5.0 ENVIRONMENTAL AND SOCIOECONOMIC CONSEQUENCES

5.1 IMPACT-PRODUCING FACTORS – NORMAL CONDITIONS

The identification and description of activities, equipment, materials, and processes that have the potential to create impacts on natural and human resources in areas proposed for use by the proposed action has been divided into two main categories, those items occurring under normal conditions, and under non-routine conditions. Normal conditions are discussed below, which are then followed by the non-routine conditions (Section 5.2). These factors are then used, as appropriate, in characterizing resource impacts in Sections 5.3 and 5.4, as well as to some extent in Section 6.0. It is important to note that these factors need to be considered within the larger context of other sources of the same or similar impact-producing factors that have occurred in the recent past, do currently occur, or could reasonably be expected to occur in the near future, within the site of the proposed action (refer to Table 5.1.1-1 for a summary of Impact Producing Factors).

5.1.1 Maintenance or Construction Vessels and Crew boats

Impacts associated with vessels to be used during construction, operation, and decommissioning of the proposed action, many of which are common to most commercial vessels operating in Nantucket Sound, can be placed into three timeframes during transit, while on station, and while at staging areas. The characteristics of how and what impact factors are associated with these three timeframes are described in the following subsections.

5.1.1.1 Vessel Activity (in Transit, on Station, and at Staging or Maintenance Base)

The most probable scenario is that the majority of material and equipment would be staged onshore, most likely at existing port facilities in Quonset, Rhode Island, and then loaded onto various vessels for transportation to the offshore site, and ultimately installation. Construction personnel would be ferried by boat and/or helicopter depending upon weather conditions and other factors. Once loaded, if traveling from Quonset, the vessels would pass through Narragansett Bay to Rhode Island Sound then to Vineyard Sound, and then North of Martha's Vineyard to the Main Channel, a distance of about 63.3 miles (101.9 km). While these vessels are in transit, certain aspects of their operation have the potential to generate a number of impacts on marine resources. During construction and decommissioning, the majority of vessel berthing and loading would likely occur at Quonset. Smaller supply or crew boats may also operate out of Cape Cod ports, such as Hyannis. During the proposed action operation phase, maintenance vessels would operate out of Hyannis or similar Cape Cod port, under normal conditions. These ports have adequate facilities for berthing and loading of the maintenance vessel(s). The impacts from all vessel activity are described below.

5.1.1.1.1 Sumps, Ballast, and Bilge Discharges

Bilge water is water that collects in the lower part of a ship. The bilge water is often contaminated by oil that leaks from the machinery within the vessel. The discharge of any oil or oily mixtures is prohibited under 33 CFR 151.10; however, discharges may occur in waters greater than 13.8 miles (22.2 km) offshore if the oil concentration is less than 100 parts per million (ppm). Discharges may occur within 13.8 miles (22.2 km) if the concentration is less than 15 ppm. Ballast water is used to maintain stability and trim of the vessel and may be withdrawn from coastal or marine waters through structures in the hulls of ships called sea chests. Generally, the ballast water is pumped into and out of separate compartments or tanks depending upon the requirements to maintain proper vessel stability and trim as cargo is unloaded. Ballast compartments are not usually contaminated with oil as they are isolated from machinery and engines; however, the same discharge criteria apply as for bilge water (33 CFR 151.10).

In other instances, vessels that arrive empty or load and unload in different locations associated with the proposed action would also result in the discharge of ballast as cargo is taken on board. For example, a barge that is loaded with construction materials and equipment at the onshore staging area would have minimal ballast. After transit to the site of the proposed action and offloading materials as the WTGs are constructed, these vessels may take on ballast water to maintain trim and stability for the transit back to shore for re-loading. Ballast water withdrawals result in entrainment of planktonic marine life and then the discharge of these organisms at a different location. Withdrawal impacts are described further in Section 5.1.1.1.5. In addition to water quality concerns associated with ballast water discharge, an additional potential impact is the introduction of invasive species into local waters, from vessels coming from over seas or from other U.S. ports.

Impact characteristics that result from discharge from vessels described above are also similar to vessels in transit, except for the fact that vessels on station are discharging at a relatively constant location. Whereas vessels in transit have the advantage of a moving discharge resulting in greater dilution and dispersion of the discharged water, vessels on station rely on local currents and passive dispersion mechanisms to dilute the waste water within the receiving water. Should these discharges have characteristics that adversely affect water quality or marine organisms, such as low dissolved oxygen (DO) or pollutants, the severity of the localized impact may be greater than for a vessel in transit.

All vessels for the proposed action would comply with applicable mandatory ballast water management practices established by the USCG in order to minimize the inadvertent transport of invasive species as well as the potential for adversely impacting water quality.

5.1.1.1.2 Deck Drainage

Deck drainage includes all wastewater resulting from deck washings, rainwater, and runoff from curbs, gutters, and drains including drip pans and work areas. The USEPA general guidelines for deck drainage require that no free oil be discharged, as determined by visual sheen. The quantities of deck drainage vary greatly depending on the size and location of the equipment. Large vessels employed during construction, operation, and decommissioning, particularly those with machinery operating on deck, such as cranes or generators, should be designed to avoid oily deck drainage discharge to the ocean.

5.1.1.1.3 Greywater Discharges

On board vessels, domestic wastewater originating from sinks, showers, laundries, and galleys is referred to as greywater. Sanitary wastewater originates from toilets and is referred to as blackwater, which is discussed in Section 5.1.1.1.4. For greywater, no solids or foam may be discharged. In general, operation of large vessels with crew quarters and full live-on-board capabilities would result in the generation of 50 to 100 gallons/person/day of greywater. Given the currents and volume of water in an open water setting, it is assumed that where allowed, discharges of greywater are rapidly diluted and dispersed. State and local governments regulate greywater from vessels when operating near shore. Unlike vessels in transit, wastewater discharges from vessels on station would occur more like a point source discharge, with less potential for dispersal and dilution. In these instances, local currents and water depth, would affect the dispersal and dilution factors, and the concentration of a wastewater plume would be higher in the localized area around the point of discharge compared to a vessel in transit. However, again, Horseshoe Shoal is essentially in an open ocean setting and greywater discharges are anticipated to rapidly dilute and disperse.

Discharge of greywater would not occur into the harbor while vessels are berthed. Instead, wastewater would either be held until offshore disposal can occur or would be pumped onshore for proper disposal. All vessel waste would be offloaded, stored and disposed of in accordance with all applicable local, state and Federal regulations.

5.1.1.1.4 Blackwater Discharges

In sanitary waste, floating solids are prohibited. Facilities with 10 or more people must meet and maintain the requirement of total residual chlorine greater than 1 mg/L. In general, operation of large vessels would result in the generation and discharge of 35 gallons/person/day of treated sanitary wastes. All vessels with toilet facilities must have a Marine Sanitation Device (MSD) that complies with 40 CFR 140 and 33 CFR 149. Vessels complying with 33 CFR 159 are not subject to State and local MSD requirements. Type I and II MSDs are systems mechanically chop up the sewage, chemically treat it, and discharge it through a screen. These MSD systems can not be used, however, in coastal waters that are designated as No Discharge Areas (NDAs). The NDAs are areas where discharge of any treated or untreated sewage is prohibited. There are currently eight NDAs in Massachusetts: the coastal waters of Plymouth, Kingston, and Duxbury, all of Buzzards Bay, Waquoit Bay in Falmouth, the coastal waters of Harwich, Three Bays/Centerville Harbor in Barnstable, Stage Harbor in Chatham, Wellfleet Harbor, and the coastal waters of Nantucket from Muskeget Island to Great Point, including Nantucket Harbor. All Rhode Island waters are also designated as No Discharge (www.mass.gov/czm).

Unlike vessels in transit, wastewater discharges from vessels on station would occur more like a point source discharge, with less potential for dispersal and dilution. In these instances, local currents and water depth, would affect the dispersal and dilution factors, and the concentration of a wastewater plume would be higher in the localized area around the point of discharge compared to a vessel in transit. However, Horseshoe Shoal is essentially in an open ocean setting and blackwater discharges are anticipated to rapidly dilute and disperse.

Discharge blackwater would not occur into the harbor while vessels are berthed. Instead, wastewater would either be held until offshore disposal can occur or would be pumped onshore for proper disposal. All vessel waste would be offloaded, stored and disposed of in accordance with all applicable local, state and Federal regulations.

5.1.1.1.5 Water Withdrawals

While no water withdrawal is associated with the operation of the proposed action's WTGs or electric service platform, water withdrawals by vessels would occur during transits and while on station for construction and maintenance. As indicated above, water withdrawals may occur for ballasting, but other water withdrawals would occur for vessel engine cooling, hoteling, and operation of on-board reverse osmosis water systems (for those vessels with such systems). Water withdrawals by themselves would not have a measurable impact on water quality or quantity in the site of the proposed action where vessels operate, but they can result in the entrainment of planktonic marine organisms, and to a lesser extent, impingement of poor swimming species on the grates of the sea chests. Impingement while under way is not usually an issue as there is a sweeping velocity across the sea chest grating, but while vessels are anchored or moored this sweeping velocity is minimal. Entrainment of organisms typically results in high mortality due to temperature changes and mechanical and hydraulic injury from pump impellors and passage through piping. Any use of a biocide to prevent fouling growth on the interior walls of pipes would further diminish survival of entrained organisms.

While some vessels are moored at the staging or maintenance base their engines would remain at idle speeds, requiring engine cooling water withdrawals. Typically these vessels are of the size of ocean going freighters. Smaller vessels, such as tugs or small crew or supply vessels would shut down engines overnight or for extended periods. In addition, as cargo is removed from freighters or supply barges, ballast water may be taken on while moored in order to maintain vessel trim and stability. As with vessels in transit and on station, water withdrawals have the potential to affect planktonic marine life through entrainment, or poor swimming fish through impingement.

5.1.1.1.6 Solid Waste and Trash Handling

The discharge of trash and debris is prohibited (33 CFR 151.51-77) unless it is passed through a shredding and screening device and can pass through a 25 mm mesh screen. All other trash and debris must be returned to shore for proper disposal at municipal or private solid waste landfill or recycling facilities.

5.1.1.1.7 Floating Debris and Trash

Trash and debris that may be lost overboard from WTGs, ESP and construction/maintenance vessels can wash ashore on Cape Cod and islands surrounding the proposed action. However, according to the Ocean Conservancy (formerly the Center for Marine Conservation), beachgoers are a prime source of beach pollution, with other sources of coastal trash including runoff from storm drains and antiquated storm and sewage systems in older cities and commercial and recreational fishermen. Cleanup of OCS trash and debris from coastal beaches adds to operation and maintenance costs for coastal beach and park administrators.

Other trash lost overboard may travel into the open ocean, or sink to the seafloor. Certain types of trash can be very harmful to certain marine organisms, such as clear or light colored plastic bags that are consumed by sea turtles which confuse them for jellyfish. Quite often, once consumed the plastic bags cause blockage in the digestive system, which can lead to death. Rope and cable that is lost overboard can become entangled on the fins or mouths of marine mammals, injuring them until the material falls off, or if not removed, can cause mortality through infected flesh wounds or inhibiting feeding.

5.1.1.1.8 Noise, Lights, and Vibration

All motorized vessels, including those involved in the construction and maintenance of the proposed action, transmit noise through both air and water. The primary sources of vessel noise are propeller cavitation, propeller singing, and propulsion; other sources include auxiliaries, flow noise from water dragging along the hull, and bubbles breaking in the wake (Richardson et al., 1995). Propeller cavitation is usually the dominant noise source. For vessels, noise and vibration are related, since both produce energy moving through the water in a wave or band motion. Vibrations associated with propulsion engines would be transmitted through the hull and into the water. The intensity of noise from maintenance vessels is roughly related to ship size, laden or not, and speed. Large ships tend to be noisier than small ones, and ships underway with a full load (or towing or pushing a load) produce more noise than unladen vessels. For a given vessel, relative noise also tends to increase with increased speed. Commercial vessel noise is a dominant component of manmade ambient noise in the ocean (Jasny, 1999). In the immediate vicinity of a vessel, noise could disturb marine mammals, fish, and sea turtles; with the intensity and duration of affect diminishing rapidly with distance from the source since the energy level associated with noise transmission diminishes with the cube of distance.

All vessels operating between dusk and dawn are required to have navigation lights turned on. In addition, temporary work lighting would illuminate work areas on vessel decks or service platforms of adjacent WTGs or ESP. In addition, cable laying may occur 24 hours a day during certain periods, and these vessels would be illuminated at night for safe operation. A number of factors can affect light transmission, both in air and water. In air, the transmission of light associated with deck and navigation lights on construction and maintenance vessels can be affected by atmospheric moisture levels, cloud cover, and type and orientation of lights. In water, turbidity levels and waves, as well as type of light, can affect transmission distance and intensity.

At least two types of vessels on station would generate noise and vibrations that do not occur with vessels in transit. The cable jetting vessel would create localized underwater noise and vibrations associated with the water jets employed on the jet plow. In addition, the barges involved in pile driving of the monopile foundation, would create noise and vibrations that are well known from other pile driving activities. The sound source level for barges or tugs, typical types of construction/maintenance vessels that may be used for the proposed action, is 162 dB re 1 μPa at 3.3 ft (1 m) (Malme et al., 1989). Marine biota would be able to hear the vessel, but would no physical harm or behavioral effects would occur.

Because the maintenance base(s) of the proposed action would be at existing industrialized port(s), there would not be a substantial increase in noise or lighting above what is normally expected. However, use of these facilities would result in some increase in noise levels and lighting for a period of time that if the proposed action were not constructed, may not occur (unless the facilities were utilized by another industrial tenant). The proposed action's use of these areas would generate noise from the operation of machinery, such as vessel engines as they arrive or depart, cranes used to load or unload equipment and construction materials and supplies, and other smaller pieces of machinery such as fork lifts or delivery trucks. Lighting would be necessary for illuminating the work area on land, at the berth, and on the vessels while at berth. Because the area is designed as an industrial port, much of this lighting already exists, and the changes to background conditions would be negligible.

5.1.1.1.9 Bottom Disturbances and Anchoring

Operation of all vessels, including those expected to be used during construction, decommissioning, and routine maintenance of the proposed action would result in several sources of bottom disturbance. When operating in shallow water areas, typically waters less than 20 ft (6.1 m) deep, the propeller wash from large vessels could contact the bottom and cause some scouring and sediment resuspension. This can injure some types of benthic organisms, or make them more susceptible to predation. Most of the large construction vessels to be used are likely to be jacked up on hydraulic legs or utilize spuds for positioning, which would result in some direct impact to the seabed. In the case of the cable laying/jetting vessel, anchoring is the method used to move the barge along the cable route, and an anchor handling tug is employed to reposition anchors as the barge advances along the route. This vessel is positioned using a series of heavy anchors deployed in an array around the vessel. Winches on the barge or vessel adjust tension on the anchor cables to make adjustments in position. Anchors in the 10,000 lb range (the largest anchor estimated to be used on the cable installation vessels) tend to dig into sandy sediments to a depth of about 3 to 5 ft (0.91 to 1.5 m) depending upon sediment type (see Section 5.1.4.3 for more detail on jetting). When the anchors are retrieved, they are pulled out by the bottom and much of the sediment on the flukes falls back into the anchor scar area so that the anchor scar remains as only a shallow depression. Over time, the dynamic environment of Nantucket Sound would level the seafloor. In addition, as the vessel position is adjusted, a portion of the anchor cable nearest the anchor slowly drags across the seafloor surface, causing a shallow sediment disturbance. This action is minimized by the use of mid-line buoys on the anchor lines, which raise a greater amount of anchor chain off the bottom, reducing the amount of chain that is swept along the bottom as the vessel moves. The setting and repositioning of anchors in this manner has the potential to injure relatively sedentary benthic organisms, such as brittlestars, sand dollars, or whelks.

It is unlikely that direct bottom disturbance or anchoring would occur at the staging and maintenance bases since these vessels would use existing mooring structures. Prop wash might occur as vessels move in or out of berths, depending upon the draft of vessels relative to bottom depths, with the resulting resuspension of sediments and possible affects on benthos, fish, and water quality.

5.1.1.1.10 Air Emissions

The operation of vessels, other than sailboats, requires engine power for movement, and the combustion of fossil fuels, whether it is gasoline or diesel, results in the production of exhaust gases that are released to the environment. Types of waste gases are described more fully in Section 5.3.1.5, but typically include carbon dioxide (CO_2), CO, nitrous oxides, sulfuric oxides, and water vapor. The release of these gases lowers air quality, and when compounds precipitate out of the atmosphere into the ocean or on land, can affect water quality, affect plant growth, and affect the health of animals and humans. The operation of vessels during construction, operation and maintenance, and decommissioning must be evaluated in the context of the other types and numbers of vessels that occur in areas to be transited by proposed action vessels.

5.1.1.1.11 Visual Aesthetics

During construction, operation, and decommissioning of the proposed action, there would be an increased number and types of vessels operating in the site of the proposed action. The presence of the proposed action-related vessels would alter the visual characteristic of areas transited by these vessels. The Nantucket Sound area has a rich maritime history that includes considerable vessel activity in and out of area ports, whether it is fishing vessels, ferries, various types of cargo vessels, and numerous recreational vessels. Nevertheless, proposed action vessels would increase the number of occurrences of vessels, and this would alter the visual environment. A number of the vessels to be used would be quite large, such as derrick crane barges, which would be visible at greater distances, whether day or night, than some of the smaller vessels that would also be used, such as crew and supply vessels.

This impact would be of greater magnitude during construction and decommissioning than operations, because of the larger and greater number of vessels involved. Also, during the time period of construction and decommissioning, nighttime work would require lighting of work areas, which would represent a visual intrusion in the nighttime view from areas on shore or passing vessels. During daylight hours, the large derrick barge(s), jack up barges, and cable laying vessel would represent larger vessels than normally occur in this portion of Nantucket Sound. Depending upon the individual, some people would be intrigued with the construction and decommissioning activities and not characterize the presence of these vessels as negatively affecting the visual aesthetics. In contrast, others would feel that these vessels are out of place and represent a degradation of the view across Nantucket Sound. As described in more detail in Section 5.3.3.4, there are a number of factors that affect the nature and extent of how the visual resource would be affected by the proposed action, such as distance from shore or meteorological conditions.

5.1.1.1.12 Channel Maintenance

Dredged materials from channels are often contaminated with toxic heavy metals, organic chemicals, pesticides, oil and grease, and other pollutants originating from municipal, industrial, and vessel discharges and nonpoint sources, and can result in contamination of areas formerly isolated from major anthropogenic sources. The vicinities around harbors and industrial sites are most noted for this problem. Hence, sediment discharges from dredging operations can be major point sources of pollution in coastal waters in and around Nantucket Sound. Given that the shore side facilities proposed for use have adequate channels to accommodate the necessary vessels during construction, operation and decommissioning, it is unlikely that any channel maintenance would occur in association with the proposed action. However, connecting the offshore transmission cable system to the onshore transmission cable system involves HDD which does require the dredging of an offshore exit point pit and the placement of a temporary cofferdam within Lewis Bay to facilitate the HDD operation. The dredged sediments from within the cofferdam pit would be temporarily removed from waters of the U.S. and replaced upon completion of the offshore transmission cable system. Testing of the sediments proposed for dredging has shown them to be classified as Category One, Type A, the least toxic and least restrictive of the three classifications in the MassDEP criteria. The dredged sediments from within the cofferdam pit would be temporarily removed from waters of the United States and replaced upon completion of the offshore transmission cable system. Samples from vibracores of these proposed dredged sediments were collected and analyzed to determine bulk chemical and physical characteristics and testing analyses were performed in accordance with the MassDEP Division of Water Pollution Control (MassDEP-DWPC) Regulations 314 CMR 9.00. This testing has shown the proposed dredged sediments are classified as Category 1, Type A, the least toxic and least restrictive of the three classifications in the MassDEP-DWPC criteria. Based upon these results the excavated material can and would be used to backfill the cofferdam following the completion of the HDD and offshore transmission cable installation. If necessary, the dredged backfill material would be supplemented with imported clean sandy backfill material to restore preconstruction contours.

5.1.1.1.13 Bottom Debris

While vessels would be required to avoid overboard loss of construction materials, supplies, or equipment, it is likely that some material would end up on the seafloor during the life of the proposed action. Based on experiences from the construction of offshore oil and gas rigs, some debris such as metal cuttings, wire clippings or strands, nuts and bolts, etc. would end up on the seafloor. In comparison, certain other marine activities result in bottom debris in quantities that exceed those expected on the proposed action. For example, commercial fishermen lose lobster traps, and trawlers, gill netters, and seiners also lose gear that comes to rest on the seafloor. However, unlike the oil and gas industry, there is very little on-site fabrication associated with the proposed action. Instead, the proposed action consists primarily of assembly of components brought to the site pre-fabricated.

5.1.2 Heliport Facilities

Helicopter sounds contain dominant tones (resulting from rotors) generally below 500 Hz (Richardson et al., 1995). Helicopters often radiate more sound forward than backward, and the underwater noise is generally brief in duration as compared with the duration of audibility in the air. From studies conducted in Alaska, a Bell 212 helicopter was 7 to 17.5 dB noisier (10 to 500 Hz band) than a fixed-wing Twin Otter for sounds measured underwater at 3 m and 18 m depths (Patenaude et al., 2002). Water depth and bottom conditions strongly influence the propagation and levels of underwater noise from passing aircraft. Lateral propagation of sound is greater in shallow than in deep water. Interestingly, the amount of sound energy received underwater from a passing aircraft does not depend strongly on aircraft altitude. However, characteristics such as more rapid changes in level, frequency, and direction of sound may increase the prominence of sound from low-flying aircraft to marine mammals (Patenaude et al., 2002). Reactions by marine mammals to aircraft are most commonly seen when aircraft are flying less than 500 to 600 ft (152.4 to 182.9 m). Helicopters, while flying offshore, generally maintain altitudes above 700 ft (213.4 m) except perhaps when traveling between WTGs or the ESP and WTGs where they may fly at between 200 and 500 ft (61 and 152.4 m) on occasion.

5.1.2.1 Helicopter Activities During Construction

Helicopter hubs or "heliports" are facilities where helicopters can land, load, and offload passengers and supplies, refuel, and be serviced. There are a number of local airports that are adequately equipped to support helicopter use during proposed action construction, operation and decommissioning. Increased helicopter activity could result in increased noise and engine exhaust emissions at the heliport or along flight paths out to the proposed action. No other impacts from helicopter use are anticipated. Helicopter use during construction would occur much more frequently than during operations, but for a much shorter timeframe.

5.1.2.2 Helicopter Activities During Operations

The same heliport facilities that were available during construction may be used during operations. Helicopter traffic is a primary source of OCS-related noise in coastal regions. Sound generated from this activity is transmitted through both air and water, and may be continuous or transient. The intensity and frequency of the noise emissions are highly variable, both between and among these sources. Helicopter sounds contain dominant tones (resulting from rotors) generally below 500 Hz (Richardson et al., 1995). The level of underwater sound detected depends on receiver depth and aspect, and the strength/frequencies of the noise source. The duration that a passing airborne source can be received underwater may be increased in shallow water by multiple reflections (echoes). Maintenance helicopters related to the proposed action may add noise to broad areas. Sound generated from maintenance helicopter traffic is transient in nature and variable in intensity.

The use of a helicopter would allow for maintenance crews to be deployed to the ESP during periods when wind and wave conditions are unsuitable for boat transfers. The helicopter platform would also allow for emergency evacuation of any individuals who may become injured. Therefore, helicopter activity is expected to be fairly infrequent.

5.1.3 Construction and Maintenance Staging Facilities

There is an existing, underutilized, industrial port facility in Quonset, Rhode Island that has the attributes required for staging an offshore construction project of the magnitude of the proposed action. The Quonset Davisville Port & Commerce Park is located on Narragansett Bay in the town of North Kingstown, Rhode Island and is owned and controlled by the RIEDC. This site is a portion of what once was a much larger government facility known as the U.S. Naval Reservation – Quonset Point, part of which is still actively utilized as a civilian airport and base for an Air National Guard Reserve squadron. Following the downsizing of the U.S. Naval Reservation – Quonset Point, the Commerce Park was created in order to develop prime industrial sites, create job opportunities and to improve the economic conditions throughout the region. The potential staging of the proposed action from the Quonset Davisville Port & Commerce Park is consistent with the Park's stated purpose.

5.1.3.1 Solid Wastes and Trash

As with any large construction project, a variety of solid wastes would be produced at the staging area, ranging from paper and wood products to scrap metal, oily wastes, and garbage. Because much of the materials used for the facility would arrive pre-fabricated, rather than built on-site, the quantities of solid waste generated are likely to be less than an equivalent sized electric generating station. For example, the large structural components such as the turbine rotors, generators, monopiles, foundation piles and electric cables would most likely arrive via over-water shipment to Quonset for staging the work in Nantucket Sound. The applicant has stated that construction and maintenance activities would be performed by contracted firms and, as part of the contract agreements, these entities would have responsibility for the proper handling and disposal of solid waste and trash generated during construction and maintenance activities.

5.1.3.2 Oily or Hazardous Wastes

Since no substantive construction or fabrication is expected to occur at the staging area, the creation of oily or hazardous wastes is anticipated to be minimal. Typically, whenever machinery is used and equipment using hydraulic power is used on construction projects, there is the potential for generation of waste oil and fluids resulting from maintenance and repair activities on the machinery and equipment. Any oily or hazardous wastes that are produced would be properly disposed of in accordance with all applicable laws and regulations.

5.1.3.3 Stormwater and Wastewater

Staging areas to be used for the proposed action are most likely to be associated with existing facilities that accommodate these types of activities. As such, stormwater and wastewater handling systems would have been previously designed and operated by the site owner/operator and the use of these properties in association with the proposed action is not likely to measurably alter existing conditions. Any changes in the stormwater and wastewater collection, treatment, and disposal systems that are attributable to the proposed action would need to be dealt with in accordance with all applicable laws and regulations.

5.1.3.4 Landfills

The applicant would contract firms to construct and maintain the proposed action. Landfills likely to be used would be at the discretion of the entity producing the waste. As indicated in Section 5.1.3.1, contractors would be responsible for waste disposal at landfills in accordance with all applicable laws and regulations. Applicable disposal sites are described in Section 4.3.2.4.

5.1.3.5 Noise, Lights, and Vibration

Noise associated with the staging area would be typical for an industrial port, where cranes are used to load and unload materials from ships. Since the Quonset Davisville Port & Commerce Park is already approved for this type of activity, if utilized there would be no substantial increase in noise levels above what would be typically expected at this facility. Similarly, smaller industrial ports on Cape Cod, that could handle much of the maintenance support for the proposed action, already involve the loading and unloading of vessels at different times of the day, using cranes, winches, davits, etc similar to what would be needed to support maintenance vessels and activities. Therefore, the noise, lights, and vibrations associated with these types of activities already occur, and the proposed action would represent only a small incremental increase in these factors.

5.1.4 Wind Turbine Generator, ESP, and Cable Installation

Installation (may also be referred to as construction) of the proposed action would involve a number of different activities requiring the use of specialized marine construction equipment and vessels, some of which would be operated in a portion of Nantucket Sound that has not historically been subject to construction activities. Impact producing factors associated with vessels are discussed in Section 5.1.1 and helicopters in Section 5.1.2, and are not repeated in Section 5.1.4. Other portions of the proposed action would involve construction using conventional construction equipment operating in areas that have already been developed. The WTGs would be constructed in a grid pattern with minimum 0.39 miles (0.6 km) by 0.63 miles (1 km) spacing. Inner-array cables would be installed in the seafloor between WTGs and between WTGs and the ESP. Lastly, two parallel transmission cables would be installed in the seafloor between the ESP and the south shore of Cape Cod, with on-land continuation to an existing substation.

5.1.4.1 Visual Aesthetics

The factors that could adversely affect the aesthetics of the coastline are oil spills and residue, tarballs, trash and debris, pollution, increased vessel and air traffic, and the presence of WTGs visible from land. Visibility is dictated not only by size and location of the structures and curvature of the Earth but also by atmospheric conditions. Social scientists added factors, such as the viewer's elevation (ground level, in a 2-story house, or in a 30-story condominium) and the viewer's expectations and perceptions. It should be noted that during the installation process, activities associated with construction that could affect visual aesthetics would consist of both relatively stationary (such as jack up barges) and mobile (cable jetting vessel) components. Vessels are discussed in Section 5.1.1. In contrast, as the construction proceeds, fixed components would become more prevalent until all 130 WTGs and the ESP are constructed and the proposed action goes into operation. Hence, the visual attributes of the proposed action would develop over time.

5.1.4.2 Noise and Vibration

The monopiles would be installed into the seabed by means of pile driving ram or vibratory hammer and to an approximate depth of 85 ft (26 m) into the seabed. This would be repeated at all WTG locations. 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 proposed action closest to shore (sounds up to 41 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 proposed action 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.

For the ESP installation, six piles would be driven through pile sleeves to the design tip elevation of approximately 150 ft (46 m). The piles would be vibrated and hammered as required. This would cause underwater noise and vibrations that could affect a variety of marine organisms, both in the water column and within the sediments.

The principal sound from construction would 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. The predicted construction impacts are 31 dBA to 76 dBA when the receiver is 1/3 to 1 mile (0.5 to 1.6 km) downwind of the pile driving activity and 7 dBA to 49 dBA when the receiver is 1/3 to 1 mile (0.5 to 1.6 km) upwind of the activity. Existing average sound levels (L_{eq}) at sea in the vicinity of the proposed action 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 proposed action construction would be audible.

Sound source data for construction effects underwater were provided by GE Wind Energy from recent tests at the Utgrunden and Gotland Projects (Report No. 4.1.2-1) which have similar environmental conditions to Nantucket Sound and provide the best available data. Data obtained during pile driving at the Utgrunden Project revealed underwater L_{max} sound levels of 177.8 dB at 1,640 ft (500 m). Noise levels of pile driving at the SMDS were found to range from 145 dB to 167 dB at a distance of 1,640 ft (500 m). The higher Utgrunden pile driving sound level data were utilized in the modeling analysis because the monopile foundations for the proposed action would be similar in size to those used at Utgrunden, and because of similarities in environmental conditions between Nantucket Sound and the Baltic Sea. Baseline underwater sound levels under the design wind condition are 107.2 dB.

5.1.4.3 Cable Jetting

The jet plow embedment process for laying submarine power cables with a cable barge produces no sound beyond typical vessel traffic in Nantucket Sound. For burial, the cable barge tows the jet plow device at a safe distance as the laying/burial operation progresses. The offshore cables are deployed from the vessel to the funnel of the jet plow device. The jet plow blade is lowered onto the seabed, water pump systems are initiated, and the jet plow progresses along the pre-selected offshore cable route with the simultaneous lay and burial operation, creating a trench approximately 4 to 6 ft (1.2 to 1.8 m) wide (top width) to a depth of 8 ft (2.4 m) below the present bottom into which the offshore cable system settles through its own weight. Temporarily re-suspended in situ sediments are largely contained within the limits of the trench wall, with only a minor percentage of the re-suspended sediment traveling outside of the trench. Any re-suspended sediments that leave the trench tend to settle out quickly in areas immediately flanking the trench depending upon the sediment grain-size, composition, and hydraulic jetting forces imposed on the sediment column necessary to achieve desired burial depths.

Other potential water quality impacts associated with fluidizing sediments during jetting include release of nutrients or sediment-bound contaminants into the water column. In areas of high organic content, resuspension of sediments can increase the oxygen demand in the water, thereby causing localized depression of DO levels.

The cable laying/jetting vessel would utilize a system of anchors as the method to move the barge along the offshore cable routes, and an anchor handling tug would be employed to reposition anchors as the barge advances along the routes. This impact producing factor is discussed in Section 5.1.1.1.9.

Another component of the cable jetting process that could cause impacts is the high pressure water jets cutting into the sediments, intended to loosen and liquefy sediments, but also potentially injuring or causing mortality of benthic organisms. Vibrations associated with the jetting would likely cause more mobile species such as lobsters, crabs, flounder and skates to move out of the way. However, infauna or slower moving epifauna, such as polychaete worms, razor clams, sand dollars, brittlestars, or hermit crabs may suffer tissue or organ damage, could become exposed and more susceptible to predation, or may suffer mortality. The jet plow embedment process will produce no audible sound for nearby marine life beyond the sound of rushing water and that from the surface vessel used to transport materials to the site.

5.1.4.4 Solid Waste and Trash Handling

Solid waste and trash generated during installation would be contained on vessels or at staging areas, and is discussed in the following sections.

5.1.4.5 Floating Trash and Debris

Floating trash and debris generated during installation would largely occur from vessels associated with the installation process, and is therefore covered in Section 5.1.1. One additional source of floating trash and debris could result from installation activities on the ESP. Once the ESP piles and base are constructed, installation of other equipment and components of the ESP would occur as a combination of fixed platform and vessel support. As transformers and other electrical components are installed, it is possible that material would fall off or blow off the ESP platform. Good housekeeping practices would be employed to minimize this occurrence.

5.1.4.6 Bottom Debris

Bottom debris is defined as material resting on the seabed (such as cable, tools, pipe, drums, anchors, and structural parts of platforms, as well as objects made of plastic, aluminum, wood, etc.) that are accidentally lost (e.g., during hurricanes) or tossed overboard from facilities. Bottom debris generated during installation would largely occur from vessels associated with the installation process, and is therefore covered in Section 5.1.1. One additional source of bottom debris could result from installation activities on the ESP. Once the ESP piles and base are constructed, installation of other equipment and components of the ESP would occur as a combination of fixed platform and vessel support. As transformers and other electrical components are installed, it is possible that material would fall off the ESP platform. Good housekeeping practices would be employed to minimize this occurrence.

Appropriate precautions would be taken to avoid the overboard loss of materials related to the proposed action and the quantity of bottom debris per operation would be kept to a minimum.

5.1.4.7 Bottom Disturbance

Installation of the WTGs and ESP would involve the use of jack up barges and/or vessels that utilize spuds to secure their position. These vessels would have some direct temporary impact to the seabed from the jack up pads, which typically range from 10 to 20 ft (3 to 6 m) in length and width, respectively. Once the jack-up legs are deployed, the barge is raised out of the water to create a stable work platform that is not influenced by tides, currents, or waves. The vessels that are anticipated for the WTG and ESP installation would not utilize anchors. Spud moored barges typically use between 2 and 4 legs that can be raised and lowered along the sides of a barge to hold the barge in place. Depending upon the size of the barge, the spud legs tend to range between 2 and 4 ft (0.61 and 1.2 m) in diameter or width. Unlike jack up barges, spud barges remain floating and are subject to tides, currents, and waves. Deployment and retrieval of jack up legs and spud legs can result in resuspension of sediments, while the lowering of legs results in direct disturbance of the sediments and mortality of infaunal and slow moving epi-benthic organisms within the footprint of the legs. After the barge has been moved, the former locations of the legs remain as small depressions in the seafloor, with the depth dependent upon factors such as length of time the barge has remained in one location, the type of sediment, and the water depth.

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 the monopile foundations may occur, depending on the location of the WTG on Horseshoe Shoal and local sediment transport conditions. Scour control mats and/or rock armor would be installed for scour protection.

Connecting the offshore transmission cable system to the onshore transmission cable system involves HDD which does require the dredging of an offshore exit point pit and the placement of a temporary cofferdam within Lewis Bay to facilitate the HDD operation. The dredged sediments from within the cofferdam pit would be temporarily removed from waters of the United States and replaced near the end of the offshore transmission cable system installation process. Testing of the sediments proposed for dredging has shown them to be classified as Category 1, Type A, the least toxic and least restrictive of the three classifications in the MassDEP criteria. These criteria are the MassDEP-DWPC classification criteria found in 314 CMR 9.07 for dredging and dredged material disposal, based on both physical and chemical characteristics. Based upon these results the excavated material can and would be used to backfill the cofferdam following the completion of the HDD and offshore cable installation. If necessary, the dredged backfill material would be supplemented with imported clean sandy backfill material to restore preconstruction contours.

5.1.4.8 New or Unusual Technologies Deployed

While some of the equipment and methods may be specialized for the construction of the proposed action, they have all been used before in other locations such as Europe. The construction of an offshore wind energy project is in itself something that has not been proposed before in the United States, Canada, or Mexico and could therefore be considered new technology deployed in this location.

5.1.4.9 Displacement of OCS Space

There would be temporary restrictions to certain areas during the construction of the proposed action. Construction vessels would also temporarily utilize space that would restrict recreational and commercial fishermen. For example, the anchoring spread around the offshore cables installation spread requires that other vessels not enter the area between the anchors and the barge, but this temporary exclusion moves as the barge moves. With respect to construction impacts on navigational activity in channels, the proposed action would be constructed in phases, and marine traffic would only be restricted in the immediate vicinity of ongoing construction activities (estimated to be one to two WTG locations at any one time) for protection of public safety. The remaining areas of the site of the proposed action would be open to unrestricted navigational access. The WTG that is closest to the Main Channel is approximately 1,190 ft (362.8 m) from the charted Main Channel edge and approximately 6,900 ft (2103.7 m) east of the Main Channel's narrowest point. The work vessels used to construct the WTGs are approximately 400 ft (122 m) long. This leaves ample room for vessels to transit past any ongoing construction. These work vessels would not need to occupy or block the Main Channel during construction. Therefore no restrictions or closures of the Main Channel to transiting vessels are anticipated. The USCG routinely deconflicts waterways and channels around marine construction activities and it is anticipated that such procedures could be implemented in Nantucket Sound during construction of the proposed action. The applicant would not prohibit vessels from entering or operating in the area of the proposed action and does not intend to establish exclusionary zones. Once the proposed action is constructed, the OCS space occupied by the WTGs, ESP, and scour protection (assuming rock armoring) is less than 50 acres. Cable installations would occupy over 80 linear miles (128.7 km) of seafloor but in an approximate 1 ft (0.3 m) width, and would be buried at least 6 ft (1.8 m) below grade. The installation of the cables would only preclude a few potential ocean uses while allowing many others to continue.

5.1.4.10 Displacement of Aviation Space

The presence of the construction equipment would require that aviators avoid the local area around the equipment, and as WTGs are erected, increasing numbers of obstacles would become present over the Horseshoe Shoal area. These areas would be added to aviation charts and FAA notices would serve to communicate the area of the proposed action to the aviation community. However, in most instances, air traffic in the middle of Nantucket Sound is flying at heights greater than the airspace occupied by the proposed action, and the occupation of this area has been determined by FAA to not be a significant issue or concern for aviation safety.

