EMF; discusses potential sources of EMF; and summarizes the current status of research, in order to provide a context for the Project discussion.

The balance of Section 5.13.1 provides background regarding EMF. Section 5.13.2 outlines the studies completed for the Project. Existing EMF conditions are described in Section 5.13.3. In Sections 5.13.4 and 5.13.5, Project impacts and mitigation measures are discussed, respectively.

5.13.1.1 Overview of Electric and Magnetic Fields

Wherever electricity is generated, transmitted or used, electric and magnetic fields are present. It is not possible to produce or use electric power without creating these fields; therefore, they are a common and ubiquitous occurrence anywhere electric energy is in use. In North America, electricity is generally supplied as alternating current (AC), in which the current switches back and forth between positive and negative 60 times per second. Therefore, the power frequency is 60 cycles per second. The electric and magnetic fields that accompany electric power also cycle at this same frequency and are referred to as power frequency electromagnetic fields, or EMF, and are said to be time-varying fields. Power frequency EMF are part of a spectrum that encompasses frequencies that range from very high ionizing energy, such as gamma rays with frequencies of billions of cycles per second, to very low non-ionizing energy below that of power frequencies. Visible light is also included in this spectrum at the threshold between ionizing and non-ionizing electromagnetic waves. The higher the frequency of the electromagnetic energy source, the shorter the wavelength and the higher the energy. Lower frequency sources have longer wavelengths and correspondingly lower energy.

Electric fields are created by differences in the amount of charge at different points in space, which exert a force on nearby charged particles. The strength of these fields is typically measured in volts per meter (V/m). Magnetic fields are created by the flow of electric current, and are measured in tesla (T) or Gauss (G), but are more often described in terms of mG (one 1000th of a Gauss).

EMFs decrease in size as the distance from the source (the electric charges or currents) increases. For electrical cables, EMF would be highest adjacent to the cable and would decrease as the distance from the cable increases. Electric fields are attenuated by objects, and are completely shielded by electrically conducting material such as metal, the earth, or the surface of the body. Magnetic fields, on the other hand, penetrate most materials. The earth's atmosphere produces slowly varying electric fields (about 0.1 to 10 kV/m) that occasionally manifest themselves as lightning. The earth's core produces a steady magnetic field, as can be readily demonstrated with

a compass needle. The earth's magnetic field ranges in strength from about 470 mG to 590 mG over the United States, and is about 560 mG in the Northeast. Knowing the strength of the earth's fields provides a perspective on the size of the magnetic field measurements from an electric transmission cable.

Power frequency fields are very low frequency fields (60 Hz in North America) with extremely long wavelengths of around 3,100 miles (5,000 km). Because of the extremely long wavelength, fields associated with power frequency are experienced as separate electric and magnetic fields and are therefore not considered radiation or emissions. They carry very little energy and cannot break chemical bonds or heat living tissue.

5.13.1.2 Sources of Exposure to Power Frequency EMF

Humans are exposed to a wide variety of natural and man-made electric and magnetic fields. Natural fields are associated with common items we use such as magnets and, as previously noted, we are continuously exposed to the geomagnetic field of the earth. These fields are static and therefore do not switch back and forth, as do power frequency fields. Overhead transmission and distribution lines are a common source of exposure to electric and magnetic fields. High voltage transmission lines can generate relatively high electric fields. However, because high voltage transmission lines are constructed along ROWs, and because electric fields drop off quickly with distance and are shielded by structures, electric fields experienced by people within dwellings are typically dominated by the internal wiring and the use of appliances. Magnetic fields from transmission lines, although not able to be shielded by structures, drop off quickly with distance. Therefore, magnetic fields within dwellings are also typically dominated by nearby distribution system wiring, house wiring, or appliance use. Electric and magnetic fields from different sources (e.g., adjacent wires) may partially cancel or be additive at a given location. Results of studies have shown that electric fields in the home, on average, range from zero to ten volts per meter and magnetic fields range from 0.6 to three mG (EMF RAPID Program Report, 2002).

Power frequency electric and magnetic fields can also be found in the vicinity of electric appliances, including fans, electric ranges, microwave ovens, can openers, refrigerators, clothes washers and dryers, fluorescent lights, televisions, toasters, vacuum cleaners, hair dryers, alarm clocks, electric blankets, and computers. Appliances produce magnetic fields that can range from one to 150 mG at distances of one foot (0.3 m) (EMF RAPID Program Report, 2002). These fields decrease in strength much more quickly with distance than do power line fields.

5.13.1.3 Current State of EMF Science and Research

Research has been conducted for over 20 years in the U.S. and around the world to examine whether the use of electricity and the associated exposure to electric and magnetic fields poses a health risk. In 1992, the U.S. Congress authorized the Electric and Magnetic Fields Research and Public Information Dissemination Program (EMF-RAPID) in the Energy Policy Act (PL 102-486). The National Institute of Environmental Health Sciences (NIEHS), National Institute of Health (NIH) and the Department of Energy (DOE) were designated to direct and manage a program of research and analysis aimed at providing scientific evidence to clarify the potential for health risks from exposure to EMF (NIEHS, 1999).

Over the course of this program, the DOE and NIEHS managed more than 100 cellular and animal studies, exposure assessment, and engineering studies. No additional epidemiology studies were conducted; however, analysis of studies already conducted was an important part of the assessments (EMF RAPID Program Report, 2002). In 1998, the NIEHS completed the review of a comprehensive body of scientific research on the potential health effect of EMF. NIEHS organized several technical symposia meetings and a Working Group meeting to review EMF research. The Working Group was made up of scientists representing a wide range of disciplines including engineering, epidemiology, cellular biology, medicine, toxicology, statistics and pathology to review and evaluate the RAPID program research and other research. The results of the Working Group's evaluation were published in the report *Assessment of Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields* (August 1998).

In June 1999 the NIEHS submitted the report, *NIEHS Report on Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields*, to Congress. In part, the report concluded the following:

The scientific evidence suggesting that ELF-EMF exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults.... In contrast, the mechanistic studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies and the animal toxicology literature fail to demonstrate any consistent pattern across studies although some sporadic findings of biological effects have been reported. No indication of increased leukemia in animals has been observed.... Virtually all of the laboratory evidence in animals and humans and most of the mechanistic work done in cells fail to support a causal relationship between ELF-EMF at environmental levels and changes in biological function or disease status. The lack of consistent, positive findings in animal or mechanistic studies weakens the belief that this association is actually due to ELF-EMF, but it cannot completely discount the epidemiological findings.

The NIEHS concludes that ELF-EMF exposure cannot be recognized as entirely safe because of weak scientific evidence that exposure may pose a leukemia hazard. However, because virtually everyone in the United States uses electricity, and therefore, is routinely exposed to ELF-EMF, passive regulatory action is warranted, such as a continued emphasis on educating both the public and the regulatory community on way in which to reduce exposure. NIEHS also suggested that the power industry continue the current practice of siting power lines to reduce exposure and encourage technologies that lower exposures from neighborhood distribution lines provided they do not increase other risks such as those from fire or accidental electrocution. The NIEHS does not believe that other cancers or non-cancer outcomes provide sufficient evidence of a risk to currently warrant concern (NIEHS, 1999, 9-10).

5.13.1.4 Human Health Effects Associated with EMF

The potential for power line electric and magnetic fields to cause adverse health impacts in humans has been reviewed by many scientific groups. Hazard is assessed by a standard scientific approach that considers data from epidemiologic, laboratory, and biophysical studies. A number of epidemiologic studies have reported a small degree of association between measures of EMF and several diseases, e.g., childhood leukemia. Other studies have failed to find an association. A causal basis for the EMF associations is not supported by laboratory and biophysical evidence, and the actual basis remains unexplained. Nonetheless, in 2002, the International Agency for Research on Cancer (IARC, 2002) designated EMF as a class 2B carcinogen ("possibly carcinogenic"), based on "consistent statistical associations of high-level residential magnetic fields with a doubling of the risk of childhood leukemia." Also, in 2002, the California Department of Health Services (CADHS, 2002) issued a report concluding that: "EMFs can cause some degree of increased risk of childhood leukemia, adult brain cancer, Lou Gehrig's Disease, and miscarriage."

Despite considerable research directed toward the topic, it has not been established that health risks result from exposure to EMF. The epidemiologic association reported between EMF and some diseases have been the subject of continued statistical analysis (Greenland et al., 2000; Ahlbom et al., 2000; Wartenberg, 2001). When Greenland et al. (2000) pooled their epidemiology studies of childhood leukemia, they found evidence of increased risk at low magnetic field levels, but at the upper-end of the magnetic fields range used in the study, to which a small proportion of United States residents are exposed. The authors estimated a relative risk (RR) of 1.7 (95% CI, 1.2 to 2.3) for exposures above 3 mG, and a population attributable fraction of 3% (95% CI, –2% to +8%) for exposures above 0.5 mG. Another pooled analysis by Ahlbom et al. (2000) produced similar results for a 4 mG cutpoint. The possibility that the EMF associations are due to bias or confounders, however, has not been ruled out (Hatch et al., 2000; Ahlbom et al., 2001; Savitz, 2003).

Extensive investigations of animals exposed at much higher levels of EMF (up to 50,000 mG) have not demonstrated adverse health effects (Mandeville et al., 1997; McCormick et al., 1998 and 1999; Boorman et al., 1999 and 2000). The elevated levels of EMF exposure in occupational settings likewise do not show a consistent pattern of increased risk (Kelsh and Sahl, 1997; Kheifets et al., 1999; Sahl et al., 2002). Laboratory studies of cells and tissues do not support the hypothesis that EMF exposure at ambient levels is a significant risk factor for human disease (NIEHS, 1999). The failure to observe biological effects from EMF exposure may be due to the fact that, mechanistically, effects of EMF on biology are very weak (Valberg et al., 1997). Cells and organs function properly in spite of many sources of intrinsic chemical "noise" (e.g., stochastic, temperature,

concentration, mechanical, and electrical noise), which exceed the effects caused by EMF by a large factor (Weaver et al., 2000).

If power line EMF initiates or modulates physiological dysfunction or onset of disease in humans or animals, then there should exist a mechanism by which EMF alters molecules, chemical reactions, cell membranes, or biological structures in a functionally significant manner. Mechanistic models begin with the recognition that EMF is a physical, not chemical, agent as illustrated in the following causal chain:

EMF → Physics → Chemistry → Biology → Disease or Behavior

A necessary condition for EMF impact on human or ecosystem biology is that the EMF-induced changes must exceed chemical changes from natural or background influences. Changes in biology are coupled to EMF through changes in forces on charged structures, which in turn, must be coupled to metabolically important chemical processes (reaction or transport rates). The size and direction of the electric field predicts the size and direction of force on electric charges. Likewise, the magnetic field predicts force on moving charges. Thus, any EMF bioeffects must solely and ultimately be the result of forces. There are no other actions of EMF. The possibility of a biological effect depends on whether EMF forces can significantly modify biological processes having electrically responsive elements (for example, ions, charged proteins, neural electric currents, magnetic molecules (free radicals), and magnetic particles).

EMF impacts can be evaluated by asking how the forces and energies conveyed by EMF compare to forces and energies endogenous to biological systems. As shown in Table 5.13-9, the energies and forces exerted by typical 60-Hz EMF are well below those present in biological systems. That is, normal living cells operate under conditions of energy and force "noise" such that 60-Hz EMF effects would be lost in this background. Aside from specialized sensory systems, fundamental force and energy considerations preclude disruption of biology by weak EMF. Table 5.13-9 lists mechanisms by which EMF might alter biologic function, but the strength of EMF interaction energies and forces are found to be small compared to the endogenous energies and forces characteristic of the living system (Valberg et al., 1997).

Table 5.13-9 shows that in terms of energy or force on the whole-body scale or on the molecular scale, the effect of "large" EMF is many orders of magnitude below the typical forces and energies that accompany life processes. For example, the energy of a 60-Hz EMF photon is vastly less than that of ionizing radiation, and EMF is too weak to alter molecular structures. The level of the electric field *per se* could be increased to levels where it accelerates individual free electrons to electron-volt energies, exceeding those needed to break a chemical bond (as for example, in corona discharge). However, electric-field levels required for this type of molecular damage is far greater than that any organism would be exposed to associated with power line EMF. Likewise the force required to distort the shape of complex biological molecules, for example DNA or enzymes, is far larger than what the electric component of EMF can provide. The magnetic component of EMF can potentially rotate magnetic particles (which would act like compass needles) or single-molecule magnetic moments (e.g., free radicals) as described in the following section.

The failure to observe laboratory effects from EMF exposure (NIEHS, 1999) is likely due to the fact that typical power line EMF does not affect biology in a manner detectable above the many sources of noise in biological systems, and this inability to detect EMF effects in bioassay systems suggests that EMF itself does not play a causal role in the epidemiologic associations. In summary, a large number of blue-ribbon panels and public health review groups have examined the issue of the public's exposure to power line EMF. The overall conclusion of these groups is that available data do not establish a cause-and-effect relationship between exposure to typical environmental levels of EMF and elevated risk of disease.

5.13.1.5 Ecological Health and Exposure Effects Associated with EMF

Both terrestrial (e.g., birds and honeybees) and marine animals (e.g., finfish, eels, sharks, and sea turtles) likely use the earth's DC magnetic field for orientation, navigation and migration (Kirschvink, 1997; Kirschvink et al., 2001; Lohmann, 2000; Phillips et al., 2001; Ritz et al., 2000; Wiltschko et al., 2002). The mechanism underlying this magnetic sense is primarily limited to slowly-varying fields, and is not expected to respond to rapidly-varying (e.g., 60 Hz) alternating current fields. Aside from orientation and navigation, other potential effects of low-

frequency electric and magnetic fields on ecological systems have been investigated, but the findings on ecological effects have been equivocal (NRC, 1997; Levin and Ernst 1997; Pagnac et al., 1998), and there is no consistent evidence to establish an adverse-effect level. In fact, the RAPID research program mentioned above was carried out on laboratory animals, and the lack of consistent findings for EMF effects in those species also supports this conclusion.

Weak electric fields can be detected by certain fish (rays, sharks) for use in orientation and prey location. For example, sharks are capable of responding to extremely weak, slowly-changing electric fields in sea water. The shark's electric sense organ (*ampullae* of Lorenzini) is complex, containing a large number (~10,000) of receptor cells, in which small interactions are integrated to generate a change which stands out against noise (Adair, 2001; Adair et al., 1998). However, the proposed cable system would be shielded, to effectively block the electric field produced by the conductors. Therefore, no electric field impacts are expected for the submarine cables.

The physics of power line EMF interactions with matter are universal, and the constituents of non-human living organisms share many similarities with human cells and tissues. Hence, the following parallels can be drawn between the potential for EMF health effects in humans and the potential for ecological effects in non-human species:

- Due to similar electrical properties (conductivity, permittivity, polarizability) of human and animal tissues, similar electrical interactions can be expected. Some differences may arise due to geometrical and size factors.
- Due to the universal structure and properties of cell membranes, the threshold field strengths for biophysical (thermal and non-thermal) effects on cell membranes can be expected to be high both for human and non-human species.
- Animals and species with special sense organs (i.e., endogenous magnetic particles, ampullae of Lorenzini) may require special consideration of possible EMF effects on behavior.
- Because of similarity in the biophysics, adverse EMF effects in the environment are unlikely at exposure levels comparable to reference levels protective of general public exposure.

With regard to potential impacts of the EMF from submarine cables on living organisms, the following summary considerations support an absence of impacts (ICNIRP, 2000; NAS, 1993; VNTSC, 1994):

- Power line EMF has not been reported to disrupt land-based, freshwater, or marine organism behavior, orientation, or migration.
- Special sense organs, such as a "compass-needle" type of receptor for steady magnetic fields, are known to exist for some animals (Kirschvink et al., 2001) [96], but such a receptor would not be affected by power line, 60-Hz magnetic fields, which alternate in direction, and average to zero over 1/60th of a second (Adair, 1994; Valberg et al., 1997). [97]
- The actual magnitude of typical 60-Hz magnetic fields in the vicinity of the submarine cables is, in most locations, many fold below that of the steady geomagnetic field (~ 500 mG).
- The very low energy content of 60-Hz EMF means that the amount of thermal energy absorbed by nearby sea creatures is extremely small.
- The volume of ocean or on-land habitat with any measurable EMF levels is a tiny fraction of overall available habitat.

In summary, the primary consideration is for organisms that may have magnetic sense organs. The current opinion as to how animals use the earth's magnetic field for magnetic orientation is that such sensing is due to a "compass needle" mechanism. Although magnetite particles are plausible geomagnetic field sensors (Adair, 1994; Kirschvink et al., 1992 and 2001), functional biogenic ferromagnetic material has been established only in a

[96] In the abstract of his 2001 article, Dr. Kirschvink states that: "All magnetic field sensitivity in living organisms, including elasmobranch fishes, is the result of a highly evolved, finely-tuned sensory system based on single-domain, ferromagnetic crystals."

[97] As illustrated in Table A, the potential effects of EMF on any organism can be evaluated in the context of fundamental physics and chemistry. Such an analyses power line EMF mechanisms has been reported in a series of articles by Dr. Robert Adair, professor of physics at Yale University. Dr. Adair showed that the effective biological EMF "signal" (relative to biological "noise") is not of sufficient strength to alter biological processes. Dr. Adair considered a wide variety of possible interactions of EMF with biological systems, and he concluded that typical EMF field strengths are "much smaller than the smallest fields that have been known to affect chemistry."

limited number of organisms (for example, magnetotactic bacteria) (Blakemore, 1982). The "compass needle" mechanism would not be expected to respond to power line magnetic fields which rapidly change in size and direction, and have a time-average magnitude of zero. Even for an optimized hypothetical biological sensor, the minimum 60-Hz magnetic field strength detectable by microscopic particles in marine organisms would have to exceed 50 mG (Adair, 1994; Polk, 1994). However no one has demonstrated an effect on animal orientation by AC fields. Moreover, this level is exceeded only directly over the 115 kV submarine cables on the sea floor and in the immediate vicinity of the ESP within 10 feet of five convergent heavily loaded inner-array (33 kV) cables. In all other locations, the 60-Hz magnetic fields are below this value.

Based on the body of scientific literature examined there are no anticipated adverse impacts to the marine environment from the 60-Hz magnetic fields associated with the operation of the Project.

5.13.2 Description of Project EMF Studies Completed

5.13.2.1 Onshore Environment

Baseline measurements of power frequency (60 Hz) magnetic field strength were made on June 5 and 6, 2002, along the proposed onshore transmission cable route. These data were extrapolated to obtain field strengths that would be representative of worst-case existing conditions during times of peak electrical loads. The baseline measurements were made along the street section of the route, and at representative locations along the NSTAR Electric 115 kV ROW.

Calculations were performed using the "ENVIRO" computer program, developed by the Electric Power Research Institute (EPRI), to determine the magnetic field strengths to be expected along the onshore route as a result of the operation of the proposed transmission lines, taking into account the effects of existing sources as well as the new transmission facilities. Calculations were performed with the Wind Park generating at a maximum delivered output of 454 MW and at the annual average output of 168 MW. All measurements and calculations were performed at one meter above grade.

Electric fields were not measured nor studied in any detail for the following reasons:

- The electric field of the proposed 115 kV cables would be effectively contained within the body of each cable (i.e., shielded) by its grounded metallic shield;
- Electric field strength is a function of power line voltage and the operating voltage of NSTAR Electric's existing overhead transmission and distribution lines would not be changed by the proposed facilities (and thus, the resulting electric field strengths would not change);
- The focus of potential health effects of power frequency fields has been primarily with magnetic rather than with electric fields; and
- Calculations performed to determine existing electric field strengths and those expected after any proposed modifications to NSTAR Electric's 115 kV transmission lines show that the existing and predicted electric field levels at the edge of NSTAR Electric's ROW are well below 0.55 kV/ft (1.8 kV/m), which has been used as a guideline by the Commonwealth of Massachusetts Energy Facilities Siting Board. The maximum electric field strength in and adjacent to the streets along the proposed route of the onshore transmission line is on the order of 0.03 kV/ft (0.1 kV/m).

5.13.2.2 Marine Environment

No existing sources of power frequency fields are present in the offshore Project area and therefore no baseline measurements were made in the marine environment. Calculations were performed using the "ENVIRO" computer program to determine the magnetic field strengths expected from both the inner-array 33 kV submarine cables and the 115 kV submarine transmission cables. Calculations were performed with the Wind Park generating at a maximum delivered output of 454 MW and at the annual average output of 168 MW. Anticipated magnetic field strength was determined for the area directly above the cables (buried six feet below the surface) at the sea floor and at varying water depths above the sea floor. In the horizontal plane, magnetic field strength was calculated approximately 20 feet (6.1 meters) on either side of the cable, at which point the magnetic field levels had significantly decreased due to distance.

The magnetic field strength associated with the 33 kV inner-array cable is proportional to its electrical current and would, therefore, vary widely depending on the location of the cable segment in relation to the turbine string, and on the power output of the turbines. To account for this variation, calculations were performed for the most lightly loaded cable segment, which would be located at the end of a string and carry the output of only one WTG, and for a "homerun" cable segment, located between the closest turbine on a string and the ESP, carrying the output of 10 WTGs, the maximum number of WTGs on a cable string.

In the immediate vicinity of the ESP, the homerun cables become more closely spaced. Within approximately 20 to 30 feet (6.1 to 9.1 meters) of the ESP, the cables begin to rise up in the subsurface trench such that they would be buried approximately 2 feet (0.61 meters) deep under the scour control mats prior to rising vertically from the sea floor to the ESP in "J-Tube" conduits secured to the ESP support structure. While this design has not been finalized, some reasonably conservative assumptions can be made to serve as a basis for magnetic field calculations at this singular location. It was assumed that a maximum of five 33 kV cables would be grouped on a single riser, spaced 6.5 inch (16.5 cm) (one cable diameter) apart, edge to edge. Magnetic field levels were then calculated at varying distances from the surface of the cables.

Calculations for the 115 kV cables were performed which represent the two methods of installation proposed. The first method is appropriate to the majority of the submarine route, where the cable would be laid 6 feet below the sea floor in two trenches with two cables per trench. The second method is for the transition to landfall where each of the four 115 kV cables would be routed in its own 18-inch (45.7 cm) diameter high density polyethylene (HDPE) conduit, installed using HDD construction techniques.

As with the onshore cable, no electric field calculations were performed because the electric field of the 33 kV and 115 kV submarine cables would be effectively contained within the body of each cable (i.e., shielded) by its grounded metallic shield.

Any fields produced by the generating equipment in the nacelle of the WTGs would be greatly attenuated at sea level (mean low low water is 246 feet (75 meters) below the nacelle). Fields produced by the electrical equipment within the ESP can be expected to be comparable to or less than those found in conventional land based substations. The principal sources of magnetic fields in a substation are the exposed high voltage buses (the magnetic field of a transformer is largely contained within the transformer). In the compact gas-insulated design proposed for the ESP, the bus bars are more closely spaced than in an outdoor air insulated substation, so the magnetic field level is expected to be less. Moreover, any fields experienced on the ESP would be attenuated at sea level (mean low low water is 39 feet (12 meters) below the ESP deck). Lastly, because the ESP electrical equipment is effectively contained in a grounded metal enclosure, no external electric field is produced. Because of these considerations, the focus of the analysis was on the magnetic field strengths associated with the submarine cables, rather than on the fields generated by the electrical equipment.

5.13.3 Existing Conditions

5.13.3.1 Conditions Outside of Massachusetts Waters

There are no known sources of power line frequency (60 Hz) fields currently in the waters of Nantucket Sound in the vicinity of Horseshoe Shoal at the proposed location of the Wind Park and therefore no predicted electric fields. The magnetic field existing in the location of the proposed 115 kV submarine transmission cable is the natural geo-magnetic field of the earth, which is a static DC field that is oriented toward the North and downward into the earth.

5.13.3.2 Conditions Inside of Massachusetts Waters

Lewis Bay

There are no known sources of power line frequency fields currently in the waters of Lewis Bay in the vicinity of the proposed 115 kV submarine cable system and therefore no predicted electric fields. As described above, the only magnetic field in the location of the proposed submarine transmission cable is the natural geo-magnetic field of the earth, which is a static DC field. There are no magnetic fields attributable to existing submarine power cables.

5.13.3.3 Onshore

Landfall to NSTAR Electric ROW

The primary sources of existing power frequency magnetic fields along the street portion of the proposed onshore transmission line route are the existing overhead distribution lines. Their nominal operating voltage is 23 kV phase-to-phase/13.2 kV phase-to-ground. They are fed radially from Distribution Line 92, which emanates from Hyannis Junction Substation. Proceeding in a southerly direction down the route (away from the substation and towards the landfall location), the load current on the lines decreases, there is branching to other distribution circuits, and (at New Hampshire Avenue) the line changes from 3-phase to single phase. Measured magnetic field strength at the edge of the pavement closest to the overhead line ranged from 1 to 21 mG along the length of the route, generally increasing in a northerly direction consistent with increasing current. Representative measurements directly under the lines did not exceed these values by more than 1 mG. At the time of the measurements, total load on Line 92 was about 14 MW. Line 92 experienced a 27 MW load during the historical system peak on August 9, 2001 [Personal Communication, NSTAR]. Extrapolating to these load levels produces maximum magnetic fields in the range of 2 to 40 mG, although local field strengths may vary depending on conductor geometry and individual loads. The measured field strength directly under the lines in front of the Marguerite E. Small School was 5 mG or 9 mG when extrapolated to peak load.

Calculated existing electric field strengths in and adjacent to the streets along this route range between 0.01 and 0.09 kV/m.

Within the NSTAR Electric ROW

Magnetic field strength was measured under existing 115 kV lines 118 and 119 and existing 23 kV lines in the NSTAR Electric ROW where it crosses Willow Street at the low point in the lines. Measuring at this location results in the highest field strength. The location is representative of the field strengths on the existing ROW between Harwich Tap and Barnstable Switching Station. Current flow at the time of the measurements was 296 Amps in line 118 and 143 Amps in Line 119. The magnetic field strength was highest under the 118/119 lines, at 26 mG, falling to 18 mG at the north edge of the ROW, and 6 mG at the south edge of the ROW. Using the same line geometry (which is much better defined and more consistent than for the in-street distribution circuits), the corresponding magnetic field strengths were calculated at NSTAR Electric's forecast peak loading (without the Project) of 643 Amps on line 118 and 311 Amps on line 119. This resulted in 127 mG directly under the lines, 56 mG at the north edge of the ROW, and 12 mG at the south edge of the ROW.

Calculated existing electric field strength directly under the 115 kV overhead lines 118 and 119 is 2.0 kV/m. At the north edge of the ROW, this falls to 0.2 kV/m, and is less than 0.1 kV/m at south edge of ROW.

5.13.4 Analysis of Impacts

5.13.4.1 Impacts Outside of Massachusetts Waters

Electric Fields

The proposed submarine cable system for the transmission line would contain grounded metallic shielding that effectively blocks any electric field generated by the operating cable system. Since the electric field would be completely contained within those shields, there are no electric fields to be calculated.

Magnetic Fields

The 115 kV Submarine Cable System would consist of four 3-conductor cables configured as two circuits of two cables each. Each circuit would carry half the electrical output of the wind farm at any given moment. Throughout most of the submarine route (all but the HDD), the cables would be laid 6 feet below the sea floor in two trenches, with two cables per trench. The trenches would be spaced approximately 20 feet (6.1 meters) apart horizontally.

Calculations were performed to predict the magnetic field strength above the trenches on the sea floor, and at varying water depths above the trenches. The calculations predicted peak magnetic field levels on the sea floor directly above each cable trench. The field strength decreases rapidly moving horizontally on the sea floor away

from the trench. At elevations 10, 20 and 30 feet (3, 6.1 and 9.1 meters) above the sea floor the field strength also decreases as a function of vertical distance. The calculated peak values at the sea floor and corresponding field levels at three vertical distances above the cable trenches are shown in Table 5.13-1.

The 33 kV Inner-array Cable System would also consist of 3-conductor solid dielectric cables. The cables would be arranged in strings, each of which would connect approximately 7 to 10 WTGs radially to a 33 kV circuit breaker on the ESP. Some strings may be bifurcated. The electrical current in the cable segments within each string would vary depending on location within the string: cable segments closer to the ESP would carry the output of more WTGs. Three different cable sizes would be used to accommodate this variation. The cables would be buried approximately 6 feet (1.8 meters) below the sea floor, one per trench.

Calculations were performed to predict the magnetic field strength over the inner-array cables on the sea floor, and at varying water depths above them. The results are similar to what was found for the 115 kV cables. Predicted peak magnetic field levels on the sea floor directly above the cable decrease rapidly with horizontal distance from the cable and with vertical distance above the sea floor. Magnetic field strength around a cable is proportional to its electrical current, and therefore, the field strength would vary widely depending on the location of the cable segment within a string of turbines and on the output of the turbines. Accordingly, calculations were performed for the most lightly loaded cable segment located at the end of a string and carrying the output of only one WTG, and for a homerun cable segment located between the closest turbine on a string and the ESP (carrying the output of 10 WTGs). The calculated peak values at the sea floor and field levels at three vertical distances above the cable trenches are shown in Tables 5.13-2 and 5.13-3

Calculations were also performed to predict the magnetic field strength generated by the 33 kV inner-array cables in the immediate vicinity of the ESP, where they converge. The calculations conservatively assumed five homerun cables, each carrying the maximum load of 10 WTGs separated by one cable diameter. Magnetic field levels were calculated at a distance of 2 feet (0.61 meters) from the cables, which would represent the maximum exposure to marine organisms on the surface of the scour protection. Magnetic field levels were also calculated at a distance of 10 feet (3 meters) from the cables, which would be the closest reasonable approach of a boater to the cables at the point where they rise vertically out of the water up to the ESP. In fact, most responsible sailors or boaters would maintain a much greater distance from this structure. Because the cross-bracing on the ESP support structure would block vessels from passing under the ESP, this was considered the maximum exposure possible for the public at this singular location. While maintenance and construction workers may be briefly exposed to higher levels, such as when in direct contact with the J-tube conduits or in the cable spreading room on the ESP, their exposure would be comparable to that experienced by workers in conventional substations and generating stations. The calculated peak values directly in line with the cables at the 2-foot (0.61-meter) and 10-foot (3-meter) distance and the calculated values a short distance to the side of the cables are presented in Table 5.13-4

Appendix 5.13-A presents additional detail regarding calculations performed to predict future expected magnetic field levels for the marine portion of the Project.