5.1.4.11 Post Lease Geological and Geophysical Field Investigations

Prior to the construction process, a post lease geological and geophysical field investigation would be conducted. The activity would require the deployment of a vessel to do mapping of the sea floor as well as require geological boring to collect subsurface geotechnical and sediment samples. The process of boring would result in minor localized turbidity near the bore hole.

5.1.5 Proposed Action Operations

Based on both offshore and onshore WTG operational experience, five days per year per turbine has been established as an anticipated maintenance requirement.

5.1.5.1 Discharges to the Sea

The structures associated with the proposed action would not produce discharges to the sea during operations. The only discharges to the sea that are anticipated are those associated with vessels performing maintenance, and these are discussed in Section 5.1.1. Accidental or unintentional discharges to the sea are discussed in Section 5.2.

5.1.5.2 Bottom Disturbances and Anchoring

During normal operations, there are no activities anticipated to require disturbance of the bottom. Maintenance vessels are unlikely to anchor and it is not anticipated that any of the offshore cables would require exposure for maintenance during the life of the proposed action. The most likely scenario resulting in bottom disturbances would probably stem from work on the scour protection on any monopiles or ESP piles that appear to be experiencing scour. These disturbances should be localized and infrequent, but could result in disruption of nearby sediments.

5.1.5.3 Floating Trash and Debris

During operation of the proposed action, the generation of floating trash and debris is likely to be limited, with a greater possibility at the ESP than at the WTGs. The overall quantity of floating trash and debris is likely to be small since the majority of maintenance activities are unlikely to produce much of this type of material.

5.1.5.4 Bottom Debris

During operation of the proposed action, the generation of bottom debris is likely to be limited, with a greater possibility at the ESP than at the WTGs. The overall quantity of bottom debris is likely to be small, associated with maintenance activities, and consists of non-toxic materials such as nuts and bolts, small hand tools, pieces of wire, etc.

5.1.5.5 Air Emissions

Any OCS activity that uses equipment that burns a fuel would cause emission of air pollutants. Some of these pollutants are precursors to ozone, which is formed by complex photochemical reactions in the atmosphere. The only air emissions anticipated from the proposed action would result from the maintenance vessels. The vessel emissions represent a mobile source and would not result in a lowering of air quality in a specific location within Nantucket Sound or surrounding areas. However, the use of at least two maintenance vessels for a majority of the days each year does represent an overall, but incrementally small, increase in air pollutants being added to the Nantucket Sound area. The WTGs would utilize the wind as the fuel to generate electricity, and would emit no air pollutants.

5.1.5.6 Visual Aesthetics

During operation of the proposed action, the presence of 130 WTGs and the ESP would be visible at different distances under different light and weather conditions. Nighttime or low light condition lighting would be employed as discussed in Section 5.1.5.8. The proposed action facilities would be visible from a number of locations along the shorelines of Cape Cod and the islands and therefore represent a change in the viewshed and an alteration of the aesthetics of the Horseshoe Shoal portion of Nantucket Sound. Opinions vary as to whether the facilities would have a negative or positive affect on the visual aesthetics. The monopile color has been selected to be as neutral as possible. The offshore cables would not affect the visual aesthetics, other than perhaps a slight reduction in some woody vegetation along the NSTAR transmission line ROW.

5.1.5.7 Noise and Vibration

As discussed in Section 5.1.1, all vessels, including maintenance vessels for the proposed action, transmit noise through both air and water. The normal operational/maintenance activity is anticipated to include two vessel trips per working day (252 days/year), which would include one crew boat from Falmouth and the maintenance support vessel from New Bedford. In addition, an occasional second round trip from Falmouth could take place in times of fair weather or for emergency maintenance.

The WTGs would also produce sound when operating. 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, proposed action operational sound levels of 40 to 45 dBA are well below existing sound levels of 60 to 65 dBA, and the proposed action would not create a pure tone (ESS, 2007 and Table 6 in Report No. 5.1.5-1); therefore, again, the proposed action 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 (ESS, 2007 and Figures 14 and 15 in Report No. 5.1.5-1) also reveal that low-frequency sound from the proposed action 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 proposed action at either the cut-in or design wind speed conditions.

The proposed action would be equipped with foghorns for boating safety. Several different devices would be deployed around the perimeter of the proposed action, 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 proposed action 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 [8+ km] away) would not hear the foghorns.

In Lewis Bay and onshore locations along the shore of Cape Cod and Martha's Vineyard the calculated maximum operational sound levels of 12 to 26 dBA are well below existing sound levels associated with cut-in to design wind speeds (41 to 71 dBA), and the proposed action would not create a pure tone. The proposed action is anticipated to be inaudible at shoreline locations.

The calculated maximum operational sound levels of 13 to 21 dBA are well below existing sound levels associated with cut-in to design wind speeds (46 to 60 dBA), and the proposed action would not create a pure tone (ESS, 2007 and Report No. 5.1.5-1), therefore the proposed action is also anticipated to be inaudible under these conditions. The frequency-specific modeling results (ESS, 2007 and Figures 16 through 37 in Report No. 5.1.5-1) also reveal that low-frequency sound from the proposed action is below the threshold of human hearing and would be largely inaudible regardless of the baseline sound levels. For example, at Lewis Bay, Yarmouth, the calculated cut-in sound levels for the low frequency of 16 Hz is only 50 dB, while the hearing threshold (the level of sound needed at this frequency in order for it to be heard) is 92 dB. At 250 Hz, the calculated cut-in sound level is only 6 dB, while the hearing threshold is 14 dB. Calculated project sound by frequency falls to 0 dB beyond 250 Hz, and would also not be audible. A similar example is found for Edgartown, Martha's Vineyard, where the calculated cut-in sound level at 16 Hz is 49 dB, and at 250 Hz is only 2 dB. Accordingly, no noise impacts are anticipated at any onshore locations due to proposed action operation for either the cut-in or design wind speed conditions.

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Existing underwater sound levels for the design condition are 107.2 dB. The calculated sound level from operation of a WTG is 109.1 dB at 66 ft (20 m) from the monopile (i.e., only 1.9 dB above the baseline sound level), and this total falls off to 107.5 dB at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 361 ft (110 m).

An analysis of predicted underwater sound levels perceived by marine biota from proposed action operation show that no injury or harassment to sea turtles are predicted, even if an individual were to approach as close as 66 ft (20 m) to a monopile.

5.1.5.8 Wind Turbine Generator Navigation Lights

The WTGs have been designed with the required USCG Private Aids to Navigation lighting. Two flashing amber lights would be located on the lower access platform about 35 ft (10.7 m) above sea level. The flashing amber lights on the ESP and perimeter WTGs are designed to be visible within distances of 2.3 miles (3.7 km). WTGs located within the perimeter of the area of the proposed action would be equipped with ATON lights of lower intensity, visible between approximately 0.29 and 0.58 miles (0.4

and 0.9 km). This lower intensity lighting is adequate to allow a vessel within the area of the proposed action to navigate from WTG to WTG, a maximum distance of 0.63 miles (1 km). Lights would flash at a frequency of 20 flashes per minute (FPM). A description of navigational lighting is provided in the Visual Section in Section 5.3.3.4.

5.1.5.9 Monopile Stability and Foundation Scour

The estimated impact to the seabed was calculated to determine plan areas of the scour ellipses around the WTGs based on the dimensions predicted in the ESS revised *Scour Report, 2005* (Report No. 4.1.1-5). The total estimated impact to the seabed by the rock armor scour protection for all 130 WTGs is approximately 47.4 acres (0.19 km^2). If scour control mats are utilized the total estimated impact is approximately 2.4 acres (9712 m^2).

5.1.5.10 WTG Blades in Motion

While in motion, the blades of the WTG have the potential to increase the risk of collision to birds. Refer to Sections 4.2.4.3 and 4.2.4.4 for further information. In addition, the rotating blades have the potential to contact the mast of any sailing vessels or superstructure of any large vessel that exceeds a height off the water of about 75 ft (22.9 m). However, given the water depths throughout much of the proposed action, vessels of this size are unlikely to transit through the proposed action. Navigation charts would be appropriately labeled to indicate the potential hazards associated with navigation within the area of the proposed action, so the probability of this occurrence is remote.

Under specific weather conditions, ice could theoretically form on the blades, and then become detached, striking vessels navigating under the area occupied by the blades. Because the WTGs have vibration sensors, it is likely that the automatic shutdown mechanism would be activated under ice formation, which would reduce the potential for flying ice to extend further than the rotor diameter. Since this is likely to be an infrequent occurrence it is discussed more in Section 5.2.2.3.

Blade throws are a potential danger as well. Turbine blades could become loose and fall off. Possible types of blade throws include root connection failure; partial failure from lightning; failure at outboard aerodynamic device; tower strike; partial failure due to defect; or extreme load buckling. Potential causes include unforeseen events out of the design envelope; failure of control system; human error; incorrect design for fatigue or ultimate loads; or poor manufacturing quality. The probability of a turbine blade throw is one-in-ten-thousand (10^{-4}) per year (Larwood, 2005). This study did not analyze the probability of impact of mobile targets; however, the likelihood of a mobile vessel sailing under the turbine at the time of a blade throw is even less.

5.1.5.11 Monopiles as Fish Attracting Devices (FAD)

The WTG monopile foundations and ESP piles may attract fish and fouling organisms, thereby acting as 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 fish 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, 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 area of the proposed action or to Nantucket Sound. Although 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, this new substrate is not favorable for colonization or reef formation due to its low complexity and rugosity (the steel material used has much lower surface roughness than comparable wood or concrete structures) (CARPG, 1998). As a result of this and along with the WTGs within the area of the proposed action being spaced approximately 0.39 by 0.63 (629 by 1,000 m) apart, the overall environment and fish species composition in the area of the proposed action is not predicted to substantially change from pre-proposed action conditions.

Should the monopiles function as FADs, a secondary affect could be realized, namely, the creation of both recreational diving and fishing opportunities. Given the general lack of offshore hard structure reefs within the relatively protected waters of Nantucket Sound, combined with the proximity to many small ports, the WTGs could become target recreation locations.

5.1.6 Proposed Action Decommissioning

5.1.6.1 Discharges to the Sea

Discharges to the sea resulting from decommissioning activities are associated with the operation of vessels performing the work, and as such are discussed in Section 5.1.1. No discharges of wastewater or liquids are anticipated to occur from the WTGs or ESP during the decommissioning process.

5.1.6.2 Bottom Disturbances and Anchoring

As with the proposed action construction, decommissioning activities would require the same kinds of vessels, resulting in similar types of bottom disturbances and anchoring as are discussed in Sections 5.1.1.1.9 and 5.1.4.7. Once the proposed action is decommissioned, there would no longer be any bottom disturbances resulting from the former facilities.

5.1.6.3 Sea Bed Site Clearance

The applicant has committed to removing offshore cables installed in the seabed, as well as the removal of piles to a depth of approximately 15 ft (4.6 m) below the natural sea bottom elevation. To the extent that scour control mats can be retrieved they would be, but depending upon how buried they are and the extent of deterioration, they may fall apart during removal with remnant fragments remaining commingled with sediments. Based on the decommissioning plans, the areas occupied by offshore cables would be cleared of proposed action materials, and each of the monopiles and the ESP, no aboveground materials would remain, other than the potential for a small amount of bottom debris that is too small to detect and recover, such as nuts and bolts, short pieces of wiring, etc.

Once the tower has been removed during decommissioning, the sediments inside the monopile would be suctioned out to a depth of approximately 15 ft (4.6 m) below the existing seabottom in order to allow access for cutting of the pile in preparation for its removal. The sediments would be pumped from the monopile and stored on a barge. Prior to the removal of the cut pile any adjacent scour protection (either scour mats or rock armor) would be removed. Armor stones would be removed using a clamshell dredge or similar equipment, placed on a barge, and disposed of at an upland location. Once the scour control has been removed, the pile would be cut from the inside and placed on a barge for removal. The assembly may be cut into pieces depending on the capacity of the crane available. The sediments from inside the monopile would be returned to the excavated pile site using the vacuum pump and diver assisted hoses in order to minimize sediment disturbance and turbidity.

It should be noted that any environmental impacts related to the removal of the armor stones would be avoided by leaving the rock armor in place following the removal of the WTG foundations. Over the operational lifespan of the proposed action it is possible that regulatory changes may allow for minimizing environmental impacts by leaving scour protection in place. However, if current regulations remain in effect and require the removal of the armor stones it can be expected that environmental impacts related to the removal of the stones would include temporary and localized impacts to benthics, sediments, fish, marine mammals, and navigation similar to those expected during offshore cables installation and/or decommissioning. It is estimated that removal of the rock armor stones would take approximately one half day per WTG site. The armor stones would be re-used at an off-site location (to be determined) pending all necessary approvals.

5.1.6.4 Floating Trash and Debris

As with most construction/removal activities that occur in the ocean or along the shoreline, the decommissioning of the proposed action has the potential to create floating trash and debris. Given the de-assembly nature of the decommissioning and lack of on-site fabrication that would require more destructive means of removal, the proposed action does not have the potential to create much in the way of floating material during decommissioning activities. Once the proposed action is decommissioned, there are no incidental materials that might unintentionally be left on site that have the potential to float.

5.1.6.5 Air Emissions

Air emissions during decommissioning would result from the operation of the construction equipment and vessels. For the period of decommissioning activities, air emissions of the combustion by-products of diesel fuel and gasoline would be increased in the local area over those occurring during operations, similar to those discussed in Section 5.1.1 for the construction period. Once the proposed action is decommissioned, there would be no air emissions resulting from the former proposed action.

5.1.6.6 Visual Aesthetics

Decommissioning consists of removing the proposed action's visual elements WTGs thereby removing any visual impacts to receptors within the proposed action’s APE and returning the seascape to pre-existing conditions.

During the actual decommissioning process, there would be an increase in vessel activity compared to the operational timeframe, including nighttime lighting of work vessels that would alter the visual aesthetics. This would be a temporary situation.

5.1.6.7 Noise and Vibration

Similar to, but to a lesser extent, decommissioning activities would result in a temporary increase in the amount of noise and vibration. The noise and vibration would primarily be associated with the operation of vessels and equipment involved in the decommissioning, and once all proposed action facilities are removed or decommissioned in place, there would be no noise or vibrations associated with the former proposed action. The biggest difference between construction and decommissioning noise and vibration is that during decommissioning there would be no pile driving noise, which avoids the higher intensity sound levels associated with pneumatic and vibratory pile driving.

5.1.6.8 Navigation Lights or Beacons

As with the construction timeframe, during decommissioning there would be a temporary increase in the amount of lighting present within the area of the proposed action in association with decommissioning work vessels, such as derrick barges. Once all proposed action structures are removed, all lighting would be removed and the area would become similar to pre-proposed action conditions.

5.1.6.9 Essential Fish Habitat Degradation With Monopile and Cable Removal

Several fish species within the site of the proposed action and other shoals in Nantucket Sound may be attracted to the monopiles in some or all of their life history stages, and thus may benefit from the presence of the monopiles even though the smooth steel monopile design minimizes opportunities for benthic organism colonization or fish habitat creation. These species include Atlantic cod, black sea bass, cunner, tautog, and scup. However, because the proposed action is not predicted to substantially change the overall environment and fish species composition in the area of the proposed action, it is also predicted that the impacts of removing the WTGs would be minor.

5.1.6.10 Restoration of Outer Continental Shelf Space

The 130 WTGs, the ESP, 115 kV offshore transmission cable system, 33 kV inner-array cables, and associated scour control devices (rock armoring) require approximately 115 acres of submerged land within Nantucket Sound. Therefore, after the decommissioning process is complete, 115 acres of OCS space would be restored.

5.1.6.11 Restoration of Aviation Space

As the WTGs and ESP are removed from Horseshoe Shoal, the airspace formerly occupied by these structures would become restored to pre-proposed action conditions, and any restrictions or hazards associated with flying within the area of the proposed action would be removed.

5.1.7 On-shore Impact Producing Factors

From the landfall at the end of New Hampshire Avenue in the Town of Yarmouth, an approximate 4.0-mile (6.4 km)-long onshore 115 kV transmission cable system would be installed in an underground conduit system within existing roadways until it intersects the existing NSTAR Electric ROW at Willow Street in Yarmouth. From this point, the onshore transmission cable system would proceed west and south for approximately 1.9 miles (3.1 km), in an underground conduit system, along the existing NSTAR Electric ROW to the Barnstable Switching Station. Impact producing factors associated with the onshore transmission cable installation, operation, and decommissioning are described below.

5.1.7.1 Transmission Cable Installation

Construction of the onshore 115 kV transmission cable system would first include installation of ductbanks, conduits, and vaults and then installation of the onshore 115 kV transmission cable system. Construction of the onshore cable system would follow a set of sequential operations including vegetation removal, trenching, and backfilling. The entire process would be coordinated in such a manner as to minimize the total time a parcel of land is disturbed and therefore exposed to erosion and temporarily precluded from normal use.

5.1.7.1.1 Vegetation Removal

Clearing and grading along the roadways and existing NSTAR Electric ROW would remove trees, large rocks, brush, and roots from the construction work area and level the surface of the ROW across its width to allow operation of construction equipment. Trees would only be removed when necessary for construction purposes. Timber and other vegetative debris may be chipped for use as erosion-control mulch, burned, cut and stacked along the ROW, or otherwise disposed of in accordance with applicable regulations. Burning of brush would be conducted in such a manner as to minimize fire hazard and prevent heat damage to surrounding vegetation.

The degree of impact on vegetation would depend on the type and amount of vegetation affected, the rate at which vegetation would regenerate after construction, and the frequency of vegetation maintenance conducted on the ROW during onshore transmission cable system operation. Clearing of trees would result in long term and permanent impacts to these vegetation communities given the length of time needed for the community to mature to pre-construction conditions. All trees within the permanent ROW would be permanently removed and prevented from reestablishing through the periodic mowing and brush clearing required for onshore transmission cable system operation. The cutting, clearing, and/or removal of existing vegetation would also affect wildlife by reducing the amount of available habitat. The degree of impact would depend on the type of habitat affected and the rate at which vegetation regenerates after construction. To minimize impacts on vegetation within the construction and permanent ROWs and to improve the probability of successful revegetation of disturbed areas, the ROW would be managed incompliance with NSTAR's vegetation management plan.

5.1.7.1.2 Sedimentation and Erosion

Construction activities associated with the onshore transmission cable system including clearing, grading, trench excavation, backfilling, heavy equipment traffic, and restoration along the construction ROW may result in adverse impacts on soil resources. Clearing removes the protective vegetative cover and exposes soil to the effects of wind, sun, and precipitation, which could potentially increase soil erosion and the transport of sediment to sensitive areas (i.e., wetlands and waterways). Grading and equipment traffic can compact soil, reducing porosity and percolation rates, which can result in increase runoff potential.

Temporary erosion control measures such as sediment barriers (silt fences) would be installed during the clearing and grading phase. After onshore transmission cable system installation, temporary erosion control measures would be regularly inspected and maintained throughout the duration of construction or until permanent erosion control measures are installed and the temporary measures are no longer needed.

5.1.7.1.3 Trenching and Soil Disturbance

A combination of trackhoes, backhoes, trenching machines, and mechanical rippers would be used to excavate the onshore transmission cable system trench. Little, if any, blasting is anticipated; however, any necessary blasting would be conducted in accordance with all applicable laws and company standards. Where rock substrates are found, the rock would either be segregated during trenching or during backfill activities using segregating machines. In residential areas, subsoil and rock would be stockpiled separately from topsoil. After the ductbanks, conduits, and vaults are lowered into the trench and the 115 kV transmission cable system is installed, the trench would be backfilled. Previously excavated materials would be pushed back into the trench using bladed equipment, backhoes, or auger type backfilling machines. Following backfilling, a small crown of material may be left to account for any future soil settling that might occur over the trench.

As described above, onshore transmission cable system construction activities along the construction ROW, including trenching, may result in adverse impacts on soil resources. Impacts to terrestrial wildlife resulting from construction activities would be short-term and minimal because most terrestrial species are reasonably mobile and are expected to temporarily relocate to similar adjacent habitats during construction activities. Some smaller, less mobile wildlife, such as small mammals, amphibians and reptiles, would likely experience direct mortality during clearing, grading, and trenching activities. Impacts to wildlife resources would be minimized through restoration of the ROW and much of the area affected by construction would be allowed to revert to pre-construction conditions following construction.

5.1.7.1.4 Noise and Vibration

Construction activity and associated noise and vibration levels would vary depending on the phase of construction in progress at any one time. These construction phases include site grading, clearing/grubbing, trenching, installation, etc. The highest level of construction noise and vibration is assumed to occur during earth work; however, these effects would be short-term and limited to the duration of construction. Since nighttime construction is not proposed there would be no alteration of nighttime ambient noise quality along the onshore transmission ROW route.

5.1.7.1.5 Air Emissions

Construction impacts on air quality are mainly due to potential fugitive dust released during construction activities. Proper maintenance of construction equipment, watering of the construction sites for fugitive dust control, if necessary, and minimizing soil disturbances to areas necessary for construction are measure that would be implemented to minimize impacts in air quality during construction. In addition, because the construction equipment would only be operated on an as-needed basis and only during daylight hours, the emissions resulting from the operation of construction equipment should be further minimized.

Open burning during construction activities also has the potential to impact air quality. If required, open burning would be regulated through the local permitting processes. Any necessary local open burning permits would be obtained prior to conducting such activities and the local open burning ordinances would be followed during such activities. Emissions from construction-related activities would not significantly affect local or regional air quality and would not cause nor contribute to an exceedance of the ambient air quality standards.

5.1.7.1.6 Dewatering Discharges

After the ductbanks, conduits, and vaults have been inspected and approved, they would be lowered into the trench using side-boom tractors and/or backhoes. Prior to lowering-in, the trench would be inspected to ensure that all foreign material has been removed. Trench dewatering may be necessary at certain times during the lowering-in process. Any trench dewatering would be accomplished in a manner designed to prevent heavily silt-laden water from flowing into wetlands or waterways.

5.1.7.1.7 Traffic Management

Construction of the onshore transmission cable system across major paved roadways, railroads, and unpaved roads where traffic cannot be interrupted would be accomplished by boring under the roadbed. Most smaller, unpaved roads and drives would be crossed by open trenching and then restored to pre-construction or better condition. If an open-cut road requires extensive construction time, provisions would be made for detours or other measures to permit traffic flow during construction. Consultations with landowners would be conducted to determine the best way to cross privately owned roads. All road damage caused by construction of the onshore transmission cable system would be repaired. The onshore transmission cable system would be buried to the depth required by applicable road crossing requirements and would be designed to withstand anticipated external loadings. Railroad crossings would be installed (typically using a bore) in accordance with the requirements of the railroad.

5.1.7.2 Transmission Cable Operation

5.1.7.2.1 Vegetation Maintenance

Routine vegetation maintenance clearing could occur within the existing permanent ROW no more than once every three years. However, to facilitate surveys, a corridor no more than 10 ft (3 m) wide centered on the onshore transmission cable system could be maintained by mowing or a similar means on an annual basis, in accordance with NSTAR's vegetation management plan.

5.1.7.2.2 Electro Magnetic Fields (EMF)

For electrical cables, EMF would be highest adjacent to the cable and 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 penetrate most materials.

Humans are exposed to a wide variety of natural and man-made electric and magnetic fields from sources including natural fields and overhead transmission and distribution lines. Electric and magnetic fields from different sources may partially cancel or be additive at a given location. A number of epidemiologic studies have reported a small degree of association between measures of EMF and several diseases (e.g., childhood leukemia) while 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.

Terrestrial animals (e.g., birds and honeybees) likely use the earth's DC magnetic field for orientation, navigation and migration. Aside from orientation and navigation, other potential effects of low-frequency EMF on ecological systems have been investigated, but the findings have been uncertain and there is no consistent evidence to establish an adverse-effect level.

Because the electric field of the onshore transmission cable system would be contained within the body of each cable, by its grounded metallic shield, the addition of the onshore transmission cable system would not change electric field levels. The electric field within the existing NSTAR Electric ROW would be effectively contained within the body of each underground onshore transmission cable system by its grounded metallic shield. No external electric field would be produced. Upon completion of the onshore transmission cable system the electric fields within the existing NSTAR Electric ROW are expected to be approximately the same as the existing condition, due primarily to the presence of the existing overhead 115 kV lines.

5.1.7.3 Transmission Cable Decommissioning

Decommissioning of the onshore transmission cable system components would be a reverse process of the construction activities and would include leaving in place the conduits, ductbanks and underground vaults beneath the roadways and the existing NSTAR Electric ROW.

During decommissioning, the onshore transmission cable system would be disconnected and pulled out of the underground conduit system. The onshore transmission cable system would be reeled and the reels would be transported to the staging area for further handling. It is expected that all material from the onshore transmission cable system would be reused via recycling.

5.2 IMPACT-PRODUCING FACTORS – NON-ROUTINE CONDITIONS

5.2.1 Maintenance or Construction Vessels and Crew Boats

5.2.1.1 Oil or Fuel Spills

Oil is a mixture of different hydrocarbon compounds that begin reacting with the environment immediately upon being spilled. Once spilled, oil begins to spread out on the water surface. A number of processes alter the chemical and physical characteristics of the original hydrocarbon mixture, which results in the original mass spilled being partitioned to the sea surface, the atmosphere, the water column, and the bottom sediments. Weathering, the type and amount of cleanup, and the existing meteorological and oceanographic conditions determine the length of time that the slick remains on the surface of the water, as well as the characteristics of the oil at the time of contact with a particular resource.

Oil and fuel spills have the potential to adversely affect a number of resources within Nantucket Sound, including but not limited to birds such as sea ducks, gulls, cormorants; water quality through the release of toxic byproducts; benthos as some of the spilled hydrocarbons may congeal into tar balls and sink to the seafloor; intertidal habitats such as beaches and mud flats; and marine mammals and sea turtles.

5.2.1.2 Vessel Collisions

Vessel collisions during any phase of the proposed action are a remote possibility, particularly given that proposed action vessels are unlikely to be operating during any phase under poor weather conditions, when risk of collision is greatest. However, engine or steerage failure could occur on any vessel at any time. Given that most vessels employed during construction and decommissioning would be moving slowly, less than 10 knots (5.1 m/s), the risk of collision is further minimized. Smaller crew and supply boats may travel at speeds up to 20 knots (10.3 m/s), but these vessels do not have the same momentum and are easier to bring to an emergency stop. Vessels operating during maintenance activities would generally be similar to the smaller crew and supply boats used during construction, and only when necessary to remove a generator, rotors or other large components in the nacelle would a derrick crane barge be used during operations.

The risk of a vessel colliding with a WTG is low, given the proposed action's location away from typical vessel routes, the small diameter of the towers (approximately 16.75 ft and 18 ft (5.1 m and 5.5 m) 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 to 18 ft [4.9 to 5.5 m] 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 72 ft (21.9 m) above MHW, and approximately 23 ft (7.0 m) from the WTG tower. Therefore, vessels with mast or structure heights less than 72 ft (21.9 m) would pass under the WTG blade should they get within 23 ft (7.0 m) of the WTG.

The location of the site of the proposed action 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 possibility for damage in the unlikely event of a collision was studied, as presented in Report No. 5.2.1-1.

5.2.1.3 Cable Repair

The potential for a fault occurring during the operational lifetime of a buried offshore cable systems is minimal, based on industry experience. Impacts associated with a cable repair would result from temporary turbidity and some deposition of sediments during the repair process. Specifically, turbidity would be caused by the jetting of sediments to uncover the damaged portion of the cable, hoisting of the cable after it is cut, laying the cable back down, and then jetting of sediments after the repaired cable is placed back into the seabed. Cable repair procedures are discussed in Section 2.4.6.

5.2.2 WTG in Operation

5.2.2.1 WTG and Electric Service Platform Fluid Spills

The oil storage components of the ESP consist of four 115 kV power transformers. The 115 kV power transformers contain 10,000 gallons each of dielectric cooling oil (40,000 gallons total). In the unlikely event that an oil spill was to occur, the oil is most likely to travel toward the south shore of Cape

Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent). It has a 90 percent chance of impacting the shoreline somewhere. The directions of the potential spill movement in the winter and fall are more variable than in the spring and summer, with the spills equally likely to impact Cape Cod, Martha's Vineyard, or Nantucket. Martha's Vineyard has the highest likelihood of impacts from spills in the spring due to prevailing wind directions from the north and east. The south shore of Cape Cod has the highest likelihood of impacts during the spring and summer due to prevailing winds from the south and west, while the likelihood of impacts to Nantucket at all times of the year are far less (<10 percent). Refer to Report No. 4.1.3-1 for further information.

In addition to the materials stored in the ESP, the turbines would house certain system components within the nacelle that contain smaller amounts of lubricants and cooling fluid. Total oil storage at each WTG is expected to be approximately 214 gallons at any given time (27,820 gallons for all 130 WTGs). The expected oil storage components are the drive train main bearing containing 19 gallons of Mobil SCH 632; the drive train main gear box containing 140 gallons of optimal synthetic A320; the drive train cooling system which holds 21 gallons of optimal synthetic A320; the hydraulic system brake and hydraulic system rotor lock that use 2 gallons and 19 gallons of Mobil DTE 25, respectively; the hydraulic crane cylinder containing 5 gallons of ATF 66; the yaw system, two pitch systems which contain 7 gallons of Mobil SHC 630, 0.25 gallons Mobil SHC XMP 220, and 1 gallon Mobil SHC XMP 460, respectively. The worst case scenario for a single incident is 42,000 gallons from the ESP; however, given the controls in place, this is an unlikely scenario. According to the Oil Spill Probability Analysis (Report No. 5.2.1-1), the estimated number of spills from both the ESP and WTGs over five, ten, and thirty years of operation are 0.31, 0.62, and 1.862, respectively. Furthermore, the analysis shows that only 7 percent of all spills expected in Nantucket Sound during a 30 year period could be attributed to the addition of the proposed action facility. Also, the fluids used in the WTGs and service platforms are easily dispersible (often on their own) and would typically float on the surface.

Oil and fuel spills have the potential to adversely affect a number of resources within Nantucket Sound, including but not limited to birds such as sea ducks, gulls, cormorants, water quality through the release of toxic byproducts, benthos as some of the spilled hydrocarbons may congeal into tar balls and sink to the seafloor, intertidal habitats such as beaches and mud flats, and marine mammals and sea turtles.

5.2.2.2 Monopile Collapse

Given the relatively sheltered nature of Horseshoe Shoal, compared to an open coastline setting, the probability of monopile collapse due to ocean conditions is remote. The proposed action has been designed with a margin of safety to allow for the conditions anticipated during the proposed action's lifespan. Similarly, the magnitude and frequency of seismic events likely to occur within Nantucket Sound are unlikely to result in monopile collapse, either from fluidization of sediments or stress on the structure resulting from ground motion.

5.2.2.3 Wind Turbine Generator and Ice Build Up and Safety

Although rotor blades would have a slick surface for aerodynamic efficiency, which would 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 proposed action maintenance staff or others from falling ice. Conditions conducive to icing would be evaluated by continuous monitoring of meteorological conditions and by monitoring the WTGs remotely (via camera). If conditions warrant, manual shutdown of the WTGs experiencing icing conditions would be initiated. The ice would remain attached until meteorological conditions allow it to melt. If the WTG is no longer operating due to icing, the melting ice would 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 would work to break them into much smaller fragments as they fall.

5.2.3 Electrical Service Platform

5.2.3.1 Oil or Fuel Spills

Because the ESP would contain 40,000 gallons of dielectric cooling oil, there is the potential for a spill of some or all of this material into the waters of Nantucket Sound. A model was created to anticipate the full release of 40,000 gallons of fluid oil from the ESP which would represent a worse case scenario; more information on the inputs used to run the model are provided in Report No. 5.2.1-1. If an oil spill were to occur, the model results indicate that oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent), it has a large probability of impacting the shoreline somewhere (>90 percent), the directions of spill movement in the winter and fall spills are more variable than in the summer and spring, with the spills equally likely to impact Cape Cod, Martha's Vineyard, or Nantucket, Martha's Vineyard has the highest likelihood of impacts from spills in the spring due to prevailing wind directions from the north and east, the south shore of Cape Cod has the highest likelihood of impacts during the spring and summer due to prevailing wind directions from the south and west, and the likelihood of impacts to Nantucket is always small (<10 percent).

In addition, during construction and decommissioning there would be an increased number of vessels operating around Horseshoe Shoal, which leads to a potential increase in vessel collisions. Depending upon the severity of such a collision, and the type of vessels involved, oil or fuel could be released.

As described Section 2.4.3 of the FEIR for the Cape Wind Project, during the 20-year operational life of the proposed action there would be boats or other motorized floating vessels used to support and perform ongoing maintenance activities.

The vessels used during the operating life of the proposed action would carry a variety of liquids. The crew transport, maintenance support vessels and the special duty supply vessel would be carrying sufficient diesel fuel to move back and forth from port as well as operate for an entire day with some additional capacity for contingency. These vessels may also carry some supplementary diesel fuel and gasoline for use in powered equipment that may be used during maintenance activities. The smaller boat used for crew movement would be gasoline powered and have sufficient gas on board to run for more than an entire day.

Other liquids to be carried would include machine oils and lubricants that would be used both for proposed action generating equipment and, as necessary, for the powered equipment used for maintenance activities. Paints and paint thinners would be transported and used in quantities appropriate for the periods of the touch-up or repainting of the proposed action's components warranted by aging over the lifetime of the operations. Antifreeze and water necessary for equipment and vessel maintenance would also be carried. Drinking water for the maintenance crews would also be carried on crew transport and movement boats.

While not expected, collisions or other failures of the vessels used during the proposed action's operations could cause the release of some or all of these fluids. In order to minimize the potential adverse impacts that may be caused by the release of these fluids, Cape Wind would address the liquids carried on work and crew vessels in its OSRP prior to the start of operations (see Table 5.2.3-1 for a list of vessels and use frequency).

The accidental release of oil or fuel may also occur during construction and decommissioning as a result of refueling operations that occur on the water. For instance, jack up or spud barges as well as the cable jetting vessel would not return to port to refuel, but would rather be serviced by a supply or fuel supply vessel, that would transfer fuel while the vessels are on station. This is a normal operation performed during offshore construction activities, and adequate safeguards should be in place to minimize the potential for accidental release, as well as to minimize the affects, should a release occur. Such safeguards include an OSRP and an Emergency Response Plan (ERP). Each of these safeguards, as well as others, is discussed in more detail in Section 9.3.2.

Oil and fuel spills have the potential to adversely affect a number of resources within Nantucket Sound, including but not limited to birds such as sea ducks, gulls, cormorants, water quality through the release of toxic byproducts, benthos as some of the spilled hydrocarbons may congeal into tar balls and sink to the seafloor, intertidal habitats such as beaches and mud flats, and marine mammals and sea turtles. A discussion on potential impacts to wildlife within the area of the proposed action can be found in Appendix C, which provides information on T&E species and potential effects to T&E species. The spill probability for the proposed action has been broken down for transiting vessels and the WTG Array/ESP over a thirty-year period by spill volume. The probability of a one gallon spill occurring from transiting vessels over thirty years is 90 percent, whereas the probability of a spill of 2,106 gallons occurring over that same period from transiting vessels is one percent. Likewise, there is a 90 percent probability of a spill of 50 gallons occurring from the operation of the WTG/ESP and a one percent probability of a spill of 10,198 gallons occurring from the WTG/ESP over thirty years (Report No. 5.2.1-1).

Given the relatively sheltered nature of Horseshoe shoal, compared to an open coastline setting, the probability of ESP collapse due to ocean conditions is remote. The proposed action has been designed with a margin of safety to allow for the conditions anticipated during the proposed action's lifespan. Similarly, the magnitude and frequency of seismic events likely to occur within Nantucket Sound are unlikely to result in ESP collapse, either from fluidization of sediments or stress on the structure resulting from ground motion.

5.2.4 Electrical Transmission Cables

5.2.4.1 Snagging or Severance

While the design of the electric cable systems, both inner-array and the offshore transmission cable systems, are intended to adequately bury the cables to a depth where they would not become exposed or be located at a depth below the seabed surface where they could be snagged by anchors or mobile fishing gear, as described in the geology section, there are parts of Nantucket Sound where sand waves reveal the mobility of bottom sediments. In the event that a section of cable no longer remains at the design depth in the sediments, it is possible that an anchor or mobile fishing gear may snag the cable. It is possible that the results of a snagging may be no damage to the cable, damage to the cable but not loss of service, or sufficient damage as to make the cable inoperable. Since the cables would be marked on navigation charts with appropriate warnings, snagging of the cables is considered a remote occurrence.

Even more remote is the possibility that some future activity may occur over a cable that results in the cable being severed. Future placement of other utilities in Nantucket Sound would need to be sited and designed to either avoid the cables or cross them in a manner that avoids snagging or severing them. Future sand mining or dredging, if not properly located relative to the proposed action cables could result in snagging or severance of cables. There are several protective layers around the core of the cable, and the cable would have to be very stressed in order to be severed. Depending upon the circumstances, snagging of the cable may result in it being pulled out of the sediment for a short section and left on the seafloor surface until repair or reburial can occur.

In the event of cable snagging or severance, repair equipment would be mobilized to repair the cable and re-bury it. These activities would result in short term and localized sediment disturbance that could affect benthos and water quality.

5.2.4.2 Exhumation

It is anticipated that the uncovering of the offshore cables due to natural processes is unlikely due to the minimum 6 ft burial depth below present bottom and because it would be inspected periodically to ensure adequate coverage is maintained. If problem areas are discovered, the offshore cables would be reburied. To rebury an exposed section of cable, a jetting vessel would be deployed and the cable re-jetted to a target depth of 6 ft (1.8 m). These activities would result in short term and localized sediment disturbance that could affect benthos and water quality.

5.2.4.3 On Land Cable Damage or Severance

The electric transmission cable on land could be damaged or severed due to the actions of others, particularly if they fail to use Dig Safe during activities that involve excavation near the cable. The use of duct banks reduces the potential for damage as the concrete provides some protection for the cables. If the cables were to be damaged or severed, repair might include the need to expose the duct bank in that section, perform the repair, and then backfill and restore the area. If the repair is required along the NSTAR transmission line segment, then minor vegetation clearing may be required, and wildlife would be temporarily displaced from the location due to the construction activity and noise. If the repair is required along the street segment, then traffic may need to be re-routed and nearby residents would experience temporary noise and construction dust.

5.3 IMPACTS ON PHYSICAL, BIOLOGICAL, SOCIOECONOMIC, AND HUMAN RESOURCES – PROPOSED ACTION

5.3.1 Physical Resources

5.3.1.1 Geology

5.3.1.1.1 Construction/Decommissioning Impacts

Description of Numerical Models and Engineering Analysis

Numerical models and engineering analysis of site specific data related to oceanographic processes were used to assess, simulate, and predict potential impacts to geologic resources for construction of the proposed action. Analyses performed were as follows:

Jet Plow Sediment Transport and Deposition

Simulations of sediment transport and deposition from jet plow embedment of the offshore transmission cable system and the inner-array cables were completed using two models, HYDROMAP to calculate currents and SSFATE to calculate suspended sediments in the water column and bottom deposition from the jet plow operations.

The SSFATE model was run for five offshore transmission cable system routes. One was a simulation of the jetting process to bury one of the 115 kV offshore transmission cable systems from the Yarmouth landfall in Lewis Bay to the ESP. Burial of four of the 33 kV inner-array cable routes from the ESP (Electric Service Platform) to their respective ends were also simulated. These four routes were chosen to be representative of the burial of the cable connecting the WTGs. The modeling and results are considered to be representative of sediment conditions throughout the area of the proposed action since they represent locations covering the range of water depths, wave conditions, currents, and sediment characteristics in the Horseshoe Shoal area.

The results of the analysis are discussed in the impact section and presented in Report No. 4.1.1-2.

Seabed Scar Recovery and Possible Cable Exposure

A slight depression, estimated to be between 0.5 and 2 ft (0.15 and 0.61 m) deep, is anticipated as a result of installation of the inner-array cables and the offshore transmission cable system. The applicant completed an evaluation to determine the seabed recovery time after jet plow installation of the offshore cable systems. Using the methodology of van Rijn (1993) to calculate bedload sediment flux on Horseshoe Shoal, estimated recovery rates for jetting scars along the cable routes were determined, and an analysis of the potential for localized scour was completed. The results of the analysis are discussed in the impacts section below and presented in Report No. 4.1.1-3.

Scour Analysis for Wind Turbine Generator Piles

Analysis of scour at the proposed WTGs was completed. Marine scouring methods developed by Sumer and Fresdoe (USACE, 2002) were used to predict the amount of scour based on wave, current, and sediment characteristics within the proposed turbine array. The analysis resulted in a predicted scour hole size at the wind turbine arrays that could be used to support scour mitigation analysis.

The results of the analysis are discussed in the impacts section and presented in Report No. 4.1.1-5.

Post-Lease Geological and Geophysical Sampling

Post-lease G&G investigations would be completed by the applicant to support final design. The sampling would include the following:

- Approximately 50 vibracores would be collected along the proposed 115 kV offshore transmission cable system routes (approximately 2 vibracores per mile [1.6 km]) and along the inner array 33 kV cable routes (1 vibracore approximately every 3 miles [4.8 km]). The diameter of the core barrel is approximately 4 inches (102 mm), and the cores are advanced up to a maximum of 15 ft (4.6 m). The vessel is anchored during coring.
- Approximately 20 borings would be advanced at selected WTG sites. The analytical program is designed to address liquefaction potential, gas concentrations in sediments, pressure regimes of gaseous sediments, and gas saturation versus shear strength properties of sediments. The borings would be advanced from a truck-mounted drill rig placed upon a jack-up barge that rests on spuds lowered to the seafloor. Each of the four spuds would be approximately 4 ft (1.2 m) in diameter. The barge would be towed from boring location to location by a tugboat. Borings generally can be advanced to the target depth (100 to 200 ft [30.5 to 61 m] depending on location) within 1 to 3 days, subject to weather and substrate conditions. Drive and wash drilling techniques would be used; the casing would be approximately 6 inches in diameter.

- CPT rig or an alternative subsurface evaluation technique (appropriate to site-specific conditions) would be used, as necessary, to evaluate subsurface sediment conditions. A CPT rig would be mounted on a jack-up barge similar to that used for the borings. The top of a CPT drill probe is typically up to 3 inches (76 mm) in diameter, with connecting rods less than 6 inches (152 mm) in diameter.

Detailed descriptions of the post-lease G&G investigation are presented in Section 2.0. Impacts to geological resources from G&G are expected to amount to temporary increases in turbidity and would be negligible.

Sediment Deposition and Transport

During installation of the inner-array cables and the offshore transmission system cables with a jet plow, some sediment would be mobilized and transported from the trench area by currents. Potential impacts to the sediment resource are the suspension and transport of sediments, formation of a seabed scar, and re-deposition of sediments at a distance away from the jet plow trackline, which would potentially include a sorting process whereby finer-grained sediments get transported and deposited at further distances.

In general, and assuming similar currents, the coarse sediments that predominate Horseshoe Shoal and Nantucket Sound would remain in suspension in the water column over a shorter duration than the finer-grained material found in Lewis Bay, and would not disperse as far. However, areas of higher currents could offset the differences in grain size/mass such that larger particles in higher currents may be transported distances equal to or farther than those of fine sediments in lower currents. At all locations along the offshore cables, the suspended sediment would return to the seabed.

An analysis was performed to estimate the amount of suspended sediment and subsequent deposition during the cable burial process. Two models were utilized for modeling, HYDROMAP for currents and SSFATE for suspended sediments in the water column during jetting operations. Parameters included the following:

- Water Depth: Due to the complex nature of Nantucket Sound bathymetry, the hydrodynamic model domain was extended to relatively deep waters (approximately 660 ft [201.2 m]) in the south and east directions, to Block Island in the west direction and the north end of Massachusetts Bay to the north.
- Current Speed and Direction: Three tidal stations, Woods Hole, Edgartown, and Nantucket were used for tidal constituents in the hydrodynamic model, which is used to drive the sediment transport model simulations.
- Sediment Characteristics: Sediment characteristics were based on actual samples collected from vibracores on Horseshoe Shoal and along the proposed 115 kV offshore transmission system cable route.
- Operational Details: The SSFATE model was used to simulate jetting operations for burial of representative cables in trenches. Assumptions based on the proposed action estimates and past studies included a trench cross section of 32 ft^2 (3.0 m^2), a trenching speed of 91 m/hr (300 ft/hr), and that 30 percent of the trench volume was injected into the water column.

For the offshore cable routes located in the coarse sediment of Nantucket Sound from Yarmouth to the ESP and the WTGs to the ESP, the modeling results indicated that re-deposition of sediment would occur within a few hundred yards of the cable route. A larger portion would be deposited adjacent to the cable route, with a thickness estimate of 0.8 to 1.8 inches (20 to 46 mm) and a thin veneer of finer-grained sediment would extend within a few hundred yards of the trench at 0.04 to 0.2 inches (1.0 to 5.0 mm) (Report No. 4.1.1-2).

As a result, a seabed scar would form. It is estimated that the seabed scars would be 6 ft (1.8 m) wide and 0.75 to 1.7 ft (0.23 to 0.52 m) deep. The seabed scars are anticipated to recover naturally, through normal sediment migration and deposition through the scar area, from tidal and storm events. Seabed scars are estimated to recover within days on Horseshoe Shoal, within 1 to 38 days along the cable route, and over many months or possible years until a major storm occurs within Lewis Bay (Report No. 4.1.1-3).

The impact to the geologic resource from re-deposition of sediment and the formation of the seabed scar during jetting operations for offshore cable installation are considered minor as the resource would recover completely without mitigation.

Placement of the monopiles would result in circular areas of the sediment on the seafloor being enclosed within the hollow monopile. This would result in a loss of available sediments to the environment, which would become available upon decommissioning.

The total surface area affected by monopiles is estimated at 0.67 acres (29,185 ft^2 [2,711 m^2]). The total estimated combined area of impacted seafloor by the inner-array cables and the offshore transmission cable system is 5.89 acres (256,568 ft^2 [23,836 m^2]). Accordingly, geological impacts as a result of land and seafloor occupation would be expected to be minor.

Impacts related to decommissioning of proposed action-related structures including wind turbine towers, foundations, scour control mats, the ESP, inner-array cables and offshore transmission cable system would result in temporary seafloor impacts and temporary re-suspension of bottom sediments.

During decommissioning, the scour mats would be removed by divers and a support vessel in a similar manner to installation, and this is expected to result in greater amounts of suspended sediments than levels associated with the original installation of the mats. It is anticipated that the sandy nature of the bottom material over most of the site of the proposed action would result in rapid settling of the suspended sediment material. Impacts to sediment from scour mat removal would be minor. In those locations where rock armoring has been used for scour protection, armor stones would be removed using a clamshell dredge or similar equipment and placed on a barge. It is estimated that removal of the rock armor stones would take approximately one half day per WTG site. The armor stones would be re-used at an off-site location (to be determined) pending all necessary approvals.

There would be no excavation around the outside of the monopile prior to the cutting, because the cutting would be done from inside the monopile following the removal of the sediments within the pile. Sediment removal to a depth of approximately 15 ft (4.6 m) below the seabottom would be accomplished hydraulic dredging/pumping with storage of the material on a barge. Once the cutting takes place, approximately 15 ft (4.6 m) below the mudline, the cut pile would be removed. Following the removal of the cut pile and any adjacent scour protection (either scour mats or rock armor) the sediments would be returned to the excavated pile site using the vacuum pump and diver assisted hoses in order to minimize sediment disturbance and turbidity. Impacts to geologic resources are considered minor for the proposed decommissioning activities.

Onshore

Transition from Lewis Bay

At the Lewis Bay landfall, a temporary sheet pile cofferdam is proposed to support HDD activities. The dredging of approximately 840 yd^3 (642 m^3) of sediments to an elevation of approximately -10 ft (-3 m) MLLW would be required. Following installation of the offshore cables, the cofferdam excavation would be backfilled with originally excavated material. The dredged backfill material would be supplemented with imported clean sandy backfill material to restore pre-construction contours, if necessary. Once the dredged area is restored, the sheet pile cofferdam would be removed from Lewis Bay.

To transition from the nearshore to onshore route, HDD techniques would be utilized. The HDD is a trenchless method that is an alternative to traditional open-cut cable installations. The result is very little disruption to surface activities and less working space requirements.

The HDD method involves drilling a small pilot hole, using technology that allows the drill to be steered and tracked from the surface. The pilot bore is launched from the surface at an angle between 8 and 20 degrees to the horizontal, and transitions to horizontal as the required depth is reached. A bore path of very gradual curvature or near-straight alignment is normally followed to minimize friction and to stay within the allowable joint deflection and the allowable curve radius for the pipe. This minimizes the chance of getting the pipeline “hung up” in the soil or damaging the pipe.

The pilot hole is enlarged (usually approximately 1.5 times the largest outside diameter of the new pipe) by pulling back increasingly larger reamers, or reaming heads, from the pipe insertion point to the rig side. After the pre-reams, the pulling head and connecting product pipe are attached to the reamer using a swivel, a device that isolates the product pipe from the rotation of the HDD drill pipe. The product pipe is then pulled behind the final reamer back through the HDD path to the exit pit on the rig side.

Drilling mud is normally utilized to lubricate the cutting head during the drilling operation and stabilize the reamed bore path prior to and during pull-back. Drilling mud is primarily a mixture of water and bentonite clay. Bentonite is a naturally occurring clay mineral that forms a mud when mixed with water. The applicant has proposed a formal monitoring program to monitor for drilling fluid release and a contingency plan to stop and cleanup an unexpected release of drilling mud to Lewis Bay.

The potential impact to geological resources during the HDD transition from offshore to onshore is considered minor.

Onshore Excavation

The installation of onshore cable vaults would result in the excavation and offsite disposition of some surficial material. It is likely that much of the excavated material would be suitable for re-use as fill with a local recycler.

Onshore transmission cable ROW easements may result in certain restrictions on the unconsolidated geologic resource, such as sand quarrying, though no existing quarrying activity was identified. Certain portions of the ROW are proposed along existing transportation and utility corridor routes, such as the first four miles (6.4 km) of the onshore route below existing roadways.

The potential impact to geological resources from the installation and operation of the on-land cable route would be negligible.

Conclusion

Overall, the construction and decommissioning impacts to geologic resources would be minor, as they would be temporary, and relatively localized in Nantucket Sound. The minor impacts are largely reversible following decommissioning. Onshore excavation is targeted for existing roadways and a utility ROW. The onshore impacts to geologic resources would be negligible.

5.3.1.1.2 Operational Impacts

Description of Numerical Models and Engineering Analysis

Numerical models and engineering analysis of site specific data related to oceanographic processes were used to assess, simulate, and predict potential impacts to geologic resources for operation of the proposed action. Individual analyses are presented below.

Effects of Wind Turbine Generator Piles in Nantucket Sound

The zone of influence of the WTG piles on currents, waves, and sediment transport was evaluated. The zone of influence experiences active sediment transport, dominated by the presence of coarse grain sediments and bedforms such as sand waves. The approach used was to assess the zone of influence of a single pile and then use the resultant information to evaluate the potential interaction of multiple piles to determine the cumulative zone of influence.

The results of the analysis are discussed below in the impacts section and presented in Report No. 4.1.1-4.

Scour Protection

Two scour mitigation methods were evaluated; scour mats and rock armor.

Two Seabed Scour Control Mats were installed on the SMDS' southwest batter pile in October 2003. No scour mats were installed on the SMDS' north and southeast batter piles to allow these piles to provide points of comparison for scour that occurred over time. In June 2005, an underwater inspection occurred to visually inspect the scour mats around the southwest batter pile and to compare the conditions at the other two unprotected SMDS piles with the protected pile. The presence of the scour mats enhanced the accumulation of sand around an installed pile suggesting the scour mats are effective at preventing scour around installed piles.

A conceptual rock armor design for scour protection was developed using methodologies presented in the Federal Highway Administration publication *Bridge Scour and Stream Instability Countermeasures – Experience, Selection, and Design Guidance* (FHWA NHI 01-003, March 2001) and the USACE engineering manual, *Coastal Engineering* (USACE, 2002). Using the same wave and current data as those used for the scour mat analysis, stone size and layer thickness were estimated for the environmental conditions anticipated.

The methods and results for this analysis are discussed in the impacts section and presented in Report No. 4.1.1-6, 4.1.1-7, and Report No. 4.1.1-8.

Cable Repair

In the event of a cable failure, the applicant would have a Cable Repair Plan in place to minimize or eliminate environmental impacts. The elements of the Cable Repair plan are detailed in Section 2.0.

Environmental impacts related to cable repair would include temporary and localized impacts to sediments and are expected to be similar to those during offshore cable installation and/or decommissioning, and would be dependent upon the amount and extent of cable damage and the duration that repair vessels are on site. The potential impact to geological resources from the repair of the cable offshore or on-land would be considered negligible.

Sediment Scour

Sediment scour would occur at the pile foundations for each WTG and the six 4 ft (1.2 m) diameter piles for the ESP, if mitigation measures are not employed. Sediment scour on piles in the marine environment is a result of the orbital motion of water produced by waves and currents and the resultant vortices produced as water flows past a pile. As water flows around a pile, the capacity of the local sediment transport system increases, sediment erosion occurs and a scour hole is formed. The sediment is suspended and transported away from the pile until the sediment transport system returns to equilibrium. At this point the sediment is deposited back to the seabed. This process would occur during the ebb and flood tides.

An analysis to predict scour factors and predicted scour depths and equilibrium conditions at the WTG and ESP was performed (Report No. 4.1.1-5). Site specific hydrographic surveys, physical analysis of sediment, and estimates of wave and current conditions across the site of the proposed action were inputs to scour prediction methods outlined by Sumer & Fredsoe in their 2002 publication titled *The Mechanics of Scour in the Marine Environment* and the USACE *Coastal Engineering Manual* (Sumer & Fredsoe, 2002; USACE, 2002). The methods and calculations described in these documents were used to create spreadsheets to predict the extent and depth of scour at each WTG location. The parameters used in the calculations included:

- Return period for wave events: 50 year;
- Wave height (locally generated average of highest 10^{th} of waves): 13.2 ft (4 m);
- Spectral peak period (locally generated waves): 6.2 seconds;
- Current speed: 8.35 ft (2.5 m/s (5.5 ft (1.7 m/s wind-generated plus 2.85 ft (0.9 m/s tidally generated);
- Current direction: not required for methodology used;
- Water depth: between 12 and 56 ft (3.6 and 17 m) (dependent on WTG location);
- Median sediment grain size: between 0.215 mm and 0.485 mm (dependent on WTG location and nearest vibracore sediment characteristics);
- WTG monopile diameter: 16.75 ft (5.1 m) or 18 ft (5.5 m) (dependent on water depth at WTG location);
- ESP pile diameter: 4 ft (1.2 m);
- Angle of internal friction for sediment: 27 degrees;
- Assumed angle for wake vortex shedding: 15 degrees;
- Slender pile regime used to estimate predicted scour depth if diffraction parameter (D/L) less than 0.1; and
- Large pile regime used to estimate predicted scour depth if diffraction parameter (D/L) greater than 0.1.

The predicted scour extent and depth presented are conservative estimates or a "worst case scenario" of the estimated maximum scour depth.

After reviewing trends and predictions on scour depth and distance at the 130 WTG locations, the 130 WTG locations were divided into two scour scenarios to develop a conceptual design for scour protection. A water depth of 40 ft (12.2 m) was selected as the dividing line between each scenario. At the WTG locations, the range of scour extent is predicted with widths of 42 to 45 ft (12.8 to 13.7 m), lengths of 88 to 94 ft (26.8 to 28.7 m), and depths of 13.7 to 14.7 ft (4.2 to 4.5 m) (Report No. 4.1.1-5). An illustration of this predicted scour extent at the monopiles, without scour protection, is presented in Figure 5.3.1-1.

At the ESP, six 4 ft piles are proposed, in a two by three layout, 75 ft (22.9 m) apart. The same methods used to predict the WTG scour were used for the ESP, with a known water depth of 28 ft (8.5 m). At the ESP location, the scour extent is predicted with a width of 18 ft (5.5 m), a length of 55 ft (16.8 m), and a depth of 9.2 ft (2.8 m) (Report No. 4.1.1-5). Due to the distance between the piles, the scour footprints are predicted to overlap in the absence of any mitigation measures. An illustration of this predicted scour extent at the ESP, without scour protection, is presented in Figure 5.3.1-2.

The applicant evaluated and has requested the use of two engineered scour mitigation methods, scour mats and rock armor. The specific type of engineered scour mitigation method proposed for each location has not been determined. Final consideration would be based on an assessment of potential environmental impact and scour performance. Long-term field monitoring of two types of scour mats are ongoing at the meteorological tower site. The multi-year pilot study is testing the effectiveness and durability of scour mats of different designs. Results would be incorporated in the final decision regarding which scour mitigation method is most effective and has the least environmental impact, and in the case of scour mats, which type is best for the particular application. More precise qualitative and quantitative evaluations are proposed for the final design process. Each method proposed, including information on the ongoing scour mat pilot study, is discussed below.

The scour mats proposed use synthetic fronds, made of buoyant polypropylene and polyester webbing designed to mimic seafloor vegetation. The fronds reduce particle velocity as suspended sediment passes over them. As the particle velocity decreases, sediment is deposited onto the scour mats. When they are attached to the bottom as a network, these synthetic fronds trap sediments and eventually become buried. The result of this sediment trapping mechanism forms a scour protection system that is of low bottom relief, similar to existing conditions.

The scour mats are placed on the seabed by a crane or davit onboard a support vessel. Final positioning is performed with the assistance of divers. To secure the scour mats to the seafloor, each scour mat section is fitted with pre-attached anchors spaced at regular intervals along the mat. The anchors are certified for 1 ton of anchor hold down capacity, with each providing 0.64 ton of hold down capacity per square meter of the mat. Additional anchors may be attached to the mats by divers. After the mat is placed on the bottom, divers use a hydraulic spigot gun fitted with an anchor drive spigot to drive the anchors into the seabed. As the mats are anchored, there is some possibility that there may be some movement of the scour control mats if the anchoring systems should become loosened.

In October 2003, two seabed scour control mats were installed on the sediment surface around one of the three piles of the SMDS. During installation, the two scour mats were positioned such that their long axes were nearly north/south on both sides of the pile. The southern, near-side corners were placed closer together than the northern, near-side corners. The observed currents were nearly perpendicular to the long axis of the mats. The fronds used in the scour mats were 4.1 ft (1.2 m) long. At the time of scour mat installation, a ratchet strap was placed on the three piles at a distance of 48 inches (1.2 m) above the present sand bottom for use during future monitoring. No scour mats were installed on the SMDS' north and southeast piles to provide control points without scour control.

In June 2005, an underwater inspection was performed to visually inspect the scour mats around the southwest batter pile and to compare the conditions at the other two unprotected SMDS piles with the protected pile. Approximately 12 inches (0.3 m) of sand accumulated over a 20 month period at the scour mat protected pile. At the unprotected pile, approximately 13 inches (0.33 m) of sand was scoured away from this pile over a 20 month period.

In May 2006, four additional Seabed Scour Control Systems (SSCS) scour mats were installed around the southeast pile. These additional scour mats are of a modified design in web materials, manufacturing processes, and various frond lengths. The existing conditions of the first two scour mats were surveyed. Sediment scour was observed at each of the three piles. Portions of the nylon webbing on the existing mats were exposed above the seabed. The fronds appear to have separated longitudinally into many fronds of smaller width, though they appeared firmly attached to the mat webbing. Measurements were again taken (similar to monitoring in June 2005, described above). The measurements indicate a net accretion of 12 inches (0.3 m) at the southwest pile, and a net scour of 7 inches (0.17 m) at the previously unprotected southeast pile (Report No. 4.1.1-8).

Rock armor (large hard rock boulders) has also been proposed. A filter layer immobilizes the sand and one or more layers of rocks, capable of withstanding the energy of currents and waves, are used to stabilize the filter layer and protect the seafloor around the piles from erosive forces. The boulders would be large enough to deter removal by current conditions and wave effects and small enough for prevention of removal of stone fill material that is placed beneath them.

The rock armor and filter layer material would be placed on the seabed using clamshell bucket or a chute. By lowering the material into the water and placing the material on the bottom rather than dumping it, more control over the placement of the material can be achieved. Sediment suspended during the installation of the rock armor material is expected to be more than that associated with the use of scour mats. It is anticipated that the dominant sandy seafloor sediment would result in rapid settling of the suspended sediment material, which would limit the extent of the impact of suspended sediments.

This would result in total scour protection area of 2,064,964 ft^2 (47.41 acres or 191,841 m^2) for all 130 wind turbine towers and 17,664 ft^2 (0.41 acre or 641 m^2) for the 6 ESP pilings. Thus, rock armor scour protection would alter approximately 0.3 percent of the site of the proposed action. The rock armor and filter material would be placed at elevations that were similar to pre-installation sea-bed elevations. It is anticipated the rock armor would not appreciably change the local seafloor topography, as this design would promote deposition of a sand/silt matrix in the interstices of the boulder framework with the eventual burial of all the rock armor. Tidal currents may expose portions of the rock armor for short periods of time, until the bi-directional currents lead to establishment of a dynamic equilibrium, allowing the average condition of the scour-protected zone to be buried by sand.

The proposed rock armor designs are based on three predicted scour conditions resulting from wave and current action, water depth, and diameter of the piles. The scenarios considered include (Report No. 4.1.1-6):

- **Scenario 1A (16.75 ft diameter WTGs; water depths 12 to 15 ft [3.7 to 4.6 m]):** Rock armor stones with a median weight of 125 lbs would extend 42 ft by 94 ft (12.8 by 28.7 m) from the WTG pile, four ft thick.

- **Scenario 1B (16.75 ft diameter WTG's & the ESP; water depths between 16 to 39 ft [4.8 to 11.8 m]):** Rock armor stones with a median weight of 50 lbs would extend 42 ft by 94 ft (12.8 by 28.7 m) from the WTG pile, three ft thick.
- **Scenario 2 (18 ft diameter WTG's; water depths between 39 and 56 ft [11.8 to 17.1 m]):** Rock armor stones with a median weight of 50 lbs would extend 45 ft by 88 ft (13.7 to 26.8 m) from the WTG pile, three feet thick.

The proposed rock armor design was reviewed against generally accepted methods along with the scour analysis parameters used for the modeled conditions to show that the design parameters in the Rock Armor Report were conservative when compared to observations from the SMDS and the hydrodynamic model predictions, and that the rock sizes would enable the scour protection to remain in place under the expected oceanographic conditions at the site of the proposed action (Report No. 4.1.1-7).

Scour protection would be installed around each foundation following the installation of the monopile. Some amount of scouring would take place around the pile prior to the scour mats or rock armoring being placed. Filter material, stones sized one-tenth the gradation and weight of the rock armor, would be placed on the bottom with a clam shell bucket to replace any scoured sediment and to help prevent the rock armor from sinking into the underlying material. In locations where monopiles are installed in sand waves and rock armoring is utilized, it is anticipated that the rock armoring would settle with the migration of the sand wave.

The impact to the seabed from sediment scour as a result of the pile foundation installation would be minor with the addition of the proposed scour controls.

Sand Waves

Sediment transport can be impacted by structures in a shallow marine environment as waves and current regimes create vortices that increase particle velocity at the seabed adjacent to a pile. This change in sediment transport at the seabed can result in scour around pilings. A site-specific study was completed to assess the effects of the WTGs on sediment transport and sand waves in Nantucket Sound.

The approach of the study followed those typically used to evaluate the effects of offshore structures. The key parameters in these analyses include the diffraction parameter, which indicates whether a wave would diffract behind a pile; and, the Keulagan-Carpenter (KC) number, which indicates whether flow around the pile would separate and shed vortices in the downstream direction. Since both parameters require wave length, analysis of one month (December, 2003) of wave data (wave height, wave period and water depth) was performed.

Diffraction effects were found to occur for 62 percent of the waves from the time series. However the largest diffraction occurred for waves with the smallest period with low induced bottom velocities. These waves cause insignificant sediment transport regardless of whether they diffract or not and so can be ignored. Larger waves, particularly ocean swells, are not affected by the presence of the piles (Report No. 4.1.1-4).

The calculation of the KC number, based on the wave data, found no value greater than 1.8, which is below the threshold for flow separation to occur. A potential flow analysis appropriate for this condition shows that the flow around the pile returns to within 89 percent of its undisturbed value within 1 pile diameter from the pile and to within 99 percent of its undisturbed value within 4 pile diameters. Using the same approach for the periodic tidal wave, a very long period shallow water wave, gave a large KC number over 5,000, indicating that vortex shedding would occur. The velocity defect created by this vortex street dissipates rapidly (Report No. 4.1.1-4).

Comparison to laboratory studies of multiple piles indicates that there is no anticipated wake interaction among the piles since interaction ceases when the piles are spaced greater than five pile diameters from each other and the spacing for this proposed action ranges from 120 to 190 pile diameters. There is no evidence that the piles would impact the migrating sand waves as a group and the impact to these migrating bedforms should be localized and minor, essentially associated with the area of scour protection at each pile. A diffraction effect occurred for waves with smaller periods that reduced sediment transport ability. Larger waves and ocean swells were not affected by the presence of a pile (Report No. 4.1.1.4).

The impact to the surficial geologic resource from the placement of piles is considered minor and would be reversible following decommissioning.

Potential impacts to the offshore cables from migrating sand waves and bedforms were evaluated. The evaluation considered the site-specific geophysical data collected for the area of the proposed action; existing data from other locations with migrating sand waves, and modeled migration estimates (see Section 5.3.1.3). It was concluded that with modeled bedform migration rates of 3.3 to 9.8 ft (1 to 3 m) per year, the potential for cable exposure on Horseshoe Shoal where migrating sand waves are located is possible within 6 to 18 years if no mitigation measures are undertaken (Report No. 4.1.1-3).

The results indicate that the seafloor may be impacted locally if the offshore cables, set approximately 6 ft (1.8 m) below the seabed, are exposed (Report No. 4.1.1-3). If the cable is exposed during sand wave migration, increased flow would occur above and below the cable, resulting in localized sediment scour. The applicant has proposed a periodic diver inspection and monitoring program to assess cable exposure and scour.

Because of the small area affected and the lack of interaction between WTGs, the potential impact to sandwaves and migrating bedforms is considered minor for the life of the proposed action and would be negligible following decommissioning.

Conclusion

Because of the small area affected and the lack of interaction between WTGs, the potential impact to sandwaves and migrating bedforms would be minor for the life of the proposed action and would be negligible following decommissioning. Mitigation being considered at this time includes sediment scour control and post-construction monitoring of sediment scour with periodic diver inspections and a monitoring program to assess cable exposure and scour developed by the design engineer. A more detailed discussion of mitigation is provided in Section 9.0.

5.3.1.2 Noise

Noise impacts generally fall into two categories: temporary impacts resulting from operation of construction equipment, and long-term or permanent impacts resulting from operation of the proposed action. Construction-related noise would result from offshore monopile pile driving and barge and ship engines. Onshore construction noise would be generated by HDD activities at Lewis Bay and installation of the cable system. Operational noise would be associated with the wind turbines themselves plus noise associated with the operation of maintenance vessels.

5.3.1.2.1 Construction/Decommissioning Impacts

Construction

Construction Impacts on Onshore Locations During Installation of Monopiles

The sound impacts during construction are associated with the installation of 130 16 to 18 ft (4.9 to 5.5 m) diameter monopiles (one for each WTG), installation of six smaller 4 ft (1.2 m) diameter piles for the ESP, and vessel traffic for transporting equipment, piles, and workers to the site. The jet plow embedment process for laying offshore 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. Monopile installation for all of the WTGs is anticipated to require approximately 8 months from start to finish, 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. Measured sound data from installation of similar sized piles at the Utgrunden Project were used in the acoustic modeling. Noise levels of pile driving at the Utgrunden Project revealed L_{max} sound levels of 177.8 dB at 1,640 ft (500 m) (see Section 2.3.1 in Report No. 4.1.2-1). The sound levels from monopile driving would depend on the distance from the receiver to the particular point in the proposed action 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).

Calculated pile driving sound levels for the onshore noise modeling locations are presented in Table 5.3.1-1, along with the range of measured existing L_{eq} sound levels. The data in this table indicate that for the vast majority of locations, pile driving noise would be below the minimum measured ambient levels, even with onshore winds, which would result in the highest pile driving noise. The only two locations where pile driving noise could at times be equal to or exceed minimum measured ambient conditions are at Point Gammon and Cape Poge. The maximum calculated pile driving sound level at any location is 41 dBA whereas the lowest ambient level measured is 35 dBA.

Any audible pile driving would be limited to brief periods and at only some locations. As such, minor noise impacts are anticipated at onshore locations due to pile driving during construction.

Post Lease G&G Investigation

The post lease G&G investigation would involve vibracores and drilling of bore holes to acquire subsurface geological information on the sea bottom. The vibracores would be accomplished via a small gasoline motor and the drilling of cores would be accomplished via a truck mounted drill rig on a barge. Both of these activities would be very short term, and these devices generate sound levels that are much lower than sound levels associated with pile driving. Sound levels from a small gasoline motor would be comparable to that associated with a small motorized boat. Sound levels from a truck mounted drill rig would be comparable to those on a small ship or large boat. These types of sounds occur regularly in the area. Thus noise impacts are expected to be negligible with respect to G&G activity.

Construction Impacts on Onshore Locations During Horizontal Directional Drilling (HDD) and Onshore Cable Laying

Elevated noise levels would occur in association with the need to conduct HDD for the borehole containing the offshore transmission cable system from Lewis Bay to the transition vault on nearby land and noise impacts associated with overland laying of cable from the transition vault to the Barnstable Switching Station. The HDD involves the use of a drilling rig, mud pump and crane, powered by diesel engines. 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 ft (15.2 m) from the equipment (HDD, excavator, backhoe) would hear sound levels (L_{eq}) in the range of 73 to 79 dBA, and at 200 ft (61 m) they would hear 61 to 67 dBA. Houses along New Hampshire Avenue where this construction would occur are generally 50 or more ft (15.2 or more meters) 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 ft (4.9 m) from the HDD pit and the closest edge of the house at No. 49 New Hampshire Avenue is 32 ft 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 L_{eq} 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 ft (19.8 m) wide and 45 ft (13.7 m) 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 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.

Construction Impacts on Offshore Locations

Predicted maximum (L_{max}) pile driving noise levels at the Buoy G5 and Buoy G20 locations are presented in Table 5.3.1-2. 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 calculated construction levels are 31 dBA to 76 dBA when the receiver is downwind of the pile driving activity and 7 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 proposed action 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. The range of calculated levels, which depend on location and wind conditions, is quite large. There would therefore be times when pile driving noise exceeds ambient conditions, and pile driving would be audible to boaters near the pile installation site. Other times, pile driving noise levels would be low, and likely inaudible. It should be noted that under high wind conditions or for boaters in motorized vessels, ambient levels would be much higher. Any construction noise impacts would be minor and temporary in nature.

Underwater Construction Impacts

The underwater sound effects of construction would be temporary and are associated with the installation of 130 16 to 18 ft (4.9 to 5.5 m) diameter monopiles (one for each WTG), installation of six smaller 4 ft (1.2 m) diameter piles for the ESP, vessel traffic for transporting equipment, piles, and workers to the site and vessel traffic associated with installation of offshore 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 would 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 cables and scour mats) would take up to approximately 1 month and installation of all 130 WTGs would occur over two construction seasons. Sound data from installation of similar sized piles at the Utgrunden Project were used in the acoustic modeling (see Section 2.3.1 in Report No. 4.1.2-1). Sound levels would depend on the distance from the underwater receiver to the monopile being driven. For a detailed analysis on underwater construction noise and the effects to protected marine species and fish, please refer to Section 5.3.2.6 and Section 5.3.2.7, respectively.

Decommissioning

The decommissioning proposed action would not require pile driving activities, which cause the highest sound levels of any activities associated with the proposed action. Pile driving only takes place during the construction phase of the proposed action. Decommissioning would involve the use of similar vessels, cranes, jet plow, cutting and welding equipment and other tools that were involved in construction, but would not include any pile driving, blasting or activities which approach the noise level of pile driving. During decommissioning, the monopiles would be cut off at 15 ft (4.6 m) below the seabottom. As such, the noise impacts from decommissioning activities would appear to be less than the worst case impacts already presented for construction and would be minor.

Conclusion

In summary, the analysis revealed that noise impacts are expected to be minor as noise levels would remain below injury thresholds of all species evaluated for both construction and decommissioning. Further, mitigation measures being considered at this time include the use of underwater sound monitoring to confirm pile driving noise levels, the use of an NOAA Fisheries approved observer, and soft start of pile driving, which would be assessed further via consultation with the Federal agencies. A more detailed discussion of mitigation is provided in Section 9.0.

5.3.1.2.2 Operational Impacts

Above Water Operational and Maintenance Noise Impacts

Operational Impacts on Onshore Locations

A detailed noise modeling analysis of both operational noise was conducted. The modeling results were evaluated in conjunction with measured ambient conditions. Modeling receptors were chosen at the same three onshore locations as where ambient measurements were conducted, and at eight additional locations along the shore. The location of the modeling receptors are: Bass River Beach, Yarmouth; Point Gammon, Yarmouth; Lewis Bay, Yarmouth; Hyannisport, Barnstable; Hyannis Point, Barnstable; Wianno Beach, Barnstable; Oregon Beach, Barnstable; New Seabury, Mashpee; Oak Bluffs, Martha's Vineyard; Edgartown, Martha's Vineyard; and Cape Poge, Martha's Vineyard. These locations are listed in Table 5.3.1-3. Ambient data for the eight additional locations were assigned from one of the three representative monitoring locations, where similar conditions were found to exist.

Industry standard methods and assumptions were utilized for the operational noise modeling analysis. This included: (1) geometric wave spreading (decrease of sound with distance); (2) absorption of sound by the atmosphere; and (3) excess anomalous attenuation (decrease of sound due to atmospheric turbulence, temperature gradients and ground characteristics). The sea surface was assumed to be a reflective surface and downwind conditions were included, essentially negating excess anomalous attenuation and resulting in a more conservative analysis. The assumptions in the construction noise analysis differed only in that calm to moderate winds were used to simulate conditions considered to be ideal for installation of the WTG piles.

Refraction of sound waves (re-direction due to changes in atmospheric conditions) can occur under certain meteorological conditions, and can cause sounds that would not normally be heard to be heard at large distances. Refraction of sound requires the presence of an atmospheric inversion (colder temperatures at the surface than aloft), which can occur under calm wind conditions. The presence of an inversion causes the sound waves from a source to bend back toward the ground at locations further away from the source. During calm wind conditions wind turbine operation would not occur. As such, the effect of sound refraction would not be a factor during operation of the proposed action. Regardless of the fact that this condition can not occur during proposed action operation, the analysis nonetheless considered potential refraction of sound by assuming a temperature inversion would exist during operation.

Research has shown that under high wind conditions (20 mph and higher), changes in wind with height can slow down sound reduction with distance for low frequency sounds below 20 Hz. This slower wave spreading (cylindrical spreading), was included in the analyses. Higher frequency sounds are not affected by this condition. Lastly, only onshore winds were considered, since these would produce the highest sound levels (sound levels are reduced during upwind conditions).

Operational noise modeling was further divided into two parts; one for the WTG cut-in speed (8 mph at hub height) and one for WTG design speed (30 mph at hub height). Cut-in modeling represents conditions when ambient sound levels would be lowest, due to lighter winds, and design speed modeling represents maximum sound output from the WTGs. Detailed sound level data for the WTGs were obtained from recent tests conducted for a GE 3.6 MW unit operating near Barrax, Spain.

The noise modeling results for cut-in wind speed conditions at onshore locations are presented in Table 5.3.1-4. Calculated levels are shown to be low, ranging from only 11.6 to 17.8 dBA. The calculated levels are also compared to the range of measured L_{eq} sound levels (41 to 63 dBA), and shown to be well below these levels. The frequency-specific modeling results (ESS, 2007 and Figures 16 through 37 in Report No. 5.1.5-1) reveal that low-frequency sound from the proposed action is below the threshold of human hearing and would be largely inaudible regardless of the baseline sound levels. For example, at Lewis Bay, Yarmouth, the calculated cut-in sound levels for the low frequency of 16 Hz is only 50 dB, while the hearing threshold (the level of sound needed at this frequency in order for it to be heard) is 92 dB. At 250 Hz, the calculated cut-in sound level is only 6 dB, while the hearing threshold is 14 dB. Calculated project sound by frequency falls to 0 dB beyond 250 Hz, and would also not be audible. A similar example is found for Edgartown, Martha's Vineyard, where the calculated cut-in sound level at 16 Hz is 49 dB, and at 250 Hz is only 2 dB. Accordingly, no noise impacts are anticipated at any onshore locations due to proposed action operation for either the cut-in or design wind speed conditions.