Project-Specific EMF Exposure

For all of the proposed offshore circuits, the high-voltage conductors are enclosed in a shielded cable, and no external electric field is produced. Therefore, the Project would not produce or add to any electric-field exposures in offshore waters.

Aside from the exposure to maintenance and other workers, the only possible magnetic exposure scenarios for humans involve boaters in the proximity of the ESP or divers on the sea floor in the vicinity of the buried cables or in the vicinity of cables that rise from the sea floor to the ESP. Potential exposures for marine organisms would be the same as for divers. The maximum levels of exposure occur over an extremely small space, and decrease rapidly within a few feet of such locations as shown in Table 5.13-5. Magnetic field strengths directly over the cables at peak load and in the vicinity of the ESP drop off rapidly with lateral and vertical distance from the cable and with distance from the ESP. Given the small area occupied by the cables and ESP, and because divers or mobile marine species would likely not spend a large amount of time directly over the cables, exposure to magnetic fields would be minimal. Also, marine species that may frequent the area around the ESP would be mobile, and therefore, their exposure would be dependant on the amount of time they were in the vicinity of the

ESP. Marine benthos such as bi-valves and worms may spend more time in the vicinity of the buried cables and therefore experience more exposure. These organisms are also mobile and have the ability to move horizontally and vertically within the sub bottom sediments. Overall, only a very small fraction of the available habitat would have potential exposure to the higher fields in the vicinity of the ESP

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to EMF outside of Massachusetts waters would include other submarine cable installations, and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY). The cumulative impacts from one potential activity that may occur within the location and timeframe of the proposed Project is discussed below.

There is a potential for future cumulative impacts if the proposed second Nantucket cable is constructed before the Cape Wind transmission facility. Under such a scenario, the Cape Wind transmission circuits would cross the Nantucket cable, and as a result, there would be a net magnetic field level produced by the interaction of the fields from the individual cables. The resultant net magnetic field would depend on a number of factors, including the position of the cables with respect to one another, the direction of current flow, phasing and load level. Depending on these factors, the net effect could be additive, or could result in a canceling or lowering of field strength. In any event, the cumulative impact would only occur over a small area surrounding the crossing location, and is not anticipated to be significantly different from the peak fields predicted for the new 115 kV and 33 kV cables. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point.

Secondary Impacts

There are no anticipated secondary EMF impacts associated with the construction staging/laydown activities at Quonset because it is an existing facility and there will be no changes to the existing electric infrastructure.

5.13.4.2 Impacts Inside of Massachusetts Waters

Lewis Bay

Electric Fields

The entire submarine cable system for the transmission line would contain grounded metallic shielding that effectively blocks any electric field generated by the operating cable system. As is the case for the offshore cable, there are no electric fields to be calculated.

Magnetic Fields

The 115 kV submarine cable system installation would continue with the same configuration described for Nantucket Sound as it traverses Lewis Bay to the landfall transition location. Therefore, the predicted magnetic fields are the same as described in Section 5.13.4.1. The transition to landfall would change the configuration so that each of the four cables is routed in an 18-inch (45.7 cm) diameter HDPE conduit, installed by HDD. It is expected that the conduits would be spaced 10.5 feet (3.2 meters) apart at their seaward end. Peak magnetic flux densities calculated for this configuration directly above the cables at the sea floor, at Mean Lower Low Water (MLLW) and at Mean High Water (MHW) are shown in Table 5.13-6

Project-Specific EMF Exposure

For all of the proposed submarine circuits, the high-voltage conductors are enclosed in a shielded cable, and no external electric field is produced.

The same design criteria and magnetic field calculation parameters described in Section 5.13.4.1 for the portion of the 115 kV transmission cable in federal waters apply to the portion of that cable in state waters. On the sea floor, there are pronounced peaks in the field above each trench; but the level falls off considerably just 15 feet (4.6 meters) away (horizontally) from each trench. At elevations 10, 20 and 30 feet (3, 6.1 and 9.1 meters) above the sea floor there are no pronounced magnetic field peaks, just a gradual decrease with increasing

horizontal distance. Surface vessels that traverse over the cable are a potentially exposed group; however, because of the depth of cable burial below the seabed and the depth of water, magnetic field strengths at the surface are very low (10 mG or less at peak load). Therefore, due to the low field strengths and the extremely short duration a vessel would be over the cable path, within the 3-nautical mile limit (5.6 km), exposure to this group is minimal to non-existent. The only potential for magnetic field exposure is to humans involved in underwater activities such as divers and marine organisms in the immediate area above the buried cables. Marine benthos such as bi-valves and worms may spend more time in the vicinity of the buried cables and therefore experience more exposure. These organisms are also mobile and have the ability to move horizontally and vertically within the sub bottom sediments. As was the case in federal waters, magnetic field strengths directly over the cables at peak load would be approximately 60 mG, dropping off rapidly with lateral and vertical distance from the cable. Given the small area occupied by the cable and because divers or mobile marine species would likely not spend a large amount of time directly over the cables, exposure to magnetic fields would be minimal.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to EMF inside of Massachusetts waters would include other submarine cable installations, and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY). The cumulative impacts from one potential activity that may occur within the location and timeframe of the proposed Project is discussed below.

There is a potential for future cumulative impacts if the proposed second Nantucket cable is constructed before the Cape Wind transmission facility. Under such a scenario, the Cape Wind transmission circuits would cross the Nantucket cable, and as a result, there would be a net magnetic field level produced by the interaction of the fields from the individual cables. The resultant net magnetic field would depend on a number of factors, including the position of the cables with respect to one another, the direction of current flow, phasing and load level. Depending on these factors, the net effect could be additive, or could result in a canceling or lowering of field strength. In any event, the cumulative impact would only occur over a small area surrounding the crossing location, and is not anticipated to be significantly different from the peak fields predicted for the new 115 kV and 33 kV cables. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point.

5.13.4.3 Onshore

Landfall to the NSTAR Electric ROW

Electric Fields

Calculated existing electric field levels in and adjacent to the streets along this route range between 0.01 and 0.09 kV/m. Because the electric field of the proposed underground 115 kV cables would be effectively contained within the body of each cable by its grounded metallic shield, the addition of the transmission line would not change these electric field levels.

Magnetic Fields

At the transition vault located at the end of New Hampshire Avenue, the HDD conduits would converge to a more compact configuration in order to facilitate the transition from submarine cable to duct type cable. Table 5.13-7 shows the peak magnetic flux density calculated at an elevation of one meter above grade at the vault.

The calculated peak magnetic field levels produced by the proposed underground 115 kV cable in the streets is 7 mG at an annual average Wind Park output of 168 MW, and 20 mG at maximum Wind Park output of 454 MW. The field level falls off fairly rapidly with distance from the center of the duct bank.

The net magnetic field strength produced by the combination of the existing overhead and new underground lines is a complex function of the relative geometry and loading of the overhead and underground circuits. The net magnetic field strength depends on the following:

- The relative position of the lines with respect to each other (i.e., whether the overhead and underground lines are on the same or opposite sides of the street);
- The phasing of the overhead conductors, which may vary along the route; and
- The north-south location along the route, since the loading on the overhead lines generally decreases along the line as it travels south toward the landfall location due to lessening loads.

Mathematical models were run for several representative laterals across the street at different points along the route. The resultant peak field strength, with the overhead lines at peak load, ranged between 8 and 36 mG with the Wind Park at average output, and between 19 and 36 mG with the Wind Park at maximum 454 MW output.

With the Project generating at either 168 MW or 454 MW, the magnitude and profile of the resultant magnetic fields on either side of the road are unchanged from a distance of approximately 20 to 30 feet from the edge of pavement and beyond. Therefore, the magnetic field levels experienced by residential or other properties along this section of the route will be the same as experienced with the existing overhead distribution lines. Likewise, the resultant magnetic fields on the side of the road closest to the Marguerite E. Small School are unchanged from those experienced under current peak loading on the existing overhead distribution lines as shown in Appendix H of Appendix 5.13-A.

Within the NSTAR Electric ROW

Electric Fields

The electric field would be effectively contained within the body of each new underground 115 kV cable by its grounded metallic shield and therefore, no external electric field would be produced. As a result, upon completion of the new underground transmission line the electric fields within the ROW are anticipated to be approximately the same as the existing condition, which is due to the presence of the overhead 115 kV lines.

Magnetic Fields

The preferred option for connecting to the Barnstable Switching Station is to continue the proposed 115 kV cable underground in the NSTAR Electric ROW. Calculations were performed to determine the net magnetic field due to this duct bank and the overhead 115 kV lines (with load flows as predicted by NSTAR Electric). At an average Wind Park output of 168 MW, this resulted in 127 mG directly under the lines, a localized peak of 23 mG directly over the duct bank, 56 mG at the north edge of the ROW, and 12 mG at the south edge of the ROW. At the maximum Wind Park output of 454 MW, these values become, respectively, 127 mG, 49 mG, 56mG, and 12 mG, which is a small change from the 168 MW case. These results indicate that the predominant fields within the ROW are those generated by the existing overhead lines, whose loading under this interconnection option is not changed by the addition of the Project. The predicted impact of adding the underground transmission lines is a negligible change from existing conditions within the ROW and no change in field strength at the ROW edges.

Appendix 5.13-A presents additional detail regarding the measurement of existing magnetic fields and calculations to predict future expected field levels for the onshore portion of the Project and for the 115 kV submarine cables.

Project-Specific EMF Exposure

For the proposed onshore circuits, each underground cable is also enclosed by a grounded metallic shield and so produces no external electric field. Upon connection with overhead NSTAR circuits, the Project would tap into existing lines that would continue to operate at their present-day voltages. Hence, the Project would not produce or add to any electric field exposures onshore.

Along the onshore route, the potential source of exposure to magnetic fields from the Project is the underground transmission line. Other sources of exposure are also present on the route. Along the street portion of the route, magnetic fields are present from existing overhead distribution lines. On the section of the route that is within NSTAR's ROW, magnetic fields exist due to the existing overhead transmission and distribution lines. Analyses previously described in this section show that neither the maximum magnetic field exposure within the ROW nor the magnetic field levels at the edge of the ROW are changed. Table 5.13-8 summarizes the maximum magnetic field levels at various locations along the onshore portion of the route. These field levels, and therefore, potential for exposure, occur over an extremely small space, and decrease rapidly within a few feet from a given location.

Therefore, any exposure from to the magnetic fields would be of short duration. Also, any potential human exposure would be small as compared to the other sources of exposure normally encountered during the day (i.e., home appliances, workplace exposure, etc.).

Cumulative Impacts

In addition to the proposed Project, other activities in the past present or future which may contribute to cumulative impacts to upland EMF levels would include other upland cable installations, modification of existing overhead transmission lines, construction of new commercial and residential structures with electrical service, construction and/or modification of electrical switching stations and substations, and other wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative).

The cumulative effects of adding the new 115 kV cable along the onshore portion of the route has been considered and is described in Section 5.13.4.3. Predicted net magnetic field strengths are presented for the cable section from the landfall to the NSTAR ROW, and take into consideration the existing overhead distribution facilities. Likewise, net magnetic fields are predicted for the section of the new 115 kV circuits that would be within the NSTAR ROW, taking into account the existing overhead transmission facilities and NSTAR's predicted load flows.

5.13.5 Mitigation Summary

There are currently no federal or Massachusetts standards limiting field levels or exposure to EMF. Several states have adopted standards for electric and magnetic fields as shown in Table 5.13-10.

The Project design incorporates economically viable and prudent measures to reduce EMF. The use of three-conductor cables – rather than a flat arrangement of single conductor cables in separate trenches – minimizes the spacing between phases, which in turn, reduces the magnetic field strength. While a burial depth of four feet (1.2 meters) is typically specified by USACE Guidelines for this type of submarine cable installation (USACE Regulation No. 1110-1-9, 1995), the design choice of six-foot (1.8-meter) burial reduces the magnetic field strength on the sea floor to about 45% of what it would be with a 4-foot (1.2-meter) cable depth. Since all of the proposed transmission cables contain grounded metallic shields, they would produce no external electric fields.

In other transmission line siting proceedings, the State of Massachusetts Energy Facility Siting Board has applied an 85 mG magnetic field strength review criteria threshold at the edge of the ROW. The proposed transmission facilities would not produce field strength above this criterion along either the submarine or overland route or at the edge of the ROW for the existing transmission line.

Since the Project encompasses both state and federal waters, the most appropriate EMF guideline for the marine environment would be that of the International Commission on Non-Ionizing Radiation Protection (ICNIRP). ICNIRP has published guidelines on limits of exposure to 50/60-Hz EMF, based on current literature and review of articles by the World Health Organization (WHO). The WHO concluded that no biological effects could be expected from magnetic fields smaller than 50,000 mG[98] (ICNIRP 1998). The ICNIRP (1998) guidelines state that occupational exposure continuing throughout the working day should be limited to 60-Hz magnetic fields below 4,167 mG. The guidelines also state that exposure for members of the general public should be limited to 833 mG, and general-public magnetic field exposure to between 1,000 and 10,000 mG is allowable, if limited to a few hours per day. As discussed earlier in this section, power line magnetic fields to which humans could be exposed in the context of this Project are significantly below ICNIRP safety guidelines, and are in compliance with available State Transmission Line Standards and Guidelines. Consequently, no adverse health impacts to humans from exposure to EMF are anticipated.

As a result of designing the Project to effectively eliminate electric fields, because economically and environmentally viable and prudent steps to reduce magnetic fields have been utilized, and because the Project does not exceed established guidelines or standards for EMF, no additional mitigation is required.

[98] Based on nervous system effects

5.14 Telecommunications Systems

5.14.1 Introduction

This section includes an analysis of potential telecommunications impacts from the Project and applicable regulatory requirements. The information contained in this section was obtained from review of existing data available for the Project area and technical analyses of specific telecommunications parameters.

Radio and microwave frequency fields, which are common in telecommunication, have frequencies (including cellular systems) that range from thousands of hertz to several billion hertz. Generally, telecommunication systems operate on a line-of-sight basis; therefore, structures have the ability to interfere with communication signals if they are within the line-of-sight between a transmitter and receiver. The Federal Communication Commission (FCC) licenses communication systems that use these frequencies to ensure proper compliance with standards.

Section 5.14.2 describes the studies conducted to address telecommunications issues. Existing conditions are described in Section 5.14.3. Potential impacts and mitigation measures are outlined in Section 5.14.4 and 5.14.5, respectively.

5.14.2 Studies Completed

To evaluate potential impacts to telecommunications, a study area was defined that included Cape Cod, Nantucket and Martha's Vineyard, and the waters of Nantucket Sound. An FCC database of existing and proposed telecommunication towers was searched to identify the number and location of these structures in the study area. The results of this search are provided in Section 5.14.3.

To assure that there would be no multi-path interference on existing or proposed microwave telecommunication systems from the proposed Project, ComSearch (Spectrum Management Solutions) of Ashburn, Virginia, was retained to perform a search of incumbent microwave licensees. The data collected included site name, call sign, status, location, frequency band, ground elevation, path azimuths, antenna centerline, antenna manufacturer and model, antenna gain, and detailed contact information. This information, including mapping, was received in a digital format. A worst-case Fresnel Zone analysis was also conducted. The results of the analysis are discussed in Section 5.14.4. The Executive Summary of the ComSearch analysis is provided in Appendix 5.14-A.

The Federal Aviation Administration (FAA) conducted an Aeronautical Survey, which, in part, evaluated potential impacts that the WTGs may have on FAA radar.

Analysis of WTG effects on marine VHF radio communications and marine radar were studied at an existing 80 turbine offshore wind facility at Horns Rev, located in the North Sea off the Danish coast. Elsam Engineering, an international consulting engineering company, evaluated marine communications during the construction and commissioning phases of the Project. Elsam's report is provided in Appendix 5.14-B and discussed in Section 5.14.4.

5.14.3 Existing Conditions

The search of the FCC database for existing and proposed telecommunication towers resulted in identification of 41 existing FCC permitted antenna towers in the study area, 31 on the mainland, five on Martha's Vineyard, and five on Nantucket. Another 17 towers have been permitted that were not yet built at the time of the analysis, but were included in the results. Two of these locations where towers are planned are on Nantucket, with the remainder located on Cape Cod.

The permitted antennae (existing and proposed) in the study area are made up of cellular phone towers, local emergency response communication towers, radio towers, and television towers. Also included in the study area are mobile sources of radio transmissions such as marine VHF radios.

Antennae operate at different frequency ranges depending on the service they provide. AM Radio transmits at 540 to 1605 kHz, and FM Radio at 88 to 108 MHz. VHF television transmits at 30 to 300 MHz, and UHF television at 300 to 3,000 MHz. Analog mobile phone signals are approximately 900 MHz, while PCS mobile phone signals range from 1,800 to 2,000 MHz (Cell Tower Operating Frequency http://www.mcw.edu/gcrc/cop/cell-phone-health-FAQ/toc.html#8).

Recreational boating activity occurs in Nantucket Sound and is most prevalent during the months of May through September. Commercial fishing and marine cargo ships also traverse Nantucket Sound. These vessels use marine radios operating at a range of 156.05 to 157.425 MHz. Shore radios operate at approximately 156.85 to 162.025 MHz. The NOAA weather service operates between 162.4 to 162.55 MHz (Marine Radio Operating Frequency http://www.naval.com/marvhf.htm; http://www.m1cvc.uklinux.net/radio_frqlst_mrn.html).

5.14.4 Analysis of Impacts

5.14.4.1 Impacts Outside of Massachusetts Waters

All of the WTGs are located beyond the 3-nautical mile (5.6 km) state territorial limit. Because of their height above the water, the wind turbines were evaluated for possible interference with existing and proposed telecommunication towers. The proposed submarine cable system associated with the Project would be buried beneath the seafloor and, therefore, no interference with the telecommunications towers, marine VHF radio, or radar is anticipated from that Project element.

As described earlier, most telecommunication devices operate on a line-of-sight basis. This means that the source of the transmission and the receiving antennae communicate along a linear path. Major obstructions and distance can impede the transmission of line-of-sight signals. The interference caused by major obstructions is referred to as "shading." Mountains and large buildings are examples, respectively, of natural and manmade sources of shading.

An evaluation of the FCC-permitted antennae in the study area (existing and proposed) compared with the proposed WTG locations, completed by ComSearch, indicated no impact to line-of-sight telecommunications. These preliminary clearance calculations identified one proposed WTG location with the potential to obstruct a 950 MHz microwave path between Hyannis and Nantucket Island licensed to Radio Nantucket, Inc. under FCC call signs WLD332 and WLD333 (Appendix 5.14-A). The preliminary calculations were based on worst-case (mid-path) horizontal Fresnel radius clearance. The Applicant subsequently relocated the WTG proposed for this location to another area of the proposed Wind Park that would not interfere with telecommunications among towers.

With this adjustment, the existing, permitted, and proposed FCC antennae on Martha's Vineyard and Nantucket would be able to maintain unimpeded line-of-sight communication with existing and permitted corresponding antennae on Cape Cod. Transmission and receiving of signals between towers on Cape Cod and within or between the Islands are not along a path that would intersect with the position of the WTGs. As a result, the WTGs would not be expected to create shading effects on existing or proposed telecommunications towers.

The FAA conducted an aeronautical study for each of the proposed 130 WTGs (Aeronautical Studies No. 2002-ANE-982-OE through 2002-ANE-1111-OE). The FAA's review focused on potential impacts to air navigation; as part of the evaluation, the FAA analyzed the potential for the WTGs to affect aviation radar. Based on its aeronautical studies, the FAA issued a "Determination of No Hazard to Air Navigation" (April 9, 2003), provided in Appendix 5.12-C.

Analysis of marine communication (VHF radio and radar) at the Horns Rev Wind Farm off the coast of Denmark has shown that vessels of various sizes working amongst the grid of 80 turbines experienced no difficulty communicating with each other or the nearby port of Esbjerg. There were no observations or reports of problems with vessel-mounted VHF communication or shadows on radar from rotating turbine blades (Appendix 5.14-B).

GPS positioning systems are not expected to be affected by the presence of the Wind Park. Each WTG is a tall, slender object that will not block signals from multiple satellites. Tall and wide objects such as buildings or mountains can block signals from satellites depending on the location of the GPS antenna in relation to the object and the position of the satellite in the sky. Since each WTG is no wider than 18 feet (5.5 meters) at its base and the WTG are spaced in a 0.34 NM (629 meter) by 0.54 NM (1,000 meter) grid, even GPS antennas located next to a WTG should not experience degraded GPS information as a result of not acquiring sufficient satellite signals.

Based on the results of the evaluations described above, no adverse impact to telecommunications is anticipated from development of the Project.

Cumulative Impacts

In addition to the proposed Project, other activities which may contribute to cumulative impacts to telecommunication would include installation of large pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY), as well as the construction of new land-based telecommunications towers, new residential or commercial structures, and other upland wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative). The cumulative impacts from two potential activities that may occur within the location and timeframe of the proposed Project are discussed below.

A new submarine transmission cable has been proposed by National Grid. Its proposed route is located within the vicinity of the Wind Park. However, since the proposed National Grid cable would be buried beneath the seabed, there are no significant cumulative impacts expected for interference to microwave transmissions to existing and proposed telecommunications towers.

There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, there are no significant cumulative impacts to telecommunications expected since the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively.

Secondary Impacts

There would be no secondary impacts associated with the construction staging/laydown activities occurring at Quonset Point to telecommunications since the site is an active industrial site that houses several industrial businesses receiving and shipping products.

5.14.4.2 Impacts Inside of Massachusetts Waters and Onshore

The proposed submarine cable system and onshore transmission line associated with the Project would be buried either beneath the seafloor or land surface. The only aboveground portion of the 115 kV transmission line would be located at the interconnection with the existing Barnstable Switching Station and would not create a meaningful additional obstruction for telecommunication devices operating on a line-of-sight basis. Therefore, no interference with the telecommunications towers, marine VHF radio or radar is anticipated from the Project cable system.

Cumulative Impacts

In addition to the proposed Project, other activities which may contribute to cumulative impacts to telecommunication would include installation of large pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY), as well as the construction of new land-based telecommunications towers, new residential or commercial structures, and other upland wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative).

A new submarine transmission cable has been proposed by National Grid. Its proposed route would cross the project's submarine cable route in the vicinity of Hyannis Harbor. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point. However, since the proposed National Grid cable would be buried beneath the seabed, there are no anticipated cumulative impacts for interference to microwave transmissions to existing and proposed telecommunications towers.

5.14.5 Mitigation Summary

Evaluation of existing and proposed telecommunications in the vicinity of proposed Project indicated the potential for interference from one of the WTGs with the microwave transmissions of a Nantucket radio station. This turbine was relocated to another area of the Wind Park in order to avoid interference. No other potential adverse impacts on telecommunications systems from development of the Project were identified. Therefore, no further mitigation is necessary.

5.15 Air and Climate

5.15.1 Introduction

This section includes a discussion of potential air quality impacts associated with the Project, summarizes applicable regulatory requirements, and describes Project compliance with the Clean Air Act during construction and operation. The information contained in this section was obtained from review of existing data available for the Project area and projections of air quality conditions if the proposed Wind Park were in operation. Section 5.15.2 provides a summary of air and climate related studies completed to date for the Project. In Section 5.15.3, existing air quality conditions and the Project's regulatory setting are discussed. Potential Project impacts and proposed mitigation are discussed in Sections 5.15.4 and 5.15.5, respectively.

5.15.2 Studies Completed

One study has been completed for the Project that has a bearing on air quality and climate. As a part of a Project Need Analysis (see Appendix 5.16-B), La Capra Associates (La Capra) estimated the quantity of emissions generated by fossil fuel fired power operating in 2000 that would have been reduced if the proposed Wind Park was in operation at that time. LaCapra's estimate is based on the marginal emission rates determined by the New England Power Pool's (NEPOOL's) Environmental Planning Committee in its evaluation of demand-side management programs. The marginal emission rate represents the emissions from the unit(s) that would be displaced by demand reductions or the introduction of a clean energy resource such as the Wind Park. Using these emission rates, LaCapra estimated that the following emission reductions would have been achieved:

- 1,180 tons of nitrogen oxides (NO_x);
- 4,000 tons of sulfur dioxide (SO_2); and
- 949,000 tons of carbon dioxide (CO_2).

La Capra also pointed out that other emissions, such as particulates and mercury (two pollutants of increased focus and concern), would also be reduced were fossil fuel sources displaced by the Project. Emissions reductions through displacement would assist the state of Massachusetts in continuing to improve air quality and visibility throughout the region.

5.15.3 Existing Conditions

The USEPA has established National Ambient Air Quality Standards (NAAQS) for criteria pollutants that are intended to protect public health and the environment. Currently, Massachusetts air quality, including the area of Eastern Massachusetts within which the Project is proposed, is in attainment with the NAAQS for all of the criteria pollutants except ozone. Air monitoring data from the "Commonwealth of Massachusetts 2000 Air Quality Monitoring Report" (MADEP, undated) indicates that monitors in both eastern and western Massachusetts show exceedances of the current one-hour ozone standard and the recently promulgated eight-hour standard. Ground level ozone is created through a series of chemical reactions involving sunlight, NO_x, and VOCs. Conventional fossil fuel fired power plants have been identified as significant contributors of NO_x emissions.

The MADEP monitoring data show that Massachusetts is in attainment with NAAQS for all criteria pollutants except for ozone. Available monitoring data show that the 1-hour and 8-hour NAAQS for ozone have been exceeded at several monitors, and all of Massachusetts is classified as a serious non-attainment area with respect to the 1-hour NAAQS for ozone. On April 15, 2004, the US EPA announced their designation of the entire Commonwealth as being in moderate nonattainment with the 8-hour standard. This designation became effective on June 15, 2004. Ground level ozone is created through chemical reactions involving precursor pollutants (NO_x and VOCs) in the presence of sunlight. Motor vehicles and fossil fuel fired power plants are among the major contributors to ozone precursor emissions.

Although Massachusetts is in attainment with the NAAQS for particulate matter larger than 10 microns in diameter (PM-10), USEPA has promulgated a new standard for particulate matter less than 2.5 microns in (2.5) diameter. USEPA agrees with the recommendation of the Commonwealth of Massachusetts that the Commonwealth be designated as "Attainment/Unclassifiable" for this standard. Attainment/Unclassifiable refers to the situation where the Commonwealth of Massachusetts does not meet the minimum data requirement, but the data which has been collected indicates that they are in attainment for this standard.

In addition to being in nonattainment with the ozone standard, other challenges threaten the maintenance of air quality in the region (i.e. acid rain, visibility impairment, and air toxics) and highlight the need to develop clean energy systems. New England is part of the Ozone Transport Region (OTR), which was established in recognition of the challenges the region faces due to transport of pollutants emitted in upwind states, located to the west and south of the region. Additional emission requirements are imposed upon states within the OTR to help offset the impacts of pollutants transported from outside the region.

5.15.4 Analysis of Impacts

As electricity demand increases, the need to expand the electricity supply would increase. If fossil fuel fired facilities are constructed to meet these requirements, they would have the potential to adversely affect air quality in New England. The NEPOOL and ISO New England's most recent report entitled "Forecast of Capacity, Energy, Loads and Transmission – 2001 to 2010 (CELT Report)" forecasts that the peak summer demand would increase from 23,242 MW in 2000 to 27,171 MW in 2010. This represents an overall 17 percent increase, or an annual growth rate of about 1.6 percent. The proposed Wind Park would provide a peak generating capacity of 454 MW and the Project, when operating, can offset the use of fossil fired generation to meet this demand.

State and Federal air regulations require that new stationary sources of air emissions, such as traditional fossil fuel fired power plants, obtain a permit and meet stringent emission control requirements. The proposed Wind Park would not emit air pollutants and therefore would have no air quality related regulatory requirements or impacts. Rather, the Project would present significant air emissions reductions and opportunities for improved air quality in the region as discussed in the LaCapra Need Analysis (discussed above in Section 5.15.2 and Appendix 5.16-B) and the Energy Facilities Siting Board's (EFSB) recent tentative decision (EFSB, 2004). While the EFSB decision points out that these emissions offsets are likely to "change over time", the EFSB stated that "operation of the wind farm will result in long-term reductions in regional and Massachusetts air emissions". These reductions may qualify the Project for certain benefits established under existing and developing regulations that serve to motivate the development of clean energy projects.

In July 2004, the MADEP promulgated regulations, 310 CMR 7.28, that allow a percentage of the allowances available through Massachusetts' NO_x budget program to be allocated to renewable energy and energy efficiency projects under a public benefit set-aside account. In addition, Massachusetts, like many other states in the New England region, is also considering the development of greenhouse gas programs that may provide similar benefits (i.e., allowances) to energy projects like the proposed Wind Park that do not emit greenhouse gas emissions.