Calculated levels for the design wind speed condition (the maximum sound output from the WTGs) are also shown to be very low, and are presented in Table 5.3.1-5. Proposed action sound levels are shown to range from 19.2 to 25.9 dBA at the onshore locations. A comparison of the calculated levels to measured existing ambient conditions (54 to 71 dBA) reveals that proposed action levels at the design wind speed would be well below ambient levels. Frequency specific modeling results indicate that low frequency sounds would be below the threshold of human hearing.

Considering the very low calculated proposed action noise levels, wind conditions, and the ambient conditions that have been measured, it is anticipated that the proposed action would be largely inaudible at onshore locations. Accordingly, negligible noise impacts are anticipated with proposed action operation under either the cut-in or design wind speed conditions.

Operational Impacts on Offshore Locations

The two noise modeling locations for the offshore analysis are the same locations as where ambient measurements were conducted (Buoys G5 and G20). Similar to the modeling for onshore locations, the offshore analysis considered both cut-in and design wind speeds. Calculated noise levels for the cut-in and design conditions are presented in Table 5.3.1-6 and compared to the measured ambient levels. Calculated levels (32 to 34 dBA) for the cut-in condition are shown to be well below measured ambient levels (46 to 51 dBA) at the Buoy locations. Calculated levels (42 to 45 dBA) for the design condition are shown to be well below measured ambient levels (60 to 65 dBA) at the Buoy locations. It is noted that the ambient levels presented are for non-motorized vessels, and ambient levels would be higher for those in motorized vessels. Accordingly, negligible noise impacts are anticipated at offshore locations.

Maintenance Impacts

Activities associated with maintenance, including crew boats, barges and small equipment (tools, utility generators, etc.) are similar to typical vessel usage of Nantucket Sound, and are not expected to measurably increase the ambient background noise levels. As such, the noise impacts from maintenance activities are expected to be minor.

Operational Noise on Underwater Locations

Calculated sound levels from operation of a WTG would only be 1.9 dB above baseline sound levels at the close in distance of 65.6 ft (20 m) from a monopile. Proposed action operation is anticipated to be inaudible to most marine life at this close-in distance. Accordingly, negligible impacts are anticipated to marine life due to proposed action operation.

Conclusion

Operational noise impacts are expected to be negligible for onshore locations, offshore locations, and underwater impacts because of the limited noise associated with the turbine operations and maintenance activities as described above.[1]

5.3.1.3 Oceanographic Processes

Anticipated impacts on the physical oceanographic environment from installation of the WTGs, the inner-array cables, and the offshore transmission cable system would be minimal and localized. The nature and extent of these impacts and proposed mitigation measures are summarized below.

Minimal impacts in the form of sediment deposition and temporary increases in water column sediment concentrations would occur within the Massachusetts Coastal Zone as a result of jet plow embedment of the 115 kV offshore transmission cable system and the backfilling of the HDD cofferdam. The post lease G&G field investigations (refer to Section 2.7) would result in only temporary and localized turbidity as the result of drilling and vibracore activities. As described below, sediment deposition amounts are expected to be small. Increases in water column sediment concentrations are expected to be short lived and significantly lower than those that result from storm events or routine commercial trawling activities.

5.3.1.3.1 Construction/Decommissioning Impacts

Currents

There are no anticipated impacts to currents during construction/decommissioning of the WTG structures on Horseshoe Shoal other than the small and localized disruption of flow that occurs around the

[1] Project noise levels were also evaluated against the MassDEP noise policy for informational purposes (see section 3.0) for both onshore and offshore areas. Project noise levels were calculated to be well below the minimum measured ambient conditions at all locations. No increases in ambient noise levels would occur at onshore locations and minimal (e.g., 2 dBA or less) increases would occur at offshore locations. The Project would not produce pure tone noises. As such, the Project would be in compliance with the MassDEP noise policy, if it were applicable.

hull of moored vessels. Therefore, impacts on currents due to construction/decommissioning activity would be negligible.

Waves

There are no anticipated impacts expected on waves due to construction/decommissioning activities other than the small and localized reflection of waves that occurs around the hull of moored vessels. Therefore, the impacts on waves would be negligible during construction/decommissioning.

Salinity

There are no anticipated impacts from construction/decommissioning of the 130 WTGs, the ESP, or any of the cables on salinity. Construction/decommissioning activities would have negligible impacts on salinity.

Temperature

There are no anticipated impacts on water temperatures within Nantucket Sound or Lewis Bay from installation of the WTGs, the ESP or any of the cables. Therefore, impacts on temperature would be negligible during construction/decommissioning activities.

Sediment Transport

SSFATE modeling techniques were used to simulate water column sediment concentration and sediment deposition thickness and extent resulting from jet plow embedment of the offshore cable systems. The SSFATE model simulations were completed along a representative straight-line segment 4,200 ft (1,280 m) 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 offshore cable system routes, as those are also primarily sand-sized sediments. The modeling and results are considered to be representative of sediment conditions throughout the site of the proposed action.

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. 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 ft (30.5 m) 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.

Special concern has been raised during the regulatory review process about the potential effects of the jetting operation on an eelgrass bed identified just west of Egg Island in Lewis Bay. In this area, the bottom sediments are relatively coarse. As a result, the sediments suspended by the jet plow are predicted to fall along the route with bottom deposition predicted to be in the range of 0.04 to 0.1 inches (1.0 to 3.0 mm) at the western edge of the eelgrass bed. The majority of the eelgrass bed is predicted to experience little or no deposition as a result of the jet plow embedment operations (Report No. 4.1.1-2).

In general, the deposition of sediments suspended by jet plow embedment operations was estimated to be minimal when compared to the active bed load sediment transport known to exist in Nantucket Sound (between 45 and 71 mg/L under natural tidal conditions). The modeling results show that the sediments suspended by the jet plow would generally fall along the route. In areas where the route is in a north-south orientation, which is perpendicular to the predominant east-west flow direction, the effects of the tides can be seen transporting the sediment slightly west or east of the route in an oscillating fashion. The actual location of these oscillations (but not the shape) would change since they are determined by the relationship between the time of the tide and the jetting start time. Generally, the sediment deposition thickness is predicted to be in the range of 0.04 to 0.2 inches (1.0 to 5.0 mm), depending on location along the route and horizontal distance from the trench. In some isolated locations, deposition is predicted to be in the range of up to 0.4 inches (10 mm), with a few locations up to 0.8 inches (20 mm) along the 115 kV offshore transmission cable system and between 1.0 to 1.8 inches (35 to 45 mm) peak along isolated locations of each 33 kV inner-array cable routes. These higher deposition areas are predicted to occur when the tidal currents are in slack water conditions, which allow the deposition to be concentrated in small areas since current velocities do not disperse the sediment material. Relatively narrow bands between 0.02 and 0.04 inches (0.5 and 1 mm) thick are deposited on the fringes of the patterns. The model predicts the following peak deposition thicknesses in isolated locations along the four representative 33 kV inner-array cable routes modeled.

- **Southwest of the ESP:** 1.4 inches (35 mm)
- **Southeast of the ESP:** 1.0 inches (25 mm)
- **East of the ESP:** 1.1 inches (27 mm)
- **Northwest of the ESP:** 1.8 inches (45 mm)

Any effects from construction/decommissioning on sediment transport would be temporary and localized, and therefore overall, construction/decommissioning impacts on sediment transport in Nantucket Sound would be minor.

Water Depth/Bathymetry

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 94 ft (28.7 m) (4.6 percent of the minimum distance between WTGs), with an associated estimated scour depth of approximately 14.7 ft (4.5 m). For the ESP, the predicted extent of scour was estimated to be 55 ft (16.8 m) with a predicted depth of 9.2 ft (2.8 m) for each of the six piles supporting the ESP. A slight depression, estimated to be between 0.5 and 2 ft (0.15 and 0.61 m) deep, is anticipated to result from installation of the inner-array cables and the offshore transmission cable system. This slight depression is expected to fill in over time through natural sediment resuspension, deposition, and consolidation. Although there is the potential for scour around each WTG and the ESP piles, the applicant has proposed scour mitigation measures and monitoring as described below, that would prevent substantial scour from occurring.

The recovery rate for jetting scars along the offshore cable routes on Horseshoe Shoal was estimated at between 0.2 and 38 days. It also determined that the presence of the jetting scar would not increase localized scour. In fact, it was estimated that the presence of the jetting scar would result in slightly decreased water flow over the scar, resulting in a decreased potential for sediment transport. These results are comparable to those for the two electric cables that have been installed by jet plowing between Cape Cod and Nantucket Island.

At the landfall in Lewis Bay, construction of the temporary cofferdam at the exit hole of the HDD to be used for cable installation under the Cape Cod Shoreline would include the dredging of sediments to a elevation of approximately -10 ft (-3 m) MLLW. After jet plow embedment of the offshore cable systems are completed, the dredged area would be restored with the original dredge material. If necessary, the dredged backfill material would be supplemented with imported clean sandy backfill material to restore preconstruction contours. Once the dredged area is restored, the sheet pile cofferdam would be removed from Lewis Bay.

The impacts to water depth/bathymetry from construction/decommissioning activities would be minor as the trenches created by the jet plow are anticipated to fill naturally over a short period of time, while suspended sediments from the jet plow are predicted to be a short-term localized event. At the landfall site the temporary cofferdam would mitigate any impacts to the surrounding area.

During decommissioning, the foundation components (transition piece, monopile and scour mats, and rock armor) would be removed. Sediments inside the monopile would be suctioned out to a depth of approximately 15 ft (5 m) below the existing seabottom in order to allow access for the cutting of the pile in preparation for its removal. The sediments would be pumped from the monopile and stored on a barge. Prior to the cutting and removal of the monopile, any adjacent scour protection (scour mats and rock armor) would be removed. After the removal of the monopile to a barge, the sediments would be returned to the excavated pile site using the vacuum pump and diver assisted hoses in order to minimize sediment disturbance and turbidity. The offshore cables would be disconnected and pulled out of the J-tubes on both the WTG and the ESP. The cables would then be cut below the seafloor. The cables would then be reeled in after being water jetted free of bottom sediments, creating a shallow linear depression that would only last a short while. This would result in a negligible impact.

Conclusion on Construction/Decommissioning Impacts

Overall, construction/decommissioning impacts on oceanographic processes would vary from negligible to minor, as they would result in only temporary and localized effects.

5.3.1.3.2 Operational Impact

Currents

The calculation of the Keulagan-Carpenter (KC) number based on the wave data found no value greater than 1.8, which is below the threshold for flow separation to occur. A potential flow analysis appropriate for this condition shows that the flow around the pile returns to within 89 percent of its undisturbed value within one pile diameter from the pile and to within 99 percent of its undisturbed value within four pile diameters.

Comparison to laboratory studies of multiple piles indicates that there is no anticipated wake interaction among the piles since interaction ceases when the piles are spaced greater than five pile diameters from each other and the spacing for this proposed action ranges from 120 to 190 pile diameters. Using a single pile zone of influence of five pile diameters long (if not significantly shorter [87 ft; 27 m]) and two diameters wide (35 ft; 11 m) or 3,014 ft^2 (280 m^2), the total area for all 130 piles is 9 acres (0.0364 km^2). This area can be compared to the total area of the WTG pile array on Horseshoe Shoal of 15,800 acres (64 km^2) showing that only 0.057 percent of the area is potentially affected. In reality, only a very small portion of this area is really affected since all these impacts decrease quickly away from the pile. The large spacing between the WTGs and the small WTG pile diameter would prevent the effects of each WTG pile on current conditions from affecting adjacent piles. Therefore, the WTGs would not act as a pile group. Operational impacts on currents would be minor.

Waves

Due to the proposed spacing of the WTGs of 0.39 miles (0.63 km) from northwest to southeast, and 0.63 miles (1 km) from east to west, the proposed action would not be expected to have significant large-scale impacts on 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).

The proposed diameter of monopiles that would be used for WTGs is either 16.75 or 18 ft (5.1 or 5.5 m), depending on the water depth at the WTG location. Each of these pile diameters is greater than one-tenth of the average locally-generated 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.

A study on effects of the WTG pile array in Nantucket Sound determined that diffraction effects were found to occur for 62 percent of the waves from the time series. However, the longest diffraction occurred for waves with the smallest period with low induced bottom velocities. These waves cause insignificant sediment transport regardless of whether they diffract or not and so can be ignored. Larger waves, particularly ocean swells, are not affected by the presence of the piles.

Based on the WTG pile diameter and wave characteristics in the area, the piles are essentially invisible to the waves. Therefore, the presence of the WTGs would not affect wave conditions in the area and therefore operation impacts on waves would be negligible.

Salinity

The proposed action is anticipated to have no impacts to salinity in Nantucket Sound because there would be no intake or discharge of seawater associated with the operation of the proposed action, no new sources of freshwater due to the proposed action, nor any other mechanism by which salinity would be altered. Therefore, operational impacts on salinity in Nantucket Sound would be negligible.

Temperature

The offshore cable systems would generate a limited amount of heat immediately around the cables; however, the proposed action is anticipated to have no measurable impacts to water temperature in Nantucket Sound because the cables would be buried a minimum of 6 ft (1.8 m) below present bottom. This absorption of the generated heat into the sediments is essential for proper operation of the cables, and the temperature change at the sediment surface would be no greater than 0.19ºF while the increase in water temperature immediately above the cables would be approximately 0.000006ºF. There would be negligible operational impacts on water temperature within Nantucket Sound during operation.

Sediment Transport

Localized effects to sediment transport patterns may occur immediately around each WTG foundation base. However, it is expected that a localized sediment transport equilibrium condition would be reached shortly after construction of the proposed action given the cyclical nature of both the tidal regime and scour. Laboratory studies have shown that interaction among piles ceases when piles are spaced greater than five pile diameters from each other. The WTG array on the proposed site has spacing from 120 to 190 pile diameters. Although local sediment transport and scour would occur around individual piles, no cumulative or interactive effects of the pile array on currents or waves would occur and therefore no effects on large scale sediment transport would occur. The greatest diffraction (bending) of waves occurred for the smallest period waves which cause insignificant bottom velocities and cannot affect sediment transport.

Sand waves on Horseshoe Shoal have amplitudes of up to 12 ft (3.7 m) and wavelengths of up to 200 ft (60 m) (Report No. 4.1.1-3). More than 26 miles (42 km) of the total proposed 33 kV inner-array cable route occurs in areas of active sand wave migration on Horseshoe Shoal. Assuming bedform migration rates of 3.3 to 9.8 ft/year (1 to 3 m/yr) and cable burial depths of 6 ft (1.8 m), it is possible that cable exposure could occur within 6 to 18 years after the burial if no mitigation measures are employed. Mitigation measures for offshore cable burial are described in Section 9.0.

There would be minor impacts on sediment transport due to operation of the proposed action, however, all impacts would be localized.

Water Depth/Bathymetry

A June 2005 underwater inspection was performed to visually inspect the scour mats around the southwest batter pile to allow comparison with the conditions at the other two unprotected SMDS piles. Results are discussed in Section 4.1.3.1.6. The divers performing the inspection observed that approximately 12 inches (0.3 m) of sand had accumulated over a 20 month period as a result of the presence of the scour mats. At the southeast pile, the divers' measurements revealed that approximately 13 inches (0.33 m) of sand has been scoured away from this pile over a 20 month period. Similar measurements were not obtained from the north pile. Based on these observations, the presence of the scour mats resulted in the accumulation of sand around an installed pile and therefore appears to be effective at preventing scour around installed piles as long as the scour mats remain intact and in place.

In keeping with the purpose of gathering additional data pertinent to the proposed action, four additional SSCS scour mats were installed around the southeast pile in May 2006 to test the efficacy of modifications to the web materials, manufacturing processes, and various frond lengths (Report No. 4.1.1-8). Measurements were again taken (similar to monitoring in June 2005, described above). The measurements indicate a net accretion of 12 inches (0.3 m) at the southwest pile, and a net scour of 7 inches (0.18 m) at the previously unprotected southeast pile, indicating that the existing mats are helping to prevent scour.

Based on the predicted scour conditions, three scenarios were developed to evaluate rock armor for scour protection around the WTGs, which are discussed in Section 4.1.3.1.6. The scenarios were developed based on the findings from the *Revised Scour Report* (Report No. 4.1.1-5), ranges of water depth, and the diameter of the WTG.

- **Scenario 1A** was developed to evaluate rock armor around the 16.75 ft (5.1 m) diameter of the WTGs located in water depths between 12 and 15 ft (3.7 and 4.6 m). Under Scenario 1A, rock armor would extend to a distance from the WTG pile of 94 ft (28.7 m) at the longest and 42 ft (12.8 m) at the narrowest parts of the ellipse. The rock armor stones would have a median weight of 125 lbs and the armor layer would be 4 ft (1.2 m) thick.
- **Scenario 1B** was developed to evaluate the rock armor around the 16.75 ft (5.1 m) diameter WTGs located in water depths between 16 and 39 ft (4.9 and 11.9 m). Under Scenario 1B, rock armor would extend a distance from the WTG pile of 94 ft (28.7 m) at the longest and 42 ft (12.8 m) at the narrowest parts of the ellipse. The rock armor stones would have a median weight of 50 lbs and the armor layer would be 3 ft (0.9 m) thick. The Scenario 1B conceptual design was also used for evaluating the rock armor requirements for the ESP.
- **Scenario 2** was developed to evaluate the rock armor around the 18 ft (5.5 m) diameter WTGs located in water depths between 39 and 56 ft (11.9 and 17.1 m). Under Scenario 2, rock armor would extend a distance from the WTG pile of 88 ft (26.8 m) at the longest and 45 ft (13.7 m) at the narrowest parts of the ellipse. The

rock armor stones would have a median weight of 50 lbs and the armor layer would be 3 ft (0.9 m) thick.

Under all the scenarios, the remaining predicted scour depth beneath the rock armor would be filled with a filter material to minimize the potential for the larger armor stone material to settle into the sediment below.

The rock armor and filter material would be placed so that the final elevations approximate pre-installation bottom contours to the extent practicable such that mounds of material would not be created. The estimated impact to the seabed from the presence of the rock armor for each WTG was multiplied by the number of WTGs in each scenario. The total estimated impact to the seabed from the rock armor for all the 130 WTGs and the ESP is approximately 47.8 acres. Operational impacts on water depth/bathymetry would be minor as final elevations associated with scour protection would approximate pre-installation bottom contours.

Conclusion on Operational Impacts

Overall, operational impacts on oceanopgraphic processes would vary from negligible to minor and would result in only temporary and localized effects.

5.3.1.4 Impacts on Climate and Meteorology

5.3.1.4.1 Construction/Decommissioning Impacts

The post lease geological and geophysical sampling activities (see Section 2.0) would have negligible impacts on the climate and meteorology, while the construction and decommissioning of the proposed action would have minor impacts on climate and meteorology. Greenhouse Gas (GHG) (e.g., CO_2) emissions would result from use of geological and geophysical sampling (e.g., drilling) and construction equipment and the vessels used to transport the equipment. Decommissioning work would also involve the use of fossil fuel-fired equipment, as well as vessels to transport the equipment; and thus, the emissions of GHGs. The post lease geological and geophysical sampling activities and construction emissions would be temporary (approximately two years for construction and less for decommissioning) prior to the operation of the proposed action, while the decommissioning activities would also be temporary (approximately two years) after the shutdown of the proposed action.

Conclusion on Construction Impacts

Based on the limited amount of CO_2 emissions that would result from the G&G investigations and construction and decommissioning work, climate and metrological impacts would be minor.

5.3.1.4.2 Operational Impacts

The turning of the WTG rotors, which react to the wind rather than create or modify it, would not affect the wind speed and/or wind direction in the waters of Nantucket Sound. The WTGs operate due to the force of the passing wind on the blades. After passing through the area of the proposed action there is some additional turbulence in the wind stream as a result of the wind's passage through the WTGs. At a distance of several rotor diameters beyond the proposed action, site winds return to laminar flow similar to that prior to encountering the site of the proposed action. Conditions such as the formation or dissipation of fog would not be affected by the WTGs operation because fog is formed during specific psychrometric (atmospheric temperature and moisture) conditions.

As discussed in Section 4.1.4.5, nearby onshore seasonal average mixing heights (4,662 ft) are substantially above the top of the rotor swept zone (440 ft). It is unlikely that the WTGs would entrain air above the mixing height to the layer below the mixing height.

During the operation of the proposed action, the only anticipated emissions of GHGs would be from the vessels used to transport the maintenance workers and any equipment necessary for possible offshore cable repair activities (see Section 2.4). These emissions would be during the life of the proposed action and the vessels and equipment would undergo regular maintenance, which would assist in minimizing the amount of GHG emissions.

Benefit Analysis for Climate

Operation of the proposed action would result in the potential to provide benefits in terms of lowering emissions of greenhouse gases and ozone precursors attributed to power production in the New England area. Emissions of CO_2 from fossil fuel combustion in New England have increased by 10 percent over the period between 1990 and 2004 (based on data from http://www.epa.gov/climatechange/emissions/state_energyco2inv.html). The total CO_2 emissions from fossil fuel combustion in 2004 were 190.8 million tons. Electric power generation contributed 24 percent to the total. The largest contributor was transportation with 40 percent of the total. The annual rate of CO_2 emissions from fossil fuel combustion in Massachusetts have increased by 4 percent over the period between 1990 and 2004.

The total generating capacity in the New England power system in the year 2004 was 30,940 MW (ISO New England, 2005). Of this total, southeastern Massachusetts has a capacity of 3,362 MW, or about 10 percent of the total New England capacity. The ISO New England Inc. (ISO-NE) predicts that the net energy need for New England will increase from 134,085 gigawatt hours (GWh) in 2005 to 152,505 GWh in 2014, a rate of about 1.4 percent per year. The peak summer and winter loads are expected to increase at a rate of 1.5 percent per year (ISO-NE, 2005). The annual growth rate in summer and winter peak loads for southeastern Massachusetts is projected to be 1.7 and 1.5 percent, respectively.

The proposed action would generate 1,600 GWh of power annually. The ISO-NE has calculated marginal emission rates for CO_2 (ISO-NE, 2004). The marginal emission rates provide an estimate of the additional emissions that would result from increased power consumption during periods of higher energy demands. For CO_2 the annual average marginal emission rate is 1,102 lb/MWh. Thus if the amount of energy produced by the proposed action would have to be produced by fossil-fuel powered plants instead, it would result in about 0.88 million tons of CO_2 emitted per year. The projected increase in energy needs in New England between 2005 and 2014 would result in an increase of about 84 tons per year of CO_2 if the power were to be produced by fossil-fuel power plants. The potential reduction in the growth of CO_2 emissions due to operation of proposed action would be about 1 percent of the total projected increase. Thus the proposed action would have the potential to very slightly reduce the growth in CO_2 emissions in the New England area.

Conclusion on Operational Impacts

The operation of the wind turbines would have negligible impacts on climate and meteorology; however, the maintenance activities associated with the proposed action, and any potential cable repair activities, would have a minor impact due to GHG emissions from the vessels transporting the maintenance workers and equipment necessary for cable repairs. Operation of the proposed action would potentially have some beneficial effects in terms of greenhouse gas emissions from power production in the region as discussed above because it would somewhat reduce the reliance on the use of fossil fuels. These benefits would outweigh the very small emissions resulting from operation of the proposed action, so the net impacts would be positive.

5.3.1.5 Impacts on Air Quality

Introduction

This section discusses applicable regulatory requirements and potential air quality impacts associated with the proposed action. It describes the proposed action compliance with the CAA during post lease geological and geophysical sampling activities, construction/decommissioning and operation. The information contained in this section was obtained from review of existing data available for the area of the proposed action.

Regulatory Analysis

The 40 CFR Part 55 – OCS Air Regulations, was promulgated by USEPA in 1992 in order to apply Section 328(a)(1) of the CAA to OCS sources of air pollution located outside of the Western Gulf of Mexico. At the time of promulgation, the regulations were intended to apply to oil and gas development, production, and extraction facilities. The regulations did not contemplate projects involving alternative energy resources or non-extractive sources of energy. However, some activities associated with the proposed action are considered an OCS source, as defined in the regulations. Thus these activities are subject to the same requirements as those applicable to the nearest onshore area, the "Corresponding Onshore Area," and USEPA Region One would conduct a consistency review and incorporate the relevant state rules (as described at 40 CFR Parts 55.12, 55.14, and 55.15).

The EPAct amended the OCS Lands Act of 1953 (OCSLA) (43 U.S.C. 1331 et seq.) to grant authority to the DOI to manage alternative energy projects on the OCS. As a result of the EPAct, the proposed action's construction activities became subject to Section 328 of the CAA (42 U.S.C. 7627) relating to air emissions from OCS sources for activities regulated or approved under the OCSLA.

Section 328 (a)(4)(c) of the CAA defines an OCS source to include any equipment, activity, or facility: (1) which emits, or has the potential to emit, any air pollutant, (2) is regulated or authorized under the OCSLA, and (3) is located on the OCS or in or on waters above the OCS. This definition also includes emissions from any vessel servicing or associated with an OCS source, including emissions while at the OCS source or en route to or from the OCS source within 25 miles of the OCS source. The proposed action has three distinct time periods during which OCS sources and the vessels servicing them would emit, or have the potential to emit, air pollutants: preconstruction G&G data gathering stage, the two-year construction period and the decommissioning period.

USEPA considers vessels to be exempt from the definition of an OCS source unless they are attached to the ocean bottom or are en route to a structure or facility defined as an OCS source. The OCS sources for the proposed action would be the vibracore boat and diesel powered boring equipment, the jack-up barges and the diesel powered cranes or hydraulic rams on those jack-up barges that are directly attached to the ocean bottom using jack-up legs or spud piles and the support vessels servicing these OCS sources while en route to or from the OCS source within 25 miles of the OCS source. Figure 5.3.1-3 shows the 25 mile area around the proposed action. The following equipment and activities are subject to permitting by USEPA as OCS sources:

1. During the post lease geological and geophysical sampling, gathering stage, the equipment associated with the seafloor boring program (vibracore boat and diesel powered boring equipment) would be considered to be OCS sources.
2. During the two-year construction period, OCS sources include the following activities: pile installation, installation of scour protection, offshore cable laying, installation of the ESP, and installation of the WTGs. OCS sources include the

following vessels: crane barges (if attached to the ocean bottom), and attendant barges (if attached to the ocean bottom). Finally, OCS sources include the following equipment: hydraulic rams and diesel powered cranes.

3. During decommissioning, the removal of the WTGs, piles and scour protection would require the use of jack-up barges that would be attached to the ocean bottom, diesel powered cranes to handle the piles, diesel powered dredgers for the removal of rock armoring, and diesel powered hydrologic dredgers to remove material from inside the monopile prior to cutting of monopile under the surface of the sea floor, and then to replace the dredged material back into the hole. These barges and cranes and dredging equipment would be considered OCS sources.
4. During construction and during decommissioning, emissions from crew boats, tugs and support vessels en route to or from these OCS sources identified in items 1 through 3 would also be regulated by the USEPA permit when they are within 25 miles of the respective OCS source.

During the 20-year operational period, there would be no emission sources attached to the ocean bottom or en route to a structure or facility defined as an OCS source. Thus there would be no operating facilities that are OCS sources. The WTGs and the ESP would not have the potential to generate air pollutants during operations and thus are not considered to be OCS sources.

Emissions during post lease geological and geophysical sampling activities, construction, operations, and decommissioning in the waters and on land designated as non-attainment areas regulated by Massachusetts and Rhode Island would also be reviewed to determine whether they meet the requirements set forth in the USEPA's General Conformity Regulations as codified in Section 176(c) of the CAA. This section prohibits Federally funded entities from taking actions in nonattainment or maintenance areas which do not conform to the SIP for the attainment and maintenance of the NAAQS. The purpose of conformity is to:

(1) ensure Federal activities do not interfere with the budgets in the SIPs;

(2) ensure actions do not cause or contribute to new violations; and

(3) ensure attainment and maintenance of the NAAQS.

The regulations provide that conformity determinations are required when the total of applicable direct and indirect emissions exceed specified *de minimis* levels. Both Massachusetts and Rhode Island are located in an ozone transport region and were designated "moderate non-attainment" for 8-hour ozone on June 15, 2004 by the USEPA. According to 40 CFR 93.153, the applicable *de minimis* level for triggering a Conformity Review in a moderate non-attainment area inside an ozone transport region is 100 tons per year for NO_x and 50 tons per year of VOC. Based on preliminary emission estimates, a General Conformity analysis would be required in Massachusetts and Rhode Island.

5.3.1.5.1 Construction/Decommissioning Impacts

Air quality impacts due to post lease geological and geophysical sampling activities, including a marine shallow hazards survey and a supplemental geotechnical program (see Section 2.7.1), would occur offshore and would be conducted prior to construction. Construction air quality impacts would result from offshore and onshore (onshore) activities. The offshore activities are anticipated to take approximately 2 years to be completed and the onshore activities are anticipated to take 1 year to complete. Offshore activities would consist of pile installation, scour protection installation, offshore cable laying, turbine installation, and ESP installation. Table 5.3.1-7 shows the potential emissions by major activity: preconstruction, construction, operations, and decommissioning, and Table 5.3.1-8 shows the potential emissions by location. Potential emissions of CO, SO_2, PM_{10}/$PM_{2.5}$, NO_x, VOC, CO_2, and HAPs range from a minimum of 7.6, 2.5, 0.6, 19.6, 0.8, 919.0, and 0.0 lb/hr, respectively, during preconstruction activities to a maximum of 214.8, 130.2, 29.4, 984.7, 30.5, 46,905, and 0.4 lb/hr, respectively, during decommissioning activities. Most of the potential emissions will occur within OCS areas and will be regulated by the EPA. The applicant has submitted an NOI to EPA for authorization for the above referenced emissions. EPA will review the NOI and determine whether air modeling is required, and coordinate the establishment of an appropriate air quality modeling protocol as necessary.

Onshore construction activities would rely on substantially less powered equipment than that involved with the offshore construction phase. The onshore work can be broken down into three general categories: HDD, duct bank construction, cable pulling and termination. The HDD at the landfall would take between 2 and 4 weeks with emissions resulting primarily from the diesel powered drilling rig. The duct bank would be excavated, constructed and backfilled using a diesel powered bulldozer and excavator. Diesel trucks would deliver duct bank materials to the onshore work site. It is expected that the duct bank would take 5 months to complete. Once the duct bank is constructed, the onshore cable would be pulled to its connection with the Barnstable Switching Station, again using diesel powered equipment. Cable pulling, splicing and termination would also take approximately 5 months to complete. Emissions of fugitive dust from onshore cable construction would occur from time to time depending on the area of exposed soils, the moisture content of those soils and the magnitude and direction of ground level winds. Fugitive dust emissions would be minimized by limiting the amount of exposed soils at a given work area and by spraying water for dust control when weather conditions warrant it.

Decommissioning activities are anticipated to take approximately 2 years and include the removal of the piles, the scour protection, and the underwater cable and the decommissioning of the turbine, ESP, and meteorological tower. Table 5.3.1-8 shows that approximately 39 percent of the decommissioning emissions will potentially occur in waters regulated by Rhode Island, approximately 39 percent will occur in OCS areas regulated by the EPA, approximately 15 percent will occur in waters regulated by Massachusetts, and an additional approximately 7 percent will occur in OCS waters but are not emission sources regulated by a permit.

The activities associated with post lease geological and geophysical sampling, construction and decommissioning of the proposed action would result in air emissions over Nantucket Sound due to the use of fossil fuel fired mobile sources (e.g., ships, cranes and other powered construction equipment). The proposed action would need to comply with all Federal and State general conformity requirements during these activities. Furthermore, the proposed action would be required to apply all mitigation measures imposed by any Federal or State regulations and permit conditions to minimize the air quality impact of these activities.

Visibility Impacts

Reduced visibility in the local area and the Class I areas (e.g., Arcadia, Presidential Range-Dry River, Lye Brook, and Great Gulf) in the region is a concern for the public and regulatory agencies. In the *Particle Pollution Report, Current Understanding of Air Quality and Emissions through 2003* (USEPA, 2004), the USEPA states "In the East, reduced visibility is mainly attributable to sulfates, organic carbon, and nitrates. Poor summertime visibility is primarily the result of high sulfate concentrations, combined with high humidity. Sulfates, which dominate the composition of these visibility-impairing particles, have been found to contribute even more to light extinction than they do to fine particle concentrations." The post lease geological and geophysical sampling, construction and decommissioning activities would have emissions of SO_x and NO_x, which directly contribute to the formation of sulfates and nitrates in the atmosphere, and PM, of which a percentage would be organic carbon. Therefore, these activities have the potential to impact the local and long range (i.e., Class I areas) visibility.

The local and long range (>50 km) visibility impacts due to the post lease geological and geophysical sampling, construction and decommissioning activities and the mobile sources used during these activities would be temporary. Thus, the “pollutant loading” in a certain area due to these activities would be minimized. However, diesel exhaust plumes may be visible from vantage points somewhere around the area of the proposed action for an extended period of time. Overall impacts on visibility would be negligible.

Emissions Impacts

The activities associated with post lease geological and geophysical sampling, construction and decommissioning of the offshore and onshore cables would result in 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 onshore cable would 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 air emissions.

Regulated by the State and Federal agencies depending on the location of the emissions, the offshore emissions would be required to comply with all regulations and mitigation requirements enforced by these agencies. As a result of complying with these various regulations, the potential emissions due to the offshore post lease geological and geophysical sampling, construction and decommissioning activities should be minimized to the extent possible. The onshore construction and decommissioning activities would be regulated by the local and State agencies and the proposed action would be required to comply with all permit limits and mitigation measures imposed on these activities. In summary, emission impacts would be minor.

Public Health Impacts

The proposed action would result in temporary and low levels of fossil fuel emissions associated with equipment used in the offshore post lease geological and geophysical sampling, construction and decommissioning activities for the proposed action. These emissions would comply with the appropriate air regulations to ensure the health and safety of the onshore area. Onshore construction and decommissioning activities would be regulated by the local and State agencies, which would also ensure that the emissions are sufficiently controlled to protect the public health. In summary, public health impacts would be negligible.

Conclusion

Overall the post lease geological and geophysical sampling, construction and decommissioning air quality impacts are expected to be negligible to minor as these impacts would be for the most part temporary in nature and localized. The proposed action would be subject to various regulations, which may require mitigation measures to reduce the emissions from the post lease geological and geophysical sampling, construction and decommissioning activities. The proposed action would be required to comply with all of the local, State, and Federal regulations. Mitigation being considered at this time includes the use of water sprays on exposed soils when weather conditions are likely to raise dust. A more detailed discussion of mitigation is provided in Section 9.0.

5.3.1.5.2 Operational Impacts

The actual wind turbines in the site of the proposed action would not have any emissions when in operation. However, maintenance work for each turbine has been anticipated to be 5 days per year. Two of these days would be scheduled maintenance work and 3 days are estimated for emergency maintenance work. Emergency maintenance work would be such work as cable repair activities in the event that a cable is damaged. The scheduled maintenance work would be planned for the summer months when weather conditions are more favorable. Emissions from the vessels used to transport the work crews and emissions from any welding, cleaning and degreasing, painting, etc. may also result during these maintenance work periods.

The maintenance work emissions that are anticipated would be minor and could be emitted anywhere within the 25 square miles (65 km^2) proposed action site depending on the turbines being serviced. The vessels used to transport the work crews would be subject to regular maintenance to enhance fuel economy and to minimize their emissions. Furthermore, the vessels would be required to apply all mitigation measures imposed by any Federal or State regulations and permit conditions to minimize the air quality impact of these activities. Finally, it should be noted that the proposed action would result in a new clean source of electricity thus reducing a considerable quantity of local emissions that would occur if a fossil fuel facility were constructed instead of the proposed action (Refer to Section 3.3.6.4, the No-Action Alternative, for a cost benefit analysis that evaluates the likely environmental consequences that would occur if the proposed action were not constructed).

Visibility Impacts

Emissions from the maintenance activities would contribute to visibility degradation. However, because the maintenance activities are dispersed throughout a 25 square miles (65 km^2) area, it is unlikely that the maintenance activities would significantly contribute to visibility degradation. Moreover, regular maintenance of the vessels and compliance with all of the operating requirements imposed on the vessels by the Federal and State agencies should minimize the amount of PM and other visibility degrading pollutants emitted by the vessels during maintenance activities. Overall, visibility impacts would negligible.

Emissions Impacts

Maintenance activities during normal operations of the proposed action would occur within the offshore proposed action. Vessels used to transport the maintenance workers would have emissions from the port of departure to the offshore proposed action and within the site of the proposed action. Maintenance activities and vessel emissions would be regulated by Federal and State agencies and would be required to comply with all of the permit conditions imposed by these agencies. The permit conditions would ensure that the emissions from the maintenance activities and vessels would be minimized to ensure local air quality impacts are minor.

Public Health Impacts

The proposed action operation would not generate fossil fuel emissions. However, maintenance of the facility would result in temporary and low levels of fossil fuel emissions (SO_x and NO_x) associated with maintenance vessels. These emissions would comply with the appropriate air regulations to ensure the health and safety of the onshore area. Onshore construction and decommissioning activities would be regulated by the local and State agencies, which would also ensure that the emissions are sufficiently controlled to protect the public health. Overall, public health impacts would be negligible.

Benefit Analysis for Air Quality

Operation of the proposed action would have the potential to provide benefits in terms of lowering emissions ozone precursors attributed to power production in the New England area. The total generating capacity in the New England power system in the year 2004 was 30,940 MW (ISO New England, 2005). Of this total, southeastern Massachusetts has a capacity of 3,362 MW, or about 10 percent of the total New England capacity. The ISO-NE predicts that the net energy need for New England will increase from 134,085 GWh in 2005 to 152,505 GWh in 2014, a rate of about 1.4 percent per year. The peak summer and winter loads are expected to increase at a rate of 1.5 percent per year (ISO-NE, 2005). The annual growth rate in summer and winter peak loads for southeastern Massachusetts is projected to be 1.7 and 1.5 percent, respectively.

The proposed action would generate 1,600 GWh of power annually. The ISO-NE has calculated marginal emission rates for nitrogen oxides (NO_x) and sulfur dioxide (SO_2) (ISO-NE, 2004). The marginal emission rates provide an estimate of the additional emissions that would result from increased power consumption during periods of higher energy demands. Massachusetts and Rhode Island are classified moderate non-attainment area for ozone. The proposed action has the potential of reducing emissions of NO_x, which is an ozone precursor. The proposed action could slightly reduce the need for added capacity for fossil-fuel generating plants in the New England area. In addition, during periods of peak demands associated with spells of hot weather in the summertime, the proposed action could supply power that would otherwise have to be produced by fossil-fuel plants that generate NO_x and other air pollutants. Warm spells are usually associated with high ozone levels and thus air quality impacts would be mitigated somewhat. The marginal emission rate for NO_x for on-peak hours in the ozone season (May through September) is 0.48 lb/MWh. If we assume that the proposed action output would be 182.6 MW, typical of an average day, the potential amount of NO_x reductions would be about 1 ton/day. In the year 2002 inventory for Massachusetts, the total NO_x emissions for all sources on a summer day is 771.8 tons/day. The amount of potential reduction would thus be very slight.

Conclusion

The proposed action would have no emissions during operations except for maintenance activities and the vessels used to transport the maintenance workers. Maintenance activities could occur anywhere within the 25 square miles (65 km^2) proposed action. Therefore, it is anticipated that the operational impacts from the proposed action would be minor as the vessels used during the maintenance activities would be required to comply with all of the Federal and State permit requirements to minimize the potential emissions impact. The proposed action would have the potential of providing some beneficial effects in terms of air quality and climate change in the region as discussed above because it would reduce somewhat the reliance on fossil fuels for power production. These benefits would outweigh the very small emissions resulting from operation of the proposed action, so the net impacts could be positive.

5.3.1.6 Water Quality

Introduction

Projects involving a discharge of dredged or fill material to a waterbody or wetland require a permit from the USACE under Section 404 of the CWA (33 U.S.C. 1344); and a 401 WQC from MassDEP under the Federal CWA (33 USC 1341; Massachusetts CWA; MGL Chapter 21§§26-53; and 314 CMR 4.00 and 9.00). The Federal CWA allows States the authority to review projects that must obtain a Federal license or permit and that result in a discharge to state waters. Please refer to Section 5.1.1 for discussion on vessel withdrawal and discharge as well as discussion of grey and black water, trash and debris, etc.

This proposed action would be subject to both Section 401 and Section 404 due to the volume of sediment to be dredged for the HDD offshore exit point and for the discharge of dredged or fill material back to Lewis Bay to backfill the cofferdam location. Section 401 and 404 jurisdiction extends to the 3.5 miles (5.6 km) State territorial limit. The only proposed action activity proposed within this 3.5 miles (5.5 km) 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 (MassDEP and the USACE, 2002). In the nearshore area at the proposed offshore transmission cable system landfall, the cable system is proposed to be placed in a conduit to be installed using HDD installation techniques. As discussed in detail below, HDD would require the dredging of an offshore exit point pit and the placement of a temporary cofferdam within Lewis Bay to facilitate the HDD operation. The dredged sediments from within the cofferdam pit would be temporarily removed from waters of the U.S. and replaced upon completion of the offshore transmission cable system installation.

Dredging of the offshore exit point pit, placement of a temporary cofferdam, installation of the conduit by HDD, cable installation via hydraulic jet plow, and construction of the WTGs and ESP are subject to the jurisdiction of Section 10 of the Rivers and Harbors Act of 1899 (U.S.C. 403) since these represent activities involving the placement of structures in Waters of the U.S. Installation of the offshore cable systems within the 3.5-mile (5.6-km) limit would also require permits under the Massachusetts WPA and local wetland bylaws. Each of these programs involves consideration of water quality issues.

The WTGs and the ESP do not require the use of water for any part of their operations. Neither the WTGs nor the ESP require the use of water to complete scheduled maintenance activities on the proposed action's equipment. Temporary living accommodations would also be provided on the ESP. These would only be intended for use during emergency periods when crews cannot be removed due to weather or sea state 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. Runoff of rainwater from the WTGs and ESP would also not affect water quality. All oil and grease bearing components would be covered and contained such that storm water would not come into contact with oil and grease during periods of rainfall.

5.3.1.6.1 Construction/Decommissioning Impacts

Suspended Sediments/Dredge

The offshore 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 2.3). Potential marine water quality impacts would be limited to temporary and localized sediment disturbance along the offshore cable corridors and at monopile locations from construction vessel anchoring, anchor line sweep, and installation of the scour protection, foundation and cables. The temporary disturbance would typically last for a few hours after operations have ceased at the specific locations. 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 or aquatic life.

Lewis Bay

The transition of the interconnecting 115 kV offshore transmission cable system from water to land would be accomplished through the use of HDD methodology in order to minimize disturbance within the intertidal zone and near shore area. The HDD borehole length between the entry point, which would be on New Hampshire Avenue near its intersection with Shore Road, and the exit point pit in Lewis Bay would be approximately 200 ft (61 m). Four 18 inch (45.7 cm) High Density Polyethylene (HDPE) conduit pipes (one for each of the three-conductors in the 115 kV offshore transmission cables) would be installed via HDD between the vaults and the pit. To further facilitate the HDD operation, a temporary cofferdam would be constructed at the end of the boreholes located within Lewis Bay approximately 90 ft (27.4 m) seaward of the landfall location. The cofferdam would be approximately 65 ft (19.8 m) wide and 45 ft (13.7 m) 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 2,925 ft^2 (0.067 acre or 271.7 square miles) and would involve the removal of approximately 840 yd^3 (642 m^3) of material. The cofferdam would be backfilled after completion of the cable installation.

The dredged material would be removed using mechanical dredging equipment (i.e., clam-shell bucket). The dredged material would be temporarily placed on a barge for storage. The dredged area of the cofferdam would be backfilled with the dredged material. If necessary, the dredged material backfill material would be supplemented with imported clean sandy backfill material to restore preconstruction contours. No removal of sediment outside of the cofferdam would be required.

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.

In Lewis Bay, elevated suspended sediment concentration levels would remain considerably longer, as a result of weak tidal currents. Suspended sediment concentrations of 10 mg/L are generally predicted to remain for less than 24 hours after the jet plow has passed a given point along the route (Report No. 4.1.1-2). However, near the Yarmouth landfall concentrations of 10 mg/L are predicted to remain for up to 2 days after the jet plow passes as a result of very weak currents and fine bottom sediments. In places along and immediately adjacent to the offshore transmission cable system route (near the Yarmouth Landfall and south of Egg Island), suspended sediment concentrations are predicted to remain at 100 mg/L for approximately 5 hours (Report No. 4.1.1-2).

In the area of the eelgrass bed south of Egg Island, suspended sediment concentrations are predicted to be in the range of 50 to 500 mg/L, depending on proximity to the cable route. Suspended sediment concentrations of 10 mg/L are predicted to remain for approximately 9 to 18 hours after the jet plow has passed this point on the route. At the western end of the eelgrass bed, suspended sediment concentrations of 100 mg/L are predicted to remain for up to 6 hours. The eastern portion of the bed may experience maximum concentration levels of less than 50 mg/L (Report No. 4.1.1-2).

Horseshoe Shoal

The installation of WTG foundations, inner-array and the offshore transmission cable system routes would physically displace sediment at specific locations through sediment suspension, transport, and deposition. In sandy sediments, such as those in the area of the proposed action, the majority of disturbed sediments are expected to settle and refill cable trenches and areas immediately surrounding these trenches shortly after installation. 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).

The scour mats are placed on the seabed by a crane or davit onboard the support vessel. Final positioning is performed with the assistance of divers. After the mat is placed on the bottom, divers use a hydraulic spigot gun fitted with an anchor drive spigot to drive the anchors into the seabed. Sediment suspended during the installation of the mats is expected to be minimal and expected to result from mat placement on the bottom and actions of the divers. The mats are removed by divers and a support vessel in a similar manner to installation, and are expected to result in greater amounts of suspended sediments than levels associated with the original installation of the mats. However, the sandy nature of the bottom material over most of the site of the proposed action would result in rapid settling of the suspended sediment material, which would limit the extent of the impact of suspended sediments.

The rock armor and filter layer material would be placed on the seabed using clamshell bucket or a chute. By lowering the material into the water and placing the material on the bottom rather than dumping it, more control over the placement of the material can be achieved. Sediment suspended during the installation of the rock armor material is expected to be more than that associated with the use of scour mats. However, the sandy nature of the bottom material over most of the site of the proposed action would result in rapid settling of the suspended sediment material, which would limit the extent of the impact of suspended sediments. In those locations where rock armoring has been used for scour protection, it would remain in place following the proposed action's decommissioning.

The SSFATE 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 (Report No. 4.1.1-2). In addition, the amount of suspended sediment injected into the water column from jet plow embedment is estimated to be approximately 0.36 yd^3 (0.28 m^3) for every linear foot of cable installed, which is much less than that introduced into the water column from commercial trawling operations (1.32 yd^3 [1.01 m^3] per foot of trawling) (Churchill, 1998).

It is important to note that the suspended sediment concentration levels are short lived due to the tides flushing the plume away from the jetting equipment and the sediments rapidly settling out of the water column. Within Nantucket Sound, suspended sediment concentrations away from the offshore cable route of 10 mg/L are predicted to largely remain for approximately 3 hours after the jet plow has passed a given point along the route. In places along and immediately adjacent to the cable route, suspended sediment concentrations are predicted to remain at 100 mg/L for approximately 2 to 3 hours.

For the four representative inner-array cable routes modeled (Report No. 4.1.1-2), suspended sediment concentrations away from the cable route of 10 mg/L are predicted to largely remain between less than 3 and 12 hours, with one area being up to 18 hours, after the jet plow has passed a given point along the route. In places along and immediately adjacent to the cable route, suspended sediment concentrations are predicted to remain at 100 mg/L for approximately 2 to 6 hours, where as the active bed load sediment transport known to exist in Nantucket Sound is approximately 45 to 71 mg/L. (Report No. 4.1.1-2). The longer time durations associated with construction related turbidity occur in areas where the inner-array cable alignments run in an east-west direction, which is in the same direction as tidal currents in the area (see Table 5.3.1-9).

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 lower compared to concentration associated with other natural and man-made occurrences in Nantucket Sound (Cape Wind, 2003). 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, minor short-term and negligible long-term impacts are anticipated.

In addition to the water quality impacts discussed, the post lease G&G field investigations (Refer to Section 2.7) would require drilling and vibracore activities to assess geological conditions on the sea floor. Impacts associated with this would include temporary and localized turbidity, which would have a minor impact on water quality.

Inland Waters

Once the offshore transmission cable system makes landfall, the transmission cable system 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 ft (2.1 m) wide by 34 ft (10.4 m) long by 7.6 ft (2.3 m) high (see Figure 2.3.7-1). The transmission cable system transition vault would be installed within the pavement using conventional excavation equipment (e.g., backhoe). This work would result in no impacts to wetland resource areas. Work may be required within the 100 ft (30.5 m) Buffer Zone of Wetland 6 in Yarmouth. No work is proposed in wetland jurisdictional areas in Barnstable.

The proposed transmission cable would not result in changes to surface or groundwater hydrology. 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 MassDEP staff regarding the proposed installation of subsurface utilities along the proposed cable route (MassDEP, 2002b; MassDEP, 2003), MassDEP would typically prefer that the utilities were installed outside of the Zone I areas. However, the MassDEP 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 cables would not contain any fluids, petroleum, oils, or lubricants. The trenchless technology proposed for the Route 6 area would not be located within a Zone I area. The MassDEP Drinking Water Program staff indicated that the MassDEP would allow the installation of the proposed transmission cables within the Zone I area (MassDEP, 2002b; MassDEP, 2003).

The proposed action would not result in the addition of impervious surface areas, nor would it change the infiltration of surface water. The MassDEP 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 proposed action along the proposed route. Based on these findings, it does not appear that the MassDEP Zone I and Zone II regulations would affect the proposed action along the proposed route.

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 cable system s would pass above or beneath these culverts. No impacts to the culverts or adjacent waterways or wetlands are proposed.

The proposed action would not alter any freshwater wetlands or regulated culverts that would trigger Section 401 review. However, the proposed action would result in minor impacts to paved Riverfront Area and Buffer Zones, as regulated under the Massachusetts WPA and would, therefore, require an approval from the town Conservation Commission via an Order of Conditions. Work within Riverfront Area and the 100 ft (30.5 m) Buffer Zone is limited to temporary construction on paved roadway surfaces for the installation of the proposed transmission cable system route.

Proposed work in Yarmouth would result in temporary alteration of locally-regulated Lake and Pond Recharge Areas. In addition, the Yarmouth Wetlands Protection Regulations establish a 35 ft (10.7 m) Vegetated Buffer, 50 ft (15.2 m) No-Structure Zone, and 100 ft (30.5 m) 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 cable system beneath existing paved roadways and onshore portions of the NSTAR Electric ROW.

Conclusion

Overall, the construction and decommissioning impacts on water quality are expected to be minor, as disturbance to marine sediments would be only temporary and localized. Mitigation measures considered at this time include silt fences and other erosion control. A more detailed discussion of mitigation is provided in Section 9.0.

5.3.1.6.2 Operational Impacts

Operation of the proposed action and cable system is not anticipated to impact wetland resource areas.

There was some concern regarding frond deterioration from the scour mats and its impact on water quality. The fronds are stitched to the webbing material in a manner that prevents them from dislodging. Degradation could result from exposure to ultraviolet radiation; however, this is not possible in this situation because the fronds are installed on the sea-bottom where direct exposure to sunlight for extended periods of time does not occur. Frond degradation, as a result of excessive heat, is not possible because temperatures in excess of 100ºF are required for such thermal degradation to take place. As previously stated, year long temperature readings at the SMDS did not record temperatures over 72ºF. During a June 2005 observation, no fronds were missing from the webbing material. During a May 2006 investigation of the fronds, they were observed to have separated longitudinally into many fronds of smaller widths; however, the fronds appeared to have remained firmly attached to the webbing material. Therefore, there is a very low probability that fronds would dislodge and impacts to water quality would be minor.

Risk Characterization for Oil or Fuel and WTG Fluid Spills

The only components of the proposed action that would come into regular contact with seawater and would be subject to potential interactions between water, encrusting organisms, and sediment are the welded steel monopile foundations. The transition piece of the WTGs, which would be located on top of the monopile at the water line/splash zone, would be coated with a product equal or similar to Interzone® 954. The portions of the structural steel and steel surfaces not directly exposed to seawater, such as the tower (above the transition piece), would be coated with an epoxy-polyamide. In addition, cathodic protection using sacrificial anodes made of pure aluminum would be employed 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 proposed action, 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 proposed action installation.

The WTGs would contain lesser amounts of the following materials in the nacelle or hub: bearing lubrication (Mobil SCH 632), gear lubrication & cooling (Optimal Synthetic A320), break and hydraulic fluid (Mobil DTE 25), transmission fluid (ATF 66), gear lubrication and heat dissipation (water/glycol). Total storage of these materials at each WTG is expected to be approximately 214 gallons at any given time (27,820 gallons for all 130 WTGs). The WTGs have been carefully configured to contain any potential fluid leakage and to prevent overboard discharges. During service or maintenance of the WTGs, the possibility of small leaks could occur during oil changes of hydraulic pump units or the gearbox oil conditioning system. During WTG operation small leaks could occur as a result of broken gear oil hoses/pipes, and/or broken coolant hoses/pipes. Gear oil leaks would be contained within the hub and main bed frame and/or tower as described above. Coolant leaks could occur on a number of locations within the nacelle fiberglass covers.

Analyses were performed to estimate the trajectories of oil spills and calculate probable estimates of area coverage and minimum travel time. The study used two models: HYDROMAP to calculate currents, and OILMAP to calculate oil spill trajectories and resulting oiled areas and travel times.

The OILMAP model was used to simulate spill trajectories and determine probabilities of areas being oiled and oil travel times for an instantaneous release of 40,000 gallons (150,000 L) of electrical insulating oil at the ESP site in Nantucket Sound. This scenario (instantaneous release of entire tank contents) is highly unlikely and therefore conservative (Report No. 4.1.3-1).

The model results indicate that oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 to 30 percent). The likelihood of a spill impacting Nantucket is consistently small (less than 10 percent), while the chance of a spill impacting a shoreline somewhere within Nantucket Sound and the immediate surrounding areas is greater than 90 percent. Typically, the central and western areas of the Cape Cod coast and the east and northeast coasts of Martha's Vineyard are most vulnerable to a spill. The shortest time to reach shore for each of the scenarios ranges from 4.8 to 11.3 hours.

Some calculations were made that showed at 10 hours the percent evaporated ranged from less than one percent to slightly over 2 percent for the range of winds (5 to 20 knots [2.6 to 10.3 m/s]) typically seen in Nantucket Sound. After 24 hours, approximately 3 to 6 percent of oil had evaporated. In light wind conditions (less than 10 knots), greater than 90 percent of the oil remained on the surface. Less than 50 percent of oil remained on the water surface after 24 hours when winds exceeded 10 knots (5.1 m/s).

In addition to the oil spill trajectory modeling, an analysis has been performed of the probability that an oil spill might occur at the site of the proposed action (Report No. 5.2.1-1). The analysis involved the determination of the probability of the theoretical occurrence of an instantaneous release of 40,000 gallons of electric insulating oil and 2,000 gallons of diesel and other oils from the ESP[2] and up to 200 gallons of turbine and other lubricating oils from each of the 130 WTGs (for a total worst case of 68,000 gallons of oil). The analysis involved two major components: (1) determining the probability that any spill might occur from the ESP and WTGs; and (2) analyzing the range of spill sizes (and associated

[2] The applicant formerly had proposed use of emergency diesel generators on the ESP, which involved the storage of up to 2000 gallons of diesel and other oils. The emergency generators have since been replaced by battery backup. While Report 5.2.1-1 includes the diesel fuel in the spill trajectory and risk analyses, the DEIS does not include an analysis of the environmental impacts of a diesel fuel spill from the ESP.

probabilities) that might be expected if a spill was to occur from the ESP and WTGs. The analysis involved a four-step process:

(1) Evaluate and describe the events that might cause damage to the ESP and/or WTGs;

(2) Estimate or qualitatively analyze the probability of each of these events occurring;

(3) Estimate or qualitatively analyze the probability that for each of these events that damage occurs to the ESP and/or WTGs; and

(4) Estimate or qualitatively analyze the probability for each of these events to cause damage sufficient to cause an oil spill from the ESP and/or WTGs.

The analysis shows that the highest possibility of an oil spill occurring in the area in and around Nantucket Sound is related to vessels transiting the area, regardless of the presence of the proposed action structures and related work vessels. Over the course of 30 years, transiting vessels alone may result in 21 spills in and around Nantucket Sound. These spills are unrelated to the presence of the facility and would occur whether or not the facility was in place. The presence of the facility may very slightly increase the risk of spills from vessels colliding with one of the proposed action structures. When the presence of the proposed action components is combined with transiting vessels, the possibility for a spill over the 30 year period increases slightly to 22.443 spills. The oil spill probability analysis shows that only 7 percent of all spills expected in Nantucket Sound during a 30 year period could be attributed to the addition of the proposed action facility. It is possible that 2 spills attributable to the proposed action itself could occur during the same 30 year period. Of these spills, there is a 90 percent chance that they would involve 50 gallons or less, and a 1 percent chance they would involve volumes of 10,000 gallons. The probability of a spill in the same 30 year period involving the entire 68,000 gallons of oil contained within the 130 WTGs and the ESP is less than one in a million (Report No. 5.2.1-1).

Conclusion

Based on the temporary and localized impacts to water quality, and the very small probability of a major oil spill, the proposed action's operational impacts on water quality are expected to be negligible.

5.3.1.7 Electric and Magnetic Fields (EMF)

This section assesses impacts of the proposed action on EMFs. The information contained in this section was obtained from review of existing data available for the area of the proposed action, EMF monitoring and modeling, and review of the scientific literature on EMF.

Research has been conducted for over 20 years in the United States 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 EPAct (PL 102-486). The National Institute of Environmental Health Sciences (NIEHS), National Institute of Health (NIH) and the 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. The 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.

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, virtually all of the population in the United States uses electricity, and therefore, is routinely exposed to power frequency EMF. As a result 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).

Human Health Effects Associated with EMF

The likelihood for power line EMF to cause adverse health impacts in humans has been reviewed by many and various scientific groups. Hazard is identified by a standard process that considers data from epidemiologic, laboratory, and biophysical studies. Several 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) (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, the direct health risks result from exposure to EMF has not been established. 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 flux densities, but not 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 of 1.7 (95 percent confidence interval [CI], 1.2 to 2.3) for exposures above 3 mG, and a population attributable fraction of 3 percent (95 percent CI, –2 percent to +8 percent) 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 a mechanism by which EMF alters molecules, chemical reactions, cell membranes, or biological structures in a functionally significant manner should exist. 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).

The EMF impacts can be evaluated by asking how the forces and energies conveyed by EMF compare to forces and energies endogenous to biological systems. 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. Mechanisms by which EMF might alter biologic function are found to be small compared to the endogenous energies and forces characteristic of the living system (Valberg et al., 1997). Table 5.3.1-10 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 what any organism would be exposed to 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.

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 and Johnsen, 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) AC 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).

Data on the Nysted Offshore Wind Farm (Nysted) Project have documented some effects from offshore cable routes on fish behavior indicating avoidance of the cable as well as attraction, depending on species. However, the observed phenomena were not significantly correlated with the assumed strength of the EMF (Danish Energy Authority, 2006).

The specifications of the proposed cable systems require the cable to be shielded. Since electric field lines start and stop on charges, this shielding would effectively block the electric field produced by the conductors. Therefore, no electric field impacts are expected for the offshore cables. Magnetic fields on the other hand cannot be easily shielded because the magnetic field lines do not stop on objects they form continuous loops around conductors carrying currents.

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.

With regard to potential impacts of the EMF from submarine cables on living organisms, the following summary supports 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) [3], 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). [4]
- 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 limited number of organisms (for example,

[3] 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."

[4] 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."

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 flux density 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, any expected levels above the 60 Hz magnetic field occurs only directly over the 115 kV offshore transmission cable system on the sea floor and in the immediate vicinity of the ESP within 10 ft 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 proposed action.

5.3.1.7.1 Construction/Decommissioning Impacts

No significant electric or magnetic fields are anticipated during construction other than possible small fields associated very close to construction equipment. As a result electric and magnetic fields impacts from construction/decommissioning are expected to be negligible.

5.3.1.7.2 Operational Impacts

Electric and Magnetic Fields at Landfall Area

Electric Fields

Calculated existing electric field levels in and adjacent to the streets along the onshore 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 cable system 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 offshore transmission cable to duct type cable. The calculated peak magnetic flux density at an elevation of 3.3 ft (1 m) above grade at the vault is 11.3 mG for the 168 MW output and 30.8 mG for the 464 MW output.

The calculated peak magnetic flux densities produced by the proposed underground 115 kV cable in the streets is 7 mG at an annual average output of 168 MW, and 20 mG at maximum output of 454 MW. The field level falls off fairly rapidly with distance from the center of the duct bank.

The net magnetic flux density produced by the combination of the existing overhead and new underground cable system is a complex function of the relative geometry and loading of the overhead and underground circuits. The net magnetic flux density 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 proposed action at average output, and between 19 and 36 mG with the proposed action at maximum 454 MW output.

With the proposed action 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 ft (6.1 to 9.1 m) from the edge of pavement and beyond. Therefore, the magnetic flux densities experienced by residential or other properties along this section of the route would 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 Report No. 4.1.7-1.

Electric and Magnetic Fields at 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 cable system 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

To connect to the Barnstable Switching Station, 115 kV underground transmission cable system would be installed 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 proposed action 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 proposed action output of 454 MW, these values become, respectively, 127 mG, 49 mG, 56 mG, and 12 mG, which are 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 proposed action. The predicted impact of adding the underground transmission cable system is a negligible change from existing conditions within the ROW and no change in field strength at the ROW edges would occur.

Report No. 4.1.7-1 provides additional detail regarding the measurement of existing magnetic fields and calculations to predict future expected field levels for the onshore portion of the proposed action and for the 115 kV offshore transmission cable system.

Electric and Magnetic Fields in Marine Environment

No existing sources of power frequency fields are present in the offshore area of the proposed action. Projections were developed using the "ENVIRO" computer program to determine the magnetic flux density expected from both the 33 kV inner-array cables and the 115 kV offshore transmission cable system. Calculations were performed with the proposed action generating at a maximum delivered output of 454 MW and at the annual average output of 168 MW. Anticipated magnetic flux density was determined for the area directly above the cables (buried 6 ft [1.8 m] below the surface) at the sea floor and at varying water depths above the sea floor. In the horizontal plane, magnetic flux density was calculated approximately 20 ft (6.1 m) on either side of the offshore, at which point the magnetic flux densities had significantly decreased due to distance.

The magnetic flux density associated with the 33 kV inner-array cables 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 ft (6.1 to 9.1 m) of the ESP, the cables begin to rise up in the subsurface trench such that they would be buried approximately 2 ft (0.61 m) 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 inner-array cables would be grouped on a single riser, spaced 6.5 inch (16.5 cm) (one cable diameter) apart, edge to edge. Magnetic flux density was then calculated at varying distances from the surface of the cables.

Calculations for the 115 kV offshore transmission cable system 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 ft (1.8 m) 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 offshore transmission cable system would be routed in its own 18 inch (45.7 cm) diameter 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 offshore 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 (MLLW is 246 ft [75 m] 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 flux density is expected to be less. Moreover, any fields experienced on the ESP would be attenuated at sea level (MLLW is 39 ft [12 m] 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 flux densities associated with the offshore cables, rather than on the fields generated by the electrical equipment.

Electric Fields

The proposed offshore cables 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 is no perceptible electric field created by the cable system.

Magnetic Fields

The 115 kV offshore transmission cable system would consist of four 3-conductor cables configured as two circuits of two cable sets each. Each circuit would carry half the electrical output of the proposed action at any given moment. Throughout most of the submarine route (all but the HDD), the cables would be laid 6 ft (1.8 m) below the sea floor in two trenches, with two cable sets per trench. The trenches would be spaced approximately 20 ft (6.1 m) apart horizontally.

Calculations were performed to predict the magnetic flux density above the trenches on the sea floor, and at varying water depths above the trenches. The calculations predicted peak magnetic flux densities 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 of 10, 20 and 30 ft (3, 6.1 and 9.1 m) above the sea floor the field strength also decreases as a function of vertical distance. The calculated peak value at the sea floor is (3 mG) and the corresponding field levels above the cable trenches are 0.4 mG at 10 ft, 0.2 mG at 20 ft, and less than 0.1 mG at 30 ft (see Table 5.3.1-11).

The 33 kV inner-array cables 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 ft (1.8 m) below the sea floor, one per trench.

Calculations were performed to predict the magnetic flux density 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 offshore transmission system cables. Predicted peak magnetic flux densities on the sea floor, directly above the cable, decrease rapidly with distance from the cable and with vertical distance above the sea floor. Magnetic flux density 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 value at the sea floor is 28 mG and field levels at the cable trenches are 4 mG at 10 ft, 2 mG at 20 ft, and 1 mG at 30 ft (see Table 5.3.1-12).

Calculations were also performed to predict the magnetic flux density 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 flux densities were calculated at a distance of 2 ft (0.61 m) from the cables, which would represent the maximum exposure to marine organisms on the surface of the scour protection. Magnetic flux densities were also calculated at a distance of 10 ft (3 m) 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 ft (0.61 m) and 10 ft (3 m) distance are

473 mG and 51 mG respectively. The calculated values a short distance to the side of the cables are 26 mG at the 2 ft distance and 18 mG at the 10 ft distance (see Table 5.3.1-13).

Report No. 4.1.7-1 presents additional detail regarding calculations performed to predict future expected magnetic flux densities for the marine portion of the proposed action.

With respect to the cable's landfall, the transition to landfall would change the configuration so that each of the four sets of 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 ft (3.2 m) apart at their seaward end. Peak magnetic flux densities calculated for this configuration directly above the offshore cables at the sea floor, at MLLW and at MHW are 29.2 mG, 18.8 mG, and 11.5 mG respectively (see Table 5.3.1-14).

EMF Exposure in the Marine Environment

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 proposed action would not produce or add to any electric-field exposures in either near shore or offshore waters.

Aside from the exposure to maintenance and other workers, the only possible magnetic field exposure scenarios for humans involve boaters in the proximity of the ESP or divers on the sea floor in the vicinity of the buried offshore 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 a narrow area along the cables, and decrease rapidly within a few feet of such locations as shown in Table 5.3.1-15. Magnetic flux densities directly over the offshore 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 offshore 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.

Marine species that may frequent the area around the ESP would be mobile, and therefore, their exposure would be dependent 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 offshore 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.

A recent report on EMFs generated by offshore windfarm cables found that burial of the cable was generally ineffective in "dampening" the magnetic field, but that burial does provide some mitigation for the possible impacts of the strongest magnetic field and induced electric fields that exist within millimeters of the cable (Centre for Marine and Coastal Studies, 2003). The study also found that increased permeability or conductivity of the soils around cable reduced the induced electric field.

There are no anticipated EMF impacts associated with the construction staging/laydown activities at Quonset Rhode Island because it is an existing facility and there would be no or minimal changes to the existing electric infrastructure.

Conclusion

As electric and magnetic field levels would be small, and the exposure to humans and marine life limited largely due to the depth of cable burial, impacts on humans and marine life from electric and magnetic fields during operation of the proposed action would be negligible.

5.3.2 Biological Resources

5.3.2.1 Terrestrial Vegetation

5.3.2.1.1 Construction/Decommissioning Impacts

The terrestrial resources impacted from this proposed action would be located along the onshore transmission cable system starting near the landfall location in Yarmouth and heading to Barnstable Switching Station. The proposed onshore transmission cable system route runs north from the landfall at New Hampshire Avenue in Yarmouth for approximately four miles (6.4 km) within roadway and road shoulder along Berry Avenue, Higgins Crowell Road, and Willow Street, and then the route leaves the roadways for approximately two miles (3.2 km), heading west and then south along the existing NSTAR Electric ROW 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 consist of an excavated trench a minimum of eight ft (2.4 m) wide and approximately 36 manholes. The manhole covers would be flush with the surface of the ground. For terrestrial work, traditional construction equipment such as backhoes and cable trucks would be utilized. The excavation would be backfilled to the original grade, with topsoil replaced on the surface, and the area would be seeded with an erosion control seed mixture for stabilization. The total width of workspace disturbance would be approximately 25 ft (7.6 m), including construction access, laydown areas, and the eight ft (2.4 m) wide trench. This work would require the temporary disturbance of approximately 5.8 acres/252,648 ft^2 (23,471.6 m^2) of vegetation within the maintained ROW. The existing Barnstable Switching Station property can accommodate the addition of the proposed transmission cable with no additional land required.

Decommissioning of the onshore transmission cable system components would involve leaving in place the conduits, ductbanks and underground vaults beneath the roadways and the existing NSTAR Electric ROW but disconnecting and removing the underground conduit system. The onshore transmission cable system would be reeled and the reels would be transported to the staging area for further handling. The decommissioning of the onshore transmission cable system would be much shorter in duration then the installation because less work would occur since the conduit and vaults are being left in place. The vegetation impacts from the decommissioning activities would be reduced compared to construction since the entire route would not be disturbed, only the areas at the vaults or where reel up occurs.

Spills during equipment refueling, hydraulic line leaks or ruptures, or sloppy application of lubricants and greases could result in contamination of soils. The applicant would construct and operate the proposed action with an approved SPCC Plan, which should serve to minimize the potential adverse affects of such unintentional releases on the environment, including vegetation and vegetated habitats.

Impacts on Terrestrial Flora

The proposed action was designed to avoid impacts to previously undisturbed landscapes. The proposed transmission cable system route from the landfall location to the Barnstable Switching Station includes work within existing paved roadways and the existing maintained NSTAR Electric ROW. Although no disturbance of natural woodlands is planned, there may be some minor tree removal (if needed) along the ROW and road shoulders of the proposed transmission cable system. By planning the proposed action to use existing disturbed and managed areas, the proposed action would not result in extensive vegetation removal, especially of woody species, and would not directly impact freshwater wetlands.

To limit possible impacts to the surrounding landscape the following protocol would be used to facilitate revegetation along the undeveloped portions of the disturbed ROW. Sedimentation and erosion control devices would be installed as needed in uplands and near wetland areas along the edge of the construction ROW to prevent sediment flow into adjacent waterbodies and wetlands. Erosion and sediment control devices would be installed following vegetative clearing operations, but prior to grading and trenching in order to insure proper installation.

Although it is unlikely that there would be any trees taller then 15 ft (4.6 m) in the ROW, any trees 15 ft (4.6 m) in height or greater would be cleared and stockpiled for later wildlife habitat use. The understory vegetation and topsoil would then be stripped and stored along the trench. After the transmission line installation, topsoil would be re-spread, since separate topsoil stockpiling and replacement is important for successful vegetation re-establishment. The topsoil would be replaced as quickly as possible to minimize drying soils, germinating seeds, leaching nutrients, and declining microorganisms.

After the topsoil is re-spread, any trees that were cleared before would be placed evenly across the construction ROW (horizontally). The logs provide an effective erosion barrier and act as sediment traps. The logs provide habitat for pioneer animals such as insects and later, small mammals. The logs would also add organic material to the soil as they decompose.

Finally, the construction ROW would be seeded to ensure soil stabilization. A typical seed mix used for ROW revegetation might be composed of the following species: Creeping Red Fescue (*Festuca rubra*), Annual Rye-grass (*Lolium multiflorum*), Timothy (*Phleum pratense*), White Clover (*Trifolium repens*), Little Bluestem (*Schizachyrium scoparium*), Red Top (*Agrostis alba*), and Side-oats Gramma-grass (*Bouteloua curtipendula*). It is an appropriate seed mix for road cuts, pipelines, detention basin side slopes, and areas requiring temporary cover during the ecological restoration process. The mix would be applied by hydro-seeding or by mechanical spreader at a rate of 35 lbs per acre. The soil would be raked to create grooves and provide a seedbed. After applying the seed, the soil would be lightly raked over and organic fertilizer (Neptune's Harvest Fish/Seaweed Fertilizer Blend 2-3-1 at a rate of 20 gallons mix per acre or equivalent) would be applied. A slow release and low nitrogen organic fertilizer is being used since the site of the proposed action is within a Significant Natural Resource Area for the presence of public water supply wellhead protection area. If seeding is by mechanical spreader, the construction ROW would be covered with a light mulching of certified weed free straw to conserve moisture and to aid in slope stabilization.

Following soil stabilization, pre-existing seeds within the re-spread topsoil would begin to sprout. The shrub and tree roots remaining in the disturbed but untrenched areas of the ROW are expected to further enhance revegetation of the ROW within two growing seasons. Based on the applicant's previous project experience on Cape Cod, scrub oak would resprout and grow to two to three ft (0.61 to 0.91 m) after one full growing season.

According to the NHESP, the proposed terrestrial cable route intersects mapped areas of habitat for the Plymouth Gentian (*Sabatia kennedyana*) a species of special concern. These mapped areas are: PH 88, EH178, PH 40, EH 680, and EH 188. Because these locations occur along the roadway portion of the onshore cable route, with construction occurring in the roadway or road shoulder, the impact to the Plymouth Gentian would be negligible. The proposed terrestrial route intersects PH 88 and EH 178 in the existing utility ROW portion of the route. The area where this occurs is in the buffer zone for Wetland 6 (see Figure 4.2.1-1). Plymouth Gentian is list as an obligate wetland plant for Region 1 according to the USDA plants database (NRCS, 2007). Because the proposed route is in the buffer zone of Wetland 6 and not in Wetland 6, the Plymouth Gentian is unlikely to occur in the work areas along the proposed route.

Through the proper implementation of construction BMPs, the potential for indirect impact to the Plymouth Gentian would be negligible.

During decommissioning, impacts to the terrestrial flora would be greatly reduced compared to the installation impacts by limiting the activity to reel locations and not excavating the entire onshore transmission route. The erosion controls and revegetation procedures that are discussed in the construction impact sections would also be employed during the decommissioning phase of the proposed action to reestablish disturbed areas created during the proposed action's decommissioning. It is possible that there could be some tree removal in the reel up locations to create a safe working environment. Since this would represent a small fraction of the proposed route, these impacts are considered negligible to minor.

Conclusion

During construction and decommissioning, impacts to the terrestrial flora are expected to range from negligible to minor as these impacts would be temporary in nature, and localized. During decommissioning there could be some tree removal in the reel up locations to create a safe working environment. This represents a small fraction of the route and these impacts would be negligible to minor in nature. The impact to the Plymouth Gentian should be negligible. With the Plymouth Gentian being an obligate wetland plant and the proposed route being located in the buffer zone of a wetland and not in the wetland, there should be no Plymouth Gentian in the direct path of the proposed route, and implementation of construction BMPs would further help to ensure impacts would be negligible.

5.3.2.1.2 Operational Impacts

During the proposed action's operations, regular vegetation maintenance would be performed along the proposed route along the NSTAR ROW. The vegetation maintenance schedule and procedures would be the same vegetation management plan that is currently employed along the ROW. The vegetation management along the roadway portions of the proposed route would also follow the current vegetation management being employed along the roads of the proposed route. In the event that repairs are needed and the cable system needs to be excavated, it is anticipated that the impact would be similar to the installation impacts, although the duration of the impact would be shorter and the disturbance localized to the repair location. The erosion controls and revegetation procedures that are discussed in the construction impact sections would also be employed during any repair needed along the terrestrial route.

Conclusion

The operations of the proposed action are expected to have negligible to minor impact on terrestrial flora, largely because of the already developed and cleared or maintained characteristic of the route. Impacts from repairs would be similar to the installation impacts, although the duration and extent of the impact would be shorter and smaller and would be considered negligible to minor depending on the repair location and the time of year. A discussion of mitigation is provided in Section 9.0.

5.3.2.2 Coastal and Intertidal Vegetation

5.3.2.2.1 Construction/Decommissioning Impacts

Once the offshore transmission cable system makes landfall at the proposed location, the transmission cable system 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 seven ft (2.1 m) wide by 34 ft (10.4 m) long by 7.6 ft (2.3 m) deep (see Figure 2.3.7-1). The transmission cable system transition vaults would be installed within the pavement using conventional excavation equipment (e.g., backhoe).

In an attempt to minimize the release of the bentonite drilling fluid into Lewis Bay during HDD operations, 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.

Cable jetting operations would result in the creation of elevated suspended sediment concentrations that could reduce photosynthetic activity in seagrass beds. If the suspended sediment concentrations are high enough for long periods of time, sediment deposition could result in smothering of eelgrass beds. As discussed below, the applicant has undertaken studies of this potential occurrence and taken measures to minimize adverse impacts.

While sedimentation from the trenching process could affect nearby seagrass beds, direct disturbance impacts have been minimized by routing the offshore cables outside of known locations of seagrass. Anchors associated with the jetting vessel positioning would result in localized disturbance to seagrass, if they are deployed within areas of seagrass. Anchor cable sweep would increase the disturbance of seagrass from any anchoring occurring within the seagrass beds.