Under the Massachusetts Climate Protection Plan, MADEP is currently working on the development of banking and trading rules for greenhouse gas emission reduction credits. While carbon dioxide emissions offsets created by the wind park will likely be eligible for banking and trading within any state or regional program, until MADEP

finalizes the rules for banking and trading, the true relationship between the Climate Protection Plan and the wind park is highly speculative.

Massachusetts has recently promulgated the Renewable Energy Portfolio Standard (225 CMR 14.08), which requires energy distribution companies to obtain a certain percentage of their total distributed power from a clean renewable source. The minimum percentage required begins at one percent in 2003 and increases to four percent by 2009. The Project would be a source of electric generation that would qualify under this requirement.

The USEPA regulations, published as "General Conformity Rule" (58 FR 63214, November 30, 1993) to implement section 176(c) of the Clean Air Act for non-attainment areas and maintenance areas, require that Federal actions, unless exempt, conform with the Federally approved state implementation plan (SIP). The impacts on air quality associated with the regulated activity described in this EIS have been considered and would not exceed *de minimus* levels of direct emissions of a criteria pollutant or its precursor, and are exempted by 40 CFR Part 93.153. Therefore, a conformity determination is not required.

The proposed Wind Park complies with the SIP because it would not increase regional emissions. In fact, implementation of the proposed Wind Park would likely result in reduced emissions by providing zero emissions energy production and reducing the need for additional fossil fuel fired generating facilities.

5.15.4.1 Impacts Outside of Massachusetts Waters

The quantity of air pollutants reduced by shifting power demand from existing fossil fuel-fired power plants servicing Massachusetts and New England to the Wind Park would not be greatly affected by the specific location of the facility. As discussed above, and concurred to by the EFSB (EFSB 2004), the study conducted by La Capra showed that significant reductions in the quantity of pollutants emitted from existing fossil fuel-fired power plants could be achieved with the operation of the proposed Wind Park. In addition to the reductions in criteria pollutant emissions predicted by La Capra, operation of a non-emitting Wind Park could serve to reduce emissions of toxic compounds such as mercury from existing fossil-fuel power plants, by displacing energy produced from fossil fuel power plants, by several hundred pounds per year, based on a presumed peak capacity of 454 MW emission level using factors provided by the USEPA (USEPA, 1998).

The operation of the Wind Park will not alter the local climate. The turning of the WTG rotors, which react to the wind rather than create or modify it, will not affect the wind speed and/or wind direction in the waters of Nantucket Sound. Conditions such as the formation or dissipation of fog will not be affected by the WTGs operation because fog is formed during specific psychrometric (atmospheric temperature and moisture) conditions. It cannot be created or dissipated by the turning of the rotors.

The activities associated with construction and decommissioning of the Wind Park will result in some level of air emissions over Nantucket Sound due to the use of fossil fuel fired mobile sources (e.g., ships, cranes and other powered construction equipment). Other WTG construction activities, such as welding, cleaning and degreasing, painting, etc. may also result in minor air emissions. These mobile sources do not require federal air permits and USACE recognizes that these emissions will be localized, short term, temporary in nature, and unlikely to result in any appreciable air quality impacts. The temporary addition of these mobile source emissions would represent a minor increase to the emissions from fuel powered craft that already navigate the shipping channels and elsewhere through Nantucket Sound.

Cumulative Impacts

In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to air quality outside of Massachusetts waters would include upwind fossil fueled power plants, other submarine cable or pipeline installations, dredging activities, trawling, pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island).

Secondary Impacts
The secondary air quality impacts associated with construction staging/laydown activities at Quonset would involve emissions from the use of heavy industrial equipment such as trucks and cranes used in the loading and offloading of cargo ships. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy and no significant land alteration would be necessary to accommodate the Project's staging activities.

5.15.4.2 Impacts Inside of Massachusetts Waters

Due to the regional nature of emissions and air quality, impacts within the 3-nautical mile (5.6 km) limit are anticipated to be similar to those outside of the state territorial limit. As noted above in Section 5.15.4, the Project would allow for a regional air emissions reduction and create opportunities for improved air quality in the region.

The activities associated with construction and decommissioning of the offshore and upland cables will result in some level of air emissions due to the use of fossil fuel fired mobile sources (e.g., trucks, ships, cranes and other powered construction equipment). In addition, the construction of the upland cable will generate fugitive particulate emissions resulting from land alteration activities (e.g., clearing, excavation, backfilling and grading, etc.). Other construction activities, such as welding, cleaning and degreasing, painting, etc. may also result in minor air emissions. These construction activities will not require any air permits. The USACE recognizes that these emissions will be localized, short term, temporary in nature, and unlikely to result in any significant or appreciable different air quality impacts at any of the alternative locations.

Cumulative Impacts
In addition to the proposed Project, other activities in the past, present or future which may contribute to cumulative impacts to air quality inside of Massachusetts waters would include upwind fossil fueled power plants, vehicular traffic, other upland cable or pipeline installations, excavation activities, construction of new commercial and residential structures, upland wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative) and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island).

Secondary Impacts
The secondary air quality impacts associated with construction staging/laydown activities at Quonset would involve emissions from the use of heavy industrial equipment such as trucks and cranes used in the loading and offloading of cargo ships. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy and no significant land alteration would be necessary to accommodate the Project's staging activities.

5.15.5 Mitigation

In the most recent State Implementation Plan (SIP) submitted to the USEPA on September 2, 2002, Massachusetts has set 2007 as the goal year to achieve attainment with the one-hour ozone NAAQS. In order to achieve this goal, Massachusetts would need to reduce emissions of pollutants that lead to the formation of ozone. Massachusetts will be revising the SIP based on the new 8-hour standard, but its goal of reducing ozone precursors will remain the same. The clean energy provided by the proposed Wind Park would serve as a mitigation measure in Massachusetts' efforts to achieve attainment for ozone.

The Clean Air Act also requires that states prevent deterioration of air quality in attainment areas. This requires states to evaluate projects based on the incremental increases in ambient air contaminants that would result from their operation. As incremental increases in air contaminants occur, the development of future projects that would result in air emissions is limited. The Wind Park would not result in any incremental increases in air

contaminants, and therefore would allow future development in the region while supplying needed growth in electrical generating capacity.

The power produced by the proposed Wind Park would serve to reduce demand on fossil fuel fired facilities, and thereby reduce air emissions from these facilities. A portion of the emissions offsets resulting from operation of the wind park may occur from existing power plants that are well inland within Massachusetts. These reductions are likely to result in some improvement to air quality within the Commonwealth, independent of the prevailing wind direction. In addition, air emissions from Massachusetts affect downwind regions, and measures taken to improve air quality and reduce emissions in Massachusetts would also improve air quality in regions downwind. Therefore, the proposed Wind Park would increase the likelihood of downwind states achieving attainment and reducing impaired visibility conditions experienced in areas such as Acadia National Park in Maine. In the several manners listed above, the Project itself is a form of mitigation with regard to air quality and climate issues.

The only negative air quality impacts from the project will be the emissions from powered equipment used for constructing the project. Mitigation for these minor, temporary impacts will be accomplished through proper maintenance of construction equipment.

5.16 Socioeconomics

This section describes socioeconomic conditions in the local ROI (Barnstable County, Massachusetts), and more generally throughout the Cape, Islands and Commonwealth; and presents the anticipated potential economic and fiscal impacts of development of the Project on the ROI, the Commonwealth, the New England Region and the nation. Information included in this section was obtained from Project-specific economic analyses and modeling; existing published literature; and correspondence with assessors, municipalities, or other organizations adjacent to existing wind farms. Existing socioeconomic conditions in the Project area are discussed in Section 5.16.3. Potential impacts to socioeconomic conditions in the Project area that may occur from construction, operation, and maintenance of the Project are described in Section 5.16.4, along with mitigation measures that would be implemented to reduce the likelihood and effects of any potential adverse impacts.

5.16.1 Introduction

As specified in the EIS scope for the Project, this section describes the socioeconomic conditions in the Project area and discusses the Project's potential impacts on electricity rates and reliability, public funding and tax credits, employment, tourism, commercial and recreational boating and fishing, other recreational activities, coastal property values, state and local tax revenues and other fiscal impacts on local governments, and public services and housing. This section also addresses compliance with Executive Order 12898 "Federal Actions to Address Environmental Justice in Minority Populations and Low-income Populations" and the Massachusetts Executive Office of Environmental Affairs (EOEA) state guidance entitled "Environmental Justice Policy of the Executive Office of Environmental Affairs."

The Project will also provide a significant opportunity for Massachusetts and the New England Region to advance and promote the implementation of existing state, regional, and federal energy policies related to renewable energy development initiatives. These policies include:

- Federal incentives under the Renewable Energy Production Credit Program and Policies;
- National Environmental Policy Act policy of enhancing the quality of renewable resources on a national level;
- The Bush Administration's National Energy Policy;
- ISO-NE's RTEPO2 programmatic objectives on improving reliability and reducing transmission congestion by use of Distributed Resources and implementation of the New England Region's Renewable Portfolio Standards (RPS);
- New England-wide RPS incentives where new renewable capacity would need to be over 800 MW by 2005 to meet regional RPS requirements;
- Massachusetts Renewable Energy Portfolio Standards requiring a minimum percentage of 4.0% of annual electrical energy sales attributed to new renewable energy generation by 2009;

- Massachusetts Coastal Zone Management Program's Energy Management Principle #1 – Encourage energy conservation and the use of alternative sources such as solar and wind power in order to assist in meeting the energy needs of the Commonwealth.
- Massachusetts Department of Environmental Protection's (MADEP) Policies to reduce greenhouse gas emissions from industrial and energy production source emissions;
- Cape Cod Commission – Regional Policy Plan related to energy initiatives to meet Cape Cod's growing demand for energy supply. The Regional Policy Plan under its Energy Policy promotes, among other things, the use of renewable energy and alternative fuels in order to meet the Cape's growing energy needs.

5.16.2 Studies Completed

Socioeconomic information relevant to the Project was obtained from Project-specific economic analyses and modeling; existing published literature; and correspondence with assessors, municipalities, or other organizations adjacent to existing wind farms. Project-specific economic studies included modeling and electricity market analyses conducted by La Capra Associates to assess the impact of the Project on the New England electricity market (Appendix 2-A), and an economic impact analysis conducted by Global Insight (Appendix 5.16-A) to assess the economic impacts of construction and operation of the proposed Project on cities and towns in Barnstable County, the Commonwealth and adjacent areas in southeastern New England. The Global Insight analysis focused on the economic impacts that would be generated from 1) the purchases of goods and services required to construct and operate the wind farm, and 2) the expenditures of wages and salaries by temporary construction workers and by permanent employees working at the facility once it begins operation.

The primary sources of information obtained from existing publications included:

- A study conducted by Harvard School of Public Health and Sullivan Environmental Consulting entitled "Estimated Public Health Impacts of Criteria Pollutant Air Emissions from the Salem Harbor and Brayton Point Power Plants" (Levy et al., 2000);
- A technical paper by Levy and Spengler (Harvard School of Public Health) entitled "Modeling the Benefits of Power Plant Emission Controls in Massachusetts" (Levy and Spengler, 2002);
- An analysis by and correspondence with Cape Clean Air on the beneficial health impacts from the proposed Cape Wind Project (Kleekamp, 2003a and b);
- A Report conducted by the UMASS Center for Policy Analysis entitled "Cape & Islands Workforce Investment Board: Workforce Development Policy Blueprint." (UMASS, 2002);
- Information and studies from other wind farms in the United States and in Europe;
- A report on New England's Fishing Communities published by MIT Sea Grant (Hall-Arber et al., 2001);
- A study performed by the Renewable Energy Policy Project (REPP) entitled "The Effect of Wind Development on Local Property Values" (Sterzinger et al., 2003); and
- Host Community Agreement between Cape Wind Associates, LLC and the Town of Yarmouth, dated July 25, 2003.

5.16.3 Existing Conditions

5.16.3.1 Public Funding and Tax Credits

The Project has not requested public funding or grants. It could, however, become eligible for Federal Renewable Energy Production Tax Credits (PTC) under Section 45 of the Internal Revenue Code. The PTC provides a general business tax credit for commercial and industrial producers of wind and certain other types of renewable energy, similar to tax credits available for other industries. The credit is currently equal to 1.8 cents per kWh of energy produced and sold for the first ten years of production. The credit is further adjusted annually for inflation, and phased out when the price of renewable energy reaches commercial levels in the United States. In order to qualify for the PTC, a facility must have been placed into service by December 31, 2003. Since the Project was not in service by that time, it would not be eligible to receive the PTC unless Congress extends the time for projects to be placed in service. There is broad bipartisan Congressional support for such an extension.

The PTC was adopted as part of the Energy Policy Act of 1992 to encourage the investment of private capital in renewable energy facilities. The Report of the Senate Finance Committee explained that "The Committee believes that the development and utilization of certain renewable resources should be encouraged through tax laws," and

that the production-type credit of the PTC targeted the activity that the Committee sought to encourage. The House Ways and Means Committee similarly stated the policy objectives behind the PTC, and also stressed the intent of fostering more level competition for renewable energy sources: "The credit is intended to enhance the development of technology to utilize the specified renewable energy sources and to promote competition between renewable energy sources and conventional energy sources."

5.16.3.2 Electricity, Rates and Reliability

New England is well ahead of much of the nation in deregulating its electricity market, and using advanced technology to provide reliable and less expensive sources of electricity. On March 1, 2003, ISO New England (ISO-NE), the independent system operator that administers the New England wholesale system under the supervision of the Federal Energy Regulatory Commission (FERC), implemented its System Market Design (SMD). The SMD is a set of market rules and procedures which the ISO-NE implemented to meet the FERC's rules for standardizing wholesale electric markets nationwide.

Under the SMD, electricity producers bid in their available electricity resources on an hourly basis. Producers base their bids primarily on the cost of their fuel, although other operating costs are part of the bid. The ISO-NE then stacks bids by price, and dispatches enough electric producers to fill the forecasted demand at various points on the system. Each supplier then receives the highest bid dispatched to satisfy the forecasted demand. Intermediate and long-term power purchases may be negotiated between electricity producer and electricity purchaser. These contracts fix prices for periods of time ranging from days to years.

The renewable energy portfolio standard (RPS) was incorporated in the Massachusetts Electric Industry Restructuring Act of 1997. The RPS requires electricity suppliers to obtain certain minimum percentages of their supply from qualified renewable sources, which include wind energy. The RPS requirements began in 2003 with each supplier obligated to obtain at least one percent of its supply from new renewable sources and then increasing that supply to four percent by 2009. Retail electricity suppliers are required to purchase Renewable Energy Credits (RECs) to fulfill these requirements.

5.16.3.3 Public Health Impacts and Economic Costs from Power Plant Emissions

A Harvard School of Public Health study (Levy et al., 2000) investigated the public health effects from pollutant air emissions from power plants that had been grandfathered under the Clean Air Act. The authors developed a model and applied it to two power plants in Massachusetts: Salem Harbor in Salem, and Brayton Point in Somerset. The model focused on emissions of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), and particulate matter (PM_{10}). To estimate health impacts from these emissions, a population of interest was defined and an atmospheric dispersion model was used to estimate pollution exposure to approximately 32 million people in the region. Epidemiological studies and data from the American Cancer Society were combined with demographic data in the area of pollution exposure identified by the model to determine health impacts.

The Levy 2000 study provides a good basis for evaluating the existing public health impacts from two of the heaviest polluting power plants in Massachusetts. The study is the first peer reviewed publication to statistically relate detrimental health effects to identifiable pollution sources and expected reductions from proposed emission controls. An updated publication by Levy and Spengler (2002) revised some of the health impacts from the first study.

The Levy 2000 study found that ambient concentrations of emissions from these power plants "...were greatest close to the source for primary pollutants (within 5 miles for PM_{10} and SO_2) and peaked further downwind for secondary particles (approximately 20 miles). Secondary particles are formed in the atmosphere by chemical reactions involving SO_2 and NO_2 emissions." The study also indicated that some pollution was distributed across the entire region of interest. Although per capita health risks were found to be greatest near the power plants, only 20% of the total impacts occurred within 30 miles of the plants since more than 90% of affected individuals live beyond a 30-mile radius of the plants (Levy et al., 2000).

According to the authors of this study, "epidemiological and toxicological evidence suggest that exposure to elevated levels of particulate matter (PM), sulfur dioxide (SO2, with most health effects associated with sulfate

particles), and other combustion pollutants can lead to numerous adverse health effects, ranging from respiratory symptoms to premature death." Some of the estimated health impacts from these emissions calculated by the authors using the model and techniques outlined in the study are summarized below. Table 5.16-1 presents the full summary of these predicted health impacts from the Levy 2000 study.

- 30 premature deaths per year from Salem Harbor and 80 premature deaths per year from Brayton Point;
- 570 emergency room visits per year from Salem Harbor and 1,140 emergency room visits per year from Brayton Point;
- 14,400 asthma attacks per year from Salem Harbor and 28,900 asthma attacks per year from Brayton Point;
- 99,000 daily incidents of upper respiratory symptoms from Salem Harbor and 199,000 daily incidents of upper respiratory symptoms from Brayton Point.

An analysis of the economic costs of these health impacts was also conducted by the authors. Monetary values were assigned to sickness, disease, and hospital visits using willingness to pay studies, cost of illness studies, and medical cost databases. These values represent the productivity and utility losses that people face, along with medical and associated economic costs. The economic value used for mortality is called "statistical life" and this value was estimated using a published EPA benefit-cost analysis as a baseline value. Both the 2000 and 2002 studies utilized the EPA value of statistical life that was in effect at the time of the study. The EPA recently decreased their valuation of human life from 6.1 million to 3.7 million (New York Times, 2003). Based on this newer revised value of statistical life and the Levy 2000 modeling, the total economic costs of the health impacts (illness and premature deaths) from the Salem and Brayton Point plants are estimated to be $135.8 million and $345.8 million per year, respectively (Levy et al, 2000; Levy and Spengler, 2002; New York Times, 2003). Potentially, these economic costs could be reduced by obtaining emissions offsets from another existing power plant or through replacement of the power generated by fossil fuel fired facilities such as Salem and Brayton Point (a power offset) by a new renewable energy source such as the proposed Project. The potential reduction in health impacts and associated potential economic benefits from the Cape Wind Project are discussed further in Section 5.16.4.3.

5.16.3.4 Local Economy

Global Insight conducted an economic impact analysis of the Cape Wind Project which is included as Appendix 5.16-A. Global Insight defined the ROI as Barnstable County, Massachusetts, which contains a total of 15 cities and towns: Barnstable, Brewster, Chatham, Dennis, Eastham, Harwich, Mashpee, Orleans, Sandwich, Yarmouth, Bourne, Falmouth, Provincetown, Truro, and Wellfleet. However, the Barnstable New England County Metropolitan Area (NECMA) is the same as Barnstable County, so the Barnstable NECMA also comprises the ROI.

Barnstable County was selected as the ROI because the majority of the direct construction and operation impacts will be concentrated there, including the hiring of construction workers, purchase of non-labor goods and services during construction and operation, presence of an on-shore support base to support offshore construction and annual operation and maintenance activities, and the presence of on-shore infrastructure such as the 115 kV transmission line that would convey power from the Project to the existing regional grid. Southeastern Massachusetts and Rhode Island would also benefit from on-shore facilities that may be established there during construction, including fabrication of blades and other components in southeastern Massachusetts, and the assembly of the WTGs and stockpiling of construction materials at Quonset Point, Rhode Island. Barnstable County is located within easy daily commuting distance of both the Boston and Providence metropolitan areas, so any skilled construction workers not available from the ROI would be obtained from these two areas, suggesting that no in-migration of temporary construction workers would occur.

Population and Income

Table 2.1 in Appendix 5.16-A summarizes recent economic data for Barnstable County from Global Insight's Spring 2003 Forecast. Table 2-1 shows the population of Barnstable County was estimated at 227,600, as of March 2003. Barnstable County's total population according to the 2000 census was 222,230 persons. The most recent population estimate as of July 1, 2002 places the County's total population at 228,577 (see Section 2.2 of Appendix 5.16-A), a slight upward revision from the previously published estimate shown in Table 2.1. Barnstable County's population grew at an annual rate of 1.71% between 1990 and 2002, well above the statewide growth rate of 0.5% (see Section 2.2 of Appendix 5.16-A).

According to Global Insight, Barnstable and Yarmouth are the two municipalities in the ROI where the direct benefits and effects from construction and operation would be most concentrated. Table 2.3 of Appendix 5.16-A presents baseline data for the towns of Barnstable and Yarmouth from the "Community Report Builder" databases maintained by the Massachusetts Department of Revenue, Division of Local Services. The Town of Barnstable had an estimated population of 47,821 persons in 2000, which had risen to 48,854 persons by July 1, 2002 according to the US Census, while Yarmouth's population in 2000 was 24,807 persons. Both communities are classified as growth communities according to the Table.

As shown in Table 2.1 of Appendix 5.16-A, Barnstable County's real personal income (in 1996 dollars) was estimated at $7.7 billion in 2002, representing a 2% increase over the previous year. By contrast, total nominal personal income in Barnstable County in 2002 was up 3.4% over 2001, compared to only 1.4% in Massachusetts. Growth in real per capita income (in 1996 dollars) was slightly lower, reaching an estimated $33,796 in 2002, a 0.76% increase over 2001. By comparison, real per capita personal income in Massachusetts in 2002 was $35,316, down 0.4% from the 2001 figure of $35,461.

According to the Bureau of Labor Statistics, the average annual pay per covered worker in Barnstable County during 2001 was $31,020, up 4.4% from the year before. By comparison, the average pay per covered worker in the Boston and Providence primary metropolitan statistical areas was $45,768 and $33,390 respectively. Global Insight estimates that the average wage per job in Barnstable County in 2003 is $34,600, well below the Massachusetts figure of $47,400. The lower figure for Barnstable County reflects its dependence on the tourism sector, with a resulting concentration of lower paying jobs in the retail and services sectors.

Employment

Global Insights reported that the Massachusetts Division of Employment and Training (MDET) estimates that the total non-seasonally adjusted (NSA) labor force in Barnstable County during the second quarter of 2002 was 115,752 workers, while the total resident labor force in the Cape Cod and Islands Workforce Investment Area, which also includes Nantucket and Martha's Vineyard, was 129,043 workers. The NSA unemployment rate in the Islands Workforce Area in June 2003 was 3.7%, up from 3.4% the previous year, but well below the Massachusetts and US NSA unemployment rates of 5.7% and 6.5%. Similarly, the NSA unemployment in Barnstable County in June 2003 was 4%. Finally, the June 2003 NSA unemployment rates in the City of Barnstable and the Town of Yarmouth were 3.7% and 4.2% respectively.

In 2002, total non-agricultural employment in Barnstable County, on a place of work basis, was 91,997 jobs, with the non-manufacturing sector accounting for 89,045 jobs. The remaining 2,952 jobs were in the manufacturing sector. The "Retail Trade" and "Services" sectors had the largest shares of non-manufacturing employment, accounting for 27,623 and 31,562 jobs respectively (Table 2.1, Appendix 5.16-A).

Economic Activity

Table 2.2 in Appendix 5.16-A presents the economic structure and growth rates for Barnstable County and the Commonwealth of Massachusetts for 1990 through 2002 for employment, number of establishments, and nominal gross output (output reported on a sales basis compared to the value added basis used for gross domestic product and gross state product). These data confirm that Barnstable County's employment is concentrated in the retail trade sector (28.8%) and services sector (31.6%). The retail trade employment share was much higher in Barnstable County compared to Massachusetts, while the services sector share was slightly lower. The data also show that the construction sector accounted for 7.1% of total Barnstable County employment in 2002, well above the statewide share of 4.2%. In addition, these data indicate that the annual growth rates in employment, number of establishments, and nominal output in Barnstable County between 1990 and 2002 were greater than in Massachusetts. According to the Global Insight report, another indicator confirming the difference in economic growth is that the annual growth rate in nominal personal income in Barnstable County between 1990 and 2002 was 5.7%; again well above the statewide growth rate of 5.0% over the same period.

Global Insight performed a shift-share analysis of the Barnstable County economy, using 2-digit Standard Industrial Classification (SIC) code employment data in order to better describe the county's economic structure and to identify key economic sectors that could be affected by the Cape Wind Project. The analysis showed that between 1990 and 2002, the total increase in the county's employment could be disaggregated into the following

three effects: 1) national effect or growth in the US economy – 71%; 2) industry mix, or the county's percentage shares of high-growth and low-growth sectors as defined at the US level – 16%; and 3) competitive effect, or the extent to which individual economic sectors in the county grew faster or slower than the same sectors in the US economy – 13%. For a region heavily dependent on tourism, these shares are typical; suggesting that economic growth in Barnstable County largely depends on economic growth in the Massachusetts and US economies (i.e., the extent to which growth in real incomes in the state or US enables people to take vacations, buy second homes, engage in recreational activities, etc.). Details on this analysis are included in Appendix 5.16-A.

Additional information on economic and business trends in the Cape and Islands region was obtained from a report conducted by the UMASS Center for Policy Analysis (UMASS, 2002). The Center for Policy Analysis identified critical and emerging industries in the Cape and Islands workforce area, including business clusters in the region. Business clusters are defined in the report as consisting of "...firms in two or more related sectors that are linked together through customer, supplier, labor market, or other relationships." (UMASS, 2002). The report identifies the following seven key business clusters in the Cape and Islands Workforce area with percent total employment identified in parentheses: hospitality (23.5%), knowledge intensive (14.1%), health services (11.4%), construction (6.1%), financial services (4.9%), distribution (2.6%), and social services (2.3%). This report also indicates that the hospitality industry, the highest employing industry in this region, is highly seasonal because it "...depends on factors such as weather and the economic condition of those regions that supply its tourist trade" (UMASS, 2002).

Tax Revenues and other Fiscal Impacts

As detailed in Appendix 5.16-A (Table 2.3), the local governments that would be most affected by construction and operation of the Project are the towns of Barnstable and Yarmouth. Information on local tax revenues and fiscal information for each of these towns is presented below.

Barnstable:

Barnstable had an estimated population of 47,821 in 2000 according to the US Census. Fiscal Year (FY) 2002 data indicate that the number of single-family parcels was 20,521 and the overall tax rate was 9.26 in the town of Barnstable. Actual revenues (FY 2000) were approximately $91 million, with expenditures of approximately $88.5 million. The Town of Barnstable Comprehensive Annual Financial Report indicated that real property tax revenues for FY 2003 were $69,272,770.

Yarmouth:

Yarmouth had an estimated population of 24,807 in 2000 according to the US Census. FY 2002 data indicate that the number of single-family parcels was 12,480 and the overall tax rate was 11.10 in the town of Yarmouth. Actual revenues (FY 2000) were approximately $39 million, with expenditures of approximately $41 million. A personal communication with the Yarmouth Town Hall on March 29th, 2004 indicated that real property tax revenues for FY 2003 were $30,598,438.

5.16.3.5 Housing and Coastal Property Values

Table 5.16-2 lists housing occupancy in the towns of Barnstable and in 2000. It should be noted the vacant housing category includes seasonal, recreational or occasional dwellings. Roughly 89% of the vacant housing would be in this category. Given the nature of Barnstable County as a vacation destination, these seasonal, recreational and occasional housing units are typically occupied during the summer months.

Home prices on the Cape and Islands have been rising for the last ten years. Average prices and percent increase in prices on the Cape and Islands are generally higher than the statewide average. The average price for a single family home in 2002 in the Cape Cod Region was $363,506, representing a 16.5% increase over the previous year. By comparison, the statewide average price for a single family home in 2002 was $346,019, representing a 12% increase over the previous year (Massachusetts Association of Realtors, 2002). Another source of information on residential home values can be obtained from the Massachusetts Department of Revenue's Division of Local Services which reviews and certifies the real and personal property values for one-third of Massachusetts' cities and towns. According to the FY02 Residential Statistical Summary (MA Department of Revenue, 2002), the towns of Barnstable, Chatham, Edgartown, Falmouth, Harwich, and Oak Bluffs all have average assessed values for single family homes well above the statewide average of $235,833.

5.16.3.6 Tourism and Recreation

Currently Cape Cod and the Islands receive a high percentage of their revenue from the tourism industry. The focus of most area tourism is the high quality recreational activities that the area offers. The Cape Cod Chamber of Commerce estimates that approximately 44% of the economic base for Cape Cod comes from seasonal tourism. An estimated six million tourists visit Cape Cod annually and will spend nearly one billion dollars. Almost two-thirds of these visitors vacation during the summer and fall seasons (MDED, 2002). Tourism on the Cape and Islands includes recreational activities such as: beach going, fishing, boating (including windsurfing and jet skiing), boat racing, golfing, hiking, picnicking, sightseeing (light houses and other historic areas, etc.), and shopping. Guided tours or charters are available for many of these activities including fishing; whale watching; wildlife, kayaking, canoeing tours and bike tours.

Beaches that are within the viewshed of the Project area (see Section 5.10) are located in the towns of Falmouth, Mashpee, Chatham, Harwich, Dennis, Yarmouth, Edgartown, and Oak Bluffs. Detailed estimates of the annual number of beachgoers is not available, however data from those towns who responded to inquiries of the number of beach stickers issued to residents and non-residents as an indicator (over 33,000 stickers between Mashpee, Chatham and Yarmouth alone) suggest that beachgoers within the viewshed number in the 100's of thousands.

Since construction and operation of the Wind Park and underwater transmission cable (exclusive from the onshore transmission line) would occur offshore and could have no direct physical effect on onshore recreational resources, this EIS focuses on potential visual impacts of the offshore components of the Project to onshore recreational areas and the related tourist industry. The recreational resources subject to potential visual impacts from construction/decommissioning, operation and maintenance of the Project are compiled on Table 5.10-4 and shown on Figure 5.10-5. Also included are the viewpoint(s) closest to each recreational area, which were prepared to represent the overall change in the viewed seascape at each location. A description of the process used to locate, identify and number these resources is provided in Section 5.10.2.6.

The construction of the onshore transmission line may temporarily affect the parking lot to a recreational resource at Englewood Beach, off of New Hampshire Avenue. However, any impact to this onshore recreational resource is expected to be minimal and limited to off-season beach visitors due to the onshore construction timeframe (Labor Day through Memorial Day).

The nearshore and offshore waters of Nantucket Sound were also identified as important recreational resources and therefore economically valuable tourist attractions. The Project site is centrally located within Nantucket Sound. Peak recreational activity is during the warmer months of the year (typically April through October), corresponding with the peak tourist season. Recreational users such as fishermen, windsurfers, swimmers, water skiers, jet skiers and other boaters are active along the nearshore and shoreline areas facing Nantucket Sound. Scuba diving is limited in the area because the soft sediment habitat is generally uninteresting. The offshore waters are used by larger power and sailboats.

A more detailed discussion of the economic value of all types of boating and fishing is provided in the following two sections.

5.16.3.7 Boating

Boating on Nantucket Sound consists of a mix of commercial and recreational activity. Commercial activity includes passenger ferries, vessels, and barges carrying liquid and dry bulk goods, occasional cruise ship visits, commercial fishing vessels, charter fishing vessels, and research activity. Recreational activity includes fishing, sailing, cruising, boat racing, jet skiing (nearshore), kayaking (nearshore), and canoeing (nearshore).

Coastwise and recreational vessels tend to use the Main Channel (south of Horseshoe Shoal) when transiting Nantucket Sound for points within Nantucket Sound and for the Atlantic Ocean. The Main Channel also serves as an inside passage for medium draft vessels to avoid Nantucket Shoals (south and east of Nantucket in the Atlantic Ocean). This channel is marked with aids-to-navigation, and has a minimum depth of approximately 30 feet. However, the drafts of vessels using the Main Channel seldom exceed 24 feet (NOAA, 1994).

The North Channel (north of Horseshoe Shoal) is used by vessels bound for the Cape Cod shore and by vessels transiting the Sound during northerly winds. This channel is marked with aids-to-navigation, and has a minimum depth of approximately 16 feet (NOAA, 1994).

The numerous shoals in Nantucket Sound limit the operating areas for vessels depending on the vessel's draft. Charted water depths on Horseshoe Shoal range from one to 45 feet at MLLW, with the majority of the shoal covered by between 20 feet and 30 feet of water at MLLW. As a result, larger vessels avoid Horseshoe Shoal and stay in the Main Channel and the North Channel. Changes in water depths over short distances and strong tidal currents (with peak currents often exceeding two knots) also tend to create steep waves that break on the shoals, causing many shallow-draft boaters to avoid the shoals. In addition, the long distance from shore and the wave and tidal action also limit use by very small recreational vessels, such as open runabouts.

Over the course of 53 total days of Project related field work during the summers of 2001, 2002 and 2003, observations of vessel traffic in the Horseshoe Shoal area were made by field personnel in the course of completing other geotechnical, geophysical and avian field investigations. Observations were made from both boats and an airplane. Recreational vessels observed during the summer (Memorial Day through Labor Day) within the Project area at Horseshoe Shoal ranged from no vessels observed (30 % of the field days) to 11 vessels observed (in one day). Using these field observations the estimated median number of recreational vessels observed daily is two.

To supplement these field observations, detailed observations of vessel movements on and around Horseshoe Shoal were made from the SMDS platform over three summer weekend days (Saturday, June 12, 2004; Sunday, June 13, 2004; and Saturday, July 3, 2004) when recreational boating activities are generally at their highest. Weather conditions were clear and conducive to recreational boating. These observations involved visually scanning the Horseshoe Shoal area and the Main Channel at intervals of approximately 15 minutes to count the number of vessels observed. Vessels observed were characterized as being either on Horseshoe Shoal[99] or in the Main Channel. Approximately 81% of the vessels observed were recreational vessels, and approximately 57% of the vessels observed were operating in the Main Channel. Recreational vessels observed on Horseshoe Shoal on these days ranged from no vessels observed in a 15 minute period to 12 vessels observed. On average, approximately 2 recreational vessels and/or one commercial vessel were observed during each 15 minute period. The data from these detailed observations appears to correlate with the data from the previous field observations in 2001, 2002, and 2003.

Additional information and discussion of related marine recreational activities is included in Sections 5.10 (Cultural and Recreational Resources and Visual Studies), Section 5.11 (Noise) and 5.12 (Transportation and Navigation).

5.16.3.8 Fishing

According to a study performed by MIT Sea Grant, Cape Cod and the Islands are ranked third in New England, following Downeast and Mid-coast Maine, on the fishery dependency index that is based on employment indices used in that study (Hall-Arber et. al., 2001). Chatham, Vineyard Haven, and Sandwich are ranked as some of the top ports in this region actively engaged in the commercial fishing industry. In terms of overall workforce, fishing, agriculture, and forestry comprise 1.8% of the workforce on Cape Cod (Table 2.2, Appendix 5.16-A).

According to the MIT Sea Grant study, Chatham is the most active port in the Cape Cod and Islands sub-region. Chatham has an important longline/hook fleet as well as gillnetters and lobster fishermen. The town also has a "thriving" shellfish industry and a well-developed support industry (transportation, processing/marketing, related supply and repair businesses). The MIT Sea Grant study references a report conducted by NMFS Fisheries Statistics Division entitled "Fisheries of the United States", where Provincetown and Chatham were combined together into one port area for investigation. This report indicated that the Provincetown-Chatham area was among the top 50 ports compared to other major ports in the United States. Landings in Provincetown-Chatham

[99] For the purposes of the observations, the boundaries of Horseshoe Shoal were Buoy N2 to the west, bell buoy G5 to the north, the ferry route to the east, and the Main Channel to the south. This study area encompasses approximately 51 square miles and is significantly larger than the Project area.

were 17.8 million pounds (value of $10.2 million) in 1998 and 20 million pounds (value of $12.9 million) in 1999. Most of these landings are likely from offshore areas, outside of Nantucket Sound.

Nantucket Sound supports a commercial fishery for various finfish species, squid, shellfish (including conch) and lobster. From 1994 through 2001, approximately 4.3 million pounds of finfish and squid were harvested from Nantucket Sound. The top ten species of finfish and squid landed by commercial fishermen in Nantucket Sound (sub-area 075) as reported from NMFS vessel trip reports from 1994 through 2001 included squid, Atlantic mackerel, black sea bass, summer flounder, scup, menhaden, butterfish, tautog, winter flounder, and bluefish. Approximately 1.8 million pounds of squid were harvested from Nantucket Sound suggesting that squid comprise 42% of the total landings (excluding shellfish and lobster) for this region. Observations from boat operations and aerial surveys conducted by or on behalf of Cape Wind over the past two years indicate that most commercial fishing vessels, including squid vessels, were observed in deeper areas of Nantucket Sound outside of the shallows of Horseshoe Shoal. Additional information on commercial fisheries in Nantucket Sound can be found in Section 5.4 (Finfish Resources and Commercial/Recreational Fisheries) and Appendix 5.4-A.

Nantucket Sound and the waters around the islands of Nantucket and Martha's Vineyard support a diverse array of recreational fishing activities. Data on recreational fishing are monitored by NMFS. The majority (99.6%) of recreational anglers surveyed by NMFS from the three counties surrounding Nantucket Sound reported hook and line as gear type used for recreational fishing activities, and most recreational anglers reported fishing from a private/personal or rented boat as the type or mode of recreational fishing. Fishing from shore is also common, with approximately 40% of all anglers surveyed reporting fishing from shore.

Common species caught by the recreational anglers interviewed by NMFS include bluefish, Atlantic mackerel, scup, striped bass, winter flounder, summer flounder, menhaden and tautog. According to a telephone survey targeting registered party/charter boat captains in the region, Horseshoe Shoal does not appear to be the favorite for charter/party fishing excursions of any time length when compared to the popularity of other fishing sites in and adjacent to Nantucket Sound. The captains that reported fishing in Horseshoe Shoal also reported that bluefish was the most frequently caught species there. Additional information on recreational fisheries is provided in Section 5.4 and Appendix 5.4-A and 5.4-B.

5.16.3.9 Environmental Justice

Presidential Executive Order 12898, "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations", directs federal agencies to consider environmental justice issues, as follows:

...Each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States...(Executive Order 12898, 1994)

A second objective of Executive Order 12898 is to ensure effective public participation and access to information during development and design of a federal or federally permitted project within the NEPA process. Federal guidance to implement Executive Order 12898 has been developed by the Council on Environmental Quality in its publication entitled "Environmental Justice Guidance under the National Environmental Policy Act" dated December 10, 1997.

The Massachusetts Executive Office of Environmental Affairs (EOEA) issued state guidance entitled "Environmental Justice Policy of the Executive Office of Environmental Affairs." The Commonwealth's Environmental Justice Policy, issued by the EOEA on October 9, 2002, applies to EOEA actions under MGL Chapter 21A, Section 2. Section 2 provides, generally, that "the office and its appropriate divisions shall carry out the state environmental policy and in doing so they shall...develop policies, plans, and programs for carrying out their assigned duties."

A review of the Project with respect to the Environmental Justice under the federal guidance and state policy is presented in Section 5.16.4.9.

5.16.4 Proposed Site Conditions and Analysis of Impacts

5.16.4.1 Public Funding and Tax Credits

As described in Section 5.16.3.1, the Project at this time is not seeking public funding or grant awards. The Project could be eligible for the PTC, however, the actual applicability and impact of the PTC in the case of Cape Wind is somewhat speculative, since the Project would not be eligible for the PTC unless Congress extends the currently-stated expiration date for credit eligibility. If the PTC is extended, the tax credit that would be potentially available would depend upon the actual output of the Project. If the average output at the interconnection with the New England Power Pool (NEPOOL) facilities is assumed to be approximately 1,489,200 megawatt hours (MWh) annually for each of the first ten years of operation, the aggregate annual amount of potentially available credits can be estimated to be $26,805,600 (i.e., 1,489,200,000 kwhs x $0.018/kwh.) Applicable limitations on claiming business credits would apply, so investors may or may not be able to use the full credit.

5.16.4.2 Electricity, Rates and Reliability

New England

The EFSB's Tentative Decision (EFSB 02-2) of July 2, 2004, includes the findings that (i) "there is a need for the capacity provided by the wind farm beginning in 2007 for reliability purposes", (ii) "there will be a need for the renewable resources provided by the wind farm to meet regional RPS requirements", (iii) "there is a need for the power generated by this wind farm for economic purposes", and (iv) "operation of the wind farm would provide average annual savings of $25 million for New England customers, including $10 million annually for Massachusetts customers, during the first five years of operation." (EFSB, 2004).

Studies conducted by La Capra Associates (Appendix 2-A) which were presented as part of the EFSB proceedings, evaluated the potential impact of the Cape Wind Project on New England electricity market prices. The main conclusions from the analysis include:

- The Project would place downward price pressure, through lower market clearing prices, on the New England electricity market;
- The Project would improve reliability of the regional electricity system by increasing the total electricity supply;
- The Project would diversify the region's energy mix in terms of fuel supply and generation technology, with associated decreased reliance on imported fossil fuels;
- The Project would displace the emissions from approximately one percent of present NEPOOL fossil fuel generation;
- Savings to ratepayers in the New England electricity market are estimated to be approximately $25 million annually for the first five years of Cape Wind's operation;
- Savings to ratepayers would increase beyond the estimated level of $25 million per year if the demand for electricity grows rapidly, or if older existing generating sources are retired, or if new generating sources are not developed; and
- By decreasing the region's overall dependency on, and demand for, natural gas, the Project would save money for natural gas customers by helping to stabilize volatile gas price fluctuations.

ISO-NE dispatches generating resources according to a bid stack. New England generators offer the output of their units at bid prices that tend to equal or exceed their variable costs (at a minimum, their cost of fuel). Energy is dispatched to fill the need for electricity from the lowest- to highest-priced generating unit in the bid stack; but all units being utilized receive a spot price equal to the highest-priced unit dispatched. The Cape Wind Project would have a marginal operating cost of near zero (free fuel). Energy produced by the Cape Wind Project will displace an equivalent amount of energy from the next available, more expensive fossil fuel fired unit(s) in the bid stack. By displacing a more expensive unit, Cape Wind will place downward pressure on the price of power in any given hour in the New England spot market for all consumers. The La Capra study indicates that the intermediate- and long-term contracts will tend to price energy based on the trends in the electricity spot market. Accordingly, Cape Wind will reduce prices in the long-term markets as well.

The La Capra study used several conservative assumptions in its analysis of the Cape Wind Project's impact on the New England electricity market, and it is likely that the realized savings from the Project may be even greater than the estimated savings of $25 million per year. La Capra assumed:

- That long term fuel costs would be based on the 2001 prices for natural gas and oil. If La Capra used fuel prices from 2002 and 2003 as the base price in the forecast, energy prices would be significantly higher than those used in the modeling;
- A significant increase in new generating capacity. La Capra did not account for the wave of bankruptcies among energy companies. In many cases, proposed generation projects have been cancelled or delayed indefinitely, and lenders have become increasingly reluctant to finance traditional power projects in the volatile New England markets;
- Relatively few periods of tight supply with price spikes. If the regional supply tightens, the savings from the Project would be significantly greater. And
- La Capra did not consider that environmental restrictions may cause older facilities, like Brayton Point and Salem Harbor, to make significant capital improvements, implement operating constraints, or use higher-cost fuels.

The price of fuel is the major determinant of the price of electricity. For environmental and economic reasons, most of the capacity now being added to the New England market is fueled by natural gas. New England relies more on natural gas for generation than any area of the country except for Texas, which has an indigenous supply of natural gas. The ISO-NE estimates that 50% of New England's generation will be from natural gas in 2006 (Reed Associates, 2001). The price of gas is volatile, and transportation to the New England markets is limited. Because New England relies so heavily on natural gas for power as well as home heating uses, New England is experiencing increasing volatility in the prices of gas and power, creating concerns for local consumers and industry (AIM Foundation, 2003).

In 2002, the ISO-NE commissioned a study to answer concerns about New England's reliance on natural gas for generation (Levitan & Associates, Inc., 2002). This study concluded that on extremely cold winter days, New England's pipelines cannot serve the demands of both gas utilities and gas-fired generators. The majority of merchant generators have not contracted for long-haul, primary firm transportation rights. These generators cannot be guaranteed firm deliveries during the coldest part of the winter, a time when each of New England's pipelines normally run at maximum flow. Accordingly, 3,101 MW is at-risk on the Peak Day, and perhaps as much as 3,960 MW.

Fuel diversity is an important goal for the New England system. A variety of fuels mitigates the reliability and pricing issues that develop in a system which is overly reliant on an uninterruptible supply of natural gas. This over reliance is compounded by the lack of natural gas production in New England. The pressures of higher cost fuels, insufficient new generating capacity, decreasing supply, and additional environmental costs will only increase the projected savings from Cape Wind. The Project will also help to increase the reliability of the region's electricity system by reducing the use of natural gas in the system, with the collateral benefit of allowing for gas to be used by homeowners and industry grappling with present capacity restraints at times of peak gas demand.

Massachusetts

RECs are created when a qualified generator produces electricity for NEPOOL. Each generator receives a certificate for each MWh produced and delivered to NEPOOL, and certificates from qualified renewable production are treated as RECs. These certificates are tracked by the NEPOOL Generator Information System (GIS), which transfers the certificates to accounts created for each supplier of load, and, in effect, creates a market for the RECs. The GIS is also able to track which units were not run because of the production of a renewable resource, and therefore, the emissions which were offset by that renewable production. RECs will therefore be available to comply with various emissions reduction programs, such as Massachusetts' NOx Allowance Trading Program (see proposed amendments to 310 CMR 7.28).

La Capra Associates estimated the supply of renewables available for the REC programs in Massachusetts as of January 2003, and the estimated demand for renewables. Based on La Capra's estimate, in 2006, the supply of

renewable power from sources other than the Project will be 479 gigawatt hours (GWh), and the demand for renewable power to comply with the Massachusetts RPS will be 1,262 GWh.

Cape Wind will reduce the cost of compliance with the RPS for Massachusetts electric consumers. The market price of RECs will depend, in part, on the amount of new renewable energy generation that qualifies to be issued as RECs. The market price of RECs will be lower with a greater supply of qualified renewable energy, thereby further driving down the cost incurred by electricity suppliers and subsequently ratepayers.

Cape Cod and the Islands

Cape Cod and the Islands are at the end of the NEPOOL system. Despite the growth of the use of power on the Cape, no new source of generation has been added since the Canal 1 and 2 plants were placed in service in 1968 and 1976, respectively. The Emission Control Plan for the Canal units issued by Massachusetts Department of Environmental Protection on June 7, 2002 requires the units to meet restrictive limits on NO_x, SO_2 and CO_2 by October 1, 2004 and more restrictive limits by October 1, 2006. In order to meet these requirements, the Canal units will have to invest significant amounts in new equipment and use more expensive low sulphur fuels, or accept operating restrictions. Given that Mirant, the owner of Canal 1 and 2, has filed a petition for bankruptcy, the source of funds for these improvements and increased costs of operation is in doubt.

Cape Wind is an intermittent resource. However, it does represent a source of capacity and power at the end of the line. This energy can be used to bolster the local grid, should the Canal plant be unavailable.

In addition, the Applicant has offered to negotiate long-term electricity contracts with electric aggregator(s) for electric consumers, including those on Cape Cod and the Islands. Cape Wind has no fuel costs and therefore can offer stable or indexed prices for the long term. Other generators must purchase oil or natural gas, and are not in a position to offer similar long term arrangements. Allowing wholesale consumers to fix costs for purchasing wholesale energy provides better control and planning resulting in lower costs to consumers. The benefits of fixed costs become even more critical given the concerns over long-term gas pricing and supply reliability.

5.16.4.3 Public Health Benefits and Associated Cost Savings

The Cape Wind Project could have a cumulative beneficial effect on public health, and result in a related reduction in the costs of adverse health impacts from existing power plant emissions. Cape Wind will bid its unit with a zero fuel cost, and in effect also present a "zero" emissions cost. Cape Wind's energy will offset a higher fuel-cost source of energy and potentially also eliminate the emissions associated with that higher fuel-cost energy source. The net reduction in emissions would reduce the total ambient air pollution in the region and the associated adverse health effects previously described in Section 5.16.3.3.

To the extent that Cape Wind replaces energy generation by existing or new fossil fuel fired generating units, it will reduce the emissions produced by NEPOOL units including SO_2, Nitrogen Oxides (NO_x), PM, Carbon Monoxide (CO), and volatile organic compounds (VOC). In addition, Cape Wind will reduce the production of CO_2, the primary emission responsible for global warming and climate change.

The potential reduction in air pollution emissions resulting from the Cape Wind Project were calculated using the 2000 ISO-NE Marginal Emission Rates (ISO New England, 2002) where available. These marginal emission rates were prepared by ISO-NE based upon New England's generating resources in order to evaluate the environmental benefits of non-combustion resource options. For those pollutants where no ISO marginal emission rates are available, pollution emission reductions were calculated by multiplying available yearly emission data from some existing New England power plants by the Wind Park offset ratios identified in Table 5.16-3. Since yearly emission data differed among studies, an average was calculated for each pollutant to be used as the estimated emission reductions for the Cape Wind Project, as shown in Table 5.16-4. The calculated yearly reductions in air pollutant emissions that would result from replacement of existing fossil fuel fired generation with Cape Wind generation are summarized in Table 5.16-5.

Using the same assumptions and data from the Harvard Public Health Study, the health effect offsets (reductions) resulting from operation of the proposed Cape Wind Project were estimated, again, using Salem Harbor and Brayton Point as example power plants whose emissions would be replaced. These calculations were initially

performed by Cape Clean Air (Kleekamp, 2003a and b) and have been updated in this document in consultation with Cape Clean Air. The calculations by Cape Clean Air were reviewed and judged reasonable by the primary author of the Harvard Public Health Study (Levy, 2002). These calculations indicate the beneficial health effects from the Cape Wind Project that could be realized every year in the New England region include a reduction of approximately 12 premature deaths, 20 cases of bronchitis, 200 emergency room visits, 5,000 asthma attacks, 15,000 restricted activity days, and 35,000 respiratory symptom days (Kleekamp, 2003a and b). The yearly monetary savings associated with these reductions in adverse public health impacts is estimated at approximately $53 million dollars[100]. These data are summarized in Table 5.16-6.

Using the assumptions described in the section, the reduction in human illness, premature loss of life, and the associated monetary savings from the proposed Wind Park would accumulate every year, resulting in potentially very significant benefits to both public health and socioeconomic conditions in the New England region.

5.16.4.4 Local Economy

Global Insight conducted an economic impact analysis of the Cape Wind Project which is included as Appendix 5.16-A. The purpose of this analysis was to determine the economic impacts in Barnstable County and the Commonwealth of Massachusetts that would be generated by: 1) the purchases of goods and services required to construct and operate the proposed project; and 2) the expenditures of wages and salaries by temporary construction workers and by residents hired to work at the facility once it begins to operate. Based on this analysis, Global Insight concluded that the manufacturing, construction, and operation of the Cape Wind Project would have a positive economic and fiscal impact on the mainland cities and towns located in Barnstable County, especially the towns of Barnstable and Yarmouth, and also on the Commonwealth of Massachusetts and adjacent areas of Rhode Island. The additional transmission capacity on Cape Cod, as a result of the Project's interconnection with the regional transmission system, will provide an additional source of needed energy supply at the Barnstable Switching Station to service the local grid demand.

5.16.4.4.1 Economic Impacts During M/A C/I

Manufacturing and assembly of the blades and other WTG components is expected to occur in Southern New England. Construction and installation activities include the installation of the undersea monopile foundations that will support the WTGs, the on-site assembly of the WTGs, the construction of the ESP, and the installation of the offshore and onshore components of the transmission line. The Applicant has estimated that the manufacturing and construction phases will require 27 months and that during this period, approximately 80% of the labor hours will be required for M/A operations and 20% of the labor hours will be required for C/I activities.

Direct Economic Effects

According to the Global Insight Analysis, the direct economic impacts in the ROI (Barnstable County) and in the Commonwealth during M/A and C/I of the Project would consist of hiring workers and purchasing non-labor goods and services. Although specialized components such as the nacelles and rotors will be purchased outside of Barnstable County and likely outside of Massachusetts, other non-labor goods and services will be bought in Massachusetts such as concrete, steel, and barge services.

Global Insights concluded that Cape Wind will have a positive impact on regional employment during the manufacturing and construction stages. Approximately 20% of the Project's total capital cost of $700 million will be needed for labor. Based on the applicant's estimate of total person-months of M/A and C/I-phase labor required, it is estimated that a total of 880 person-years of labor will be required during the M/A and C/I phase, 711 for M/A operations and 169 for C/I activities. This translates into a direct employment increase of 391 full-time jobs (on an annual average basis) during the 27-month construction period, consisting of an average of 316 for M/A activities, and an average of 75 for C/I activities. However, in actuality the M/A and C/I activities will not be evenly distributed across the entire construction phase, but will instead peak during year 2 when the maximum employment at one time will be about 600 workers.

[100] Monetary savings calculations were based on the Levy (2000) and Levy and Spengler (2002) studies, updated with the revised EPA value of statistical life as discussed in Section 5.16.3.3.

The 316 M/A jobs will likely occur in one or more of the following locations: Quonset Point, RI; Fall River, MA; or Quincy, MA. C/I will require an average of 75 jobs. Given the size of the regional M/A and C/I labor market, and proximity of M/A and C/I phase operations to both the Boston and Providence metropolitan areas, it is reasonable to assume that 75 percent of the C/I jobs (or approximately 56 workers) will be from Massachusetts (and potentially Barnstable County), and 25 percent of the M/A (or approximately 79 workers) will be from Massachusetts. The latter proportion could rise if some or all of the M/A operations are conducted in Fall River, or another location in southeastern Massachusetts. Global Insight estimates that total payments of wages and salaries to Massachusetts residents hired during the manufacturing and construction phase will be approximately $17.2 million; much of which will be spent in Barnstable County and the Commonwealth.

The portion of the 80% share of the Project's total capital cost used for non-labor expenditures during construction that would be spent in Barnstable County, Massachusetts, and elsewhere in New England will depend primarily on the value of goods and services purchased within these regions. Based on the location of likely suppliers for the WTG components, as identified by the Applicant, Global Insight estimated that between $150 million and $250 million in purchases of non-labor goods and services will occur in Massachusetts during the manufacturing and construction phase.

Total Economic Impacts

The total temporary increase in economic activity during the manufacturing and construction phase (as well as later during the operations phase) will be produced by the: 1) direct economic effects – payment of wages and salaries to new workers and local purchase of goods and services; 2) indirect effects – the additional demands for goods and services from local businesses that sell directly to the Project; and 3) induced effects – increases in employment and income generated by the expenditure of disposable income of the new workers at local businesses.

The size of the temporary increase in economic activity in Barnstable County, the Commonwealth and adjacent areas of Rhode Island during construction will depend on the value of direct expenditures that take place within these regions. Cape Wind's direct purchases of goods and services will increase regional economic activity (e.g., employment, income, output, and value added) as the affected vendors, due to an increase in demand, hire new workers and order more raw materials and supplies. This is the indirect effect. Cape Wind's payments of wages to construction workers will also generate additional economic activity as workers spend their income at local businesses, whose owners in turn will order more supplies and hire new workers. This is the induced effect.

The extra rounds of spending due to the indirect and induced effects will produce a total increase in economic activity that is greater than the direct economic effects. The ratio of the total increase in economic activity over the direct economic effects is known at the economic multiplier. The resulting total increase in regional economic activity is the sum of the direct, indirect, and induced effects. The indirect and induced effects will occur during both the construction and operations phases. The direct effects during construction will be much higher than during operation, resulting in a larger, but temporary increase in regional economic activity, while the increase in economic activity during the operations phase will be smaller but permanent.

Global Insight used the IMPLAN I/O economic model to estimate the temporary increases in total economic activity during the manufacturing and construction phases. The IMPLAN model produces multipliers for the total statewide increases in employment, output, value added, and income. Global Insight obtained the year 2000 structural matrices for Massachusetts, and then used the I/O model to derive the appropriate multiplier impacts at the state level. The multiplier effects will be lower within Barnstable County compared to the state level due to the leakage of expenditures from the local economy and because much of the purchases of non-labor goods and services may be made outside of Barnstable County.

Since the total purchases of labor and non-labor inputs will occur over a three-year period, Global Insight performed three separate simulations with the IMPLAN model and allocated the probable purchases of both labor and non-labor inputs to each year based on the labor schedule prepared by the Applicant. Global Insight averaged the model results, recognizing that at any point in time during the M/A and C/I phase the actual total economic impacts would be higher or lower. Using the results of this model, Global Insight estimated the following average annual, temporary changes in economic activity in Massachusetts during the manufacturing and construction phase of the Project:

- Between 597 and 1,013 direct, indirect, and induced full-time jobs will be created in Massachusetts, with the range varying based on the value of non-labor purchases of goods and services;
- Total economic output in Massachusetts will increase by between $85 million and $137.4 million annually, while the annual increase in value added will range between $43.9 million and $71.0 million.101
- A portion of the regional increase in labor income of between $32 million and $52 million annually would accrue to Massachusetts residents and be spent in the Commonwealth; and
- Other property income, comprised of rent, dividends and interest, and corporate profits, would increase by between $9.2 million and $14.8 million annually.

Other economic benefits are derived from increased tax revenues from personal and corporate income taxes generated by increases in total labor income and other property income. These are discussed in more detail in Section 5.16.4.4.3.

5.16.4.4.2 Economic Impacts During O/M

Direct Economic Effects

Global Insights concludes that Cape Wind will have a positive impact on regional employment during the operation phase by creating approximately 50 full-time jobs for operation and maintenance activities. These 50 workers would each earn, on average, $52,880 in annual salary and wages. Global Insight assumed that 90% of the O/M jobs (or approximately 45 workers) would be filled by residents of Massachusetts.

Once the Project is in operation, the Applicant estimates that annual O/M purchases would be approximately $16 million, including $2.644 million for wages and salaries paid to the O/M workers required to maintain the facility. The annual purchase of O/M services would generate additional permanent increases in economic activity in Barnstable County and in Massachusetts. The direct economic effects from operation would be permanent changes to the Commonwealth of Massachusetts and Barnstable County economies.

Total Economic Effects

The annual purchase of O/M services would generate additional permanent increases in economic activity. The combination of the direct, indirect, and induced effects, as described previously, would generate the following permanent economic changes in Massachusetts (beginning in 2007) during the operation phase, most of which would be concentrated in Barnstable County:

- An annual permanent increase of 154 jobs;
- An annual permanent increase of $21.8 million in output;
- An annual permanent increase of $10.2 million in value added; and
- An annual permanent increase of $6.93 million in labor income.

The total permanent employment increase presented above of 154 jobs is the sum of the 50 full-time jobs at the Wind Park, and an additional 104 jobs produced by indirect and induced effects.

The "multiplier effect" during the operations phase would be larger than during the construction phase for two reasons: 1) a higher share of the O/M workers would likely be residents of Barnstable County; and 2) experience at other energy facilities indicates that, over time, local vendors develop the expertise and add the required product lines to provide an increasing share of the specialized goods and services required to operate and maintain new facilities; thus increasing the local permanent economic impacts. Overall, Global Insight concluded that the operation and maintenance of the Project would have a positive effect on the economy of both Barnstable County and the Commonwealth of Massachusetts.