Impacts on Coastal Flora

Since the landfall location is devoid of vegetation (made up of intertidal sand and mud flats and concrete) and the transmission cable route immediately heads under an existing paved road, the impact to any coastal flora would be negligible. Inside the proposed action's buffer zone, there are residential properties directly east and west with associated yards with riprap and concrete walls towards the water. There are no known significant populations of coast flora at the landfall location. A salt marsh is located approximately 200 ft (61 m) west of the landfall location, but would remain unaffected by the proposed action due to the distance from the cable landfall and use of HDD technology for transmission cable installation.

Impacts on Seagrass Beds

In order to address special concerns about the potential effects of the jetting operation on an eelgrass bed identified just west of Egg Island in Lewis Bay, simulations of sediment transport and deposition from jet plow embedment of the offshore transmission cable system and the inner-array cables were performed. These simulations, which used two models (HYDROMAP to calculate currents and SSFATE to calculate suspended sediments in the water column and bottom deposition from the jet plow operations), estimated the suspended sediment concentrations and deposition that could result from jet plow embedment of the cables. The full analysis is included in Report No. 4.1.1-2 and summarized below.

In the area of the eelgrass bed in Lewis Bay, the bottom sediments are relatively coarse. As a result, the sediments suspended by the jet plow are predicted to fall along the route with bottom deposition predicted to be in the range of 1.0 to 3.0 mm (0.04 to 0.1 in) at the western edge of the eelgrass bed. The majority of the eelgrass bed is predicted to experience little or no deposition as a result of the jet plow embedment operations. Suspended sediment concentrations in this area are predicted to be in the range of 50 to 500 mg/L, depending on proximity to the cable route. Suspended sediment concentrations of 10 mg/L are predicted to remain for approximately 9 to 18 hours after the jet plow has passed this point on the route. At the western end of the eelgrass bed, suspended sediment concentrations of 100 mg/L are predicted to remain for up to four hours. Concentrations at that level are not predicted to occur at the bed's eastern end, which experiences maximum concentration levels less than 50 mg/L (Report No. 4.1.1-2).

Eelgrass beds typically experience some level of sedimentation under natural conditions as a result of tidal currents, waves, and storms. As a result, eelgrass has morphological, physiological, and reproductive means of dealing with exposure to a certain amount of deposited sediments. Regrowth of seagrasses such as eelgrass can occur if sediment deposition only results in a light covering of sediment material and if the rhizome system is not damaged (Duarte, 1997). Since the majority of the eelgrass bed is expected to experience little or no deposition as a result of jet plow operations, it is anticipated that the natural means of seagrass adaptation to changing sedimentation conditions would allow the eelgrass bed to withstand the short-term jet plow operations that would pass by the eelgrass bed (Report No. 4.1.1-2). In addition, the short duration of exposure to elevated total suspended solids (TSS) levels would have negligible affects on photosynthesis and there should be no indirect impacts to the eelgrass beds.

Macroalgae is less tolerant of suspended and deposited sediments since areas of hard substrate to which the algae attach are typically areas of minimal sediments. However, as with the eelgrass, the duration of anticipated elevated suspended sediment concentrations is unlikely to measurably reduce photosynthesis and there should be negligible indirect impacts to areas of macroalgae. Hard substrates that become covered with sediment up to 0.12 inch (3 mm), may not allow for settlement and attachment of macroalgae, if the hard substrates remain buried during the reproductive period. However, it is likely that wind and tidal induced currents may remove deposited sediments, since the Horseshoe Shoal area is shallow and experiences both tidal and wave induced currents.

While the majority of the potential SAV observed in the Horseshoe Shoal area was macroalgae consisting of red macro-algae (*Grinnellia americana, Dasya pedicellata* and *Gracillaria tikvahiae*), and green macro-algae (*Codium fragile, Ulva lactuca*), some eelgrass was observed. It is possible that some of the small clumps of eelgrass located at the northern end of the western SAV area, per the OSI 2003 and 2005 surveys in the Horseshoe Shoal area, could be disrupted by the cable jetting since an exact survey of eelgrass locations relative to the specific cable routes has not been performed. However, since the cable installation process involves disturbance of only a small percentage of the overall site of the proposed action in the western portion of Horseshoe Shoal, the majority of the small clumps of eelgrass should experience little to no direct impact from the installation and overall impacts on eelgrass would be minor.

Installation of WTG monopiles or ESP piles could result in the permanent loss of marine vegetation at the pile location. Jack up or spud barges could also result in very small, localized loss of vegetation within the footprint of the pads or spuds However, most of the monopiles occur in areas of no or very sparse macroalgae or seagrass, so direct impacts are unlikely. The dispersed and infrequent loss or alteration of small patches of macroalgae or seagrass would only result in minor affects on these species, and recovery of the area would occur over time.

During decommissioning, the offshore cables would be disconnected and pulled out of the J-tubes on both the WTGs and the ESP, and the cables would be cut below the seafloor. The cables would then be reeled in after being water jetted free of the bottom sand. The jetting to remove the cables would have the same affects as the jetting during cable installation, resulting in direct loss of vegetation within the trench area, and minor indirect sedimentation affects nearby, due to the predominance of coarse sediments which limits sediment resuspension, transport, and deposition.

In association with the construction process, particularly cable jetting, construction vessels would be held in position using a series of large anchors with thousands of feet of anchor cable deployed. While the applicant has committed to using mid-line buoys to help suspend a portion of the cable off the seafloor, there would be areas where the cable sweeps across the seafloor surface as the jetting barge moves. This could have the affect of a wire cheese cutter slicing the top layer of sediment, resulting in disturbance to rooted plants such as seagrass or severing the holdfasts of attached macroalgae which would turn it into drift algae. Since much of the macroalgae experiences seasonal die-back, the anchor cable removal of patches of algae would result in minor changes in the biomass of the algae present along the cable routes at levels well below the natural die-back. Since the presence of seagrass and macroalgae is predominantly only in a portion of the western part of Horseshoe Shoal, only a limited number of the inner-array cables would be constructed where this vegetation occurs.

Conclusion

The construction and decommissioning impacts on coastal flora are expected to range from negligible to minor, considering there is no significant coastal flora located at the landfall location or seagrass within close proximity to the undersea work area. The largest source of potential impact is associated with anchor cable sweep during jetting of inner-array cables in the western portion of Horseshoe Shoal.

5.3.2.2.2 Operational Impacts

The impacts of the buried transmission cable in the coastal and intertidal environment during the operation phase of the proposed action should be negligible, but in the likelihood that the cable needs to be repaired, it is anticipated that the impact would be similar to the installation impacts, although the duration of the impact would be shorter. The nature of the impacts would also be dependent on where the cable repair was needed, since the marine vegetation varies throughout the site of the proposed action. For example, between Horseshoe Shoal and Lewis Bay, there are no areas of seagrass or macroalgae. The probability of a repair being needed, and for it to be required within an area of vegetation, is low. As a result, impacts on marine vegetation during the operational phase if repairs are needed would be negligible.

Conclusion

The day-to-day operational impacts on coastal and intertidal flora are expected to be negligible as the cable is buried and there is no expectation that it would need to be uncovered for normal maintenance, so no seafloor disturbance should occur. Impacts from repairs would be similar to the installation impacts, although the duration of the impact would be shorter and would be considered negligible to minor depending on the repair location and the time of year. The WTGs and ESP maintenance activities would primarily be above water and not involve seafloor disturbance. If the scour protection needs maintenance, there would be disturbance of any macroalgae that has colonized the area, resulting in the minor loss of biomass that was artificially generated due to the installation of the monopiles and scour protection in the first place.

5.3.2.3 Terrestrial and Coastal Faunas Other Than Birds

This section discusses impacts to those animals occurring along the land portion of the cable route as well as bats. There are species that are common to the area that have the potential to be affected by construction/decommissioning and operation of the proposed action. In addition, certain species, such as bats, may spend a majority of their time over land, but do have the potential to occur within the vicinity of the turbines on Horseshoe Shoal.

5.3.2.3.1 Construction/Decommissioning Impacts

Installing the transmission cable within existing roadways serves to greatly reduce the potential impacts to local reptile and amphibian populations as many of the local populations of these species have adjusted the migratory patterns to avoid the roadways as well as the fact that roadways do not serve as habitat for these species.

Small mammals, reptiles, amphibians and invertebrates that utilize onshore areas adjacent to Long Pond may experience limited displacement or mortality during construction, 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 be negligible.

The Eastern Box Turtle has been known to be found in this general area of Cape Cod along the roadway portion of the landfall route. The roadway itself would not be used for breeding, foraging, or nesting. The roadway may be crossed by the Eastern Box Turtle when migrating from breeding, foraging, or nesting areas, but the temporary affects of construction are limited compared to daily traffic. Overall, the construction impacts on the Eastern Box Turtle would be negligible. Since decommissioning only involves work at reel in locations, potential decommissioning impacts would be even less than during construction.

The impacts to state listed T&E invertebrates would be minimized by installing and decommissioning the onshore transmission cable system during times when these threatened species are limited to the wetlands, that is, seasonal periods outside of summer months. This would be accomplished by installing the cable system when damselfly and dragonfly species are in there egg or aquatic nymph phases of their lifecycles and through the use of proper construction BMPs to prevent any sediment from entering wetlands. Using these BMPs, the construction impacts on the threatened or endanger damselfly and dragonfly species would be negligible. The damselfly and dragonfly egg or aquatic nymph, phase of life is also the Water-willow Stem Borers egg or larval phase of life. The Water-willow Stem Borer is a moth that is only found in southeastern Massachusetts. According to the NHESP fact sheet on the Water-willow Stem Borer, the only plant species used by the Water-willow Stem Borer is swamp loosestrife *(Decodon verticillatus*). Swamp loosestrife is listed as an obligate wetland plant for Region 1 according to the USDA plants database. With the proposed route only being in the buffer zone of wetlands, rather than directly crossing freshwater wetlands, no Swamp loosestrife would be directly damaged by the construction activities and with proper construction BMPs, the potential for indirect impact on the Water-willow Stem Borer would be negligible.

Short-term 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. Most wildlife species are anticipated to move into similar nearby habitat areas until construction is completed and the disturbed areas become revegetated. In addition, small mammals, such as voles, may suffer some mortality due to trenching activities. However, the noise and vibration of construction machinery may cause some individuals to leave the construction workspace in front of the trenching activity, thereby avoiding mortality.

Spills during equipment refueling, hydraulic line leaks or ruptures, or sloppy application of lubricants and greases could result in contamination of soils. The applicant would construct and operate the proposed action with an approved SPCC Plan, which should serve to minimize the potential adverse affects of such unintentional releases on the environment, including wildlife.

During the construction installation phase and decommissioning in the ROW, the local terrestrial wildlife may be disturbed by construction activity and noise. The construction activity would most likely cause some wildlife to alter their travel patterns but this would be limited to small-localized areas. This impact would be relatively short in nature and be limited to small-localized areas. During the roadway installation, the noise could also disturb some of the wildlife. However, due to the installation being under the current roadway, much of the wildlife inhabiting the surrounding landscape should be accustomed to noise produced by traffic and should be familiar with avoiding the road. Thus noise impact to wildlife would be minor.

Significant bat foraging locations or migratory corridors are not anticipated to be impacted by construction or decommissioning of the WTG structures. Construction of the WTGs would not result in the loss of roosting habitat. Construction and decommissioning activities including the transport of large equipment, increased vessel traffic, monopile driving, or cable trenching are anticipated to have negligible to minor impacts to bat habitat as bats are not expected to frequent the area of the proposed action.

Onshore activities associated with installation of the transmission cable system would occur in existing ROWs (road or transmission line) within a developed region, and would therefore not result in loss of habitat. Use of onshore locations for the staging of offshore construction and decommissioning equipment would occur at existing developed locations that experience similar uses. Therefore, onshore activities associated with construction or decommissioning of the proposed action are not expected to result in loss of bat habitat.

There is a potential for collisions of bats with WTGs under construction, or construction equipment, if bats' migratory movements were to occur within the area of the proposed action. More information is needed to assess bat occurrence and flight behavior over areas of Nantucket Sound, as well as the mechanisms that result in collisions, including potential bat attraction to tall structures as potential roost habitat, or noise interferences with bat acoustical detection. However, bat occurrence greater than five miles offshore is anticipated to mainly be limited to migratory or dispersal periods due to the lack of suitable habitat offshore. Additionally, bat migratory or dispersal movements across the Sound are expected to be sporadic. There are no known bat migration corridors through the site of the proposed action and bats are not expected to frequent the area of the proposed action. Therefore, the risk of collision during construction or decommissioning activities is anticipated to result in negligible to minor impacts to bats.

Conclusion

The construction and decommissioning impacts on terrestrial and coastal faunas other than birds are expected to be negligible to minor. Short-term displacement and avoidance of active construction areas and noise disturbances are expected to have a minor impact on wildlife present along the ROW. The decommissioning activity should have a negligible impact to the wildlife along the proposed route, with the affected locations representing a small fraction of the habitat available to these species.

5.3.2.3.2 Operational Impacts

By landscapes along the proposed cable route not changing in land management or land use, the resources available to the fauna using terrestrial route should not be significantly different from the current condition. In the event that repairs are needed and the cable system needs to be excavated, it is anticipated that the impact would be similar to the installation impacts, although the duration of the impact would be shorter. This would again cause some localized displacement of wildlife in the repair area work zone. This would also disturb any wildlife habitat that has established itself on top on the buried utility cable system. However, this would represent a small fraction of the proposed route.

Onshore wind projects have emerged as a potentially significant source of mortality for migrating bats based on the results of recent studies (Johnson and Strickland, 2004; Kerns and Kerlinger, 2004; Arnett et al., 2005; Curry and Kerlinger 2007; Kunz et al., 2007). These studies have raised numerous concerns regarding the potential for collision mortality associated with wind turbines to impact bat populations (Williams, 2003). However, the concerns lie primarily with wind farms on forested ridgelines in the eastern United States, where documented bat fatality rates have been considerably higher (bats/turbine/year) than at western and mid-western wind farms (Johnson et al., 2003; Williams, 2003; Arnett et al., 2005). Mortality at western and mid-western facilities is much lower, with documented fatality rates ranging from only 0.07 to 2.32 fatalities/turbine/year while those from some eastern facilities ranging from 30 to 40 fatalities/turbine/year (Erickson et al., 2001; GAO 2005). Emerging evidence from one facility on the prairies of Alberta, however, indicate that bat mortality in those open habitats can be comparable to that observed along the forested ridgelines of the central Appalachian Mountains (unpublished data presented by Robert Barclay, University of Calgary, Alberta, at the North American Symposium on Bat Research, October 2005).

Several hypotheses regarding bats' vulnerability to collision with wind turbines have been proposed, but none have been adequately tested to date. Bats may be attracted to wind turbines due to curiosity about motion or noise, acoustic interference produced by turbines, or potential roost habitat on the turbines themselves. Insects may also concentrate around turbines due to lighting or the heat of the nacelles, which could in turn attract bats to turbines. Landscape features such as topography, forest edges, roads, or watercourses may serve as corridors for migrating or foraging bats, funneling them towards wind turbines located near these features (Arnett et al., 2005). Some bats that fly close to turbines may not actually collide with turbines but may become trapped in the blade-tip vortices, and may be injured or killed by decompression as the blades rotate downward (Kunz et al., 2007). Specific weather conditions may attribute to bat collisions with wind turbines. Low cloud cover or thermal inversions following the approach of fronts may influence bats to fly at lower altitudes when migrating (Kunz et al., 2007).

Cryan and Brown (2007) determined that certain weather factors are associated with the arrival of migratory hoary bats at an island migration stop-over location in the Pacific. Low wind speeds, low moon illumination, overcast conditions, and low barometric pressure were associated with bat arrivals and departures. Island arrivals were most associated with passing storm fronts in autumn (Cryan and Brown, 2007). High intensity lights emitted from a lighthouse on the island was believed to influence the presence of migratory bats at this location. However, aviation lighting on wind turbines has not been shown to influence bat fatalities at existing wind farms (Cryan and Brown, 2007). The study supports the conventional belief that bats use vision to navigate during long-distance migration, and that bats may orient themselves toward visual landscape features during migration.

A few consistent patterns have emerged from mortality studies of bats at onshore operating wind energy facilities regarding the timing of mortality and the species most commonly found. The timing of fatalities documented at existing wind facilities and other structures suggests that fall migrating bats are at the highest risk, while risk during the summer feeding and pup-rearing period is low (Johnson and Strickland, 2004; Johnson et al., 2003; Whitaker and Hamilton, 1998; Cryan and Brown, 2007). Additionally, only certain species of bats may be at risk. Of the 45 species of bats that occur in the United States, only 6 have been found during mortality searches (Erickson et al., 2001). The species most commonly found during mortality searches are the migratory tree bats (eastern red bat, hoary bat, and silver-haired bat) and the Eastern pipistrelle. Although bat collision mortality has been documented during inclement weather (Johnson et al., 2003), collisions occur most frequently on nights with wind speeds of less than 9 to 13 mph (4 to 6 m/s) (Arnett et al., 2005; Kunz et al., 2007).

Because the exact mechanisms that cause high collision rates among migratory bats at onshore projects are understudied, the process of accurately characterizing potential impacts of an offshore wind farm is difficult. Bats are known to migrate or disperse over-water and they are known to inhabit and stop-over at migratory locations on Martha's Vineyard in Nantucket Sound. Radar surveys conducted in the area of the proposed action in the absence of thermal imaging confirmation to differentiate between bird and bat targets cannot be used to assess bat use of the area of the proposed action. Therefore, there is limited information available to characterize bat frequency and flight behaviors within the area of the proposed action. However, due to the relatively low food availability and a lack of roosting structures offshore, the abundance of bats over the ocean is conventionally believed to be far less than the abundance of bats among onshore habitats.

Mortality data from onshore wind farms indicate that bat collision mortality is expected to occur mainly on nights with calm winds during migratory periods. Species at risk of collision with operating WTG structures mainly include long-distance migratory species. Non-migratory bats are expected to make infrequent crossings of the Sound during dispersal periods, and would therefore be at a very low risk of collision. Long-distance migratory bat species may be at a greater risk of collision due to the observed mortality at existing onshore facilities, however, bat use of Nantucket Sound is poorly understood and basing potential impacts of an offshore wind farm on existing data from onshore facilities may not be appropriate. There are likely differences between bat flight behaviors over water verses over forested landscapes or other open landscapes such as agricultural fields. The actual mechanisms that result in bat collisions as well as bat occurrence and flight behavior within the area of the proposed action require further investigation.

Bats may be among species of terrestrial animals impacted by artificial sources of EMF produced by the onshore transmission cable system. EMF may directly deter bats from an exposed area. Studies show that due to the thermal effects of EMF exposure, bat foraging activity was significantly reduced in habitats exposed to EMF (>2 v/m) when compared to similar habitats with no EMF levels (Nicholls and Racey, 2007). However, the addition of the onshore transmission cable system would not change electric field levels. The electric field within the existing NSTAR Electric ROW would be effectively contained within the body of each underground onshore transmission cable system by a grounded metallic shield. No external electric field would be produced. Upon completion of the onshore transmission cable system the electric fields within the existing NSTAR Electric ROW are expected to be approximately the same as the existing condition, due primarily to the presence of the existing overhead 115 kV lines. Therefore, impacts associated with EMF to bats are anticipated to be negligible.

Conclusion

The day-to-day operational impacts on terrestrial and coastal faunas other than birds are expected to be negligible. Impacts from repairs would be similar to the installation impacts, although the duration of the impact would be shorter and would be considered negligible to minor depending on the repair location and the time of year.

Because bat habitat does not occur within the area of the proposed action, the development of the proposed action is not expected to result in loss of habitat. There are no known migration corridors over Nantucket Sound; therefore, bats are expected to occur infrequently and sporadically within the area of the proposed action during migratory or dispersal periods. Therefore, the presence and operation of the turbines are not expected to present a major barrier to the flight paths of bats. Impacts are expected to be limited to occasional collision mortality associated with bats migrating or dispersing through the area of the proposed action. The proposed action is anticipated to result in minor adverse impacts to migratory bats, and is expected to be negligible for non-migratory bats.

5.3.2.4 Avifauna

Potential impacts to avian species can result from the development and operation of an offshore wind farm. Construction and decommissioning activities can result in disturbances associated with increased human presence or boat traffic, the operation or presence of large construction equipment, displacement due to habitat loss or modification, as well as the risk of collision with WTGs under construction or large equipment. Such impacts can result in changes to foraging or flight behavior resulting in increases in energy expenditure, decreased breeding success, or increased mortality. Operation of a wind facility can result in more long-term disturbances including habitat loss, disturbances associated with EMF from the offshore cables or onshore transmission cable system, or barriers to flight movement due to the presence of operating turbines. Additional disturbances associated with operation of a facility include increased vessel traffic or human presence during routine maintenance activities associated with monopile collapse or cable repair, impacts associated with oil spills, as well as the risk of collision with operating turbines.

Potential project impacts are largely species specific depending on each species use of the area of the proposed action as well as the particular flight or foraging behaviors of a species within the area of the proposed action. The following sections summarize the results of 2002 to 2006 boat, aerial, and radar bird surveys, and describe the potential proposed action impacts, and the magnitude of these impacts that could occur during the construction and decommissioning, and operational phases.

5.3.2.4.1 Construction and Decommissioning Activities

Terrestrial Birds

Raptors (hawks, owls, eagles, falcons, etc.)

There are a multitude of raptor species that occur during the breeding and wintering seasons in the region. A range of species also occur along the Atlantic Coast during spring and fall migration. The potential proposed action impacts to raptors during construction and decommissioning of the proposed action include loss or modification of habitat, impacts associated with EMF from the onshore transmission cable system, the risk of collision mortality. Impacts associated with these sources of disturbance are anticipated to be negligible as most species of raptor do not regularly occur 5 miles (8 km) out to sea. However, exceptions include a few species that are known to cross large expanses of ocean during migration and other raptors species that could get blown offshore during migration. Additionally, osprey may forage in Lewis Bay, the proposed cable landfall location.

Raptor Observations in Nantucket Sound

Raptors observed during surveys consisted of a total of eight ospreys seen during boat surveys in Nantucket Sound on August 15 and 22, 2002, and September 12, 2003 (Report Nos. 4.2.4-5 and 4.2.4-10). All individuals observed were seen less than one mile offshore south of Falmouth. The ospreys observed were foraging at heights less than 50 ft (15 m). No other raptor species were observed during the 125 aerial surveys or 89 boat surveys of Nantucket Sound conducted between 2002 and 2006.

Raptor Observations at Existing Wind Facilities

Relatively few observations of raptors at existing offshore facilities have been reported. Raptor observations in the vicinity of the Kalmar Sound facility in Sweden during Spring 1999 to 2003 and Fall 2000 to 2003 reported 150 individuals consisting of species of osprey, eagle, harrier, falcon, *buteo*, and *accipiter*. Raptors that flew through the area generally flew at high altitudes 492 to 656 ft (150 to 200 m), above the rotor zone of the Kalmar Sound facility. Migrant raptors that were observed near the project mainly passed between the facility and the shoreline (Pettersson, 2005); however the majority of raptors were observed closer to shore. At the Horns Rev Offshore Wind Farm (Horns Rev) facility in Denmark, raptor observations near the facility consisted of eight total individuals including species of accipiter and falcon, during survey periods from August 2002 to November 2003, and March through May 2004. A few birds were observed as migrants, however, Eurasian sparrowhawk (*Accipiter nisus*) were observed perching on turbine foundation structures (Christensen et al., 2003).

At land-based facilities located in close proximity to nesting or foraging habitat, high collision mortality of raptors has been reported. White-tailed eagles have experienced high mortality at an island-based facility on Smola off of the northwest Norwegian coast (Bird Life Intl., 2006). The island was designated as an Important Bird Area due to a high density of the nesting eagles. Altamont Pass in California is notorious for its high raptor collision mortality mainly due to turbines located in the vicinity of optimal foraging habitat and the model of turbines that occur there. Raptor mortality in the United States, outside of California, has been documented to be very low. For example, mortality rates found at onshore wind developments outside of Altamont Pass have documented 0 to 0.07 fatalities/turbine/year from 2000-2004 (GAO, 2005). As of 2002, there were seven reported raptor fatalities which occurred in North America outside of California (Kerlinger and Curry, 2002) and few have been reported from onshore facilities since then. The factors that explain why raptor mortality outside of California has been notably lower include: significantly lower raptor use of existing area of the proposed actions; the lack of topographical features that funnel migrants toward existing facilities; the deployment of larger turbines with slower moving blades that may be more easily avoided by raptors; and the now standard use of tubular towers that eliminate perching sites below the spinning blades.

Potential impacts during construction and decommissioning activities include loss of habitat or habitat modification, and the risk of collision with construction equipment or WTGs undergoing construction.

Onshore activities associated with installation of the transmission cable system would occur in existing ROWs (road and transmission line) within a developed region, and would, therefore, not result in loss of habitat or other disturbances to raptors. Near-shore construction and decommissioning activities may result in the temporary loss or modification of foraging habitat for osprey. Cable trenching would occur in Lewis Bay where osprey may forage. Increases in human presence and vessel activity during construction and decommissioning may temporarily displace foraging osprey. Cable trenching would result in sediment plumes that may temporarily displace prey fish. However, sediment suspended by trenching during cable installation is expected to be localized (20 mm/liter within 1,500 ft [457 m] from the trench) and is expected to quickly resettle (within minutes or up to a few hours). Jet plow embedment would allow for simultaneous plowing and cable-laying to minimize impacts. Therefore impacts to foraging osprey during cable laying are anticipated to be temporary and negligible.

Offshore construction and decommissioning may result in the potential for collision with WTG structures under construction or construction equipment. However, because raptors are mainly diurnal, and have exhibited high turbine avoidance behaviors at wind farms that do not occur in high raptor use areas, and because they are not expected to regularly occur within the area of the proposed action, the risk of collision during construction and decommissioning is low. The risk of collision mortality during construction and decommissioning activities are expected to have negligible impacts to raptors.

Passerines

A substantial portion of the land bird population of North America consists of neotropical and regional migrant passerines. A number of local or migrant passerine species occur in the area of Nantucket Sound at varying times of the year. While it's a conventional belief that coastal areas concentrate migrant songbirds during active migratory flights and during stopover events, little information exists on the actual numbers of night migrants in the air along the Atlantic Coast. While relatively few species routinely use open water, marine habitat, large numbers of songbirds could occur in and over the area of the proposed action during both nighttime and daytime migration. Migrants may be blown offshore depending on the prevailing wind direction during nighttime movements along the coast. Some neotropical migrant species, specifically those of the family Paurlidae (wood warblers), may make substantial water crossings during nocturnal migration (Richardson, 1978). Although a number of terrestrial ornithological radar studies have been conducted to determine the characteristics of nocturnal migration, there is little information available that thoroughly quantifies nocturnal migration over the ocean.

Potential impacts to migratory songbirds during construction and decommissioning of the proposed action include risk of collision with WTGs undergoing construction, and onshore activities associated with installation of the underground transmission line, which would occur in roads and in an existing ROW. The majority of flight heights are well above the rotor zone, and impacts associated with collision mortality during offshore construction and decommissioning are anticipated to be minor.

Onshore activities associated with installation of the transmission line would occur in roads and an existing ROW, and would therefore, not result in any permanent loss of habitat. Construction would cause the temporary displacement of birds that breed or forage in the immediate secondary vegetation or edge habitats present in uplands and wetlands on ROW. During the breeding season, this could include such species as Eastern towhee (*Pipilo erythrophthalmus*), song sparrow (*Melospiza melodia*) and field sparrow (*Spizella pusilla*) within the ROW, and species such as blue-winged (*Vermivora pinus*), prairie (*Dendroica discolor*), and chestnut-sided (*Dendroica pensylvanica*) warblers, and Baltimore oriole (*Icterus galbula*) along the edge of the ROW (King, 2003). Since secondary vegetation will be quickly restored, any impacts due to displacement will be temporary and minor.

Coastal Birds

A number of shorebirds, including piping plover (federally-threatened) and red knot (federally-listed as a species of conservation concern), as well as wading bird species such as herons and bitterns, are known to either breed, stage, or winter along the mainland and island shores of Nantucket Sound and surrounding areas. Wetlands and inter-tidal areas around the bay provide important habitat for a multitude of shorebirds and wading birds, including migratory species that commonly occur along the Atlantic coast.

Construction and decommissioning activities can result in impacts to coastal bird species as a result of disturbances associated with increased human presence or boat traffic, the operation or presence of large construction equipment, displacement due to habitat loss or modification, as well as the risk of collision with WTGs under construction or the risk of collision with large equipment. Such impacts can result in changes to foraging or flight behavior resulting in increases in energy expenditure, decreased breeding success, or increased mortality. Operation of a wind facility can result in more long-term disturbances including habitat loss, or barriers to flight movement due to the presence of operating turbines. Additional disturbances associated with operation of a facility include increased vessel traffic or human presence during routine maintenance activities associated with cable repair in Lewis Bay, impacts associated with oil spills, as well as the risk of collision with operating turbines.

Detailed analysis for species of conservation concern including piping plover and red knot have been provided in Appendix C and Section 5.3.2.9.

Shorebird Observations in Nantucket Sound

Few shorebirds were observed within the study area during aerial and boat surveys conducted by the applicant and MAS from 2002 to 2006. This may be due to the fact that aerial and boat surveys focused effort on shoal areas within Nantucket Sound instead of the shorelines of the mainland and islands of Nantucket Sound where the majority of local or stopping-over shorebird species aggregate for foraging. Few observations may also represent the limitations to aerial and boat surveys. Low flying, small, light-colored birds may not be easily detected from altitudes of 246 ft (75 m) or greater during aerial surveys. Alternately, high flying birds may go undetected during boat surveys conducted at the surface of the water. Shorebirds species migrating over the Nysted and Horns Rev wind farm in Denmark would have gone undetected by an observer had the radar not detected a flock flying over 984 ft (300 m) (Petersen et al., 2006). Surveys were limited to daytime periods of good visibility, therefore there is no data to describe shorebird occurrence in the study area at night or during periods of inclement weather.

Shorebird observations in the study area were limited to: one American oystercatcher (Report No. 4.2.4-8); one red knot in a mixed species flock with six other unidentified sandpipers observed flying low over the water near Cape Poge, Martha's Vineyard; and 20 dunlins observed on Muskeget Island (Report No. 4.2.4-9).

Potential impacts associated with construction and decommissioning activities may include habitat loss or modification, disturbances associated with human presence, the activity of construction equipment, and increased boat traffic, as well as the risk of collision with turbines under construction or large construction equipment.

Habitat Loss or Modification

The effects of habitat loss or modification can result in increases in energy expenditure as birds access alternate foraging habitats, which may ultimately result in decreases in nesting success or survival. HSS does not provide habitat for foraging shorebirds or wading birds, therefore, impacts would be limited to the proposed landfall of the transmission cable. The shoreline where the offshore transmission cable system would make landfall is developed and primarily consists of concrete and stone with minimal sandy areas. This area is not likely to provide important habitat for shorebirds or wading birds. Impacts associated with habitat loss or modification for shorebirds or wading birds at Great Island are expected to be negligible because the shoreline would be drilled under for installation of the cabling.

Specific construction techniques, including horizontal drilling and jet plow embedment, would minimize the impacts to the inter-tidal community within the vicinity of the landfall site. Sediment suspended by trenching during cable installation is expected to be localized (20 mm/liter within 1,500 ft [457 m] from the trench) and is expected to quickly resettle (within minutes or up to a few hours). The laying of offshore transmission system cables in Lewis Bay and near the inlet of the bay are not expected to cause significant changes to the inter-tidal habitat structure or prey availability. The increase in suspended solids and the relocation of sandy sediments would be temporary and would result in no substantial changes in the coastal areas of interior Lewis Bay, or the beaches on either side of the inlet.

Because of the inherent dynamic nature of the inter-tidal zone, disturbances created during construction and decommissioning are not expected to cause lasting or particularly harmful effects. Small mortality events of infaunal organisms are likely to occur, but effects on local inter-tidal assemblages would be negligible. Disturbance of the sea floor within Lewis Bay may provide for opportunistic colonization by disturbance tolerant benthos after construction, and similarly after decommissioning activities; however, these changes are not expected to influence inter-tidal areas. Impacts associated with changes in inter-tidal habitat during installation of the offshore transmission cable system in Lewis Bay are anticipated to result in negligible impacts to coastal bird habitat.

Human Disturbance (human presence, vessel activity, noise created by construction equipment)

Red knot and piping plover are among species of shorebird that are sensitive to human disturbances, particularly during critical nesting or pre-migratory staging periods. Substantial disturbances may flush foraging shorebirds, resulting in increases in energy expenditure, decreased breeding success, and potentially decreased survival. Piping plover may abandon nests as a result of disturbance (USFWS, 1996). Red knot are among species known to be particularly sensitive to relatively high levels of vessel activity (Peters and Otis, 2007). Piping plover are known to nest on Great Island, the beach that occurs in closest proximity to the proposed offshore transmission system cable. Additional shorebird and wading bird species may occur at this beach. However, the island occurs in a developed area which experiences high human activity. The buried cables at their closest point would occur approximately 820 ft (250 m) from Kalmar Point/Dunbar Beach and approximately 1,210 ft (369 m) from Great Island. There would be an 820 ft (250 m) buffer or greater between cable construction activities and the beach area; therefore, increases in boat activity as well as the operation of loud construction equipment offshore would not result in significant impacts to shorebirds or wading birds. Human activity associated with performing the HDDs and pulling the cables through the installed conduits would involve minor and temporary disturbances, similar to other people walking and being present along the shoreline. A tracking system, consisting of a wire to power the drill head may be placed across the beach; however, this disturbance would be equal to a person walking across the beach. Due to the buffer between the beach and offshore construction activities, disturbances associated with construction and decommissioning would be minimal and temporary.

Risk of Collision

Risk of collision is based on the frequency of occurrence through the area of the proposed action, visibility conditions during encounters with structures, and the flight behaviors of birds during crossings of the area of the proposed action. Shorebirds and wading birds typically remain onshore except during migration although they occasionally cross water bodies such as bays to access foraging or high-tide roosting locations. As the site of the proposed action is located over five miles (8 km) offshore, coastal birds may only occur within the area of the proposed action during migration movements. Migrants may occur over areas of Nantucket Sound, however, there are no known shorebird or wading bird migration corridors that occur over HSS. During construction or decommissioning, shorebirds or wading birds may be at risk of collision with WTGs under construction or large construction equipment, particularly species that migrate at night or during periods of low visibility.

There is data that suggest refraction caused by lighting mounted on tall structures during periods of fog and rain can disorient birds traveling at night (Huppop et al., 2006). Lighting on tall structures is believed to be associated with high collision rates of nocturnal songbird migrants. The effects of lighting on nighttime migrating shorebirds and wading birds are not well studied. Shorebirds and wading birds represent a relatively small fraction of collisions documented with tall, lit structures (Huppop et al., 2006); however, the effects of refraction to lighting during periods of rain or fog may contribute to increased collision risk.

Petersen et al. (2006) observed a substantial decrease in the volume of migrating birds during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of low visibility and strong headwinds (Petersen et al., 2006). Due to limitations of boat and aerial surveys, there is no coastal bird data available for nighttime migration or inclement weather conditions within the area of the proposed action. However, shorebird species have been documented at flights greater than 1.2 miles (2,000 m), well above the proposed rotor zone during nighttime migration movements (Richardson, 1978b). Shorebirds that migrate both day and night have been documented at heights as high as 2.8 to 3.7 miles (4,500 to 6,000 m) (Sibley, 2001). Shorebird species are known to migrate at altitudes from just above the surface of the water to 3.7 miles (6,000 m), depending on the altitude where favorable wind conditions exist (Sibley, 2001).

Many species are known to depart beaches for migration during rising tides, throughout the day, but mainly in the late afternoon or early evening (Sibley, 2001). Other observations indicate shorebirds may depart for migration mainly on sunny days, in the few hours before twilight (Harrington, 2001). Inclement weather may deter the departure of migrants as many shorebird species move inland during coastal storms to nearby agricultural fields (Sibley, 2001). Due to the generally high altitude of migrating shorebirds and the low risk of occurrence of shorebirds or wading birds in the site of the proposed action during periods of inclement weather, the risk of collision is low. Nighttime construction activities for the proposed action would occur and lighting would be used to illuminate structures under construction, however, construction activities would be limited on those nights with the greatest risk of collision during inclement weather. The risk of collision or shorebirds is low due to the generally high altitude of migrants and the low chance of occurrence in the area of the proposed action during periods of reduced visibility. Depending on the species affected, impacts associated with collision during construction are anticipated to be minor. Although the risk of collision is anticipated to be low for coastal bird species, any level of collision mortality for species of conservation concern, such as the federally-threatened piping plover, would represent a more substantial impact. The risk of collision of piping plover is discussed in detail in Appendix C and a more detailed description of risk of collision to coastal birds in general is in provided in Section 5.3.2.4.2. Impacts associated with collision during construction and decommissioning activities are anticipated to be minor for coastal non T&E bird species.

Marine Birds

The potential impacts to marine birds due to the proposed action vary among taxonomic groups of birds depending on use of the site of the proposed action, flight behavior within the site of the proposed action (particularly flight altitude), and the duration of time spent in the site of the proposed action.

Construction and decommissioning activities can result in disturbances associated with increased human presence or boat traffic, the operation or presence of large construction equipment, displacement due to habitat loss or modification, as well as the risk of collision with WTGs under construction or large equipment. Such impacts can result in changes to foraging or flight behavior resulting in increases in energy expenditure, decreased breeding success, or increased mortality.

The following sections summarize marine bird uses of Nantucket Sound, and describe the potential proposed action impacts to marine birds according to taxonomic group during the construction and decommissioning phases, and finally, attempts to gauge the magnitude of impacts to marine bird populations.

Marine Bird Observations in Nantucket Sound

Observations of marine birds during aerial and boat surveys conducted by the applicant and MAS documented that the diversity and numbers of birds found in the area of the proposed action is a small subset of those found in other parts of Nantucket Sound (See Table 4.2.4-2 and Section 4.2.4.3 for more detailed study results). Of all the types of marine birds those most often seen on Nantucket Sound include terns and sea ducks.

The majority of tern observations in Nantucket Sound occurred outside of the Shoal study areas. Terns were generally concentrated around the mainland and island coasts of the Sound, particularly Monomoy Island during the late-August and early-September staging period. During this period HSS likely had the lowest level of activity out of any similar habitat surveyed in the Sound.

In general, throughout Nantucket Sound, the numbers of marine birds are highest in the months from October through April. These high numbers are related primarily to the occurrence of wintering sea ducks, mainly common eider, scoters, and long-tailed ducks. Aerial survey data collected by the applicant and MAS from 2002 to 2006 were used to calculate average densities of sea ducks for the season from October 8 through April 23. High densities of sea ducks (>1000 birds per km^2) were documented within and on the edge of the area of the proposed action boundary (Report No. 4.2.4-2). This would indicate that in recent winters, sea ducks are using HSS for foraging. Based on winter aerial survey data, the average numbers of eiders detected during surveys were between 60 and 280 (see Tables 4.2.4-15 and 4.2.4-16). Scoters were regularly detected in HSS during winter surveys, often in large flocks (>500 individuals) (see Tables 4.2.4-19 and 4.2.4-20). However, sea ducks were observed to be less abundant in HSS than other parts of Nantucket Sound. The total number of individuals observed in HSS (25,125) comprised 6.8 percent of the total sea ducks observed during aerial surveys, which is substantially lower than the 13 percent expected if the birds had been evenly distributed across the study area.

Terns, skimmers, and gulls

Nantucket Sound is known breeding and foraging habitat to a number of terns including common tern (Special Concern), least tern (Special Concern), and roseate tern (Endangered). A detailed description of impacts to roseate terns is provided in Appendix C. Tern species nest on South Monomoy and Minimoy Islands. A few other species of tern seldom occur in the bay including black (*Chlidonias niger)*, arctic, royal (*Sterna maxima*), and Forster’s (*Sterna forsteri*) terns. Black skimmers (*Rhynchops niger*), a relative to terns, are known to nest on South Monomoy (USFWS, 2005). Several species of gull are common and numerous in Nantucket Sound during various periods of the year including great black-backed gull, herring gull, ring-billed gull, laughing gull, and Bonaparte’s gull. Gulls breed within areas of the Sound, however, their nests in vicinity of protected term breeding locations are sometimes destroyed for predatory species control.

Terns forage over shallow areas, reefs, and sand spits within the Sound where their prey, primarily sand lance, is available. As gulls are opportunists they take advantage of a variety of food sources, however, over the Sound, their foraging behaviors are similar to terns. During migration, large percentages of the North American populations of roseate, common, and least terns many occur in areas of the Sound.

Habitat Loss or Modification

There is no available tern or gull breeding habitat within or in close proximity to the proposed action boundary, and the transmission cable and proposed landfall would not cross breeding locations. Therefore, the effects of habitat loss or modification would be limited to foraging areas in proximity to the WTGs and submarine cable.

Construction, operation, and decommissioning activities could directly deter terns or gulls or their prey from the area of the proposed action resulting in the temporary or permanent loss of habitat. A decrease in food availability can result in decreased breeding success or increased mortality (Safina et al., 1988). However, baseline surveys conducted in Nantucket Sound documented minimal tern use of the area of the proposed action in relation to other locations in the Sound. Most terns were observed traveling, fewer were seen actively foraging. Terns and gulls are known to regularly forage near recreational fishing boats, ships, and other man-made structures. Terns and gulls are among species of birds that have been observed in the vicinity of operating turbines at European offshore facilities (Everaert and Stienen, 2006; Petersen et al., 2006; Pettersson, 2005). Visual data collected at the Nysted and Horns Rev facility in Denmark indicate that the majority of terns generally avoided the direct wind farm area but increased their use of the 1.2 miles (2 km) zone surrounding the facility (Petersen et al., 2006). One study documented habituation of gulls to turbines that were constructed on a jetty where the gulls were observed feeding, apparently undisturbed near the turbines (Kerlinger and Curry, 2002). Terns and gulls would be expected to habituate to the presence of the proposed turbines similar to how they have demonstrated habituation to a variety of man-made structures, including other turbines. These birds would likely continue to forage and travel in the vicinity of construction activities and operating WTGs, assuming that their food sources were not displaced.

Vibrations from pile-driving could startle and temporarily displace prey fish from the area of the proposed action. Increases in turbidity from cable trenching could temporarily impede fish foraging and navigation in disturbed areas (Jarvis, 2005). Construction activities could affect fish and benthic communities up to 328 ft (100 m) from the activity (Nedwell et al., 2004 *as cited by* Gill 2005). However, impacts to foraging habitat are anticipated to be minimal as construction activities would be temporary and localized within the area of the proposed action. A jack-up barge (approximately 172 ft^2 [15.9 m^2]) with a crane would be used to install the monopiles. There would be a total of two pile driving rams used to fix the 130 monopile structures into the seabed and it is unlikely that both rams would be used simultaneously. The hollow monopiles are expected to trap the majority of sediment displaced during pile driving. Sediment suspended by trenching during offshore cable installation is expected to be localized (20 milligrams/liter within 1,500 ft [457 m] from the trench) and is expected to quickly resettle (Report No. 4.1.1-2). Jet plow embedment would allow for simultaneous plowing and cable-laying to minimize impacts. As a result of disturbances to sediment during trenching and pile driving, small benthic organisms would be stirred up and prey fish may be attracted to the area to forage. This in turn could attract terns and gulls to forage.

As the area of the proposed action is not a significant foraging location or traveling corridor, and because of the small footprint of the actual development area, minimal habitat loss is anticipated during proposed action construction and operation activities. Impacts associated with displacement of prey fish during construction are anticipated to be minimal and temporary. The natural benthic substrate and prey fish communities would be essentially maintained after a short recovery period, therefore, adverse impacts associated with loss of habitat or modification are not anticipated. The impacts associated with decommissioning are anticipated to be similar to or less than construction activities because pile driving would not be required (Jarvis, 2005).

Human Disturbances

Increases in human presence and vessel traffic could result in impacts to terns and gulls during the construction, and decommissioning phases of the proposed action. A large vessel(s) would be used to transport and install the monopiles, towers, nacelles, hubs, and blades during construction and decommissioning. The vessel would be loaded in Quonset, Rhode Island, and would be anchored near the monopiles that are undergoing construction. During installation and decommissioning of the WTGs, the large vessel would make several trips from Quonset to the area of the proposed action. Additionally, small vessels from Falmouth, Massachusetts, and a maintenance support vessel from New Bedford would make regular trips to HSS during the construction period.

During high surf conditions, workers may be transported by helicopter to the platform on the ESP. There may also be occasional helicopter landings at the ESP in association with some regular maintenance activities. An increase in recreational fishing may occur around the WTGs if fish populations aggregate around foundations. The arrival of vessels and helicopters could temporarily displace terns or gulls from localized areas within the larger area of the proposed action. This type of disturbance already occurs to some extent within and adjacent to the area of the proposed action due to existing levels of vessel activity.

Terns and gulls appear to be less sensitive to human disturbances than other species of birds, and are also thought to be attracted to some areas of human activity (Borberg et al., 2005; Drewitt and Langston, 2006; Sadoti et al., 2005a). Terns are known to habituate to some levels of human presence and disturbance. Terns are regularly observed traveling and foraging in the vicinity of vessels and other man-made structures. At the Nysted and Horns Rev facilities in Denmark, gulls were abundant in the construction area likely as a result of increased vessel activity (Petersen et al., 2006). An increase in the presence of terns and gulls observed in areas around the Horns Rev offshore facility in Denmark was believed to be associated with increased boat activity for maintenance activities (Petersen et al., 2006). Therefore, terns and gulls are expected to continue their traveling and foraging activities despite the presence of increased boat traffic and the few anticipated helicopter landings in HSS. Terns and gulls would be expected to return to the area after the departure of the vessels.

Terns and gulls are expected to be among those species of bird that would habituate to the presence of increased boat traffic associated with construction and decommissioning activities. Therefore disturbances associated with increases in human presence and vessel activity are anticipated to have minor impacts on terns.

Risk of Collision

The potential exists for terns and gulls to collide with WTGs under construction, and large construction equipment. The results of available mortality studies indicate that the majority of avian collisions with man-made structures take place at night during periods of inclement weather (Kerlinger, 2000). Birds that fly within proximity to construction equipment or within the rotor zone of the turbines would be at greatest risk of collision. Risk of collision is expected to result in minor impacts to gull species based on the stable populations of species that are most abundant in the area (risk of collision is discussed in more detail in Section 5.3.2.4.2). Impacts to terns associated with collision during construction are anticipated to be moderate (risk of collision is discussed in more detail in Section 5.3.2.4.2). Although the risk of collision during construction is anticipated to be low for tern species, any level of collision mortality for species of conservation concern, such as the endangered roseate tern, or for common or least terns (both species of special concern) would represent a more substantial impact. A discussion of the risk of collision specific to roseate terns is provided in Appendix C. Risk of collision for tern species during the construction phase is anticipated to result in moderate impacts.

Pelagic Species (shearwaters, petrels, gannets, auks)

Oceanic or pelagic species such as shearwaters, gannets, storm-petrels, and auks typically spend most of their lives well offshore, particularly during the non-nesting season. However, storm events and strong, consistent on-shore winds can push these offshore species into coastal areas and occasional seasonal influxes of these species might occur during migration. Potential proposed action impacts are limited to risk of collision during operation of the proposed action (See Section 5.3.2.4.2). Due to the infrequent occurrence of pelagic species anticipated during the construction phase, risk of collision is anticipated to be low. Therefore, impacts associated with collision risk are expected to be minor.

Waterfowl and Non-Pelagic Water Birds

There are a number of sea duck, waterfowl, and diving species that occur within Nantucket Sound, particularly during the winter months. Species such as scoter, eider, and long-tailed duck over-winter in large flocks in the region. A number of common and red-throated loon (*Gavia stellata*), as well as grebes, geese, brant, and dabbling ducks are also local to the bay during various times of the year. Double-crested cormorant are abundant in the site of the proposed action through the breeding season and late-fall. Great cormorant occur in the area mainly in the winter months.

Habitat Modification

Habitat modification during construction and decommissioning could displace sea duck and waterfowl. Displacement can lead to over-crowding and competition at alternative foraging sites and can ultimately result in increased mortality of more vulnerable species (Maclean et al., 2006). Optimal foraging locations are generally restricted to waters no deeper than 164 ft (50 m) deep, however, they are typically less than 31 ft (10 m) deep (USFWS, 2001b; Robertson and Savard, 2002). This is due to the energetic costs of diving to access resources. Sea ducks, including long-tailed duck, scoter, and eider, which forage on sedentary benthic invertebrates, are among species most sensitive to loss of habitat due to offshore wind development. A study at the Tuno Knob facility, in Denmark failed to find any evidence that the distribution of common eiders was affected by the presence of the turbines themselves, but was correlated to changes in bivalve distributions (Guillemette and Larsen, 2002). The impact of habitat modification on sea ducks would be dependent on the location of the turbines in relation to suitable feeding areas.

The area of the proposed action is characterized by water depths of 8 to 60 ft (2.4 to 18.3 m), and the average depth is less than 20 ft (6 m). The dominant substrate is medium and fine sand. Benthic macroinvertebrate sampling indicated the HSS benthic community included a variety of organisms such as crustaceans, clams, snails, and worms. Mussel habitat, such as boulders and ledges, are not a notable component of the area of the proposed action. Common eider diet consists mainly of mollusks and crustaceans (Palmer, 1976) and they prefer blue mussels (*Mytilus edulis)* which are typically attached to rocky substrates. Scoter diet consists of mollusks (Bordage and Savard, 1995; Brown and Fredrickson, 1997; Savard et al., 1998), such as Arctic wedge clam (*Mesodesma arctatus*) and Atlantic razor clam (*Siliqua costata*), found in sandy substrates along coastlines (Stott and Olson, 1973). The benthic community provides suitable foraging habitat for scoters and marginal foraging habitat for eiders. Long-tailed duck forage for crustaceans including amphipods and isopods, bivalves, gastropods, fish and fish eggs (Robertson and Savard, 2002). Other waterbirds such as cormorants may prey on small fish in the area of the proposed action.

Surveys conducted in the Nantucket Sound study area indicate that in recent years, sea ducks such as scoter and eider forage in the area of the proposed action during the winter. However, the abundance of sea duck in the area of the proposed action was low compared to other locations surveyed in the Sound, indicating abundant alternative foraging habitat outside of the area of the proposed action (Report Nos. 4.2.4-2, 4.2.4-12, 4.2.4-13). Long-tailed ducks are thought to forage during the day south of Nantucket Island, on Nantucket Shoals (NS), and then commute in the evening to roost overnight in Nantucket Sound. Because much of the long-tailed duck population of Nantucket Sound is assumed to forage in NS, substantial loss of foraging habitat is not an anticipated impact for long-tailed duck.

During construction, increases in turbidity from cable trenching could temporarily impede foraging, as well as displace prey fish for foraging cormorant. Vibrations from pile driving could displace prey fish as well. Construction activities could affect fish and benthic communities up to 328 ft (100 m) from the activity (Nedwell et al., 2004 *as cited by* Gill, 2005). However, impacts to foraging habitat are anticipated to be minimal as construction activities would be temporary and localized within the area of the proposed action. A jack-up barge (approximately 172 ft^2 [15.9 m^2]) with a crane would be used to install the monopiles. There would be a total of two pile driving rams used to fix the 130 monopile structures into the seabed and it is unlikely that both rams would be used simultaneously. The hollow monopiles are expected to trap the majority of sediment displaced during pile driving. Sediment suspended by trenching during cable installation is expected to be localized (20 milligrams/liter within 1,500 ft [457 m] from the trench) and is expected to quickly resettle (within minutes or up to a few hours). Jet plow embedment would allow for simultaneous plowing and cable-laying to minimize impacts. As a result of disturbances to sediment during trenching and pile driving, small benthic organisms may be injured or killed. However, such benthic impacts would be minor and there are expected to be minimal impacts to the prey base due to construction of the proposed action.

Due to the small footprint of the actual development area in relationship to the overall habitat available in Nantucket Sound, and due to the relatively low abundance of sea duck and other waterfowl species in the area of the proposed action, minimal habitat loss is anticipated during proposed action construction, decommissioning, and operation activities. Impacts associated with displacement of prey fish during construction are anticipated to be minimal and temporary. The natural benthic substrate and prey fish communities would be essentially maintained after a short recovery period, therefore, adverse impacts associated with loss of habitat or modification are not anticipated. The impacts associated with decommissioning are anticipated to be similar to or less than construction activities because pile driving would not be required (Jarvis, 2005). Therefore, impacts associated with loss of habitat or habitat modification during proposed action construction, and decommissioning, are anticipated to be minor.

Human Disturbances

Disturbances such as increased human presence and vessel activity during proposed action construction and decommissioning associated with the operation of loud construction equipment may result in impacts to sea ducks and waterfowl. If these disturbances are substantial, they may displace sea duck and waterfowl. The level of disturbance is based on the proposed action design and proximity to roosting, feeding and breeding habitat (Exo et al., 2003). Divers including loons and scoters are particularly sensitive and could be disturbed during construction and decommissioning activities due to their strong reaction to boats (Maclean et al., 2006).

Noise and vibrations associated with construction activities such as drilling and piling and cable laying can impact the acoustic systems of benthic species within 328 ft (100 m) of the source and can cause some mobile species to avoid the area (Nedwell et al., 2004 *as cited by* Gill, 2005). Underwater noises are known to deter foraging waterfowl from the area (Gill, 2005). As pile driving and cable laying would be temporary and limited to small areas directly under construction, these disturbances are expected to result in minimal impacts to foraging birds (see previous section for a description for impacts associated with habitat modification).

Observations at existing offshore facilities indicate that increased vessel activity during the construction and decommissioning could result in disturbances to sea duck or waterfowl foraging in the vicinity of the area of the proposed action. The area surrounding the proposed development experiences regular vessel activity, therefore, increased human presence or vessel activity is not anticipated to present a substantial increase in disturbances. Results from other facilities indicate that divers and other sea ducks may be displaced by approaching vessels, however, they return after the vessel departs. Therefore, human disturbances are not expected to result in long-term or adverse impacts to foraging sea duck or waterfowl. Minor adverse impacts are anticipated to result from human disturbances associated with construction, decommissioning of the proposed action.

Risk of Collision

The potential exists for migrating or dispersing birds to collide with WTGs under construction and with large construction equipment. The risk of collision depends on use of the area of the proposed action, visibility during crossings of the area of the proposed action, and flight behaviors exhibited during encounters with turbines. In general risk of collision during construction/decommissioning is expected to be negligible as impacts associated with collision are primarily related to operation of the wind turbines (See Section 5.3.2.4.2).

Conclusions on Construction/Decommissioning Impacts

Based on research cited and information discussed herein, with respect to affects resulting from habitat modification, human disturbance, and risk of collision, the overall construction and decommissioning impacts to non T&E avifauna would be minor.

5.3.2.4.2 Operational Impacts

Terrestrial Birds

Raptors (hawks, owls, eagles, falcons, etc.)

The potential impacts to raptors associated with operation of the proposed action include loss or modification of habitat, a barrier effect due to the presence and operation of the WTGs, and risk of collision with the operating WTGs, and impacts associated with EMF from the onshore transmission cable system,

Osprey, in outstanding situations have been known to forage as far offshore as 0.6 to 3.2 miles (0.6 to 5 km) (Poole et al., 2002), however, they would not be expected to forage in HSS which is approximately 5 miles (8 km) offshore. No other raptor species would be expected to forage in the vicinity of the proposed action (Buehler, 2000). Therefore, no loss of habitat is expected to occur in HSS. Habitat loss associated with the presence of the offshore transmission cables system within Lewis Bay is anticipated to be negligible for raptors, since the buried cable does not represent a permanent alteration of habitat. During operation, the cable itself would result in minimal influences on the benthos, and therefore impacts to raptor foraging locations would be negligible.

There is a potential that the presence of WTG structures or ESP could result in habitat modification in the form of perching opportunities for migrant raptors. A Eurasian species of raptor at the Horns Rev facility was occasionally observed perching on turbine foundation safety railings (Christensen et al., 2003). However, specific design features have been incorporated to discourage avian perching on the ESP and WTG structures. The above water foundations, WTGs, and the ESP would be equipped with stainless wire and vision restriction perch deterrent devices. Each turbine foundation would have a deck which would be covered by aluminum chain link fencing to discourage access on the sides (and the deck overhangs the access ladder). There would be a taught 0.12 inch (3 mm) stainless steel wire on top of the railing, and a 25 inch (0.65 m) solid panel to restrict the view of birds from the deck. The spacing between the wire and the rail would be 1.2 inch (3 cm). The ESP would have a perimeter railing and the ladders and railing would be equipped with stainless steel wire, chain-link fence, and panels similar to the WTG foundations. The use of tubular towers instead of lattice towers also discourages perching. Therefore, it is not anticipated that migrant raptors would use structures in the site of the proposed action for perching habitat.

The presence and operation of WTGs may result in a barrier to the flight path of migrating raptors. Due to the northeast to southwest orientation of the Atlantic Coast, many raptor and owl species follow the major ridgelines and the Atlantic coastline as ‘leading lines’ while migrating. Some species are known to occasionally migrate offshore and others may be blown offshore by changing weather conditions. Most raptor species are not expected to occur in the area of the proposed action during migration as most species generally avoid major water crossings (Wheeler, 2003). Exceptions include peregrine falcon, merlin, Northern harrier, and, occasionally, sharp-shinned hawk, and short-eared owl (Wheeler, 2003; Warkentin et al., 2005; MacWhirter and Bildstein, 1996; Wiggins et al., 2006). Wind direction and speed could result in migrants getting blown offshore while following the coast, however, raptors have been observed making adjustments to their flight behavior to avoid flying away from land in changing wind conditions (Crocoll, 1994; Bildstein and Meyer, 2000; Curtis, 2006). There are no topographic features (such as leading lines or shortest crossings) that would funnel migrants that may occur offshore into the area of the proposed action. If migrants were to occur offshore, they would not be expected to concentrate in the area of the proposed action. Therefore, it is not anticipated that development of the proposed action would result in a significant barrier effect to raptors that may occur offshore. Raptors may make alterations to their flight behavior to avoid encountering turbines during migration (refer to the following section describing turbine avoidance behavior); however, increases in energy expenditure are anticipated to result in negligible impacts to migrating raptor.

Raptors may be among species of terrestrial animals impacted by artificial sources of EMF. Some birds can detect the earth's magnetic fields and may use magnetic fields for orientation during migration (Hanowski et al., 1996). Artificial sources of EMF could potentially influence the navigational systems and reproductive success of birds, including raptors (Fernie et al., 2000; Hanowski et al., 1996). However, the addition of the onshore transmission cable system would not change electric field levels. The electric field within the existing NSTAR Electric ROW would be effectively contained within the body of each underground onshore transmission cable system by a grounded metallic shield. No external electric field would be produced. Upon completion of the onshore transmission cable system, the electric fields within the existing NSTAR Electric ROW are expected to be approximately the same as the existing condition, due primarily to the presence of the existing overhead 115 kV lines. Therefore, impacts associated with EMF to raptor species are anticipated to be negligible.

There is a risk of collision of migrant raptors with the operating turbines. The risk of collision depends on the frequency of occurrence in the area of the proposed action, weather conditions and visibility during encounters with WTGs, and the flight height of traveling raptors. Daytime boat and aerial surveys between 2002 and 2006 documented no raptor observations within the area of the proposed action. HSS is not anticipated to be an area of concentrated use by migrant raptors. The flight behaviors of raptors, if they were to occur in the area of the proposed action would depend on weather conditions.

The majority of raptor migration flights have been documented at elevations well above the proposed rotor zone 75 to 440 ft (23 to 134 m) (Poole et al., 2002; MacWhirter and Bildstein, 1996) although some have been documented flying just above the surface of the waves (Warkentin et al., 2005). Limited information on owl migration flight behaviors suggest owls occur at relatively low altitudes. Observations of barn owls over coastal migration sites reported flight altitudes greater than 32.8 ft (10 m) (Marti et al., 2005). Long-eared owls have been observed flying at altitudes of 98 to 164 ft (30 to 50 m) just after sunset (Marks et al., 1994). The majority of raptors migrate during the day during periods of strong thermal development when the risk of collision is low. However, some species of raptor, including peregrine falcon and Northern harrier, and owls are known to make movements at night (Wheeler, 2003). Merlin and Northern harrier will fly in periods of light rain and fog when conditions would increase the risk of collision (Wheeler, 2003; MacWhirter and Bildstein, 1996). However, the occurrence of raptors in HSS is anticipated to be infrequent and sporadic therefore the chance of turbine encounters is anticipated to be minimal. Some species of raptor have demonstrated high turbine collision avoidance behaviors at existing onshore wind farms. Whitfield and Madders (2006) used the Band Collision Risk Model to estimate the avoidance rate of hen harriers (*Circus cyaneus*) at eight wind farms in the U.S.: estimates were 100 percent turbine collision avoidance at 6 sites, 99.8 percent at 1 site, and 93.2 percent at 1 site. Another study reported a 99.5 percent turbine avoidance rate for golden eagle (*Aquila chrysaetos*) at a U.S. facility (Chamberlain et al., 2006). These avoidance behaviors reduce the risk of raptor collisions. Additionally, there are observations of raptors waiting out poor weather during migration (White et al., 2002). Although most owl migration occurs at night, movements are associated with clear weather during periods of light following winds (Marti et al., 2005; Cannings, 1993). Therefore, the chance of migrants occurring in the area of the proposed action during periods of elevated risk of collision is low. The risk for collision of raptors with operating WTGs is anticipated to be low; therefore, impacts associated with collision mortality are anticipated to be negligible.

The proposed action is anticipated to result in negligible impacts to raptor foraging habitat. The presence and operation of the WTGs is not expected to present a major barrier to the flight paths of migrating raptors because raptors are expected to occur infrequently and sporadically over the Sound. The overall risk of raptor collisions with WTG structures is low as raptor occurrence in the area of the proposed action is expected to be infrequent and sporadic. Therefore, operation of the proposed action is expected to result in negligible impacts to raptors.

Passerines

A substantial portion of the land bird population of North America consists of neotropical and regional migrant passerines. A number of local or migrant passerine species occur in the area of Nantucket Sound at varying times of the year. While it's a conventional belief that coastal areas concentrate migrant songbirds during active migratory flights and during stopover events, little information exists on the actual numbers of night migrants in the air along the Atlantic Coast. While relatively few species routinely use open water, marine habitat, large numbers of songbirds could occur in and over the area of the proposed action during both nighttime and daytime migration. Migrants may be blown offshore depending on the prevailing wind direction during nighttime movements along the coast. Some neotropical migrant species, specifically those of the family *Paurlidae* (wood warblers), may make substantial water crossings during nocturnal migration (Richardson, 1978a). Although a number of terrestrial ornithological radar studies have been conducted to determine the characteristics of nocturnal migration, there is little information available that thoroughly quantifies nocturnal migration over the ocean.

Potential impacts to migratory songbirds during construction, operation, and decommissioning of the proposed action include risk of collision mortality, and potential impacts associated with EMF from the onshore transmission cable system.

Known Collision Mortality at Existing Facilities

Passerines are the most abundant group of birds occurring in North America and species of this group (e.g., warblers, vireos, thrushes, sparrows) account for up to 80 percent of known fatalities reported at onshore wind facilities (Johnson et al., 2003; Erickson et al., 2001). The estimated mortality rate of birds in Eastern North America due to terrestrial wind energy facilities is approximately 0 birds per kW per year to 11.7 birds per kW per year. However, due to the small size of most passerine species and the inherent difficulty in finding and identifying carcasses near turbines, it is likely that mortality rates have been underrepresented by post-construction mortality surveys (NRC, 2007). Mortality of these species has included both daytime and nocturnal fatalities (Erickson et al., 2001). A wide variety of species have been found during mortality surveys but, to date, no large fatality events, as have been occasionally observed at tall communications towers, have been reported in the literature. In the U.S., outside of California, wind turbines have generally been found to not pose a substantial threat to any one species of bird, though potential impacts at any facility can vary according to location and species presence.

Erickson et al. (2001) provided a summary of known avian collisions with wind turbines. Fatality rates varied from 0 to 4.5 fatalities/turbine/year with most of the reported rates being less than 2 fatalities/turbine/year although more recent work has documented rates as high as 7.28 fatalities/turbine/year (GAO, 2005). They estimate an average of 2.19 bird fatalities/turbine/year in the United States, although this estimate does not reflect the variability in fatalities among wind energy facilities (i.e., some have reported dozens of fatalities while others have reported very few or none). However, they do recognize that sites in California have significantly more fatalities than elsewhere, and estimate the fatality rate to be lower outside of California, at approximately 1.83 fatalities/turbine/year (corrected for searcher efficiency and scavenging).

There are limited data available from existing offshore facilities. A study conducted at a coastal wind farm in the Netherlands documented songbird, water bird, and shorebird collision fatality rates ranging from 0.04 to 0.14 fatalities per turbine per day (Kerlinger and Curry, 2002). The study indicated that these coastal turbines created higher fatalities rates than other, onshore wind farms, likely as a result of the large concentrations of migrant and wintering waterfowl, shorebirds, and songbirds in the area (Winkelman, 1995, *as cited by* Kerlinger and Curry, 2002). It was believed that these fatalities were not only linked to migratory flight but also to birds undertaking low flights between feeding locations (Winkelman, 1995, *as cited by* Kerlinger and Curry, 2002).

Risk of Collision

An assessment of nocturnal migration over Cape Cod was made in the early 1960's, using radar. This survey at South Truro, Massachusetts, showed that migration was occurring at heights of approximately 600 ft to over 6,000 ft (183 m to 1,829 m) above ground level (Nisbet, 1963). Subsequent assessments of nocturnal migration in Nantucket sound, using modern radar systems, documented that the majority of nocturnal targets occurred at heights greater than 75 ft (23 m) AMSL (see Table 4.2.4-4; Report Nos. 4.2.4-5, 4.2.4-6 and 4.2.4-7).

Flight heights documented during 69 radar surveys conducted over eight seasons in terrestrial ecosystems throughout the Northeast, revealed that flight heights typically average 1,401 ft (427 m) above ground level, and nightly average flight heights ranged from 505 ft (154 m) to 2,112 ft (644 m) above ground level. Average seasonal passage rates ranged from 64 targets/km/hour to 732 targets/km/hour, with an overall average of 313 targets/km/hour (see Table 5.3.2-1).

In general the characteristics of migration documented at the Nantucket Sound radar site are similar to the characteristics of migration documented across the northeast, over land. However, the average flight heights documented over Nantucket sound are slightly lower than those documented above terrestrial ecosystems, and the passage rates were lower over Nantucket Sound than at the majority of terrestrial radar sites. It is reasonable to assume that although flight heights were on average lower at the Nantucket Sound radar site than at terrestrial sites, the risk of collision with turbines migrants over both inland radar locations and over Nantucket Sound may be comparable and perhaps lower over the Sound due to the slightly lower passage rates observed over the Sound.

It is evident from radar ornithology studies that the majority of nocturnal migrants move above the height of modern turbines. The Nantucket Sound surveys indicate that flight heights there are generally lower than average flight heights documented above terrestrial radar sites, although the majority of targets were flying above the rotor swept zone. The observed lower flight heights at Nantucket may be a result of difference in the radar systems used at the site and those used elsewhere. However, if the data reflect an accurate portrayal of migration over the Nantucket sound, the observed flight heights, which are slightly lower than the average terrestrial flights heights, are likely mitigated by the lower overall passage rate of targets in the area.

Despite the majority of migration occurring well above turbine height birds have been known to collide with tall solid structures, although minimal evidence is available documenting direct turbine blade collisions (Erickson et al., 2001). The ecological significance of the number of birds killed by turbines on regional populations has not been adequately addressed. Similarly, the significance of turbine related deaths in relationship with other anthropogenic mortality events has not been adequately defined. It is estimated that tens of millions of birds are killed annually by colliding with buildings, transmission lines, and vehicles, where as the annual estimate of birds killed by wind turbines numbers in the tens of thousands (Erickson et al., 2001).

Calculating risk of collision to species or groups of birds is difficult because of a paucity of information identifying exposure to collision. Certain passerine species may be more likely to fly within the rotor swept zone and are therefore at higher risk. The specific behavior patterns of birds species or groups coupled with their relative abundance in the proposed development area, must also be considered.

The results of radar surveys can help to identify the magnitude of birds using the air space proposed for turbine construction, and the characteristics of their flight. Because the majority of passerine species avoid water crossings and because nocturnal migration is of a lower magnitude over Nantucket sound than over other inland radar sites available for comparison, it is likely that the risk of collision by nocturnal migrants is less than at terrestrial sites. Comparisons of risk to individuals at terrestrial wind energy facilities and at near shore and off shore facilities can help to put the potential magnitude of mortality into perspective.

It is likely that the specific risk to passerine migrants moving above the proposed Cape Wind facility is similar to the risk presented by inland wind energy facilities. Due to the characteristics of the nocturnal migration documented above Nantucket Sound, the risk to passerines may be similar to or less than that posed by inland facilities, due to the passage rates and flight heights observed (Report Nos. 4.2.4-5, 4.2.4-6 and 4.2.4-7).

In general nocturnal migrant passerines do not fly within the turbine zone, and those flying over open water often return to land at dawn (Kerlinger and Curry, 2002). Despite the possibility that songbirds may be flying at relatively lower altitudes over Nantucket Sound it is likely that during periods of decent visibility these individuals would not be at risk for collision. The lighting of turbines is an important factor that can change the amount of risk to passerines and can be easily adapted. However, some evidence has shown that lighting structures can increase the risk of collision to birds during migration (Kerlinger and Curry, 2002), particularly during periods of fog or rain (Huppop et al., 2006).

Collision risk associated with operation of the proposed action for nocturnal migrant passerines is anticipated to be low due to the relatively low passage rates observed over Nantucket Sound, and due to the majority of flight heights well above the rotor zone. It is suspected that the risk posed by the proposed action would be similar to or less than the collision mortality observed at existing facilities. Therefore, the impacts associated with collision mortality are anticipated to be minor.

Electromagnetic Fields

Birds may be among species of terrestrial animals impacted by artificial sources of EMF. Some birds can detect the earth's magnetic fields and may use magnetic fields for orientation during migration (Hanowski et al., 1996). Artificial sources of EMF could potentially influence the navigational systems and reproductive success of birds (Fernie et al., 2000; Hanowski et al., 1996). However, the addition of the onshore transmission cable system would not change electric field levels. The electric field within the existing NSTAR Electric ROW would be effectively contained within the body of each underground onshore transmission cable system by a grounded metallic shield. No external electric field would be produced. Upon completion of the onshore transmission cable system the electric fields within the existing NSTAR Electric ROW are expected to be approximately the same as the existing condition, due primarily to the presence of the existing overhead 115 kV lines. Therefore, impacts associated with EMF to passerine species are anticipated to be negligible.

Coastal Birds

Operation

The potential impacts to shorebirds or wading birds during proposed action operation may include impacts associated with disturbance from vessel activity during cable repair, impacts associated with oil spills or WTG or ESP damage fluid spills, the risk of collision of migrants with WTG structures, as well as barrier effects to traveling birds.

Vessel Traffic

There would be an increase in vessel activity associated with maintenance of the WTGs during the operation of the proposed action. During operation, maintenance vessels would mainly operate out of Hyannis or similar Cape Cod ports. These ports have adequate facilities for berthing and loading of the maintenance vessels. These ports occur in developed areas and currently experience similar uses. There are no known important coastal bird areas in the vicinity of these ports, therefore, the increase in vessel activity in these areas is anticipated to result in negligible impacts.

There may be an increase in vessel activity associated with offshore cable repair during the operation phase. However, the cable is designed under normal conditions to last the life of the proposed action. The buried cables at their closest point would occur approximately 820 ft (250 m) from Kalmar Point/Dunbar Beach and approximately 1,210 ft (369 m) from Great Island. Near shore maintenance activities in Lewis Bay would be temporary and there would be an 820 ft (250 m) or greater buffer between the offshore cable maintenance activities and potential shorebird habitat. Therefore, disturbances associated with maintenance activities are anticipated to result in negligible impacts.

Oil Spills

The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. Oil spills may result in the release of contaminants from vessels or from the WTG or ESP foundations themselves. Depending on the location and the size of a spill, shorebirds and wading birds may be impacted. If the feathers of birds become coated with oil, birds loose their ability to repel water and to insulate, and in some instances, loose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening (Jarvis, 2005).

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2005). Shorebird habitat was impacted by the oil spill, particularly at Barney's Joy, Dartmouth, and shorebird mortality was a resulting impact (NOAA, 2005), including 18 shore birds (12 dunlin, 2 willet, 4 yellow-leg), but no wading birds were documented (BBNEP, 2005).

Monopile collapse, vessel collisions, or storm damage to the ESP or WTG structures could result in oil or other fluid contamination. The total maximum oil storage on the ESP is expected to be approximately 42,000 gallons at any given time. The total oil storage at each WTG is expected to be approximately 214 gallons at any given time (27,820 gallons for all 130 WTGs). In the unlikely event that an oil spill was to occur, the oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent). It has a 90 percent chance of impacting any shoreline in the area.

The potential impacts of oil spills associated with the operation of the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in the mortality of coastal birds if nesting, staging, or over-wintering areas were to be impacted. However, the event of an oil spill is unlikely, and due to the distance between the WTG area and the closest potential habitat on either the mainland or island shores of Nantucket Sound, the potential for impacts are reduced. Therefore, oil spills are anticipated to result in minor adverse impacts to coastal birds.

Risk of Collision

Risk of collision is based on the frequency of occurrence through the area of the proposed action, visibility conditions during encounters with wind turbines, and the flight behaviors of birds during crossings of the area of the proposed action. Shorebirds and wading birds typically remain onshore except during migration although they occasionally cross water bodies such as bays to access foraging or high-tide roosting locations. As the site of the area of the proposed action is located over five miles (8 km) offshore, coastal birds may only occur within the area of the proposed action during migration movements. Migrants may occur over areas of Nantucket Sound; however, there are no known shorebird or wading bird migration corridors that occur over HSS. During operation of the wind farm, shorebirds or wading birds would be at risk of collision with WTGs, particularly birds that migrate at night or during periods of low visibility.

There is data that suggest refraction caused by lighting mounted on tall structures during periods of fog and rain can disorient birds traveling at night (Huppop et al., 2006). Lighting on tall structures is believed to be associated with high collision rates of nocturnal songbird migrants (Huppop et al., 2006, Shire et al., 2000). The effects of lighting on nighttime migrating shorebirds and wading birds are not well studied. Shorebirds and wading birds represent a small fraction of collisions documented with tall, lit structures (Huppop et al., 2006; Shire et al., 2000); however, the effects of refraction to lighting during periods of rain or fog may contribute to increased collision risk of these birds. However, Petersen et al. (2006) observed a substantial decrease in the volume of migrating birds at an offshore wind farm in Europe during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of low visibility and strong headwinds (Petersen et al., 2006).

Due to limitations of boat and aerial surveys, there is no coastal bird data available for nighttime migration or inclement weather conditions within the area of the proposed action. However, shorebird species have been documented at flights greater than 1.2 miles (2,000 m), well above the proposed rotor zone during nighttime migration movements (Richardson, 1978b). Shorebirds that migrate both day and night have been documented at heights as high as 2.8 to 3.7 miles (4,500 to 6,000 m) (Sibley, 2001). Shorebird species are known to migrate at altitudes from just above the surface of the water to 3.7 miles (6,000 m), depending on the altitude where favorable wind conditions exist (Sibley, 2001). Available data from existing offshore facilities in Europe indicate shorebird species generally migrate at altitudes well above the rotor zone, and birds that occur in the vicinity of the wind farm make efforts to avoid flying within the wind farm. Visual confirmation coupled with radar surveys during migration periods from 2003 to 2005 at the Nysted and Horns Rev offshore facility in Denmark observed shorebird migration through the project area. Shorebird migration generally occurred at altitudes high above the wind turbines >0.18 miles (>300 m). The flight altitude of one flock of shorebirds was estimated to be 0.25 miles (398 m) above sea level.

Many species are known to depart beaches for migration on rising tides, during all times of the day, but mainly in the late afternoon or early evening (Sibley, 2001). Other observations indicate shorebirds may depart for migration mainly on sunny days, in the few hours before twilight (Harrington 2001). Inclement weather may deter the departure of migrants as many shorebird species move inland during coastal storms to nearby agricultural fields (Sibley, 2001). It is, however, during periods of inclement weather when birds are traveling at lower altitudes or when birds are arriving or departing stopover habitats that these birds could be most at risk of encountering the proposed wind turbines. In fact, studies from the existing offshore wind farms in Europe indicate that shorebirds can be at risk of collision at stopovers during short flights to foraging or resting areas (Kerlinger and Curry, 2002, Everaert, 2004). However, the location of the proposed turbines would be at least five miles (8 km) from concentrated shorebird or wading bird use areas such as shorelines and shallow areas exposed at low tide; therefore, the risk of collision is reduced.