[101] Amounts are in 2002 dollars.

5.16.4.4.3 Tax Revenues and other Fiscal Impacts

Barnstable and Yarmouth - Construction

As previously discussed the increase in the number of local workers to fill the requirements of the construction phase of the Project will be modest: approximately 79 M/A jobs (25 percent of 316) and 56 C/I jobs (75 percent of 75). According to the Global Insight study, all of the construction phase labor needs are expected to be obtainable from within a daily commuting distance, since the Project is in close proximity to the Boston and Providence metropolitan areas. Global Insight indicates that Yarmouth and Barnstable would experience minimal, temporary increases in the demand for local police and traffic control due to the likely increase in daily commuter traffic caused by construction workers. However, since Global Insight did not forecast any significant permanent in-migration by these workers or their dependents, there would be no corresponding increase in the demand for other locally provided public services. Even if these workers were to relocate to Barnstable County from outside the area, the influx of approximately 135 workers is likely to be easily absorbed by the public service infrastructure already serving a population of almost 226,000.

Both Yarmouth and Barnstable would receive one-time building permit fees for the construction and installation of the onshore transmission cable. Therefore, there is likely to be a minimal net fiscal impact on Barnstable and Yarmouth during construction.

As described in Appendix 5.16-A, based on the estimated capital cost for the onshore improvements associated with the onshore transmission cable system of approximately $26,250,000, there would be an estimated permanent annual increase in the real property tax revenues of $62,510 for the Town of Barnstable and $217,168 for the Town of Yarmouth.

Barnstable and Yarmouth - Operation

Other benefits to the Town of Yarmouth would be implemented if the Project becomes operational. These benefits are outlined in a Host Community Agreement (the Agreement) that Cape Wind entered into with the Town of Yarmouth, dated July 25, 2003. Among other things, the Agreement provides that Cape Wind would take a number of steps to mitigate impacts of its proposed transmission line on the Town, including: making physical improvements to Berry Avenue, New Hampshire Avenue, and the Englewood Beach area; and, if feasible, locating its operations center in the Town. Following its commercial operation, Cape Wind has agreed to make payments of $250,000 annually to cover any real and personal property taxes (which as stated above are estimated at $217, 168), increased by inflation, and will also contribute $100,000 annually, increased by inflation, to a charitable fund for benevolent purposes in the Town. The Agreement further provides that the Town agrees to act reasonably and in good faith with respect to any street opening permits, grants of location, or other similar authorizations requested by Cape Wind. Accordingly, Cape Wind will pay a total of $350,000 annually or $7,000,000 over twenty years of operation, (excluding the effects of inflation) to the Town of Yarmouth according to the Agreement.

The majority (90%) of the 50 permanent O/M workers are expected to commute daily from the surrounding areas to an on-shore support base, possibly located in Yarmouth or elsewhere on Cape Cod, before being transported to the offshore WTGs. As a result, there would be a negligible in-migration of new workers and there families and, therefore, a minimal increase, if any, in the demand for locally provided public services in Barnstable and Yarmouth during the operation phase of the Project. In addition, there would not be any increase in demand for public services in adjacent municipalities.

Commonwealth of Massachusetts

The Global Insight analysis found that a significant increase in Massachusetts personal income tax revenues, estimated to be between $4.8 and $7.8 million during the construction phase and approximately $350,000 annually thereafter during operation, is expected. Corporate income tax revenues will also increase during both phases. The total increase in corporate income tax revenues during the manufacturing and construction phase could range between $1.304 million and $2.106 million. The annual increase in corporate income tax revenues from O/M activities would be approximately $113,900. Overall the Commonwealth would incur little, if any, increase in demand for government services attributable to the Project. Therefore, the net fiscal impact to the Commonwealth would be positive.

5.16.4.4.4 Economic Benefits at the National Level

As explained in a letter from the U.S. Department of Energy, Boston Regional Office (DOE – Boston) to the USACE, the proposed Cape Wind Project would also have economic benefits at the national level. The DOE - Boston office states in that letter:

In a slow economic period, large capital projects, such as the offshore wind project, will favorably affect the country's 'gross national product'. This can be expressed as a multiplier on the capital cost as that amount of funds will be turned over within the economy by an economic factor estimated to be between 3 and 4. On this basis, the procurement and installation of U.S. made turbines (estimated to cost approximately $1200/KW times 420,000KW equals approximately $500 million) would have favorable impact on the U.S. economy in the range of $1.5 billion to $2.0 billion (Benson, 2003).

5.16.4.5 Housing and Coastal Property Values

As previously discussed, the increase in the number of workers to fill the requirements of the Project will be modest: approximately 135 during construction and 45 during operation. It is unlikely that this level of employment would require significant migration of workers from outside of the ROI. However, as shown in the existing conditions discussion, the Barnstable County communities of Barnstable and Yarmouth had over 10,000 vacant housing units in the year 2000. Even considering that 89 percent of those vacant units are considered to be seasonal or recreational in nature, there would still be approximately 1,200 housing units available in Barnstable/Yarmouth to accommodate the new residents.

Studies of the effect of wind farms on property values in both the United States and Europe show that property and real estate values are generally not affected by wind farm development.

U.S. Studies

A recent government-funded study prepared by the Renewable Energy Policy Project (REPP) (Sterzinger et al., 2003) reviewed data on property sales in the vicinity of wind farms, and determined through statistical analysis that there is no evidence that wind farm development has harmed property values within an established viewshed.

This study compared 25,000 property transactions over a period of approximately six years within a 5-mile viewshed of significant wind farm developments with transactions in comparable communities outside of the viewshed. All but one of the wind farms cited in the study (Bennington County VT being the exception) had FAA lighting on some or all of its turbines. The analysis included data from wind farms that came on-line after 1998 and which had 10 MW or greater installed capacity. Projects that came on-line after 2001 were not included because there would not be sufficient data to evaluate property value trends (Sterzinger et al., 2003). The ten wind farm development areas upon which the study is based include:

- Riverside County, CA (San Gorgonio Pass; over 3,000 turbines)
- Madison County, NY – Madison (southeast of Syracuse; 7 turbines)
- Madison County, NY – Fenner (southeast of Syracuse; 20 turbines)
- Carson County, TX (middle of Texas panhandle; 80 turbines)
- Bennington County, VT (Searsburg; 11 turbines)
- Kewaunee County, WI (Lincoln and Red River Townships; 31 turbines)
- Somerset County, PA (Somerset and Green Mountain; 6 turbines and 8 turbines)
- Buena Vista County, IA (Alta; 257 turbines)
- Kern County, CA (Tehachapi Mountains; over 3,700 turbines)
- Fayette County, PA (Stewart and Springfield Townships; 10 turbines)

For each of these ten wind farm development areas, REPP statistically compared the change in property values over time in the viewshed with changes in the comparable community. Case 1 examined the property value changes in the viewshed and comparable community over the entire period of the study. Case 2 examined how property values changed in the viewshed before and after the project came on-line. Case 3 examined how

property values changed in the viewshed and comparable community after the project came on-line (Sterzinger et al., 2003).

Case 1 found that property values increased faster in the viewshed than the comparable community in eight of the ten projects analyzed. Case 2 found that, in nine of the ten projects analyzed, property values increased faster after the project came on-line than before the project came on line. Case 3 found that property values increased faster in the viewshed than in the comparable community after the projects came on-line in nine of the ten projects. According to the authors, this study shows that there is no evidence to support statements that wind development has harmed property values within the defined viewshed (Sterzinger et al., 2003).

Other studies conducted in the United States also support the conclusions of the REPP study. An economic impact study conducted by ECONorthwest for Phoenix Economic Development Group in October 2002 evaluated twenty-two wind farm locations in the mid-west and western portions of the United States. Data were obtained by interviewing local tax assessors to quantify the impact of the wind farms on surrounding property values. The overall conclusion of the study was that a view of the local wind farm did not negatively impact property values (ECONorthwest, 2002).

To obtain specific information on wind farms in the Northeastern U.S., the Applicant contacted assessors and real estate agents in communities adjacent to four wind turbine facilities in the Northeast including, Hull, MA; Madison County, NY; Searsburg, VT; and Princeton, MA. The results of these communications are summarized below.

Hull, MA (1 WTG)

According to the Assistant Assessor for the Town of Hull, there has been no change in value to the properties that are in view of the wind turbine (Beck, 2003). There was also an advertisement in the *Hull Times* that advertised a view of the wind farm as an amenity, stating, "Wonderful views of ocean, city and windmill" (Hull Times, 2002). Hull residents are now eager to build five more turbines in the town (The BostonChannel.com (WCVB), July 15, 2003).

Madison County, NY (Fenner - 25 WTG, Madison - 7 WTG)

Fenner and Madison have seen no negative impact from the wind parks (Brophy, 2003). The top selling real estate agent in the community has also seen no negative effect on the property values or real estate sales (Clarke, 2003).

Searsburg, VT (11 WTG)

According to the Town Clerk in Searsburg, VT, a re-appraisal of the town property in 2000 showed no negative impact on property values (Kilbride, 2003).

Princeton, MA (8 WTG)

According to the Board of Assessor's in the Town of Princeton, there have been no negative impacts on surrounding property values since the wind farm was built (Lyssen, 2003). The Princeton Municipal Light Department has signed an agreement for two additional 1.5 MW turbines on the site.

European Studies

A study conducted by researchers at the Riso National Laboratory in Denmark and the Technical University in Denmark investigated the externalities of the Tunø Knob offshore wind farm development including visual/aesthetic impacts and associated financial impacts. Tunø Knob is located on the east coast of Denmark. The wind park is located between three and ten kilometers (2.4-6.0 miles) from the shore of the nearest towns. Coastal towns near the wind park are popular recreational retreats for beach goers and summer residents. Based on reports that most of the people in the neighboring area accept the wind farm and that there have been no reported lighting or noise-related impacts from the Project, the authors of the study concluded that there were no financial impacts to residents from the visual presence of the wind park (Schleisner and Nielsen, 1997).

An article in a local Danish newspaper, *Arhus Stiftstidende*, dated July 13, 2002, discusses the effect on property values near the Tunø Knob offshore wind farm. According to the article, a local real estate agent, Lars Isaksen, who sells most of the holiday cottages between Mariendal and Hov, says that the wind turbines have not influenced the value of the waterfront cottages in the area (Arhus Stiftstidende, 2002).

Regardless of the availability of existing documentation that indicates that the value of property within the viewshed of a wind farm is not likely to be negatively impacted by wind farm development, the Applicant has taken measures to mitigate the potential impact of the Project on property values. The mitigation measures are summarized in Section 5.16.6.

5.16.4.6 Tourism and Recreation

The significant tourist industry on Cape Cod and the Islands is closely dependent on the availability of high quality recreational resources in the area. As a result, potential impacts to either tourism or recreation would likely affect the other and there are discussed together in this EIS. Potential impacts on tourism and recreation would result from either direct physical effects, the effects of increased noise or the visual impact, should the wind farm be located in the viewshed of a resource.

Direct physical impacts would disrupt or occupy all or a portion of a tourist/recreational site or prevent or deter access to those sites. There may be temporary traffic disruptions in the immediate vicinity of the construction of the portion of the onshore cable installation beneath public roads which may effect the parking lot to a recreational resource at Englewood Beach, off of New Hampshire Avenue. However, any impact to this onshore recreational resource is expected to be minimal and limited to off-season beach visitors due to the onshore construction timeframe (Labor Day through Memorial Day. Given the proposed location of the offshore wind farm and transmission cable and the onshore electric transmission line underground beneath existing public roads and the NSTAR ROW, with the exception of the parking lot mentioned above there will be no physical impact or change of use to existing onshore tourist/recreational resources such as beaches, parks, light houses and other historic areas, golf courses, freshwater fishing, and other onshore attractions on the Cape and Islands. Construction/decommissioning, operation and maintenance of the Project will not physically affect the present day or continuing use of onshore recreational or tourist resources.

There will be temporary noise impacts in the immediate vicinity of the onshore cable installation during construction, but no tourist or recreational resources (other than the parking lot to Englewood Beach mentioned above) should be affected, given the distances of these resources from the cable route. There will be no impact on existing noise levels at onshore tourist/recreational areas from operation of the Project.

The most significant potential for adverse effects on tourism and recreational areas is from visual effects of the Project. However, visual impacts associated with the construction of the onshore and offshore facilities would be temporary in nature and would not have a significant long-term effect. In addition, given the proposed location of the onshore electric transmission line underground beneath existing public roads and the NSTAR ROW, the Project would not have long-term visual effects on any resources during operation.

Potential visual impacts from development of the Cape Wind Project on recreational areas are presented and discussed in detail in Section 5.10. Since recreation and tourism are so closely integrated on the Cape and the Islands, these impacts could also result in potential impacts on tourism. In order to evaluate the potential for measurable adverse effects on tourism and recreation post-construction, from changes in existing views of Nantucket Sound, the Applicant conducted additional research into existing studies of the overall impact on tourism from existing wind power developments. The following paragraphs summarize that research.

Studies conducted on wind farms throughout the world have shown that wind farms generally have a positive impact on tourism. One study performed for the British Wind Energy Association (BWEA) and Scottish Renewables Forum titled, "Tourist Attitudes towards Wind Farms", found many examples of wind farms that enhanced tourism, and no examples of wind farms that had a negative impact on local tourism (MORI Scotland, 2002).

Three distinct qualities of the Cape Wind Project location are relevant in assessing the Project's potential impact on tourism:

1) It is located in proximity to an established tourist destination;
2) It is located offshore; and
3) It is located in the Northeastern United States.

Wind farm projects that had one or more of the above characteristics were reviewed for their impact on tourism to help assess the potential impacts of the proposed Cape Wind Park Project on tourism. It was not possible to review wind farm projects with all three of the characteristics since there are currently no offshore wind farms in the United States.

Wind Farms Located in Proximity to Established Tourist Areas

The previously-referenced study completed in September 2002 for the BWEA and Scottish Renewables Forum titled, "Tourist Attitudes towards Wind Farms" (MORI Scotland, 2002), was conducted in Argyll and Bute, two towns in Scotland that are frequently visited due to their high landscape value. The area has the highest concentration of wind farms in Scotland. The study concluded that the wind farms have had a positive effect on visitor's impressions of the local town, with 43% of those polled saying that the wind farms had either a completely positive effect or a generally positive effect and 43% saying that the wind farms made no difference. When asked if the wind farms would affect their likelihood to visit the town in the future, 91% said that it made no difference.

A large 4,000 turbine wind farm is located in the San Gorgonio Mountain Pass approximately 5 miles north of Palm Springs, California. Prior to construction of the wind farm, Palm Springs was primarily a tourist destination and still remains a tourist destination today. A local company, Windmill Tours, Inc., runs tours of the Palm Springs wind farm and estimates that up to 10,000 people tour the wind farm each year (Regalado, 2003). The Visitors Bureau of Palm Springs featured the wind farm on the cover of their Fall 2001/Winter 2002 visitors guide. Palm Springs saw no measurable decline in tourism after the wind farm was constructed (Perkovich, 2003).

Ten Mile Lagoon and Salmon Beach in Southwestern Australia were heavily visited tourist locations prior to the construction of two wind farms. Both of these areas are adjacent to "the Great Ocean Drive", a well promoted tourist drive. The Ten Mile Lagoon wind farm is a nine turbine wind farm located on this 'tourist loop' that now includes an access road to the wind farm. A road counter was placed on this access road to record the number of visitors to the site. This road counter measures approximately 80 cars per day (AusWEA, 2003). According to the Australian Wind Energy Association, the Esperance Region, where the Ten Mile Lagoon and Salmon Beach wind farms are located, attracts 150,000 visitors each year, a large percentage of which will visit the wind farms. The Tourist Bureau in this region directs visitors to the wind farms and includes them in their information and visitor guides (AusWEA, 2003).

The twelve turbine Albany wind farm, also located in Southwestern Australia, is on a bluff along some of the most scenic coastline in the region. During its first year of operation, 60,000 tourists visited the wind park (Kujda, 2003). Both the Albany and Ten Mile Lagoon wind farms are listed as attractions on the website of the Western Australian tourism commission (Western Australian Tourism Commission, 2003a & 2003b).

Offshore Wind Farms

Offshore wind farms in Denmark and Sweden have been a draw for tourism. Currently, the two largest offshore wind parks in the world are Horns Rev in the North Sea, six miles off Denmark's west coast; and Nysted in the Baltic Sea, two and a half miles off the south coast of Denmark's Lolland.

Horns Rev was completed late in 2002 and consists of 80 wind turbines offshore of Denmark in the North Sea. The nearest point of land is the resort community of Blåvandshuk near the center of a 60 kilometer stretch of beach. The focal point of the shoreline is a 100 year old, fully functional lighthouse. The 2003 Blåvandshuk Tourist Guide promotes the wind farm as part of the outstanding view. The guide encourages visitors to climb to the top of the lighthouse to enjoy the "outstanding view" and notes that the wind turbines are visible in clear weather. Blåvandshuk also has a visitor's/learning center with information on the wind farm (Nybo Jensen, 2003). Several local tour companies also offer airplane tours of the wind farm.

The Nysted wind farm project in the Baltic Sea is complete. Another rural resort area, the Nysted municipality's focal point is a 14th century chateau that overlooks a harbor of fishing and pleasure boats. The wind park is clearly visible. There is a substantial visitor's center focused on the wind park. In addition, a "World of Wind" experience center will be built at a nearby site overlooking the sea and the turbines. The cost is $7.5 million and is expected to attract 40,000 visitors annually.

Other offshore wind farms in Denmark and Sweden include a 20 turbine offshore wind farm in Middelgrunden, located three miles off the coast of Copenhagen in Denmark. According to the website for Middelgrunden, presentations and tours of the facility are offered (Middelgrunden Wind Turbine Co-Operative, 2003). Utgrunden, a seven wind turbine facility off the coast of Torsås in Sweden is viewed by the town as a tourist attraction (Blank, 2003).

Wind Farms in the Northeastern United States

There are several wind farms throughout the Northeastern United States that have given rise to a new tourist industry within local towns. Madison County in upstate New York has seen an increase in tourism since the installation of the Madison and Fenner wind farms. A January 23, 2003 article in the Syracuse newspaper, the Post Standard**,** discussed the tourism industry that surrounds the twenty turbine Fenner wind project. Local residents sell souvenirs related to the wind farm and they are considering opening up a wind farm visitor's center to accommodate the high interest in the project (Coin, 2003). Madison County also features a wind turbine prominently on the cover of their visitor's guide (Madison County Travel Guide, 2002).

An eleven turbine wind farm located on a ridge-top in Searsburg, Vermont has brought more tourism to the community. The wind turbines have been a constant tourist attraction since their installation in 1997. They have brought a noticeable increase in tourists near the wind farm and the managing company, Vermont Environmental Research Associates, runs tours of the project (Leaning, 2003).

Conclusion

As evidenced by the experiences at other wind farms, the Project will likely have a negligible effect on the use of recreational resources and a positive effect on tourism in general for Cape Cod and the Islands. It is conceivable that the additional tourist activity could result in an increase in other recreational activities in the area. All the evidence presented in this research has shown wind farms to be a draw for tourists. The Project will likely help to maintain and add to the current tourism activity on Cape Cod and the Islands. Measures proposed to promote tourism and encourage educational opportunities related to the Project are discussed Section 5.16.6.

Potential impacts on offshore recreational boating and fishing are discussed in the following sections.

5.16.4.7 Boating

The presence of the Wind Park will not result in large-scale changes to recreational or commercial vessel movements on Horseshoe Shoal as previously discussed in Section 5.12.

Most of the Wind Park is located on the shallow portions of Horseshoe Shoal. Approximately 64% of the Wind Park area is located in areas with charted water depths of 30 feet MLLW or less. The portions of the Wind Park that are located in waters deeper than 30 feet at MLLW are in the central and easterly portions of the Wind Park, which are bounded on three sides by shallow water. Therefore, it is unlikely that a larger vessel would knowingly enter this area as it transits through Nantucket Sound in either an east-west or north-south direction, since grounding on the shoal is likely. The presence of the Wind Park will not restrict large vessel movements in the area since they are naturally restricted from the area by the charted water depths. Medium draft vessels could physically enter the Wind Park from the east, but this is unlikely since the shoal prevents these vessels from traveling to western portions of Nantucket Sound. Small vessels such as recreational boats and charter fishing boats will not be required to change their present operations. The common presence of breaking waves and strong tidal currents precludes the existing use of the shoal by large numbers of small vessels.

As described in more detail in Section 5.12 and demonstrated in Appendix 5.12-B, the WTGs will be constructed in a widely-spaced grid pattern (minimum 0.34 nautical mile by 0.54 nautical mile spacing) rather than randomly scattered throughout the Wind Park area. Mariners not restricted by depth, waves or currents will be able to easily navigate through the area by maintaining a straight course between the WTGs. Smaller sailboats (not limited by draft) and motor powered vessels will be able to maneuver safely between WTGs.

Each WTG will be an ATON simply by its presence in Nantucket Sound. The WTGs will be marked on NOAA navigation charts, and will serve as points of reference for mariners navigating in and around Horseshoe Shoal.

Each WTG will be clearly marked with an alphanumeric designation that will also assist mariners in determining their position within the Wind Park. In addition, CWA has committed to providing USCG approved private ATONs (low intensity flashing lights and fog-activated sound signals) within the Wind Park to assist mariners when navigating in and around the Wind Park. These private ATONs will add to the existing network of USCG maintained ATONs, and will provide more navigational references for mariners. Mariners traveling near the Wind Park will be able to hear the sound signals (located on the four perimeter corner WTGs), just as they now hear the various gongs and bells on floating ATONs in Nantucket Sound.

Special marine events (such as regattas and fireworks displays) must be registered with and approved by the local USCG District Office at least 30 days prior to the event. The Figawi Race, described in more detail in Section 5.10.3.1.3, between Hyannis and Nantucket and back, is held every year on Memorial Day Weekend. The course varies every year, but typically starts to the north of Horseshoe Shoal and proceeds around or over portions of the shoal. Approval of the Figawi Race course in the immediate vicinity of the Wind Park will be at the discretion of the USCG.

Installation of the WTGs will result in structures being present where no structure has previously existed. As such, the presence of the Wind Park will require that all mariners (including recreational boaters) be more attentive to the types of navigational equipment needed onboard to safely operate in and around the Wind Park, their vessel's position, and the proximity of other vessels and WTGs to their own vessel as they navigate in and around the Wind Park. This will be especially challenging during foggy conditions or other times of reduced visibility, high winds or waves.

Nevertheless, the presence of the Wind Park may be perceived as an adverse impact by some mariners. Mariners are reminded that, once appropriate design measures to promote safe navigation and installation of required ATON are incorporated in a project proposed for federal and state waters, it is the responsibility of each vessel's captain to ensure that his vessel can pass safely through any given area on those waters.

Wildlife and sightseeing tours will not be impacted as they generally stay closer to shore and their primary viewing targets are focused toward land, including seal watching, bird watching, and tours of the Kennedy Compound. As discussed in Section 5.16.4.5, it is likely that the presence of the Wind Park will generate interest in sightseeing tours within the Wind Park.

Potential noise impacts on offshore recreational uses are discussed in Section 5.11.

5.16.4.8 Fishing

The Applicant has minimized impacts to finfish and commercial and recreational fishing by spacing the turbines 0.34 by 0.54 nautical miles apart, imposing no restrictions on fishing within the WTG array, and burying the cables six feet below the seabed.

As described in Sections 5.2, 5.4, and Appendix 5.2A, the Project is not expected to have impacts on finfish populations or finfish migration. Due to the wide spacing of the WTGs, the Wind Park is not expected to have far-field effects on waves, currents, or water circulation. The inner-array cables and the submarine cable system connecting the Wind Park to the landfall will be buried 6 feet below the seabed, and will not pose a physical barrier to fish passage. The considerable depth to which the cables will be buried will allow benthic organisms and demersal fish species to colonize surface sediments without being affected by the cable operation. The burial depth of the cable system also minimizes potential thermal impacts from operation of the cable system. In addition, the cable system utilizes solid dielectric AC cable designed for use in the marine environment that does not require pressurized dielectric fluid circulation for insulating or cooling purposes. Finfish will not be directly impacted during the normal operation of the inner-array or submarine cable systems.

The Project is not anticipated to have significant impacts on commercial fishing activities currently occurring in the vicinity, since the Applicant will not impose any restrictions on fishing within the Wind Park during Project operation. Temporary impacts to all vessels (including commercial fishing vessels) will be limited to the temporary confined work area around the cable and each WTG during construction. Any potential conflicts with commercial fishing activity and gear, will be minimized by notifying registered fishermen as to the location and

timeframe of specific Project construction activities well in advance of mobilization. As described in more detail in Section 5.12, due to the wide spacing of the WTGs, the physical presence of these structures should not interfere with commercial fishing activity, including maneuvering of commercial vessels. The inner-array cables and the submarine cable system will be buried to a minimum of 6 feet below the seabed to avoid the potential for conflicts with fishing vessels and gear operation. Additional discussion of potential impacts to commercial fishing is provided in Section 5.4.

The proposed Project should not adversely affect recreational fishing in Nantucket Sound. The majority of recreational anglers surveyed in the MRFSS program reported hook and line as gear type used and most recreational anglers reported fishing from a private/personal or rented boat as the type or mode of recreational fishing. Due to the wide spacing of the WTGs, the physical presence of these structures should not interfere with recreational fishing activity, including maneuvering of recreational vessels or using recreational gear. As described in more detail in Section 5.4, the presence of the WTGs may in fact enhance recreational fishing for certain species such as Atlantic cod, black sea bass, and scup. The Project should not affect other modes of recreational fishing such as fishing from shore.

Given that no substantial adverse impacts to finfish and commercial/recreational fishing are anticipated from the Project, no net change in the socioeconomic condition of the fishing industry on the Cape and Islands is expected as a result of the Project. Recreational fishing may be enhanced for certain species.

5.16.4.9 Environmental Justice

Federal Guidance

As discussed in Section 5.16.3.9, Presidential Executive Order 12898 directs federal agencies to consider environmental justice issues by identifying and addressing disproportionately high and adverse human health and environmental effects on minority populations and low-income populations in the United States. A second objective of the Executive Order is to ensure effective public participation and access to information during development and design of a federal or federally permitted project within the NEPA process. A review of these environmental justice issues with respect to the Cape Wind Project is provided below.

Human Health Effects

As stated in the CEQ Guidance (Appendix A, Section 1-1; 1-101), "adverse health effects may include bodily impairment, infirmity, illness or death." (CEQ, 1997) Executive Order 12898 calls for environmental human health research to include population segments at high potential "risk from environmental hazards, such as minority populations, low-income populations and workers who may be exposed to substantial environmental hazards." (Executive Order 12898, Section 3-301, 1). The CEQ Guidance states "the term environmental hazards means a chemical, biological, physical or radiological agent, situation or source that has the potential for deleterious effects to the environment and/or human health." [Section 3-3, 3-301 (a)].

Because the Cape Wind Project will generate energy from wind and will not burn fossil fuels or emit other substances, operation of the Project will not cause disproportionately high and adverse human health impacts upon any human population group, including minority and low-income populations and Indian tribes. In fact, operation of the Project will help to improve human health, by offsetting use of polluting electric generating facilities, and lowering societal health care costs, as previously described in Section 5.16.4.3.

Environmental Effects

Environmental justice issues may also arise from Project impacts on the natural or physical environment, and resulting social, cultural and economic effects that significantly (as used by NEPA) and adversely affect a minority population, low-income population or Indian tribe. The CEQ implementing regulations define "effects" or "impacts" on the natural or physical environment to include ecological, cultural, economic or social impacts, when those impacts are interrelated to impacts on the natural and physical environment (CEQ Guidance, Appendix A, Section 1-1, 1-101).

Environmental studies conducted to date have not identified significant adverse environmental Project impacts that could affect a human population, including a minority population, low-income population or Indian tribe. In addition, the Project is not expected to cause permanent adverse impacts on fish populations, wildlife, or

vegetation, and therefore subsistence consumption of these resources will not be adversely affected (CEQ Guidance, Section II).

Visual changes will occur to the seascape in the viewshed of the Wind Park, particularly for shorefront property owners and visitors along portions of the south shore of Cape Cod, the eastern side of Martha's Vineyard, and to a lesser extent the north shore of Nantucket. Given the market values of residential properties in shorefront areas, owners cannot be considered to constitute a low-income population. Census bureau information lists low-income and minority populations and Indian tribes by permanent residence, and does not report day visitation to beaches or short term seasonal or vacation use of the shorefront. Therefore, reliable data on the use of shorefront recreational resources by minority populations, low-income populations and Indian tribes is not available.

No disproportionately high and adverse human health impacts or environmental effects to human populations, including minority and low-income populations and Indian tribes, are expected due to construction and operation of the onshore transmission cable system. Construction impacts, such as noise and dust, will be short term and will be mitigated using best construction management practices. There will be no operational impacts to human health, as the onshore cable system will be entirely below ground within already disturbed roadways and rights of ways.

Demographic Analysis

"Where a proposed agency action would not cause any adverse environmental impacts, and therefore would not cause any disproportionately high and adverse human health or environmental impacts, specific demographic analysis may not be warranted." (CEQ Guidance, Section III, C, 3). As no adverse human health or adverse environmental impacts that could cause adverse human impacts are expected due to construction and operation of the Project, no demographic analysis is necessary.

Public Participation and Access to Information

The Cape Wind Project has been the subject of a comprehensive ongoing public outreach and involvement program. Dozens of informational meetings and opportunities for public review and comment have been conducted to date, and will continue throughout the permitting process. A chronology of public, community and regulatory meetings and a list of groups with whom the Applicant has met are included in Section 11 of the DEIR/DEIS.

Public notice requirements of milestones within the NEPA, USACE and MEPA processes have been and will continue to be fulfilled. A distribution list for application filings has been developed in accordance with these regulations and submitted as part of the regulatory filings. Complete copies of the filings are available to the public at designated information repositories for the Project. The distribution list is continually updated with names and addresses of those who request copies of Project filings.

In summary, there will be no environmental justice issues created by construction or operation of the Cape Wind Project, based upon the federal guidance.

Massachusetts EOEA Policy

Effective October 9, 2002, EOEA issued "Environmental Justice Policy of the Executive Office of Environmental Affairs" (the Policy). Although certain areas of the Cape and Islands have been identified by EOEA as containing environmental justice populations, review of the Cape Wind Project with respect to Policy requirements indicates that the Project is not subject to the Policy, as discussed below.

The Policy calls for enhanced public participation under MEPA for projects that exceed an ENF threshold for air, solid and hazardous waste (other than remediation projects), or wastewater and sewage sludge treatment and disposal, if the project is located within one mile (or five miles for air) of a population identified as an Environmental Justice population based upon 2000 Census Bureau data. This Policy requirement is not applicable to the Project, as the Project exceeds none of the specified ENF thresholds.

The Policy requires enhanced analysis of impacts and mitigation under MEPA for projects that exceed a mandatory EIR threshold for air, solid and hazardous waste (other than remediation projects), or wastewater and

sewage sludge treatment and disposal, if the project is located within one mile (or five miles for air) of a population identified as an Environmental Justice population based upon 2000 Census Bureau data. This Policy requirement is not applicable to the Project, as the Project exceeds none of the specified mandatory EIR thresholds.

The Policy notes that projects that have filed an ENF prior to October 1, 2002 are not subject to the requirements of the EJ Policy, unless there is a subsequent material change in the proposed Project. The Cape Wind Project's ENF was filed on November 15, 2001.

The Cape Wind Project's wind-generated electricity will utilize "Cleaner Production" technology cited as an objective in the Policy and defined as:

"a manufacturing process…that is based on toxics use reduction and pollution prevention and that strives to incorporate the following components: waste reduction, non-polluting production, energy efficiency, safe and healthy work environments, and environmentally sound projects and packaging."

In summary, the Cape Wind Project does not trigger thresholds requiring environmental justice analysis under the EOEA Policy. Because the Cape Wind Project will generate non-polluting electricity, operation of the Project will be beneficial to human health relative to production of electricity from the burning of fossil fuels.

Cumulative Impacts

In addition to the proposed Project as discussed above, other activities in the past, present or future which may contribute to cumulative impacts to socioeconomics would include other submarine cable or pipeline installations, dredging activities, trawling, installation of pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY), as well as upland cable or pipeline installations, excavation activities, construction of new commercial and residential structures, and other upland wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative).

Secondary Impacts

The secondary economic impacts associated with construction staging/laydown activities at Quonset are expected to be positive. The Quonset site is currently an active, yet underutilized, industrial site that houses several industrial businesses receiving and shipping products. The Quonset facility is currently not operating at full occupancy and no significant land alteration would be necessary to accommodate the Project's staging activities.

5.16.5 Summary and Conclusion

The Cape Wind Project is not expected to have adverse impacts on socioeconomic conditions and in some cases is expected to have positive or beneficial impacts. Based on the studies and discussions in this section, a summary of some of the Project's effects on socioeconomic conditions in the Project area is provided below.

Electricity Rates and Reliability

- The Project would place downward price pressure on the New England market.
- The Project would improve reliability of the regional electricity system.
- The Project would increase the supply of renewable energy and as a result, could reduce dependence on imported fossil fuel generation.
- The Project would help to stabilize volatile natural gas price fluctuations.

Public Health Impacts

- The Project would create the potential for a net reduction in emissions from other power plants which could reduce the total ambient air pollution in the region.
- By reducing the total ambient air pollution in the region, the adverse health effects and costs associated with these emissions would also be reduced on an annual basis and could be cumulative over time.

Local, State and National Economy

- The manufacturing, construction, and operation of the Project would have a positive economic and fiscal impact on Barnstable County and also on the Commonwealth of Massachusetts.
- The Project would have a positive impact on regional employment.
- Based on the estimated capital cost for the onshore improvements associated with the upland transmission cable system, the Project would provide a permanent increase in the real property tax revenues for Barnstable and Yarmouth.
- The Project would increase Massachusetts personal and corporate income tax revenues.
- According to the U.S. Department of Energy, Boston Regional Office, the Project would have a favorable effect on the U.S. gross national product and therefore on the U.S. economy.
- The Project would not result in a significant increase in the need for local public services or other governmental services.

Tourism and Recreation

- Based on studies conducted at wind farms in the United States and in Europe, no adverse impacts on tourism and recreation are expected from the Project.
- The Project could provide new tourism and educational opportunities in the region.

Coastal Property Values

- Based on recent studies conducted in the United States and in Europe, property and real estate values are generally not affected, or actually increase in areas near wind farm development. Based on these studies, the Project is not expected to adversely affect property values.

5.16.6 Proposed Mitigation Measures

Coastal Property Values

As evidenced by the experiences at European offshore wind farms and U.S. land based wind farms, the most influential factors potentially affecting property values are visibility and distance from the wind turbines. Even though existing studies do not indicate a negative impact on property values, the Applicant has proposed or completed the following mitigation measures to help protect coastal property values:

- The Project has been sited as far from shore as practicable, considering the effects on the cost and safety of construction and operation imposed by constraints associated with water depths and distance from shore. The distance from major population centers in proximity to the Project are as follows: Hyannis (6 miles), Cotuit (6 miles), Edgartown (8.9 miles), and Nantucket (13.8 miles). At the closest point of land, Point Gammon, the nearest WTG will be 4.7 miles from shore.
- In order to further minimize visibility from shore, the WTGs will be painted light blue/gray to better blend with the horizon.
- The navigational warning lights (both FAA and USCG) use the lowest intensity lighting to minimize visual impact at night, while ensuring safe navigation for mariners and aviators.
- The WTGs are located far enough offshore that noise associated with operation of the Project will not be audible on land.

Tourism and Educational Opportunities

Cape Wind would follow the example of other wind parks, and encourage tourism in the following ways:

- Local operators and guides will be encouraged to operate boat and aerial tours. As the first offshore wind park in this country, Cape Wind expects to see a significant amount of "eco-tourism".
- Cape Wind has already generated dozens of school projects from elementary school to college. Topics for these projects include current events, energy production, renewable energy, and the environment. Cape Wind has also provided speakers at dozens of schools around Massachusetts.
- Cape Wind has provided the Cape Cod Community College with a $100,000 grant to start a Renewable Energy Education Curriculum. The community college will manage the program and will work with several other institutions to implement it, including the University of Massachusetts - Dartmouth, Massachusetts Maritime Academy and others. The curriculum will involve all forms of renewable energy and will cover topics such as design, operation and maintenance of renewable energy facilities.

Additional mitigation measures related to socioeconomic concerns are proposed by the Applicant to reduce or eliminate potential adverse effects from visual, noise or navigation impacts, as described in Sections 5.10, 5.11 and 5.12, respectively.

5.17 Summary of Cumulative Impacts

In addition to the activities involved with the proposed Project, there are a number of other offshore and land-based activities in the past, present or future that may contribute to cumulative impacts to the resources previously discussed. "Cumulative Impact is the impact on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable future actions regardless of what agency (Federal or nonfederal) or persons undertakes such other acts." (40 CFR section 1508.7)

Offshore activities which may contribute to cumulative impacts include other submarine cable or pipeline installations, dredging activities, trawling, installation of pile supported marine structures and other offshore wind power installations (which at this time are limited to a small scale project proposed off the coast of Hull Massachusetts, and a large installation proposed by Long Island Power Authority (LIPA) off the southern coast of Long Island NY). Land-based activities which may contribute as well include fossil fueled power plants, vehicular traffic, upland cable or pipeline installations, excavation activities, construction of new commercial and residential structures, the construction of new land-based telecommunications towers and other upland wind power installations (which at this time are limited to a number of small community initiated wind projects being considered as a result of the Massachusetts Technology Collaborative's (MTC) Community Wind Collaborative).

The cumulative impacts from several activities that may occur within the location and timeframe of the proposed Project include:

- A new submarine transmission cable that has been proposed by National Grid involves the installation of a second electric transmission cable between Cape Cod and Nantucket. Its proposed route would cross the Project's submarine cable route in the vicinity of Hyannis Harbor, within the Massachusetts 3-mile limit. In locations where the two projects may be proximate, the construction vessel activity impacts of each project may be coincident in nature. However, because sediment suspension and deposition impacts from jet plow cable embedment associated with the Project are minimal and of short duration, it is likely that impacts associated with the proposed Project would have ceased, and would not be coincident with other potential project impacts. Minimal cumulative impacts are expected to result from the onshore portion of National Grid's Nantucket Cable should it be installed at the same time as the onshore portion of the Project's cable system. The proposed Nantucket Cable's onshore route is approximately a mile (1.6 km) from the Project's proposed route, and would pass through the central portion of Hyannis, while the Project's onshore route bypasses the center of town to the east. There is a potential for future cumulative impacts from EMF if the proposed second Nantucket cable is constructed before the Cape Wind transmission facility. Under such a scenario, the Cape Wind transmission circuits would cross the Nantucket cable, and as a result, there would be a net magnetic field level produced by the interaction of the fields from the individual cables. The resultant net magnetic field would depend on a number of factors, including the position of the cables with respect to one another, the direction of current flow, phasing and load level. Depending on these factors, the net effect could be additive, or could result in a canceling or lowering of field strength. In any event, the cumulative impact would only occur over a small area surrounding the crossing location, and is not anticipated to be significantly different from the peak fields predicted for the new 115 kV and 33 kV cables. Prior to final design and construction, the Applicants for both projects would need to coordinate plans, design, and schedule for installation of the cables at this crossing point.

- There are existing submarine cables that cross from Falmouth to Martha's Vineyard and from Harwich to Nantucket. These submarine cables require routine maintenance. However, the existing cables are approximately 13 miles (21 km) and 8 miles (13 km) away from the Project area, respectively. The Project is unlikely to contribute to cumulative impacts due to these activities.

- The submarine cable system would be placed adjacent to the eastern edge of the Federal Navigation Project in Hyannis Harbor. Maintenance dredging of the channel, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent, cumulative sediment suspension and

deposition. Hyannis Harbor was dredged in 1985, 1991, and 1998. No dredging is currently scheduled, but based on this history it could be needed within 3-4 years. If the cable installation is completed in 2006 as expected, these activities will not be concurrent. If, however, the Projects were to be coincident, time of year restrictions that could be placed on marine construction activities to protect fisheries resources could result in increased cumulative impacts to marine navigation as these would require that all work be done during the same time of year. As discussed in Appendix 5.2-C, sediment deposition resulting from the cable installation would be minimal and localized, and would not substantially contribute to cumulative impacts to environmental resources.

- It is possible that additional dredging may occur at marinas in the region. However, such marina dredging projects are very localized and would not result in sediment suspension and deposition that would be coincident with the cable installation (the closest would be a minimum of 0.5 miles (805 meters)). Thus, the Project will contribute minimally to the cumulative impacts to environmental resources anticipated from these activities.

- Minimal cumulative impacts to terrestrial ecology, wildlife, or protected species are anticipated to result from the installation of the onshore transmission line. Based on discussions with the Town of Yarmouth DPW and the MHD, there are no other major transportation projects scheduled in the vicinity during the estimated construction timeframe for the onshore cable route.

The vast majority of birds that fly through Nantucket Sound nest farther to the north and west and originate across an enormous geographic area. Populations of many of these birds exceed a million individuals. The actual numbers of birds likely to be impacted at Horseshoe Shoal represent only a small proportion of their global or regional populations. Localized impacts that may occur in the Project area would not appreciably increase the normal mortality of the species concerned nor are the impacts expected to be biologically important when considered cumulatively with other sources of impacts.

It is difficult to predict to what extent this project would contribute to cumulative effects due to the construction of offshore wind energy projects along the Northeast coast. Although there has been much speculation that this is a precedent setting project that will encourage numerous similar proposals along the Atlantic coast, the opportunities to build large projects are limited. Suitable sites are limited by wind resource, geotechnical conditions, water depths/wave height and transmission grid capacity. Small, widely spaced projects would not contribute cumulatively to impacts to environmental resources.

Although it is recognized that a wide range of natural (storms) and anthropogenic (fishing, construction, anchoring, etc.) disturbances occur on a regular basis in the relatively shallow waters of Nantucket Sound, the cumulative impacts associated with the Project would not be anticipated to exceed the normal background levels of disturbance. The benthos and shellfish populations in the shallow waters of Nantucket Sound are adapted to continually recovering from various disturbances. Any impacts from construction activities are expected to be localized and temporary. Therefore, no significant cumulative impacts to benthic resources or shellfish are expected from construction of the WTGs, the inner-array cables, or the two submarine cable circuits within federal waters. Maintenance vessel activity (estimated at 1-2 vessels per day) should have no significant cumulative impacts because the increase in vessel traffic in the area will be minimal when compared to existing vessel traffic.

5.18 References

Able, K.P. 1970. A radar study of the altitude of nocturnal passerine migration. Bird Banding 41:282-290.

Adair, R.K. 1994. Constraints of thermal noise on the effects of weak 60-Hz magnetic fields acting on biological magnetite. Proceedings National Academy Sciences USA 91:2925-2929.

Adair, R.K. 2001. Simple neural networks for the amplification and utilization of small changes in neuron firing rates. Proceedings National Academy Sciences USA 98:7253-7258.

Adair, R.K., R.D. Astumian, J.C. Weaver. 1998. On the detection of weak electric fields by sharks, rays and skates. Chaos 8:576-587.

Advanced Research Projects Agency. 1995. Final Environmental Impact Statement/ Environmental Impact Report for the California Acoustic Thermometry of Ocean Climate Project and its Associated Marine Mammal Research Program. Advanced Research Projects Agency, Arlington, VA.

Ahlbom, A., E. Cardis, A. Green, M. Linet, D. Savitz, A. Swerdlow. 2001. Review of the epidemiologic literature on EMF and health. Environ Health Perspectives 109 (Suppl 6):911-933.

Ahlbom, A., N. Day, M. Feychting, E. Roman, J. Skinner, J. Dockerty. 2000. A pooled analysis of magnetic fields and childhood leukaemia. British Journal Cancer 83 :692-8.

Akamatsu, T., Y. Matsushita, Y. Hatakeyama, and Y. Inoue. 1996. Startle Response Level of Japanese Anchovy (Engraulis japonicus) to Underwater Pure Tone Signals. Fish. Sci. 62(4): 648-649.

Algonquin Gas Transmission Company. 2000. USACE Section 404/10 Permit Application for the HubLine Pipeline Project. November 30, 2000.

Altringham, J.D. 1996. Bats: Biology and Behaviour. Oxford University Press, Inc., New York. 262 pp.

AMEC. 2002. Lynn Offshore Wind Farm Environmental Impact Statement Non-Technical Summary. 18 pp. http://www.amec.com/uploadfiles/LynnNTS.pdf

Arhus Stiftstidende. 2002. A Grace for wind turbines. July 13, 2002 newspaper article.

Arrow Street Atlas of Cape Cod, including Martha's Vineyard and Nantucket. 1998. Arrow Map, Inc. Bridgewater, Massachusetts.

Associated Industries of Massachusetts Foundation, Inc. (AIM). 2003. Electric Industry Restructuring in Massachusetts: After the Revolution, the Evolution. AIM Foundation Report, Vol. 1 no.1

Australian Wind Energy Association (AusWEA). 2003. Wind farm impacts on local tourism. [http://www.auswea.com.au/]. Accessed on February 12, 2003.

Avery, M.L., P.F. Springer, and N.S. Dailey. 1980. Avian mortality at man-made structures: An annotated bibliography. U. S. Fish and Wildlife Service, Biological Services Program. FWS/OBS-80/54.

Avery, D.E., J. Green and E.G. Durbin. 1996. The distribution and abundance of pelagic Gammarid amphipods on Georges Bank and Nantucket Shoals. Deep Sea Research II. Vol. 43, Nos.7-8, 1521-1532.

Bach, L., R. Brinkman, H.J.G.A. Limpens, U. Rahmel, M. Reichenbach, and A. Roschen. 1999. Bewertung und planerische Umsetzung von Fledermausdaten im Rahmen der Windkraftplanung. Bremer Beitraege fuer Naturkunde und Naturschutz, Band 4. Themenheft "Voegel und Windkraft": 163-170.

Baker, C.S., L.M. Herman, B.G. Bays, and W.S. Stifel. 1982. The impact of vessel traffic on the behavior of humpback whales in southeast Alaska: 1981 season. Report for the National Marine Mammal Laboratory, Seattle, WA.

Barbour and Davis. 1969. In DeGraaf. Barbour, R. W.; Davis, W.H. 1969. Bats of America. Lexington: University of Kentucky Press. 286 pp.

Barclay, R.M.R. 1984. Observations on the migration, ecology and behaviour of bats at Delta Marsh, Manitoba. Canadian Field-Naturalist 98:331-336.

Barnstable County, 2002. www.barnstablecountyhealth.org/.

Battelle. 2001. Technical Report Submitted to ESS, April 2001.

Beck, D. 2003. [Letter] Assistant Assessor, Town of Hull, Massachusetts. Sent to Rachel Pachter, Cape Wind, dated January 14, 2003.

Bellrose. F.C. 1976. Ducks, Geese, and Swans of North America. Stackpole Books. Harrisburg, PA.

Benson, A.H. 2003. [Letter] U.S. Department of Energy Boston Regional Office (DOE-Boston). Sent to Karen Adams, Regulatory Division, U.S. Army Corps New England District, dated May 9, 2003.

Berry, W., N. Rubinstein, B. Melzian, and B. Hill. 2003. The biological effects of suspended and bedded sediment (SABS) in aquatic systems: a review. Internal Report. U.S. EPA Office of Research and Development. National Health and Environmental Effects Laboratory. August 20, 2003.

Berthold, P. 2001. Bird migration, a general survey. Oxford University Press, New York.

Blakemore, R.P. 1982. Magnetotactic bacteria. Annual Review Microbiology 36:217-38.
Blancher, Peter. 2003. Importance of Canada's Boreal Forest to Land Birds. Bird Studies Canada. Port Rowan, Ontario, Canada.

Blank, A. 2003. [Email] Information and Marketing Department, Municipality of Torsås, Sweden. Sent to Rachel Pachter [rpachter@capewind.org] from Anders Blank [anders.blank@torsas.se]. Sent on February 10, 2003.

Blodget, B.G. 2001. Massachusetts Tern Inventory 2001. Mass. Div. Fisheries and Wildlife, Westborough, MA.

Blodget, B.G., and J.E. Livingston. 1996. Coastal colony-nesting waterbirds. Mass. Wildlife 46:10-20.

Blodget, B.G., and S. M. Melvin. 1996. Massachusetts Tern and Piping Plover Handbook: a manual for stewards. Mass. Div. Fisheries and Wildlife, Westborough, MA.

Bohlen, Frank. 2002. Personal communication regarding monitoring of sediment resuspension and turbidity monitored along the Cross Sound Cable corridor, Long Island Sound, Connecticut. May 2002

Bohnsack, J. A. 1989. Are high densities of fishes at artificial reefs the result of habitat limitation or behavioral preference? Bulletin of Marine Science 44, 631-45.

Bombace, G. 1997. Protection of biological habitats by artificial reefs; In A.C. Jensen (ed) European Artificial Reef Research, Proceedings of the 1st EARRN Conference, Ancona Italy March 1996. Pub. Southhampton Oceanography Centre, Southhampton, UK. 449 pp.

Boorman, G.A., C.N. Rafferty, J.M. Ward, R.C. Sills. 2000. Leukemia and lymphoma incidence in rodents exposed to low-frequency magnetic fields. Radiation Research 153: 627-636.

Boorman, G.A., D.L. McCormick, J.C. Findlay, J. R. Hailey, J.R. Gauger, T.R. Johnson. 1999. Chronic toxicity/oncogenicity evaluation of 60 Hz (power frequency) magnetic fields in F344/N rats. Toxicologic Pathology 27: 267-278.

Brophy, C. 2003. [Letter] County Director, Madison County Department of Real Property Tax Services. Sent to Rachel Pachter, Cape Wind, dated, January 22, 2003.

Brown, R. 2004. [Personal Communication] National Marine Fisheries Service (NMFS), Northeast Fisheries Science Center. Conversation on May 18, 2004.

Buck, B.M., and D.A. Chalfant. 1972. Deep water narrow band and radiated noise measurement of merchant ships. Delco Electronics Rep. TR72-28, for the Office of Naval Research, Washington, D.C. 30 pp.

Buckley, J.L. 1989. Species Profile: Winter flounder (North Atlantic). Biol. Rep. 82(11.87):12 p.

Bumpus, D.F., R.E. Lynde, and D.M. Shaw. 1973. Physical oceanography. Pp. 1-1 to 1-72, in Coastal and Offshore Environmental Inventory: Cape Hatteras to Nantucket Shoals. Marine Publication Series No. 2. Univ. of Rhode Island, Kingston, RI.

Bumpus, D.F., W.R. Wright, and R.F. Vaccaro. 1971. Sewage disposal in Falmouth, Massachusetts: Predicted effect of the proposed outfall. J. Boston Soc. Civ. Engin. 58: 255-277.

Caia, C. 2002. [Personal Communication] Town of Yarmouth, Division of Natural Resources Shellfish Section. Conversation on July 29, 2002.

California Department of Health Services (CADHS). 2002. An evaluation of the possible risks from electric and magnetic fields (EMF) from power lines, internal wiring, electrical occupations and appliances. California EMF Program, 1515 Clay Street, 17th Floor, Oakland, CA 94612. Available: http://www.dhs.ca.gov/ehib/emf/RiskEvaluation/riskeval.html .

Cape Cod Commission, 2001. Cape Cod Atlas of Tidally Restricted Salt Marshes.

Cape Cod Commission, 2002. Cape Cod Coastal Embayment Project: Project Overview excerpted from the Interim Final Report, September 1998. Accessed at: http://www.vsa.cape.com/~cccom/water/overview.htm.

Cape Wind Associates (CWA). 2003. CWA Information Request EFSB-PA-19. February 21, 2003. Commonwealth of Massachusetts Energy Facilities Siting Board Department of Telecommunications and Energy. First Set of Information Requests to Cape Wind Associates, LLC and Commonwealth Electric Company, d/b/a NSTAR Electric. EFSB02-2/D.T.E. 02-53.

Cell Tower Operating Frequency http://www.mcw.edu/gcrc/cop/cell-phone-health-FAQ/toc.html#8

Center, Cliff. 2003. Pirelli Submarine Cable. Personal Communications. August 21, 2003.

CeTAP. 1982. A Characterization of Marine Mammals and Turtles in the Mid- and North-Atlantic Areas of the U.S. Outer Continental Shelf. Final Report of the Cetacean and Turtle Assessment Program, University of Rhode Island, Kingston, Rhode Island. U.S. Dept. of the Interior, Bureau of Land Management, Washington, D.C. Contract AA551-CT-48. 450 pp.

Churchill, J.H. 1998. Sediment resuspension by bottom fishing gear; In Dorsey, E.M. and J. Pederson (eds.), Effects of Fishing Gear in the Seafloor of New England. Puritan Press, Hollis, NH.

Clarke, C. 2003 [Email] RE/MAX Masters Real Estate, Fayetteville, NY. Sent to Rachel Pachter [rpachter@capewind.org] from Cindy Clark [ClarkCindy@aol.com]. Sent on January 21, 2003.

Coin, G. 2003. From currents come currency: Fenner wind farm attracts visitors who buy souvenirs, The Post-Standard.

Colarusso, P. 2002. [Personal Communication] U.S. Environmental Protection Agency. Conversation on June 17, 2002.

Coleman, J.S. and S.A. Temple. 1996. On the prowl. Wisconsin Natural Resources 20(6):4-8.

Collin, R. 2001. The effects of mode of development on phylogeography and population structure of North Atlantic Crepidula (Gastropoda: Calyptraeidae). Molecular Ecology. 10: 2249-2262.

Compilation of Air Pollutant Emission Factors, AP-42, Fifth Edition, Volume 1 Stationary Point and Area Source, January 1995, USEPA, Section 1.1, Supplement E, September 1998.

Connecticut Light & Power Company. 2002. Benthic Habitat Mapping & Shellfish Enumeration, Sediment Dispersion Modeling, and Simulations of Sediment Transport and Deposition Long Island Sound – Connecticut. NORWALK, CONNECTICUT TO NORTHPORT, NEW YORK SUBMARINE CABLE REPLACEMENT PROJECT.

Costello, C., 2002. [Personal Communication] Massachusetts Department of Environmental Protection, Wetlands Conservancy Program. Conversation on December 16, 2002.

Council on Environmental Quality (CEQ). December 10, 1997. Environmental Justice Guidance under the National Environmental Policy Act. Washington, D.C.

Davis, J.P. and R.T. Sisson. 1988. Aspects of the biology relating to the fisheries management of New England populations of the whelks, Busycotypus canaliculatus and Busycon carica. J. Shellfish Res. 7:453-460.

Davis, W.E. 1997. The Nantucket Oldsquaw flight: New England's greatest bird show? Bird Observer 25: 16-22.

DeGraaf, R.M. and M. Yamasaki. 2001. New England Wildlife: Habitat, Natural History, and Distribution. University Press of New England: Hanover, NH.

DeLeuw, Cather, & Company. 1991. Technical Memorandum #8, An Inventory of Selected Aquatic and Biological Resources in the vicinity of the Quinnipiac River Bridge.

ECONorthwest. 2002. Prepared for Phoenix Economic Development Group. Economic Impacts of Wind Power in Kittitas County. October 2002.

EMF RAPID Program Report, EMF Electric and Magnetic Fields Associated with the Use of Electric Power, Questions & Answers, June 2002, National Institute of Environmental Health Sciences, National Institutes of Health

Energy Facilities Siting Board (EFSB). July 2, 2004. EFSB 02-2. Tentative Decision In the Matter of the Petition of Cape Wind Associates, LLC and Commonwealth Electric Company, d/b/a NSTAR Electric for Approval to Construct Two 115 kV Electric Transmission Lines.

Enger, P.S. 1981. Frequency discrimination in teleosts—central or peripheral?. In W.N. Tavolga, A.N. Popper, and R.R. Fay (eds.), Hearing and Sound Communication in Fishes,., pp. 243-255. Springer-Verlag: New York.

Environmental Laboratory, 1987. Corps of Engineers Wetlands Delineation Manual.

Erickson, W.P., et al. 2001. Avian collisions with wind turbines: a summary of existing studies and comparisons to other sources of avian collision mortality in the United States. A National Wind Coordinating Committee (NWCC) Resource Document. Western EcoSystems Technology Inc.

ESS, Inc. 2001. Geotechnical Sampling and Analysis Protocol: Sediment Core Logging Information: Cape Wind Associates, LLC. Wellesley, Massachusetts. July 27, 2001.

ESS Group, Inc., J.J.Hatch, and P.Kerlinger. 2002. A late winter and early spring 2002 waterbird survey for the Cape Wind Energy Project Nantucket Sound. Prepared for Cape Wind Associates. Appendix 5.7-D of the DEIS-DEIR.

ESS Group, Inc., J.J.Hatch, and P.Kerlinger. 2002. Spring and Summer 2002 waterbirds survey for the Cape Wind Energy Project Nantucket Sound. Prepared for Cape Wind Associates. Appendix 5.7-F of the DEIS-DEIR.

ESS Group, Inc. and Kerlinger. 2003. A Comparison of the Audubon Christmas Bird Counts and MassWildlife Winter Waterfowl Populations. Prepared for Cape Wind Associates. Appendix 5.7-B of the DEIS-DEIR.

ESS Group, Inc., J.J. Hatch and P. Kerlinger. 2004. Spring/Fall 2002 avian radar studies for the cape wind energy project Nantucket Sound. Prepared for Cape Wind Associates. Appendix 5.7-E of the DEIS-DEIR.

ESS Group, Inc., J.J.Hatch, and P.Kerlinger. 2004. Summer 2003 Waterbirds Survey for the Cape Wind Energy Project Nantucket Sound. Appendix 5.7-L of the DEIS-DEIR.

ESS Group, Inc., J.J.Hatch, and P.Kerlinger. 2004. Fall 2003 and Winter 2004 WaterbirdS Survey for the Cape Wind Energy Project Nantucket Sound. Appendix 5.7-M of the DEIS-DEIR.

Estey, D.E., 2004, Preliminary Assessment of the Electric and Magnetic Field Impacts Associated with the Cape Wind Park for the Preferred Alternative _- Appendix 5.13-A of the DEIS-DEIR. E-PRO Engineering & Environmental Consulting.

Executive Order 12898: February 11, 1994. Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. Washington, D.C.

Everaert, J., K. Devos and E. Kuijken. 2002. Windturbines en vogels in Vlaanderen: Voorlopige onderzoeksresultaten en buitenlandse bevindingen. [Windturbines and birds in Flanders: preliminary research data and results from other countries] Rapport van het Instituut voor Natuurbehoud, 2002.3, Brussels.

Exo, K.-M., Hüppop, O. & Garthe, S. 2003. Birds and offshore wind farms: a hot topic in marine ecology. *Wader Study Group Bull*. 100: 50-53.

Fenton, M.B. and G.P. Bell. 1979. Echolocation and feeding behaviour in four species of Myotis (Chiroptera). Canadian Journal of Zoology 57:1271-1277.

Fitzgerald, J.P., C.A. Meaney, and D.M. Armstrong. 1994. Mammals of Colorado. University Press of Colorado, Niwot, CO. 467pp.

Fogerty, M. 2000. National Marine Fisheries Service. [Personal Communication] Conversation on October 31, 2000.

Forecast of Capacity, Energy, Loads and Transmission–2001 to 2010 (CELT Report) ISO New England Inc., April 1, 2001, NEPOOL Forecast Report Of Capacity, Energy, Loads And Transmission 2001-2010 (CELT Report), pg. 1.

Forestell, P. 1986. Assessment and verification of abundance estimates, seasonal trends, and population characteristics of the humpback whale in Hawaii. Final Report for the Marine Mammal Commission. Contract No. MM29110414-6.

Freeman, Bruce L. and Lionel A. Walford. 1974. Anglers Guide to the United States Atlantic Coast: Fish, Fishing Grounds and Fishing Facilities. Section II: Nantucket Shoals to Long Island Sound, Seattle, Washington.

Furlonger, C.L., H.J. Dewar, and M.B. Fenton. 1987. Habitat use by foraging insectivorous bats. Canadian Journal of Zoology 65:284-288.

Gauthreaux, S.A., Jr and C.G. Belser. 1999. The Behavioral responses of migrating birds to different lighting systems on tall towers. A workshop sponsored by The United States Fish and Wildlife Service, The ornithological Council, and The American Bird Conservancy. Held at the 119th meeting of the American Ornithologists' Union Cornell University - August 11th, 1999.

Gauthreaux, S.A., Jr. 1972. Behavioral responses of migrating birds to daylight and darkness: a radar and direct visual study. Wilson Bulletin 84:136-148.

George, J.C., L.M. Philo, K. Hazard, D. Withrow, G.M. Carroll, and R. Suydam. 1994. Frequency of killer whale (Orcinus orca) attacks and ship collisions based on scarring on bowhead whales (Balaena mysticetus) of the Bering-Chikchi-Beaufort Seas stocks. Arctic 47(3):247-255.

GeoTesting Express Inc. 2001. Data Sheets for Geotechnical Sediment Analysis: Cape Wind Project. Boxborough, Massachusetts.

GeoTesting Express, Inc. 2003. Geotechnical Test Report: Cape Wind Project, Hyannis, Massachusetts. Boxborough, Massachusetts. November 12, 2003.

Geraci , J.R., and D.J. St. Aubin. 1987. Effects of offshore oil and gas development on marine mammals and turtles. Pp. 587-617 in D.F. Boesch and N.N. Rablais, Eds., Long-Term Environmental Effects of Offshore Oil and Gas Development. Elsevier Applied Science Publishers, London, UK.

Gibson, G.R., M.L. Bowman, J. Gerritsen, and B.D. Snyder. 2000. Estuarine and coastal marine waters: bioassessment and biocriteria technical guidance. EPA 822-B-00-024. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

Gill, F.B., 1995. Ornithology 2nd Edition. Freeman and Co. NY, NY.

Gordon, R.B. and M.L. Spaulding. 1979. A nested numerical tidal model of the Southern New England Bight. Report to NOAA, Hampton, VA, from Univ. of Rhode Island, Kingston, RI.

Gosner, K.L. 1978. The Peterson Field Guide Series. A Field Guide to the Atlantic Seashore From the Bay of Fundy to Cape Hatteras. Houghton Mifflin Company.

Goud, M.R. and D.G. Aubrey. 1985. "Theoretical and Observational Estimates of Nearshore Bedload Transport Rates." Marine Geology, vol. 64, 91-111.

Graber, R. R. 1968. Nocturnal migration in Illinois - Different points of view. Wilson Bulletin 80 36-71.

Graves, Anna K.; and Herbster, Holly. January 2004, Revised March 2004. Technical Report: Terrestrial Archaeolgoical Reconnaissance Survey of Terrestrial Route Alternatives #1 and #2 (Barnstable, Mashpee and Yarmouth, Massachusetts) and Intensive (Locational) Archaeological Survey, Terrestrial Route Alternative #1: Cape Wind Energy Project, Barnstable and Yarmouth, Massachusetts. Submitted by PAL, Inc. to Cape Wind Associates, LLC. Pawtucket, Rhode Island.

Greenland, S., A.R. Sheppard, W.T. Kaune, C. Poole, M.A. Kelsh. 2000. A pooled analysis of magnetic fields, wire codes, and childhood leukemia. Childhood Leukemia-EMF Study Group. Epidemiology 11: 624-634.

Greenlaw, C.G. 1987. Psychoacoustics and pinnipeds. In B.R. Mate and J.T. Harvey, Eds., Acoustical Deterrents in Marine Mammal Conflicts with Fisheries. NTIS PB88-17439. 116 pp.

Griffin, D.R. 1970. Migrations and homing of bats. Pages 233-264 in W.A. Wimsatt, ed. Biology of bats. Vol. 1. Academic Press, New York. 406pp.

Griffin, D. R. 1974. Bird Migration. Dover Publications, Inc., NY, NY pp.180.

Guillemette, M., J.H. Himmelman, and C. Barette. 1993. Habitat selection by Common Eiders in winter and its interaction with flock size. Can. J. Zool. 71: 1259-1266.

Guillemette, J.K. Larsen, and I. Clausager. 1998. Impact assessment of an off-shore wind park on sea ducks. NERI Tech. Report No. 227. Denmark.

Guillemette, J.K. Larsen, and I. Clausager. 1999. Assessing the impact of the Tuno Knob wind park on seaducks; the influences of food resources. NERI Tech. Report No. 263. Denmark

GZA GeoEnvironmental, Inc. 2003. October 2003 Geotechnical Data Report: Cape Wind Energy Project, Nantucket Sound, Massachusetts. Providence, Rhode Island. October 2003.

Hall, B., 2003. [Personal Communication] Town of Yarmouth Conservation Agent. Conservation on February 24, 2003.

Hall-Arber, M., C. Dyer, J. Poggie, J. McNally, and R. Gagne. 2001. New England's Fishing Communities. MIT Sea Grant College Program. MITSG 01-15.

Harvey, Michael J., J. Scott Atlenbach and Troy L Best. 1999. Bats of the United States. Arkansas Fish and Game Commission, in cooperation with U.S. Fish and Wildlife Service.

Hastings, M.C. 1995. Physical Effects of Noise on Fishes. Proceedings of Inter-Noise Conference, Newport Beach, CA: July 10-12, 1995.

Hatch, E.E., R.A. Kleinerman, M.S. Linet, R.E. Tarone, W.T. Kaune, A. Auvinen. 2000. Do confounding or selection factors of residential wiring codes and magnetic fields distort findings of electromagnetic fields studies? Epidemiology 11:189-198.

Hatch, J.J. 2001. Terns *(*Aves: Sterninae*)* and the Cape Wind Project in Nantucket Sound. A report to Cape Wind Associates and ESS Group, Inc. Appendix 5.7-C of the DEIS-DEIR.

High Energy Seismic Survey (HESS). 1997. High Energy Seismic Survey Team Workshop. Pepperdine University School of Law, June 12-13, 1997.

Hill, M.; Briggs, J.; Minto, P.; Bagnall, D.; Foley, K.; Wouldiams, A. 2001. Guide to Best Practice in Seascape Assessment. Welsh-Irish Seascapes Project. Maritime Ireland/Wales INTERREG 1994-1999. March 2001.

Hodos, W., A. Potocki, T. Storm, and M. Gaffney. 2001. Reduction of motion smear to reduce avian collisions with wind turbines. Proceedings of the National Avian Wind Power Interaction Workshop IV, 2000, Carmel, CA. National Wind Coordinating Committee/RESOLVE, Inc.

Howe, R. W., W. Evans, and A.T. Wolf. 2002. Effects of Wind Turbines on Birds and Bats in Northeast Wisconsin. University of Wisconsin-Green Bay. November 2002. pg 68.

Howell, J. A. 1997. Avian mortality at rotor swept area equivalents, Altamont Pass and Montezuma Hills, CA. Report to Kenetech Windpower, Livermore, CA.

Howes, B.L. and G.R. Hampson, 2000. Water Quality & Habitat Health of the Three Bay Estuarine System. http://www.3bays.org/water2000.ccml.

Howes, B.L., D.R. Schlezinger, J.A. Blake, and D.C. Rhoads. 1997. Infaunal "recovery" as a control of sediment organic matter remineralization and the fate of regenerated nutrients in Boston Harbor: 14th Biennial Estuarine Research Federation (ERF) International Conference - The State of Our Estuaries. Oct. 12-16, Providence, R.I. Abstracts; p. 84.

http://gazetter.hometownlocator.com Website accessed on March 25, 2004

Hull Times. June 27, 2002. Real Estate Advertisement. Jack Conway, Realtor.

Humphrey, S.R. and J.B. Cope. 1976. Population ecology of the little brown bat, Myotis lucifugus, in Indiana and north-central Kentucky. American Society of Mammalogists Special Publication No. 4. 81pp.

Hynes, H.B.N. 1970. The ecology of running waters. University of Toronto Press, Toronto. 555 pp.

ICNIRP. 1998. Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz): International Non-ionizing Radiation Committee of the International Radiation Protection Association. Health Physics 74:494-522.

International Agency for Research on Cancer (IARC). 2002. Non-Ionizing Radiation, Part 1: Static and Extremely Low Frequency (ELF) Electric and Magnetic Fields. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. 80: 1-429.

International Commission on Non-ionizing Radiation Protection (ICNIRP). 2000. Effects of Electromagnetic Fields on the Living Environment, Proceedings of the International Seminar on Effects of Electromagnetic Fields on the Living Environment. Ismaning, Germany, October 1999. R Matthes, JH Bernhardt, MH Repacholi (eds). ISBN 3-9804789-9-8. Märkl-Druck, München. 279 pp.

International Maritime Organization (IMO). 1995. International Regulations for Preventing Collisions at Sea 1972 (COLREGS). With amendments adopted from November 1995.

Jackson, H.H.T. 1961. Mammals of Wisconsin. Madison: University of Wisconsin Press. 504 pp.

Jen, P.H.S. and J.K. McCarty. 1978. Bats avoid moving objects more successfully than stationary ones. Nature 275:743-744.

Johnson, G.D., W.P. Erickson, D.A. Shepherd, M. Perlik, M.D. Strickland, and C. Nations. 2002. Bat interactions with wind turbines at the Buffalo Ridge, Minnesota wind resource area: 2001 field season. Electric Power Research Institute, Palo Alto, California.

Jury, S. H., W. H. Howell, and W. H. Watson III. 1995. Lobster movements in response to a hurricane. Mar. Ecol. Prog. Ser. 119:305-310.

Katona, S.K., V. Rough, and D.T. Richardson. 1993. A field guide to the whales, porpoise and seals from Cape Cod to Newfoundland. (4th edition). Washington: Smithsonian Institute Press.
Kelsh M.A., J.D. Sahl. 1997. Mortality among a cohort of electric utility workers, 1960-1991. American Journal Industrial Medicine 31: 534-44.

Kenney, R.D., and H. E. Winn. 1986. Cetacean high-use habitats of the northeast United States continental shelf. Fish. Bull. 84(2):345-357.

Kerlinger, P. 1989. Flight Strategies of migrating hawks. University of Chicago Press. Chicago, IL.

Kerlinger, P and Moore, F.R. 1989. "Atmospheric structure and avian migration", Current Ornithology, Vol. 6, Plenum, New York, 1989. pp. 109-142.

Kerlinger, P. 1995. How birds migrate. Stackpole Books, Mechanicsburg, PA. pp. 228.

Kerlinger, P. 2000. Avian mortality at communications towers: a review of recent literature, research, and methodology. Report to the U. S. Fish and Wildlife Service. www.fws.gov/r9mbmo

Kerlinger, P., and J.J. Hatch. 2001. Preliminary avian risk assessment for the Cape Wind Energy Project. November 2001. Report prepared for Cape Wind Associates, LLC and Environmental Science Services, Inc. Appendix 5.7-A of the DEIS-DEIR

Kerlinger, P. 2003b. Curry and Kerlinger. [Personal Communication] Conversation on December 23, 2003.

Kerlinger, P. 2004. Wind turbines and avian risk: lessons from communication towers. Paper presented to the American Bird Conservancy-American Wind Energy Association Meeting in Washington, DC, May 18, 2004 (www.nationalwind.org). in press

Kerlinger, P. and J. Kerns. 2003. FAA lighting and bird collisions at wind turbines. Paper presented at the National Wind Coordinating Committee – Wildlife Working Group Meeting, November 17-18, 2003, Washington, DC.

Kerns, J. and Kerlinger, P. 2004. A study of bird and bat collision fatalities at the mountaineer wind energy center, Tucker County, West Virginia: Annual Report for 2003.

Kheifets, L.I., E.S. Gilbert, S.S. Sussman, P. Guenel, J.D. Sahl, D.A. Savitz, G. Theriault. 1999. Comparative analyses of the studies of magnetic fields and cancer in electric utility workers: studies from France, Canada, and the United States. Occupational Environmental Medicine 56: 567-74.

Kilbride, J. 2003. [Email] Town Clerk, Searsburg, Vermont. Sent to Rachel Pachter [rpachter@capewind.org] from Josephine Kilbride [josiekil@yahoo.com]. Sent on January 24, 2003.

King, John. 2003. Report on Organic Layers Observed in Vibracores Obtained for the Cape Wind Project. University of Rhode Island Graduate School of Oceanography, Narragansett, Rhode Island. Unpublished letter report on file at ESS Group, Inc.

Kirschvink, J.L. 1997. Homing in on vertebrates. Nature 390: 339-340.

Kirschvink, J.L., A. Kobayashi-Kirschvink, B.J. Woodford. 1992. Magnetite biomineralization in the human brain. Proceedings National Academy Sciences USA. 89:7683-7.

Kirschvink, J.L., M.M. Walker, C.E. Diebel. 2001. Magnetite-based magnetoreception: A Review. Current Opinion Neurobiology 11: 462-7.

Kleekamp, C. 2003b. [Personal Communication]. Cape Clean Air. Conversations during week of July 14, 2003 and July 21, 2003.

Kleekamp, C. 2003a. [Letter to the U.S. Army Corps of Engineers]. Comment letter from Cape Clean Air to U.S. Army Corps of Engineers, New England District.

Klem, D., Jr. 1990. Collisions between birds and windows: mortality and prevention. J. Field Ornithol. 61(1):120-128.

Kraus, S.D. 1990. Rates and potential causes of mortality in North Atlantic right whales (Eubalaena glacialis). Mar. Mammal Sci. 6(4): 278-291.

Kujda, H. 2003. [Email] Western Australia Tourism Commission. Sent to Rachel Pachter [rpachter@capewind.org] from Henry Kujda [hkujda@tourism.wa.gov.au]. Sent on February 20, 2003.

Kurkul, P. 2002. NMFS, Regional Administrator. [Letter to Christine Godfrey, U.S. Army Corps of Engineers]. June 27, 2002.

Kurta, A. 1995. In DeGraaf. Mammals of the Great Lakes region. Ann Arbor: University of Michigan Press. 246 pp.

Laist D.W., A.R. Knowlton, J.G. Mead, A.S. Collet, M. Podesta. 2001. Collisions between ships and whales – Marine Mammal Science, 17(1). 35-75

Larkin, Ronald P., and Barbara A. Frase. 1988. Circular paths of birds flying near a broadcasting tower in cloud. *Journal of Comparative Psychology* 102:90-93.

Leaning, J. May 12, 2003. Wind Mountain. Cape Cod Times.

Lenhardt, M.L. 1994. Brief presented at the 14th Annual Symposium on Sea Turtle Biology and Conservation, March 1-5, 1994, Hilton Head, SC. Cited in Advanced Research Projects Agency. 1995. Final Environmental Impact Statement/Environmental Impact Report for the California Acoustic Thermometry of Ocean Climate Project and its Associated Marine Mammal Research Program. Advanced Research Projects Agency, Arlington, VA.

Lenhardt, M.L., S. Bellmund, R.A. Byles, S.W. Harkins, and J.A. Musick. 1983. Marine turtle reception of bone conducted sound. J.Aud. Res. 23:119-125.

Levin, M., and S.G. Ernst. 1997. Applied DC magnetic fields cause alterations in the time of cell divisions and developmental abnormalities in early sea urchin embryos. Bioelectromagnetics 18: 255-63.

Levitan & Associates, Inc. 2002. Steady-State and Transient Analysis of New England's Interstate Pipeline Delivery Capability, 2001-2005. February 2002.

Levy, 2002. [Letter regarding Cape Clean Air calculations]. Dated December 4, 2002.

Levy, J. I. and J.D. Spengler. 2002. Modeling the Benefits of Power Plant Emission Controls in Massachusetts. J. Air Waste Manage. Assoc. 52:5-18.

Levy, J. I., J.D. Spengler, D. Hlinka, and D. Sullivan. 2000. Estimated Public Health Impacts of Criteria Pollutant Air Emissions from the Salem Harbor and Brayton Point Power Plants. Harvard School of Public Health and Sullivan Environmental Consulting, Inc. May 2000.

Limeburner, R., R.C. Beardsley, and W. Esaias. 1980. Biological and hydrographic station data obtained in the vicinity of Nantucket Shoals, May 1978 – May 1979. Report WHOI-80-7. Woods Hole Oceanographic Institution, Woods Hole, MA. Report to NOAA Sea Grant Program. 87 pp.

Limpens, H.J.G.A. and K. Kapteyn. 1991. Bats, their behaviour and linear landscape elements. Myotis 29:39-47.

Ljungblad, D.K., B. Würsig, S.L. Swartz, and J.M. Keene. 1988. Observations on the behavioral responses of bowhead whales (Balaena mysticetus) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic 41:183-194.

Lohmann, K.J., and S. Johnsen. 2000. The neurobiology of magnetoreception in vertebrate animals. Trends Neuroscience 23: 153-9.

Long, E. R., D. D. MacDonald, S. L. Smith, and F. D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management 19 (1): 81-97.

Lowther, S. 2000. The European perspective: some lessons from case studies. Proc. National Avian - Wind Power Planning Meeting III, San Diego, CA, May 1998. National Wind Coordinating Committee, Washington, DC.

Lyssen, E. 2003. [Letter] Board of Assessors, Town of Princeton, Massachusetts. Sent to Rachel Pachter, Cape Wind, dated January 14, 2003.

MacKenzie, C.L., Jr. 1997. The U.S. molluscan fisheries from Massachusetts Bay through Raritan Bay, N.Y. and N.J. In C.L. MacKenzie, Jr., V.G. Burrell, Jr., A. Rosenfield, and W.L. Hobart (Editors), The history, present condition, and future of the molluscan fisheries of North and Central America and Europe. Volume 1, Atlantic and Gulf coasts, p. 87-118. U.S. Dep. Commerc. NOAA Tech Rep. 127.

Madison County 2002 Travel Guide. 2002. Madison County Tourism, Inc., Morrisville, New York.

Madsen O. S. and W. D. Grant. 1976. Sediment Transport in the Coastal Environment. Report No. 209, MIT, Dept. of Civil Engineering, Cambridge, MA. 105 pp.

Madsen, O.S. 1993. Sediment Transport Outside the Surf Zone. Unpublished Technical Report, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Malme, C.I., P.R. Miles, G.W. Miller, W.J. Richardson, D.G. Roseneau, D.H. Thomas, and C.R. Greene, Jr. 1989. Analysis and ranking of the acoustic disturbance potential of petroleum industry activities and other sources of noise in the environment of marine mammals in Alaska. OCS Study MMS 89-0006. Report to U.S. Minerals Management Service, Anchorage, AK.

Mandeville, R., E. Franco, S. Sidrac-Ghali, L. Paris Nadon, N. Rocheleau, G. Mercier. 1997. Evaluation of the potential carcinogenicity of 60 Hz linear sinusoidal continuous-wave magnetic fields in Fischer 344 rats. FASEB Journal 11:1127-1136.

Manville, A. 2000. The ABC's of avoiding bird collisions at communication towers: next steps. Avian interaction with utility and communication structures. Proc. Of a workshop held in Charlston, SC Dec 2-3, 1999. pages 85-103. Tech report APLIC and Edison Electric Institute and EPRI, ed. RG Carlton.

Marcotti, T. 2002. [Personal Communication] Town of Barnstable, Natural Resources Division. Conversation on August 7, 2002.

Marine Radio Operating Frequency http://www.naval.com/marvhf.htm; http://www.m1cvc.uklinux.net/radio_frqlst_mrn.html

Martin, E.M. and P.I. Padding. 2002. Preliminary estimates of waterfowl harvest and hunter activities in the United States during the 2001 hunting season. US Fish and Wildlife Service Division of Migratory Bird Management. Laurel, MD.

Massachusetts 2000 Air Quality Report, pg. 1-98

Massachusetts Army National Guard (MAARNG). 2001. Integrated Natural Resources Management Plan, Camp Edwards Massachusetts. Plan prepared by the Massachusetts Army National Guard Natural Resources Management Program. Camp Edwards, MA.

Massachusetts Association of Realtors. 2002. 2002 Homes Sales Statistics – Year End Single Family. [http://www.marealtor.com]. Accessed on July 10, 2003.

Massachusetts Coastal Zone Management Office. 2002. Massachusetts Coastal Zone Management Plan. Boston, Massachusetts. March 2002.

Massachusetts Department of Economic Development (MDED). 2002. Toward a new prosperity.

Massachusetts Department of Environmental Protection (MADEP). n.d. Truro Monitoring Station on Cape Cod. Commonwealth of Massachusetts 2000 Air Quality Report, pg. 31.

Massachusetts Department of Environmental Protection (MADEP). 1995. Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act.

Massachusetts Department of Environmental Protection (MADEP). 2001. Letter from Michael Stroman, Acting Director of Wetlands and Waterways Program to Wouldiam Chapman, ESS. Boston, Massachusetts. July 11, 2001.

Massachusetts Department of Environmental Protection (MADEP). 2002a. DEP website: http://www.state.ma.us/dep/smerp/files/brochure.htm.

Massachusetts Department of Environmental Protection (MADEP). 2002b. Personal Communications with Michael Quink. June 14, 2002.

Massachusetts Department of Environmental Protection (MADEP). 2003. Personal Communications with Terry Martin. March 2003.

Massachusetts Department of Revenue, Division of Local Services. 2002. FY02 Residential Statistical Summary. In: City and Town. Volume 15(8). September 2002.

Massachusetts Division of Marine Fisheries (MDMF). 2001. [Personal Communication]. V. Malkoski, November 2001

Massachusetts Division of Marine Fisheries (MDMF). 2001. R. Johnston, personal communication, November 2001.

Massachusetts Historical Commission. 1981. Lighthouse Information Form: Cape Poge (Pogue) Light, Edgartown, Massachusetts. August 1981.

Massachusetts Historical Commission. 1981. Lighthouse Information Form: Nobska Point Light Station, Falmouth, Massachusetts. Boston, Massachusetts. July 24, 1981

Massachusetts Historical Commission. 1985. Form A-Area. Craigville, Barnstable, Massachusetts. March 1985.

Massachusetts Historical Commission. 1985. Form A-Area: Hyannis – Main Street Central, Barnstable, Massachusetts. June 1985.

Massachusetts Historical Commission. 1985. Form A-Area: Craigville, Massachusetts. March 1985.

Massachusetts Historical Commission. 1987. Form A-Area: Cotuit Historic District, Cotuit, Massachusetts. November 10, 1987.

Massachusetts Historical Commission. 1987. Form A-Area: Craigville Historic District, Barnstable, Massachusetts. November 10, 1987

Massachusetts Historical Commission. 2001. Form A-Area: Tuckernuck Island, Nantucket, Massachusetts. July 2001.

Massachusetts Historical Commission. 1987. Form A-Area: Wianno Historic District, Osterville, Massachusetts. November 10, 1987.

Massachusetts Historical Commission. Undated. Lighthouse Information Form: Nantucket Light (Great Point Light or Sandy Point), Nantucket, Massachusetts.

Massachusetts Office of Coastal Zone Management website www.state.ma.us/czm/buar.htm (accessed 5/03/02).

MassGIS, 1999. Massachusetts Department of Environmental Protection 1994-1995 Eelgrass Resources Datalayer.

Maurer D. & W. Leathem. 1981. Polychaete feeding guilds from Georges Bank, USA. Marine Biology 62: p. 161-171.

McBride, H.M. and T.B. Hoopes. 1999. Massachusetts Lobster Fishery Statistics – 1999. Massachusetts Division of Marine Fisheries Technical Report TR-2 (Lobster Statistics Publication 34).

McCauley, R.D. 1994. Seismic surveys. Pp. 19-121 in J.M. Swan, J.M. Neff, and P.C. Young, Eds., Environmental Implications of Offshore Oil and Gas Development in Australia - The Findings of an Independent Scientific Review. Australian Petroleum Exploration Association, Canberra, Australia.

McCormick, D.L., B.M. Ryan, J.C. Findlay, J.R. Gauger, T.R. Johnson, R.L. Morrissey. 1998. Exposure to 60 Hz magnetic fields and risk of lymphoma in PIM transgenic and TSG-p53 (p53 knockout) mice. Carcinogenesis 19:1649-1653.

McCormick, D.L., G.A. Boorman, J.C. Findlay, J.R. Hailey, T.R. Johnson, J.R. Gauger. 1999. Chronic toxicity/oncogenicity evaluation of 60 Hz (power frequency) magnetic fields in B6C3F1 mice. Toxicologic Pathology 27:279-285.

MDMF. 2002. Bi-annual Research Trawl Data from area 10, Nantucket Sound, 1990 through 2002.

Middelgrunden Wind Turbine Co-Operative. 2003. Presentations and Tours. [http://www.middelgrunden.dk/MG_UK/project_info/presentation_tours.htm]. Accessed on July 16, 2003.

Miles, P.R., C.I. Malme, and W.J. Richardson. 1987. Prediction of drilling site-specific interaction of industrial acoustic stimuli and endangered whales in the Alaskan Beaufort Sea. BBN Report 6509: OCS Study MMS 87-0084. Report from BBN labs, Inc., Cambridge, MA and LGL Ltd., King City, Ontario, for the U.S. Minerals Management Service, Anchorage, AK. NTIS PB88-158498. 341 pp.

Mitson, R.B. 1995. Underwater Noise of Research Vessels: Review and Recommendations. Cooperative Research Report No. 209. International Council for the Exploration of the Sea, Denmark.

MMS. 1992. Outer Continental Shelf Natural Gas and Oil Resource Management. Comprehensive Program 1992 - 1997. Environmental Impact Statement. Volume I. U.S. Dept. of the Interior, Minerals Management Service, Herndon, VA.

MORI Scotland. 2002. Tourist Attitudes towards Wind Farms - Summary Report. Prepared for Scottish Renewables Forum and the British Wind Energy Association. [http://www.bwea.org/pdf/MORI.pdf]. Accessed on July 15, 2003.

Montevecchi, W. A., Wiese, G. K. Davoren, F. Huettmann, A. W. Diamond, and J. Linke. 2001.
Seabirds at risk around offshore oil platforms in the North-west Atlantic. Marine Pollution
Bulletin in press

Montevecchi, W.A., F.K. Wiese, G. Davoren, F. Huettmann, A.W. Diamond, and J. Linke. 1999. Seabird attraction to offshore platforms and seabird monitoring from offshore support vessels and other ships. Canadian Assoc. of Petroleum Producers, Contract Report, St. John's, Newfoundland, Canada.

Mulheisen, M. and K. Berry. 2000. "Eptesicus fuscus" (On-line), Animal Diversity Web. Accessed March 30, 2004 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Eptesicus_fuscus.html.

Myers, P. 1999. "Pipistrellus subflavus" (On-line), Animal Diversity Web. Accessed March 30, 2004 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Pipistrellus_subflavus.html.

Myers, P. and J. Hatchett. 2000. "Lasiurus borealis" (On-line), Animal Diversity Web. Accessed March 30, 2004 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Lasiurus_borealis.html.

National Academy of Sciences (NAS). 1993. Assessment of the Possible Health Effects of the Ground-Wave Emergency Network (GWEN). Committee on the Assessment of the Possible Health Effects of GWEN, Board on Radiation Effects Research, Commission on Life Sciences, National Research Council. National Academy Press, Washington, D.C. 166 pp.

National Institutes of Environmental Health Sciences (NIEHS). May 1999. Health Effects from Exposure to Power line Frequency Electric and Magnetic Fields. 99-4493. Research Triangle Park, NC.

National Marine Fisheries Service (NMFS) (NOAA Fisheries). 2002. Southeast Regional Office. Endangered Species Act - Section 7 Consultation Biological Opinion. Gulf of Mexico Outer Continental Shelf Lease Sale 184. Consultation # F/SER/2002/00145.

National Marine Fisheries Service (NMFS). 1991. Proposed regime to govern interactions between marine mammals and commercial fishing operations C Draft. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, D.C. 526 pp.
National Marine Fisheries Service (NMFS). 1998. National Marine Fisheries Service (Office of Protected Resources) Workshop on Acoustic Criteria, Silver Spring, MD, September 9-12, 1998.

National Marine Fisheries Service (NMFS). 2001. Northeast Region Sustainable Fisheries Division. Endangered Species Act Section 7 Consultation Biological Opinion. Authorization of Fisheries under Monkfish Fishery Management Plan. Consultation # F/NER/2001/00546.

National Marine Fisheries Service. 2002. Commercial landings data as reported from Vessel Trip Reports from statistical sub-area 075, 1994 through 2001.

National Marine Fisheries Service. 2002. Recreational data as reported from the Marine Recreational Fishery Statistics Survey for Dukes, Nantucket and Barnstable Counties, 1990 through 2001.

National Park Service. National Register of Historic Places: Listing a Property. http://www.cr.nps.gov/nr/listing.htm (accessed 9/2/03).

National Park Service. Undated. National Historic Landmark Survey.

National Parks Service Maritime Heritage Program. Inventory of Historic Light Stations: Edgartown Harbor Light, Martha's Vineyard, Massachusetts. http://www.cr.nps.gov/maritime/light/edgar.htm (accessed 9/3/03).

National Register of Historic Places. Massachusetts-Barnstable County-Historic Districts. http://www.nationalregisterofhistoricplaces.com/MA/Barnstable/districts.html (accessed 9/23/03).

National Registry of Natural Landmarks. 1980. Muskeget Island, Nantucket County, Massachusetts. http://www.nature.nps.gov/nnl/Registry/USA_Map/States/Massachusetts/nnl/mi/index.htm (accessed 8/14/03). April 1980.

National Research Council (NRC). 1997. An Evaluation of the U.S. Navy's Extremely Low Frequency Communications System Ecological Monitoring Program. Committee to Evaluate the U.S. Navy's Extremely Low Frequency (ELF) Submarine Communications Ecological Monitoring Program, National Academy Press, Washington, D.C. 176 pp.

National Weather Service (NWS). 2003. NWS Taunton, MA Forecast Office. April 21, 2003. Personal Communication. David Vallee.

Natural Heritage Endangered Species Program (NHESP). 2002. Massachusetts Rare and Endangered Wildlife Fact Sheet: Gray Seal. http://www.state.ma.us/dfwele/dfw/nhesp/nhfacts/halgry.prf

Natural Heritage and Endangered Species Program, 2003. Massachusetts Natural Heritage Atlas, 11th Edition: Part 1 – Eastern Massachusetts.

Naval Civil Engineering Laboratory (NCEL). 1987. "Drag Embedment Anchors for Navy Moorings". Technical Data Sheet 83-08R, June 1987.

Naval Facilities Engineering Command (NAVFAC). 1985. "Fleet Moorings". Design Manual 26.5. June 1985.

New York Times. 2003. EPA Drops Age-Based Cost Studies. Published on May 8, 2003.

NOAA Fisheries. 2001. Website Overview of Marine Recreational Fisheries Statistics Survey. Fisheries Statistics and Economic Division, Silver Spring, Maryland. [http://www.st.nmfs.gov/st1/recreational/survey/overview.html].

Nicholson, C.P. 2003. Buffalo mountain windfarm bird and bat mortality monitoring report. October 2001 – September 2002. Tennessee Valley Authority. Knoxville, TN.

Nisbet, I.C.T., and W.H. Drury, Jr. 1967. Scanning the sky-birds on radar, weather and migration. Massachusetts Audubon , Summer and Autumn 1967.

NOAA Fisheries. 2004. Marine Recreational Fisheries Statistics Survey Website. http://www.st.nmfs.gov/st1/recreational/the_mrfss.html. Accessed on July 13, 2004.

NOAA. United States Coast Pilot 2, Atlantic Coast: Cape Cod to Sandy Hook. 28th Edition, 1994.

NOAA. 1994. United States Coastal Pilot 2, Atlantic Coast: Cape Cod to Sandy Hook. 28th Edition. Washington D.C.

NOAA. 2001. Navigational Chart #13237 – Nantucket Sound and Approaches. Ed. 38, March 3, 2001.
Nowak, Ted. 2002. Ocean Surveys, Inc. Old Saybrook, Connecticut. Personal communication, email to Sarah Faldetta, ESS. July 30, 2002.

Norton-Griffiths, M. 1978. Counting animals. Nairobi, African Wildl. Leadership Found. Rev. 2nd ed. 139p.

NRCS. 1993. Natural Resource Conservation Service (formerly the Soil Conservation Service) Soil Survey of Barnstable County. March 1993.

Nybo Jensen, J. 2003. [Email] Information Officer, Fredericia, Denmark. Sent to Rachel Pachter [rpachter@capewind.org] from Jens Nybo Jensen [JNJ@Elsam.com]. Sent on January 28, 2003.

O'Hara, Charles J. and Oldale, Robert N. 1987. Maps Showing Geology, Shallow Structure, and Bedform Morphology of Nantucket Sound, Massachusetts. Miscellaneous Field Studies Map MF 1911. United States Geologic Survey. Reston, Virginia.

Ocean Surveys, Inc. 2002. Final Report: Marine Geophysical Survey and Sediment Sampling Program: Cape Wind Energy Project, Nantucket Sound, Massachusetts. Old Saybrook, Connecticut. July 25, 2002.

Ocean Surveys, Inc. 2003. Final Report: Supplemental Marine Geophysical Survey: Cape Wind Energy Project, Nantucket Sound, Massachusetts. Old Saybrook, Connecticut. November 20, 2003.

Office of Naval Research (ONR). 1998. Office of Naval Research Workshop on the Effects of Man-Made Noise on the Marine Environment, Washington, DC, February 9-12, 1998.

O'Hara, Charles J. and Oldale, Robert N. 1987. Maps Showing Geology, Shallow Structure, and Bedform Morphology of Nantucket Sound, Massachusetts. Miscellaneous Field Studies Map MF 1911. 1987.

Oldale, Robert N. Revised 2001. Cape Cod, Martha's Vineyard & Nantucket: The Geologic Story. Originally published in 1992. On Cape Publications. Yarmouth Port, Massachusetts.

Oldale, Robert N. and Barlow, Roger A. 1986. Geologic Map of Cape Cod and the Islands, Massachusetts. Miscellaneous Investigations Series Map 1-1763. Scale 1:100,000. Reston, Virginia.

Oldale, Robert N., and O'Hara, C. J., 1980. New radiocarbon dates from the Inner Continental Shelf off southeastern Massachusetts and a local sea-level-rise curve for the past 12,000 yr. Geology, Vol. 8, p.102-106

Ollendorff, J. 2002. "Myotis septentrionalis" (On-line), Animal Diversity Web. Accessed March 30, 2004 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Myotis_septentrionalis.html

Orloff, S., and A. Flannery. 1992. Wind turbine effects on avian activity, habitat use, and mortality in Altamont Pass and Solano County wind resource areas, 1989-1991. California Energy Commission, Sacramento, CA.

Orloff, S., and A. Flannery. 1996. A continue examination of avian mortality in Altamont Pass Wind Resource Area. California Energy Commission. P700-96-004CN. Sacramento, CA.

Packer, D.B., L.M. Cargnelli, S.J. Griesbach, and S.E. Shumway. 1999. Sea Scallop, Placopecten magellanicus, life history and habitat characteristics. NOAA Technical Memorandum NMFS-NE-134.

Pagnac, C., A.M. Geneviere, J.M. Moreau, A. Picard, J. Joussot-Dubien, B. Veyret. 1998. No effects of DC and 60-Hz AC magnetic fields on the first mitosis of two species of sea urchin embryos. Bioelectromagnetics 19: 494-7.

Painter, S., B. Little, and S. Lawrence. 1999. Continuation of bird studies at Blyth Harbour Wind Farm and the implications for offshore wind farms. ETSU W/13/00485/00/00 Border Wind Limited.

PAL, Inc. June 2004. Visual Impact Assessment of Multiple Historic Properties: Cape Wind Energy Project. Nantucket Sound, Cape Cod, Martha's Vineyard and Nantucket, Massachusetts. Submitted by PAL, Inc. to Cape Wind Associates, LLC. Pawtucket, Rhode Island.

Paradiso, J.L. 1969. Mammals of Maryland. North Am. Fauna Ser. 66:1-193.

Perkins, S., A. Jones, and T. Allison. 2003. Survey of tern activity within Nantucket Sound, Massachusetts, during pre-migratory fall staging. Final report for Massachusetts Technology Collaborative, 8 January 2003. From Mass. Audubon Soc.

Perkins, S., T. Allison, A. Jones, and G. Sadoti. 2004. A Survey of tern activity within Nantucket Sound, Massachusetts, during the 2003 breeding season. Final report for Massachusetts Technology Collaborative, 12 April 2004. from Mass. Audubon Soc.

Perkovich, L. 2003. [Personal Communication] Manager of Palm Springs Visitor's Center. Palm Springs, CA. Conversation on February 12, 2003.

Pfand, A. 1996 (November/December). Fatal light. The Storm-Petrel 17(6), Kalmiopsis Audubon Society, Port Orford, Oregon.

Phillips, J.B, M.E. Deutschlander, M.J. Freake, S.C. Borland. 2001. The role of extraocular photoreceptors in newt magnetic compass orientation: Parallels between light-dependent magnetoreception and polarized light detection in vertebrates. J Experimental Biology 204: 2543-52.

Polk, C. 1994. Effects of extremely-low-frequency magnetic fields on biological magnetite: Limitations on physical models. Bioelectromagnetics 15: 261-270.

Pratt, S.D. 1973. Benthic fauna. Pages 5-1 – 5-55 In: Coastal and Offshore Environmental Inventory. Cape Hatteras to Nantucket Shoals. Marine Publication Series No. 2. University of Rhode Island, Kingston, RI.

Rayment, W.J. 2001. Crepidula fornicata. Slipper limpet. Marine Life Information Network: Biology and Sensitivity Key Information Sub-Programme [on-line]. Plymouth: Marine Bilogical Association of the United Kingdon. [cited 19/06/03]. Available from: <http://www.marlin.ac.uk/species/Crefor.htm>

Redfield, Alfred C. and Rubin, M. 1962. The Age of Salt Marsh Peat and its Relation to Recent Changes in Sea Levels at Barnstable, Massachusetts, Woods Hole Oceanographic Institution and U.S. Geological Survey, Science, Vol. 136, No. 3513, p. 328.

Redfield, Alfred C. and Rubin, M. 1962. The Age of Salt Marsh Peat and its Relation to Recent changes in Sea Levels at Barnstable, Massachusetts, Woods Hole Oceanographic Institution and U.S. Geological Survey, Science, Vol. 136, No. 3513, p. 328.

Reed Associates. 2001. An Assessment of the Impacts of Natural Gas Prices on New England's Wholesale Electricity Prices. Prepared for ISO New England. July 25, 2001.

Regalado, C. 2003. [Personal Communication] Owner Windmill Tours, Inc., Palm Springs, CA. Conversation on February 11, 2003.

Renaud, M.L., and J.A. Carpenter. 1994. Movements and submergence patterns of loggerhead turtles (Caretta caretta) in the Gulf of Mexico determined through satellite telemetry. Bull. Mar. Sci. 55:1-15.

Rhoads, D.C., P.L. McCall, and J.Y. Yingst. 1978. The ecology of seafloor disturbance. Am. Sci. 66: 577-586.
Richardson, W. J. 1978. Southeastward shorebird migration over Nova Scotia and New Brunswick in autumn: a radar study. Canadian Journal of Zoology 57:107-124.

Richardson, W.J., and C.J. Malme. 1993. Man-made noise and behavioral responses. Pp. 631-700 in J.J.Burns, J.J. Montague, and C.J. Cowles, Eds., The Bowhead Whale. Special Publication No. 2. The Society for Marine Mamma logy, Lawrence, KS.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thompson. 1991. Effects of noise on marine mammals. OCS Study MMS-90-0093. LGL Rep. TA834-1. Report from LGL Ecol. Res. Assoc., Inc., Bryan, Texas, for U.S. Minerals Management Service, Atlantic Outer Continental Shelf Region, Herndon, VA. NTIS PB91-168914. 462 pp.

Richardson, W.J., M.A. Fraker, B. Wüsig, and R.S. Wells. 1985. Behaviour of bowhead whales Balaena mysticetus summering in the Beaufort Sea: reactions to industrial activities. Biol. Conserv. 32:195-230.
Ritz, T., S. Adem, K. Schulten. 2000. A model for photoreceptor-based magnetoreception in birds. Biophysical Journal 78:707-18.

Robinson, David S.; Ford, Ben; Herbster, Holly; Waller, Joseph N. Jr. June 2003. Marine Archaeolgoical Sensitivity Assessment: Cape Wind Energy Project. Nantucket Sound, Massachusetts. Submitted by PAL, Inc. to Cape Wind Associates, LLC. Pawtucket, Rhode Island.

Robinson, David S.; Ford, Ben; Herbster, Holly; Waller, Joseph N. Jr. March 2004. Marine Archaeolgoical Reconnaissance Survey: Cape Wind Energy Project. Nantucket Sound, Massachusetts. Submitted by PAL, Inc. to Cape Wind Associates, LLC. Pawtucket, Rhode Island.

Rosenberg, D.M. and V.H. Resh (eds). 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman & Hall, New York, N.Y. 488 pp.

Ruppert, E.E. and R.D. Barnes. 1991. Invertebrate Zoology (Sixth Edition). Saunders College Publishing.
Sahl, J.D., G. Mezei, R. Kavet, A. McMillan, A. Silvers, A. Sastre, L. Kheifets. 2002. Occupational magnetic field exposure and cardiovascular mortality in a cohort of electric utility workers. American Journal Epidemiology 156: 913-8.

Sanders, H. L. 1958. Benthic studies in Buzzards Bay. I. Animal-sediment relationships. Limnol Oceanogr 5:138-153.

Sanders, H.L. 1956. Oceanography of Long Island Sound. X. The biology of marine bottom communities. Bulletin Bingham Oceanography collection 15: 245-258.

Santulli, A., A. Modica, C. Messina, L. Ceffa, A. Curatolo, G. Rivas, G. Fabi, and V. D'Amelio. 1999. Biochemical Responses of European Sea Bass (Dicentrarchus labrax L.) to the Stress Induced by Offshore Experimental Seismic Prospecting. Marine Poll. Bull. 38(12): 1105-1114.

Savitz, D.A. 2003. Health effects of electric and magnetic fields: are we done yet? Epidemiology 14: 15-7.
Schleisner, L. and P.S. Nielsen. 1997. ExternE National Implementation Denmark, Final Report. The European Commission. Contract JOS3-CT95-0010. December 1997.

Scholik, A.R. and H.Y. Yan. 2001. Effects of Underwater Noise on Auditory Sensitivity of a Cyprinid Fish. Hear. Res. 152: 17-24.

Scrimger, P., and R.M. Heitmeyer. 1991. Acoustic source-level measurements for a variety of merchant ships. J. Acoust. Soc. Am. 89:691-699.

Shire, G.G., K. Brown, and G. Winegrad. 2000. Communication towers: a deadly hazard to birds. American Bird Conservancy, Washington, DC.

Snyder, Ellen J. Undated. Wildlife Profile: Little brown bat (Myotis lucifugus). University of New Hampshire Cooperative Extension. Accessed online at http://www.wildlife.state.nh.us/Wildlife/Wildlife_profiles/profile_LB_bat.htm.

Sterzinger, G., F. Beck, and D. Kostiuk. 2003. The Effect of Wind Development on Local Property Values. Renewable Energy Policy Project (REPP). Analytical Report, May 2003. Washington, D.C.
Stewart, L. 2000. The Long Island Sound Lobster Resource and Fishery. [Presentation] Lobster Health Symposium. Stamford, CT. April 17, 2000.

Still, D., B. Little and S. Lawrence. 1995. The Effect of Wind Turbines on the Bird Population at Blyth. ETSU Report W/13/00394.

Still, et al. 2000. Pages from this publication were sent to authors, but a complete reference could not be located.

Strickland, D., M.D., G. Johnson, W.P. Erickson and K. Sarappo R.M. Halet. 2000. Avian use, flight behavior, and mortality on the Buffalo Ridge, Minnesota Wind Resource Area. Proceedings of the National Avian Wind Power Interaction Workshop III, May, 1998, San Diego, CA. National Wind Coordinating Committee/RESOLVE, Inc.

Suthers, R.A. 1970. Vision, olfaction, and taste. Pages 265-309 in W.A. Wimsatt, ed. Biology of bats. Vol. 2. Academic Press, New York. 477pp.

Taylor B. 2002. [Personal Communication]. Naval Facilities Engineering Service Center (NFESC). Conversation on December 20, 2002.

Teas, W.G. 1994a. 1993 Annual Report of the Sea Turtle Stranding and Salvage Network. Atlantic and Gulf Coasts of the United States. January - December 1993. Contribution No. MIA-94/95-12 from the Miami Laboratory, U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Center, Miami, FL. 46 pp.

Teas, W.G. 1994b. Marine turtle stranding trends, 1986 to 1993. Pp. 293-295 in K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar, Eds., Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration Tech. Memo., National Marine Fisheries Service, Southeast Fisheries Center, NMFS-SEFC-351. 323 pp.

Theroux, R.B. and R.L. Wigley. 1998. Quantitative composition and distribution of the macrobenthic invertebrate fauna of the continental shelf ecosystems of the northeastern United States. NOAA Technical Report NMFS 140. NOAA, Washington, DC. 240 pp.

Timm, R.M. 1989. Migration and molt patterns of red bats. Illinois Bull. Chicago Academy of Science.

Town of Yarmouth Conservation Commission, 1997. Wetlands Protection Regulations.

Town of Yarmouth Natural Resource Commission, 1998. Aquaculture Lease Site Maps.

Town of Yarmouth Natural Resource Commission, 1999. Recreational Shellfish Area Maps.

Trapp, J. L. 1998. Bird kills at towers and other man-made structures: an annotated partial bibliography (1960-1998). U. S. Fish and Wildlife Service web report: www.fws.gov/r9mbmo.

Trull, P., S. Hecker, M.J. Watson & I.C.T. Nisbet. 1999. Staging of Roseate Terns *Sterna dougallii* in post-breeding period around Cape Cod, Massachusetts, USA. Atlantic Seabirds 1: 145-158.

Tucker, V.A. 1996. Using a collision model to design safer wind turbine rotors for birds. Journal of Solar Energy Engineering 118:263-269

Tulp, I., Schekkerman, H., Larsen, J.K., van der Winden, J., van de Haterd, R.J.W., van Horssen, P., Dirksen, S., Spaans, 1999. Nocturnal flight activity of seaducks near the windfarm Tuno Knob in the Kattegat. Bureau Waardenburg project No. 98.100, report No. 99.64.

Uchupi, E. Giese, G.S., Aubrey, D.G., and Kim, D.J. 1996. The Late Quaternary Construction of Cape Cod, Massachusetts: A Reconnaissance of the W.M. Davis Model. G.S.A. Special Paper 309.

Uniform Building Code, Volume 2. 1997. Structural Engineering Design Provisions. Whittier, California.

United States Army Corp of Engineers (USACE) and MADEP. 2002. USACE-NED Regulatory Branch and MADEP. Personal Communication, October 2002.

United States Army Corp of Engineers (USACE). 1991. Western Long Island Sound WLIS. Final Supplemental Environmental Impact Statement for a Dredged Material Disposal Site. (February).

United States Army Corp of Engineers (USACE). 2002b. Letter to USACE Karen Kirk Adams. Re: Responses to Comments on Benthic Community Sampling and Analysis. May 10 ,2002.

United States Army Corp of Engineers (USACE). 2003. Coastal Engineering Manual. EM 1110-2-1100

United States Army Corp of Engineers (USACE). October 18, 1995. New England Division Regulation No. 1110-1-9. Engineering and Design Setting Pipeline and Cable Cover Requirements in Navigable Waters and Navigation Channels.

United States Army Corp of Engineers New England Dvision (USACE-NED) and MADEP. 2002. USACE-NED Regulatory Branch and MADEP, 2002. [Personal Communication] Conversation in October 2002.

United States Army Corps of Engineers, New England Division (USACE). 2002a. Cape Wind Energy Project Benthic Sampling and Analysis Protocol Nantucket Sound. April 18, 2002.

United States Coast Guard (USCG). 1999. Navigation Rules: International-Inland. COMDTINST M16672.2D. March 25, 1999.

United States Coast Guard (USCG). 2003. USCG Air Station Cape Cod Representative LCDR Balda. May 2003.

United States Coast Guard (USCG). July 31, 2003. Letter from Patrick E. Little, Commanding Officer, USCG Marine Safety Office, Providence, RI.

United States Department of Agricultural (USDA). March 1993. Soil Survey of Barnstable County, Massachusetts. Washington, D.C.

United States Department of Energy. 2002. Draft Site-Wide Environmental Assessment of National Renewable Energy Laboratory's National Wind Technology Center. U.S. Department of Energy, Golden, Colorado.

US Department of the Interior Fish and Wildlife Service. 2000. U. S. Fish and Wildlife Service guidelines for communication towers, 2000. Washington DC.

US Department of the Interior Fish and Wildlife Service. 2003. Interim guidelines to avoid and minimize wildlife impacts from wind turbines. Washington DC.

United States Department of the Interior, National Park Service. 1972. National Register of Historic Places Inventory—Nomination Form. Kennedy Compound, Hyannis Port, Massachusetts. September 8, 1972.

United States Department of the Interior, National Park Service. 1975. National Register of Historic Places Inventory Nomination Form. Nantucket Historic District, Nantucket Massachusetts. July 24, 1975.
United States Department of the Interior, National Park Service. 1987. National Register of Historic Places Inventory—Nomination Form. Barnstable Multiple Resource Area, Barnstable Massachusetts. July 29, 1987.

United States Department of the Interior, National Park Service. National Register of Historic Places Inventory—Nomination Form. Certified August 8, 1979. Flying Horses: 33 Oak Bluffs Ave., Oak Bluffs, Massachusetts.

United States Department of the Interior, National Park Service. National Register of Historic Places Inventory—Nomination Form. Certified October 19, 1983. Edgartown Village Historic District (preferred) and/or Downtown Edgartown, Massachusetts.

United States Department of the Interior, National Park Service. National Register of Historic Places Inventory—Nomination Form. Monomoy Point Lighthouse, Monomoy Island, Chatham, Massachusetts.

United States Department of the Interior, National Park Service. National Register of Historic Places Inventory—Nomination Form. Oak Bluffs Christian Union Chapel, Oak Bluffs, Massachusetts.

United States Department of the Interior, National Park Service. National Register of Historic Places Inventory—Nomination Form. The Dr. Harrison A. Tucker Cottage: 42 Ocean Ave., Oak Bluffs, Massachusetts.

United States Department of the Interior, National Park Service. 1978. National Register of Historic Places Inventory—Nomination Form. "Martha's Vineyard Campground, Oak Bluffs, Massachusetts. June 21, 1978.

United States Department of the Interior, National Park Service. Undated. National Register of Historic Places Inventory—Nomination Form. Martha's Vineyard Lighthouses: Gay Head Lighthouse; West Chop Lighthouse; East Chop Lighthouse; Harbor Light Lighthouse; Cape Poge Lighthouse, Martha's Vineyard, Massachusetts.

United States Environmental Protection Agency (US EPA). 2000. Global Warming Impacts – Health. [http://yosemite.epa.gov/oar/globalwarming.nsf/content/ImpactsHealth.html]. Accessed on February 12, 2003.

United States Environmental Protection Agency (USEPA), 2002. EPA website: http://oaspub.epa.gov/waters/.

United States Environmental Protection Agency (USEPA). 2004. USEPA Oil Program. Website accessed on July 16, 2004. http://www.epa.gov/oilspill/impact.htm.

United States Geological Survey. 2001. Earthquakes in and Near the Northeastern United States, 1638-1998. Geologic Investigations Series I-2737. Reston, Virginia.

Unites States Army Corps of Engineers (USACE). 1992. Automated Coastal Engineering System, Version 1.07

Universal Atlas of Cape Cod and Southeastern Massachusetts, including Martha's Vineyard and Nantucket, 3rd Edition. 1997. Universal Publishing Company, Inc. Stoughton, Massachusetts.

University of Massachusetts (UMASS) Center for Policy Analysis, 2002. Cape & Islands Workforce Investment Board: Workforce Development Policy Blueprint. Economic Research Series No. 39. September, 2002.

Valberg P.A., R. Kavet, C.N. Rafferty. 1997. Can low level 50/60-Hz electric and magnetic fields cause biological effects? Radiation Research 148: 2-21.

Veit, R.R., and W.R. Petersen. 1993. Birds of Massachusetts. Massachusetts Audubon Society, Lincoln, MA.

Vella, G. 2002. Offshore Wind: The Environmental Implications. Utilities Project, Volume 2. University of Liverpool.

Vella, G., I. Rushforth, E. Mason, A. Hough, R. England, P. Styles, T. Holt, and P. Thorne. 2001. Assessment of the effects of noise and vibration from offshore wind farms on marine wildlife. Report to ETSU (Department of Trade and Industry). DTI/Pub.URN 01/1341. 71 pp.

Volpe National Transportation Systems Center (VNTSC). 1994. "Northeast Corridor Improvement Project Electrification - New Haven, CT to Boston, MA: Final environmental impact statement/report. Volume II: Technical studies." US Dept. of Transportation, Federal Railroad Administration, Office of Railroad Development (Washington, DC) National Technical Information Service (Springfield, VA) NTIS PB95-174447. 478 pp.

Ward and Sutton. 2001. History of the Avalon Sea Watch in Proceeding of a Conference - KL Bildstein. B Klem. Hawk Watching in the Americas. Published by the Hawk Migration Association of North America. North Wales, PA.

Waring, G. T., J. M. Quintal, S. L. Swartz, P. J. Clapham, T. V. N. Cole, C. P. Fairfield, A. Hohn, D. L. Palka, M. C. Rossman, USFWS, and C. Yeung. 2001. U. S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2001. NOAA Tech. Memo. NMFS-NE-168, 318 pp.

Wartenberg, D. 2001. Residential EMF exposure and childhood leukemia: meta-analysis and population attributable risk. Bioelectromagnetics Supplement 5: S86-S104.

Watkins, W.A. 1986. Whale reactions to human activities in Cape Cod waters. Mar. Mamm. Sci. 2:251-262.

Weaver, J.C., T.E. Vaughan, R.D. Astumian. 2000. Biological sensing of small field differences by magnetically sensitive chemical reactions. Nature 405:707-709.

West. 2002. Synthesis and Comparison of Baseline Avian and Bat Use, Raptor Nesting, and Mortality Information from Proposed and Existing Wind Developments. Western Eco-Systems Technology, Inc. Cheyenne, Wyoming. Prepared for Bonneville Power Administration. www.bpa.gov.

Westerberg, H. 1999. Impact Studies of Sea-Based Windpower in Sweden. Technische Eingriffe in marine Lebensraume.

Western Australian Tourism Commission. 2003b. Product Snapshot, Ten Mile Lagoon Wind Farm. [http://www.westernaustralia.net/servlet/watc.WATCServlet?servletName=ViewProduct&systemName=View&subSystemName=Advanced&searchType=All&productID=10154]. Accessed on February 12, 2003

Wigley, R. 1968. Benthic Invertebrates of the New England Fishing Banks, in "Underwater Naturalist", American Littoral Society, Vol. 5, No. 1.

Ward and Sutton. 2001. History of the Avalon Sea Watch in Proceeding of a Conference - KL Bildstein. B Klem. Hawk Watching in the Americas. Published by the Hawk Migration Association of North America. North Wales, PA.

Wiltschko, W., U. Munro, R. Wiltschko, J.L. Kirschvink. 2002. Magnetite-based magnetoreception in birds: the effect of a biasing field and a pulse on migratory behavior. J Experimental Biology 205: 3031-7.

Winkelman, J. E. 1992. The impact of Sep wind park near Oosterbierum (Fr.), The Netherlands, on birds, 2: nocturnal collision risks. RIN Rep. 92/3. DLO-Instituut voor Bos-en Natuuronderzoek, Arnhem, Netherlands.

Winkelman, J. E. 1995. Bird/wind turbine investigations in Europe. Proceedings of National Avian-Wind Planning Meeting, Denver, CO, July 1994. Pp. 110-119. (see other references and summaries within this Proceedings volume).

Witt, Shelly. 1999. Bats: Masters of the Night Skies. National Continuing Education for Watershed, Fish, Wildlife, Air & Rare Plants. USDA Forest Service.

Woods Hole Group Environmental Laboratories. 2001a. Analytical Reports (3 data reports reporting laboratory results of chemical analyses of Cape Wind vibracore sediment samples). Raynham, Massachusetts. August 31, 2001.

Woods Hole Group Environmental Laboratories. 2001b. Analytical Reports (2 data reports reporting laboratory results of chemical analyses of Cape Wind vibracore sediment samples). Raynham, Massachusetts. September 19, 2001.

Woods Hole Group Environmental Laboratories. 2003. Analytical Report: Cape Wind Associates, Inc. Raynham, Massachusetts. November 7, 2003.

www.capecodconnection.com Website accessed on May 27, 2003

www.capesearch.com Website accessed on May 27, 2003

www.harwichma.virtualtownhall.net Website accessed on May 27, 2003

www.mvy.com Website accessed on May 27, 2003

www.nantucket.ma.us Website accessed on May 27, 2003

www.thetrustees.org Website accessed on May 27, 2003

www.town.barnstable.ma.us Website accessed on May 27, 2003

www.town.chatham.ma.us Website accessed on May 27, 2003

www.town.dennis.ma.us Website accessed on May 27, 2003

www.town.falmouth.ma.us Website accessed on May 27, 2003

www.yarmouthcapecod.org Website accessed on May 27, 2003

Zajac, R.N. 1998. A review of research on benthic communities conducted in Long Island Sound and an assessment of structure and dynamics. Chapter 4 in Long Island Sound Environmental Studies, U.S. Geological Survey Open-File Report 98-502.

Zen, E-an; Editor. 1983. Bedrock Geologic Map of Massachusetts. Compiled by Richard Goldsmith, Nicholas M. Ratcliffe, Peter Robinson and Rolfe S. Stanley, United States Geologic Survey. Reston, Virginia.