Due to the generally high altitude of migrating shorebirds and the low risk of occurrence of shorebirds or wading birds in the area of the proposed action during periods of inclement weather, the risk of collision is low. Therefore, collision mortality associated with the proposed action is anticipated to result in minor negative impacts to shorebirds as well as wading birds, with the exception of species of conservation concern. Any level of collision mortality of the threatened piping plover would represent a more substantial impact because the loss of one breeding individual is detrimental to the regional population (the risk of collision of piping plover is discussed in more detail in Appendix C). Although the risk of collision is low, impacts associated with collision are anticipated to be minor to moderate for coastal bird species.

Barrier Effect

The presence of operating WTGs may present a barrier to the flight path of migrating shorebirds or wading birds. The creation of a barrier may result in increased energy expenditure to avoid the wind farm. Visual confirmation coupled with radar surveys during migration periods from 2003 to 2005 at the Nysted and Horns Rev offshore facility in Denmark observed shorebird migration through the project area. The behavior of shorebirds flying towards the wind farm was noted for four flocks of shorebirds: Golden Plover (N = 11), Curlew (N = 4), Whimbrel (N = 1), and Oystercatcher (N = 15). The flocks of golden plover and oystercatcher passed above the turbines, while the single Whimbrel entered the wind farm at the height of the rotors and flew southward through the wind farm. The one flock of Curlews hesitated before entering the wind farm, then increased their flight altitude and increased their wing beat frequency in order to pass above the wind farm (Petersen et al., 2006). These observations suggest that some birds may increase energy expenditure to fly above or around offshore wind turbines. The energy expended while birds make efforts to avoid offshore wind farms is believed to result in small increases in energy expended during migration movements. These increases are believed to be comparable to other increases in energy spent to avoid additional migration hazards including adverse weather (Petersen et al., 2006). There are no known migration corridors that would concentrate shorebird or wading bird migration through the site of the proposed action, therefore, barrier effects associated with the operating turbines are expected to result in minor adverse impacts to migrants.

Marine Birds

Operation

Operation of a wind facility can result in more long-term disturbances including habitat loss, disturbances associated with EMF from the offshore cable, or barriers to flight movement due to the presence of operating turbines. Additional disturbances associated with operation of a facility include increased vessel traffic or human presence during routine maintenance activities associated with monopile collapse or cable repair, impacts associated with oil spills, as well as the risk of collision with operating turbines.

The following sections summarize marine bird uses of Nantucket Sound, describe the potential proposed action impacts to marine birds according to taxonomic group during the operational phase, and finally, attempt to gauge the magnitude of impacts to marine bird populations. Detailed analysis for roseate tern, a federally-endangered species has been provided in Appendix C.

Scour control around monopiles and ESP piles would be accomplished either through the use of rock armor or scour control mats. These mats and the monopiles would increase the available surface area and provide substrate for the colonization of benthic invertebrates and habitat for prey fish. Fish may concentrate around turbine foundations similar to how invertebrates cluster around oil platforms (Vella, 2002 *as cited by* Jarvis, 2005). Habitat with more ‘physical heterogeneity’ can result in greater fish abundance (Jenkins et al., 1997 and Charbonnel et al., 2002 *as cited by* Gill, 2005). The underwater structures could create a localized ‘artificial reef effect’, providing foraging habitat for terns and gulls. Wide spacing of turbines (0.39 to 0.63 miles [0.63 to 1.0 km] apart) would allow for tern and gull foraging between turbines (see section Risk of Collision below).

The boundary of the area of the proposed action would include approximately 25 square miles (65 km^2) of WTGs and ESP (electrical service platform) foundations, and 5.89 acres (0.024 km^2) of transmission cable. The total area represents 11 percent of Nantucket Sound (Jarvis, 2005). However, the total area of seabed that would permanently be disturbed would be less than 1 percent of the total wind farm area: including less than one acre (0.004 km^2) for the 130 turbines, 100 by 200 ft (30 by 60 m) for the ESP platform, and approximately 2.4 acres (0.01 km^2) for scour mat coverage (Jarvis, 2005). The additional amount of surface area (approximately 1,200 ft^2 or 0.03 acres [111 m^2] per tower would result in a minor addition to the substrate that is currently available (Section 3.9 in ESS, 2007). Due to the small amount of additional surface area in relation to the total area of the proposed action in Nantucket Sound, and the spacing between WTGs, the proposed structures are not expected to have a significant effect on the benthic community, the presence of prey fish, or foraging terns or gulls. However, the additional substrate would be oriented vertically in the water column, and could result in localized and minor increases in certain fish prey species.

As the area of the proposed action is not a significant foraging location or traveling corridor, and because of the small footprint of the actual development area, minimal habitat loss is anticipated during proposed action operation activities.

Human Disturbances

While the proposed turbines are in operation, there would be regular vessel trips made from Falmouth and New Bedford harbors to the site of the proposed action. The expected maintenance schedule would be approximately two vessel trips per day for 252 days per year (five maintenance days per turbine per year) (see Section 2.4.3.1). However, the vessels would depart busy ports where similar uses occur, and therefore impacts are limited to areas along the offshore transmission cable system as well as the WTG area.

Terns and gulls are expected to be among those species of bird that would habituate to the presence of increased boat traffic associated with maintenance activities. Therefore disturbances associated with increases in human presence and vessel activity are anticipated to have minor impacts on terns.

Electromagnetic Fields

There is a concern that electromagnetic fields emitted from the offshore cables may impact prey fish. It has been suggested that EMF may disorient or attract prey fish, however, it is unknown what these actual impacts may be (Gill, 2005).

The specifications of the proposed cable system require the cable to be shielded. Since electric field lines start and stop on charges, this shielding would effectively block the electric field produced by the conductors. Magnetic fields, however, can not be completely shielded because the magnetic field lines do not stop on objects; they form continuous loops around conductors carrying currents. The actual magnitude of typical 60 Hz magnetic fields in the vicinity of the offshore cables is, in most locations, well below that of the geomagnetic field (~ 500 mG). Therefore, no additional electric field impacts are expected to result from the submarine cables. There are no anticipated substantial adverse impacts to foraging birds or their prey from the 60 Hz magnetic fields associated with the operation of the proposed action.

Oil Spills

During operations, the presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. Oil could be released from tankers or damage to WTG structures or the ESP could result in the release of fluid contained within these structures. The total maximum oil storage on the ESP is expected to be approximately 42,000 gallons at any given time. The total oil storage at each WTG is expected to be approximately 214 gallons at any given time (27,820 gallons for all 130 WTGs). In the unlikely event that an oil spill was to occur, the oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha’s Vineyard (20 percent to 30 percent). It has a 90 percent chance of impacting any shoreline in the area.

Because terns and gulls forage at the water’s surface, they are among those species of birds that are particularly vulnerable to oil spills (Jarvis, 2005). If the feathers become coated with oil, birds lose their ability to repel water and to insulate, and in some instances, lose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening. Also, nesting birds can transfer oil to their eggs resulting in decreases in hatching success, developmental problems, or the mortality of embryos (Jarvis, 2005).

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2005). At least three adult roseate terns were found dead with traces of oil. Terns were discouraged from nesting on Ram Island in 2003 because it was soiled from the oil spill. Consequently, 250 pairs of roseate terns nested on Penikese Island that year and productivity suffered due to the late initiation of egg-laying (BBNEP, 2005). Gull species represented 15 of 315 dead birds collected after the spill.

The potential impacts of oil spills associated with the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in mortality or could lead to decreased nesting success. Oil spills could directly impact tern colonies, as the Ram Island colony was affected in 2003. However, due to the distance of the proposed action from nesting colonies, oil spills associated with the proposed action are unlikely to impact nesting gull or tern colonies. Some individuals foraging in the direct oil spill area may be displaced from the area, or may become slicked with oil. However, the event of an oil spill is unlikely. Therefore, potential oil spills are anticipated to result in minor adverse impacts to terns or gulls.

Monopile Collapse

In the event of a monopile collapse, recovery and replacement activities would be similar to decommissioning and construction of a single WTG. A very minor amount of benthic habitat would be disturbed with a short term and localized increase in suspended sediments. Foraging opportunities for terns and gulls would be reduced in areas of elevated suspended sediments. Some lubricating fluid would likely leak from the submerged nacelle, but would rapidly disperse given the small quantity involved. However, should a tern or gull dive for fish within this small plume, it could be harmed (see previous section for description of impacts associated with oil spills). There is a low likelihood of this occurrence and low probability of it occurring coincidentally with tern or gull use of the immediate area. Potential impacts to tern or gull in the event of a monopile collapse would therefore be negligible.

Cable Repairs

Cable repair activities would be similar to cable installation activities, but would occur for a short period in a small discrete location. Cable jetting, splicing, and re-jetting would result in minor and temporary increases in suspended sediments and would temporarily disturb benthos. Tern or gull foraging in areas of elevated suspended sediments would be reduced. In both instances the habitat and species would recover and no impacts to terns or gulls are anticipated from cable repair activities.

Barrier Effect

The presence of wind turbines and the spinning of the blades could present barriers to the flight paths of terns or gulls and could potentially affect or restrict access to breeding, staging, or foraging habitat. A wind farm could potentially lead to significant impacts if it were to occur in an area of high use by birds (Drewitt and Langston, 2006). Barriers can result in increases in energy expenditure if birds are forced to travel greater distances while accessing foraging habitats or while undertaking migration movements. However, there are no known situations where a wind farm has created a 'barrier effect' resulting in an avian population level impact (Drewitt and Langston, 2006).

Terns and gulls have been observed to continue to use WTG areas at existing offshore facilities during both migration and breeding periods. Post-construction radar studies during migration at the Nysted and Horns Rev wind farms in Denmark indicate that, although the greatest levels of movement occurred outside of the wind farms, terns continued to migrate through the wind farm areas (Petersen et al., 2006). The facility is located 8.7 miles (14 km) offshore and is comprised of 80 turbines with a rotor zone of 98 to 360 ft (30 to 110 m). The turbines are spaced 1640 ft (500 m) apart, half the distance of the proposed action turbines. Visual data collected at the Nysted and Horns Rev facility indicate that the majority of terns generally avoided the direct wind farm area but increased their use of the 1.2 miles (2 km) zone surrounding the facility (Petersen et al., 2006). Terns were observed foraging at the outer edges of the facility around turbine structures. Small flocks flew into the farm, but then exited the area after passing through the second row of turbines (Petersen et al., 2006). Sandwich terns (*S. sandvicensis*) entered the wind farm between two turbines more frequently when one or both of the turbines were not active (Petersen et al., 2006). Common and artic terns (*S. paradisaea*), observed flying in the vicinity of turbines at a facility in Kalmar Sound, Sweden, flew between turbines or right next to the turbines instead of veering off in wide curves as waterfowl species were observed to do (Pettersson, 2005).

A post-construction study at the Zeebrugge wind farm in Belgium investigated the level of project disturbance on nesting terns. An artificial peninsula, created to provide nesting habitat for common, sandwich, and little (*S. albifrons*) terns, was built adjacent to 25 small to medium-sized turbines on a jetty. In 2004, terns nested as close as 98 ft (30 m) from the turbines, while the majority of nests were situated 328 ft (100 m) or further from the turbines (Everaert and Stienen, 2006). In 2005, terns nested as close as 164 ft (50 m) from the turbines. The greater distance between nests and turbines in 2005 was believed to be a result of the distribution of vegetative growth on the peninsula and not due to the operation of the turbines themselves (Everaert and Stienen, 2006). While terns traveled to and from the colony past the turbines, many made no apparent changes in their flight paths. The terns that exhibited a reaction to the turbines made slight changes in their flight paths to fly between turbines (Everaert, 2004). The turbines did not present barriers to the flight paths of terns and observations suggest the presence of turbines resulted in minimal increases in energy expenditure for the terns. It was concluded that the presence of the turbines represented little disturbance to the activity of breeding terns (however, the project has resulted in high numbers of collisions due to the facility's location in close proximity to the colony, discussed in the following section, Risk of Collision).

A tern-turbine interaction study closer to the area of the proposed action was conducted at the Massachusetts Maritime Academy (MMA) campus turbine. The MMA turbine has a maximum height of 243 ft (74 m) (85 to 243 ft [26 to 74 m] rotor zone) and is located at the western entrance of the Cape Cod Canal. The turbine is situated 328 ft (100 m) from the water's edge on a landmass adjacent to a popular common and roseate tern foraging location, the Mashnee Flats Shoal located 5.3 miles (9 km) from one of the largest roseate tern breeding colonies, Bird Island. Visual surveys and mortality searches were conducted from April 24 to November 30, 2006, during the breeding, staging, and fall migration periods (see the following Risk of Collision for information regarding mortality searches). Terns were most abundant in the area during the post-breeding period when they were foraging in large, mixed-species flocks. Terns were most abundant in the turbine airspace (within 164 ft [50 m] of turbine tower, rotor, and blades) during the chick-rearing period and least abundant during the nesting period. The average flight height of terns in the turbine airspace was 83 ft (25.4 m) and the mean flight height was 49 ft (15 m). The one positively identified roseate tern observed in the turbine airspace flew at 26 ft (8 m). In summary, of the terns observed in the 164 ft (50 m) airspace surrounding the turbine: 17 percent flew within, 74 percent flew below, and 9 percent flew above the rotor zone (85 to 243 ft [26 to 74 m]). The study demonstrated that terns continued to use the 164 ft (50 m) airspace around the turbine while traveling between foraging locations (Vlietstra, 2007). However, the operating rotors and spinning blades were observed to deter terns from flying directly within the rotor zone of the turbine when the rotor velocity was greater than 1 rotation per minute (rpm). Under these conditions, terns were found to be 4 to 5 times less abundant in the turbine airspace. Therefore, it was assumed that the terns visually and acoustically detected the spinning blades when the rotor was operating (Vlietstra, 2007). Despite the turbine's location in between foraging locations, terns continued to use the area and their access to habitat was not evidently restricted.

As terns and gulls are known to travel and forage around other man-made structures, including lighthouses, bridges, and wind turbines, it is likely terns would continue to travel through and around the area of the proposed action after construction of the proposed action. Although the majority of terns are expected to avoid the direct WTG rotor swept area (refer to the following section, Risk of Collision for detailed information of avoidance behavior), it is anticipated that terns would continue to travel and forage in the vicinity of the proposed action. Also, because the turbines are widely spaced (0.39 to 0.63 miles [0.63 to 1.0 km] apart), it is anticipated that most terns and gulls would occur between turbines while traveling at heights within the rotor swept zone. Barrier effects are anticipated to result in minimal increases in energy expenditure for terns and gulls as they generally avoid direct encounters with turbines while continuing to use the site of the proposed action for foraging and traveling purposes. Therefore barrier effects are expected to result in no measurable impacts to terns or gulls.

Risk of Collision

The potential exists for terns and gulls to collide with WTGs under operation, including the blades and tubular towers during the breeding, staging, and migration periods. The results of available mortality studies indicate that the majority of avian collisions with man-made structures take place at night during periods of inclement weather (Kerlinger, 2000). Birds that fly within the rotor zone of the proposed turbines (75.5 to 440 ft [23 to 134 m]) during periods of low visibility would be at greatest risk of collision.

Poorly sited facilities can result in high collision rates for terns and for gulls. A mortality study conducted at the Zeebrugge, Belgium facility reported notably high tern collision mortality. At this facility, terns have nested on a peninsula as close as 98 ft (30 m) from a string of 25 small to medium sized turbines located on an adjacent breakwater. The mean number of terns killed for all turbines was 6.7 terns per turbine per year, and the mean number of terns killed at the 14 turbines closest to the colony was 11.2 terns per turbine per year for 2004 and 2005 (Everaert and Stienen, 2006). The rotor zone (52.5 to 164 ft [16 to 50 m]) of the 14 turbines that are responsible for the high number of tern fatalities is lower than that of the proposed turbines, and the turbines are spaced closer together (394 ft [120 m] apart) (Report No. 5.3.2-1). The collision mortality observed at the Belgium facility was determined to have an adverse impact on the breeding terns. However, the majority of these collisions occurred at the 14 turbines located closest to the tern colony and most collisions may have been associated with the circular, erratic flight behaviors that terns exhibited near the colony (Everaert and Stienen, 2006). Ten tern collisions were documented when observers were onsite and it is likely that the observers themselves caused a disturbance to the colony, resulting in the observed collisions (Everaert and Stienen, 2006). If the peninsula colonized by the terns had not been created adjacent to the string of turbines on the breakwater, it is very likely that the observed collision mortality would have been substantially lower. Because no colony is located adjacent to HSS, this data is not particularly relevant to the proposed action's potential impacts. Gulls are known to occasionally collide with bridges and vehicles, as well as communication towers. Some studies suggest that gulls could be particularly vulnerable to wind turbine mortality as they are often observed flying 100 ft (30 m) off the ground (Airola, 1987 *as cited in* Kingsley and Whittham, 2001). A study conducted at Blyth Harbour, Great Britain, concluded that great black-backed gulls were killed by turbines 'disproportionately to both their overall abundance and natural mortality' (Kingsley and Whittham, 2001). The collisions were associated, however, with poor weather and periods of low visibility.

If terns or gulls were to cross the area of the proposed action during crepuscular periods or at night, aspects of the proposed action design are expected to reduce the risk of collision. Each perimeter WTG nacelle would be lit at night with one red flashing FAA light. Corner WTGs would be equipped with medium intensity FAA L-864 lighting. The other perimeter WTGs would be equipped with low intensity lights visible up to 1.15 miles (1.9 km). The eight turbines adjacent to the ESP would have one L-810 flashing red light. FAA lighting would be synchronized to flash in unison at 20 FPM (Section 2.0 in ESS, 2007). Construction structures and equipment would be lit at night and construction activities would be limited during inclement conditions, particularly at night.

The lighting mounted on nacelles as well as natural sources of nighttime lighting are expected to decrease the risk of tern and gull collisions if their migratory movements result in nighttime crossings of the area of the proposed action during periods of good visibility. At the Nysted and Horns Rev wind farm in Denmark, all the wind turbines are equipped with yellow navigational lighting. In addition, all wind turbines positioned at the outer edge of the wind farm are equipped with two medium intensity flashing red lights on the top of the nacelles. The lights operate at a frequency of 20 to 60 FPM (Petersen et al., 2006). Radar observations suggest that birds approached the turbines at closer distances at night than during the day, and that more birds entered the wind farm at night than during the day; however, observations indicated avoidance behavior of the turbines by nighttime migrants. The typical distance at which an avoidance reaction occurred was 1,640 ft (500 m) from turbines at night and 1.8 miles (3 km) during the day (Petersen et al., 2006). It may be that that migrating birds react later to the turbines at night due to decreased visibility, but are eventually able to detect the turbines due to lighting mounted on the nacelles or natural sources of night lighting. Another study conducted with a vertically oriented radar suggests that migrating birds may also react to turbines by 'vertical deflection' at night instead of the linear avoidance primarily observed during the day (Blew et al., 2006 *as cited by* Petersen et al., 2006).

However, refraction from lighting may be associated with collisions during periods of fog or rain. A mortality study conducted at a potential wind farm site in the North Sea found that collisions occurred at a radar platform that was illuminated at night, and that 50 percent of these collisions occurred on two nights with conditions of fog and drizzle during a heavy migration period (Huppop et al., 2006). Of the 442 birds (mainly passerines) believed to have collided with the lit research platform, four were gulls. It was believed that the birds may have been attracted to the lighting on the platform during inclement conditions. However, Petersen et al. (2006) observed a substantial decrease in the volume of migrating waterbirds during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of low visibility and strong headwinds (Petersen et al., 2006).

Based on the available data, terns have been observed at heights well above the rotor zone when making migratory movements. There have been observations of what were assumed to be both roseate and common terns departing South Beach in the fall around sunset, apparently heading toward their wintering grounds, and quickly gaining altitudes of hundreds of meters (Veit and Petersen, 1993). Other species of terns have been observed migrating at heights above 4,270 ft (3,000 m) when migrating over land (Alerstam, 1985). It is likely that nighttime migration movements, if they were to cross the area of the proposed action, would occur well above the rotor zone. The flight height, however, would be dependent on weather conditions. If terns were to depart in unfavorable conditions such as strong headwinds, their flight heights would likely be lower as other tern species have been observed flying close to the water's surface during strong headwinds (Alerstam, 1985). However, it is unlikely that flocks of staging terns would depart for migration in unfavorable weather conditions during the day, and less likely at night. More data would be necessary to assess tern and gull flight behavior in the area of the proposed action during a variety of weather conditions.

Above water foundations are not anticipated to create perching habitat or result in increased risk of collision for terns or gulls. The above water foundations, WTGs, and the ESP would be equipped with stainless wire and vision restriction perch deterrent devices. Each turbine foundation would have a deck which would be covered by aluminum chain link fencing to discourage access on the sides (and the deck overhangs the access ladder). There would be a taught 0.12 inch (3 mm) stainless steel wire on top of the railing, and a 25 inch (0.65 m) solid panel to restrict the view of birds from the deck (some species prefer perches with views). The spacing between the wire and the rail would be 1.2 inch (3 cm). The ESP would have a perimeter railing and the ladders and railing would be equipped with stainless steel wire, chain-link fence, and panels similar to the WTG foundations. The use of perch deterrent devices has discouraged terns perching on the fence and deck of the platforms supporting the Cape Wind SMDS. The final design of perch deterrents would be based on recommendations from USFSW. The use of tubular towers instead of lattice towers also discourages perching under the rotors. Vibrations and low level noise created by operating WTGs may also deter terns and gulls from perching. Therefore, perching opportunities are not expected to increase the risk of collision of terns and gulls with the proposed turbines.

Terns and gulls are anticipated to continue minimal foraging and traveling activities in the vicinity of the site of the proposed action with a low risk of collision given the turbine-avoidance behavior exhibited by terns at the majority of existing offshore and near-shore facilities. Terns and gulls would be expected to make direct flights while traveling through HSS to access foraging or breeding locations. The majority of flight heights observed in the area of the proposed action occurred below the rotor zone. During conditions of good visibility, terns would be expected to visually detect and react to turbine structures. Terns are not expected to frequent the area of the proposed action during those periods of inclement weather or at night, however, surveys have not been conducted under these conditions and therefore the potential for collision under these conditions can not be ruled out. However, if flying into strong headwinds, terns would be expected to fly closer to the water's surface. If flying at night, they would be expected to avoid encountering the proposed turbines based on the observed turbine avoidance behavior observed by other waterbirds at night. Skimmers are known to forage during periods of low visibility, however, they do so just above the surface of the water (Sibley, 2001); therefore, they are at a decreased risk of collision. These factors decrease the risk of tern collisions with the proposed action's structures. Hatch and Brault (2007) (Report No. 5.3.2-1) used a collision probability model to estimate the number of roseate tern, least tern, and common tern collisions with the proposed turbines per year. Their estimates suggest that 0.8 roseate terns, 12 common terns, and minimal least tern fatalities per year may occur as a result of the proposed action.

Some studies suggest that gull flight altitudes often occur below 100 ft (30 m) but do occur within the rotor zone of modern wind turbines (Kerlinger and Curry, 2002). Due to the great abundance of gulls in the area and their typical flight characteristics, there is a moderate risk of collision with the proposed turbines. Population-level effects from those collisions, however, would be less likely to occur because of their overall larger population sizes relative to other species, like terns, and therefore the impacts to gulls would be minor. The risk of collision for tern species is anticipated to be low; however, impacts associated with collision are anticipated to be moderate for tern species of conservation concern as the loss of a single breeding individual may be detrimental to the regional population. A discussion of collision related impacts for roseate terns is included in Appendix C.

Pelagic Species (shearwaters, petrels, gannets, auks)

Risk of Collision

The magnitude of collisions with wind turbines by these species is expected to be lower than other species, as they are expected to be infrequently present. However, if the presence of these species is typically associated with storm events and reduced visibility, the actual potential for collisions may be greater under these conditions. Additionally, these birds could be at risk of collision because they may react differently to turbines as they are not as habituated to obstacles in their flight path as near-shore species are (Tulp et al., 1999). However, observations from a study conducted in the North Sea near Denmark suggest that many species, including gannets, actively avoided the wind farm area and only occasionally entered turbine areas (Christensen and Houninsen, 2005).

Within this group of birds, some species may be more at risk than others. Soaring species (shearwaters) and species that plunge dive for food (gannets) may occur more commonly in the rotor swept zone of the proposed turbines while those that feed at the waters surface (storm-petrels) and heavy-bodied divers (the alcids) may spend far less time at heights above the water that would put them at risk of collisions with turbine blades. Aerial and boat surveys conducted in the study area were limited to daytime periods of good visibility. While documenting these species during periods of inclement weather (when they are most likely to occur near shore) presents difficulties, additional information on the frequency of occurrence and activity patterns should be investigated during a variety of weather conditions both day and night. However, due to the anticipated infrequent occurrence of pelagic species in the area of the proposed action, the risk of collision with WTG structures is anticipated to be low. Therefore, the risk of collision is expected to result in minor impacts.

Waterfowl and Non-Pelagic Water Birds

There are a number of sea duck, waterfowl, and diving species that occur within Nantucket Sound, particularly during the winter months. There are a number of sea duck, waterfowl, and diving species that occur within Nantucket Sound, particularly during the winter months. Species such as scoter, eider, and long-tailed duck over-winter in large flocks in the region. A number of common and red-throated loon (*Gavia stellata*), as well as grebes, geese, brant, and dabbling ducks are also local to the bay during various times of the year. Double-crested cormorant are abundant in the site of the proposed action through the breeding season and late-fall. Great cormorant occur in the area mainly in the winter months.

Habitat Modification

Habitat modification as a result of the operating facility could displace sea duck and waterfowl. Displacement can lead to over-crowding and competition at alternative foraging sites and can ultimately result in increased mortality of more vulnerable species (Maclean et al., 2006). The impact of habitat modification on sea ducks would be dependent on the location of the turbines in relation to suitable feeding areas.

Petersen et al. (2006) found that common scoters (*Melanitta nigra*) were among those species that exhibited complete avoidance of turbine areas, however were numerous in the surrounding waters. Sea duck may avoid the direct area of the wind farm; however, they are expected to continue to forage in the vicinity of the proposed action, assuming that their food sources were not displaced.

Sets of six scour-control mats (each mat would be 16.5 ft by 8.2 ft [5 m by 2.5 m] with 8 anchors to secure the mat to the seafloor) would be placed at the base of each monopile. The underwater structures could create a localized 'artificial reef effect', providing foraging habitat for sea ducks and other waterbirds. Wide spacing of turbines (0.39 to 0.63 miles [0.63 to 1.0 km] apart) would allow for diving between turbines.

The boundary of the area of the proposed action would include approximately 25 square miles of WTGs and ESP (electrical service platform) foundations, and 5.89 acres of transmission cable. The total area represents 11 percent of Nantucket Sound (Jarvis, 2005). However, the total area of seabed that would permanently be disturbed would be less than 1 percent of the total wind farm area: including approximately 0.004 km^2 (less than one acre) for the 130 turbines, 30 by 60 m (100 by 200 ft) for the ESP platform, and 0.01 km^2 (approximately 2.4 acres) for scour mat coverage (Jarvis, 2005). The additional amount of surface area (approximately 1,200 ft^2 or 0.03 acres [111 m^2]) per tower would result in a minor addition to the substrate that is currently available (Section 3.9 in ESS, 2007). Due to the small amount of additional surface area in relation to the total area of the proposed action in Nantucket Sound, and the spacing between WTGs, the proposed structures are not expected to have a significant effect on the benthic community, the presence of prey fish, or sea duck or other water birds. However, the additional substrate would be oriented vertically in the water column, and could result in localized and minor increases in certain invertebrates and prey fish species.

Although there may be minimal impacts to the prey base due to construction of the proposed action, sea duck and waterfowl are among species of birds that may experience habitat loss due to the presence of operating turbines. Petersen et al. (2006) found that common scoters (*Melanitta nigra*) were among those species that exhibited complete avoidance of turbines, yet were numerous in the surrounding waters.

At Tuno Knob in Denmark, aerial and ground surveys were used to compare the abundance of birds before and after the construction of the wind farm determined that there were fewer birds post-construction although numbers remained stable in a control site (Guillemette et al., 1998). However, the change was believed to be due to differences in natural changes in food availability and not the presence of the wind facility. It was concluded that the wind turbines did not have any effect on the abundance and distribution of eiders during the winter of 1996 to 1997 (Guillemette et al., 1998). Scoter numbers however, did not increase to their original, pre-construction numbers (Drewitt and Langston, 2006). At Horns Rev, divers and scoters occurred in numbers lower than expected in the wind-farm area post-construction. At the Horns Rev and Nysted wind farm in Denmark, loons and common scoters showed an increased avoidance of both wind facilities and this effect was documented to two to four km around the facility (Petersen et al., 2006). These results suggest that these birds may avoid wind farm areas.

Kaiser (2002) used field data in combination with a modeling approach to predict the change in over-winter mortality rates of common scoter as a result of displacement from potential feeding habitat through avoidance of wind facilities in Liverpool Bay. The study indicated that the displacement of common scoter from areas around four of five wind facilities (existing, authorized, or proposed) would have no adverse effects to the over-winter mortality of the population.

Due to the small footprint of the actual development area in relationship to the overall habitat available in Nantucket Sound, and due to the relatively low abundance of sea duck and other waterfowl species in the area of the proposed action, minimal habitat loss is anticipated during proposed action construction, decommissioning, and operation activities. Impacts associated with displacement of prey fish during construction are anticipated to be minimal and temporary. The natural benthic substrate and prey fish communities would be essentially maintained after a short recovery period, therefore, adverse impacts associated with loss of habitat or modification are not anticipated. The impacts associated with decommissioning are anticipated to be similar to or less than construction activities because pile driving would not be required (Jarvis, 2005). Therefore, impacts associated with loss of habitat or habitat modification during operations are anticipated to be minor.

Human Disturbances

Disturbances, such as increased human presence and vessel activity during proposed action operation, may result in impacts to sea ducks and waterfowl. Divers including loons and scoters are particularly sensitive and could be disturbed during maintenance activities due to their strong reaction to boats (Maclean et al., 2006).

Observations at existing offshore facilities indicate that increased vessel activity during the operational phases could result in disturbances to sea duck or waterfowl foraging in the vicinity of the area of the proposed action. Helicopters and boats approaching a wind farm in Denmark for maintenance services flushed flocks of scoter. It was observed that birds tended to eventually return to the same area after the helicopter or service boats had left the area (Petersen et al., 2006). At a Sweden facility, it was observed that service boats are more of a disturbance to birds than the operating turbines (Pettersson, 2005). Long-tailed duck and scoter foraging in the immediate vicinity of turbines were flushed as facility service boats approached (Pettersson, 2005). Spring 2003 studies showed that long-tailed duck and possibly scoter that stage in the wind farm area leave the area when the service boat comes but were observed to return in the evening after the boat was out of the area (Pettersson, 2005). It was suggested that was it the boat activity in the area that displaced the birds, not the wind farm structures themselves; the birds were present in the morning and evening when the boats were not present (Pettersson, 2005). Despite the presence of turbines and service boats, many species of waterfowl continued to use the area as foraging and staging habitat at the Sweden facility. Eider feeding in vicinity of the turbines at the Sweden facility in an area that receives less boat activity, appeared to be unaffected by the presence of the boats suggesting boat disturbance is limited to the immediate vicinity of the boats, for most species.

The area surrounding the proposed development experiences regular vessel activity, therefore, increased human presence or vessel activity is not anticipated to present a substantial increase in disturbances. Human disturbances are not expected to result in long-term or adverse impacts to foraging sea duck or waterfowl. Minor adverse impacts are anticipated to result from human disturbances associated with operation of the proposed action.

Electromagnetic Fields

There is a concern that electromagnetic fields emitted from the offshore cables may impact prey fish. It has been suggested that EMF may disorient or attract prey fish, however, it is unknown what these actual impacts may be (Gill, 2005).

The specifications of the proposed cable system require the cable to be shielded. Since electric field lines start and stop on charges, this shielding would effectively block the electric field produced by the conductors. Magnetic fields, however, can not be completely shielded because the magnetic field lines do not stop on objects; they form continuous loops around conductors carrying currents. The actual magnitude of typical 60 Hz magnetic fields in the vicinity of the offshore cables is, in most locations, well below that of the geomagnetic field (~ 500 mG). Therefore, no additional electric field impacts are expected to result from the submarine cables. There are no anticipated substantial adverse impacts to foraging birds or their prey from the 60 Hz magnetic fields associated with the operation of the proposed action.

Oil Spills

The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. Oil could be released from tankers or damage to WTG structures or the ESP could result in the release of fluid contained within these structures. The total maximum oil storage on the ESP is expected to be approximately 42,000 gallons at any given time. The total oil storage at each WTG is expected to be approximately 214 gallons at any given time (27,820 gallons for all 130 WTGs). In the unlikely event of an oil spill, the oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent). It has a 90 percent chance of impacting any shoreline in the area.

Because sea duck and waterfowl dive at the water's surface, they are among those species of birds that are particularly vulnerable to oil spills. If the feathers become coated with oil, birds lose their ability to repel water and to insulate, and in some instances, lose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening.

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2003). Diving species including loon and scoter suffered relatively high mortality from the spill. Over 100 loons were collected dead. More than double this number were slicked and collected alive. This likely represents a high regional population impact to these birds. Over 70 diving duck, sea duck, merganser, and grebe (combined) were collected dead. Cormorant species (N=17) also represented a substantial portion of the dead birds found (315 total) associated with the oil spill (BBNEP, 2005).

The potential impacts of oil spills associated with the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in mortality. Some individuals foraging in the direct oil spill area may be displaced from the area, or may become slicked with oil. However, the event of an oil spill is unlikely. Therefore, potential oil spills are anticipated to result in minor adverse impacts to sea duck and other waterfowl.

Monopile Collapse

In the event of a monopile collapse, recovery and replacement activities would be similar to decommissioning and construction of a single WTG. A very minor amount of benthic habitat would be disturbed with a short term and localized increase in suspended sediments. Foraging opportunities for sea duck and other waterfowl would be reduced in areas of elevated suspended sediments. Some lubricating fluid would likely leak from the submerged nacelle, but would rapidly disperse given the small quantity involved. However, should a bird dive for food within this small plume, it could be harmed (see previous section for description of impacts associated with oil spills). There is a low likelihood of this occurrence and low probability of it occurring coincidentally with bird use of the immediate area. Potential impacts to sea ducks or waterfowl in the event of a monopile collapse would therefore be negligible.

Cable Repairs

Cable repair activities would be similar to cable installation activities, but would occur for a short period in a small discrete location. Cable jetting, splicing, and re-jetting would result in minor and temporary increases in suspended sediments and would temporarily disturb benthos. Sea duck or waterfowl may be temporarily displaced from areas of suspended sediments. In both instances the habitat and species would recover and no impacts to sea duck or waterfowl are anticipated from cable repair activities.

Barrier Effect

Structures that extend above the natural landscape such as towers, buildings, and bridges can act as barriers in the flight paths of birds. A barrier effect to migrating sea duck or waterfowl may occur if their movements were to cross HSS. Barriers to the flight paths of birds can result in increases in energy expenditure during migration movements. Significant impacts may result if access to preferred foraging habitat is restricted or if movements along migration corridors are impeded. There are no existing facilities known to create a barrier effect that has resulted in a population level impact. A wind facility, however, could potentially lead to significant impacts if it were to occur in a frequented flight path between nesting and foraging locations (Drewitt and Langston, 2006).

Observations at existing wind farms indicate that migrating waterbirds make efforts to avoid entering or encountering wind farms. At the Horns Rev wind farm in Denmark, radar studies showed that 71 to 86 percent of birds approaching the windfarm avoided entering the wind farm. There was a 78 percent observed avoidance of the wind farm by approaching birds (Petersen et al., 2006). For eider, it was found that of 10 flocks that would have entered the wind farm prior to construction, eight flocks would avoid the wind farm during post-construction (this number however, was believed to be over-estimated due to detection bias) (Petersen et al., 2006).

At a Sweden wind facility, it was observed that the post-construction migratory flight paths of ducks, geese, and cormorants shifted up to 1.2 miles (2 km) eastward from the baseline corridor as the birds made efforts to avoid flying less than 0.6 miles (1 km) from turbines (Pettersson, 2005). The birds' increased energy expenditure was calculated; it was estimated that their migration flight path was extended by 0.7 to 1.8 miles (1.2 to 2.9 km) resulting in a 0.2 to 0.5 percent extension of the total estimated migration distance of the waterfowl (Pettersson, 2005).

At the Utgrunden wind facility in the Baltic Sea, long-tailed ducks were observed to fly between turbines as they traveled between foraging locations (Pettersson, 2005). The birds made minor changes to their flight behavior to avoid encountering turbines.

At the MMS turbine in Buzzards Bay, cormorants, geese, and other birds were observed heading toward the turbine, and as they approached, they abruptly changed their flight direction to avoid the turbine (Vlietstra, 2007). Generally, the likelihood of terns and other birds including double-crested cormorants, rock doves, and gulls entering the turbine airspace was dependent on the velocity of the rotor and blades. However, no measurable impacts were observed as birds traveled between foraging locations and their access to these areas was not believed to be restricted. Therefore, the effects of the barrier appeared to be minor.

Barrier effects may result in changes in the flight behavior of traveling birds. Observations at existing facilities indicate there are no known situations where a barrier effect has resulted in a population level impact to birds. Sea duck and waterfowl are expected to make altercations to their flight behavior to avoid encounters with turbines. However, these altercations are anticipated to result in minimal increases of energy expenditure. No adverse impacts associated with barrier effects are anticipated for sea duck or waterfowl.

Risk of Collision

The potential exists for migrating or dispersing water birds to collide with WTGs under construction, large construction equipment, or operating WTGs. The risk of collision depends on use of the area of the proposed action, visibility during crossings of the area of the proposed action, and flight behaviors exhibited during encounters with turbines.

Sea duck and waterfowl exhibit certain characteristics that may decrease their ability to avoid wind turbines: they travel in flocks, and due to their large size, they are less agile fliers than smaller seabirds. Sea duck and waterfowl can be active during a variety of times of the day, including at night. Studies suggest that the vast majority of collisions with turbines take place at night and in twilight, especially on those nights with strong winds and poor visibility (Winkelman, 1992 *as cited by* Tulp, 1999).

Diving ducks may fly just above the surface of the water in lines or V's during their daily movements between foraging locations, and may migrate at heights just above the surface of the waves to altitudes well above the rotor zone (Bordage and Savard, 1995; Cramp and Simmons, 1977 *as cited by* Savard et al., 1998). During surveys in the study area, diving species typically flew below 98 ft (30 m) above the waves, although they were occasionally observed flying between 98 and 197 ft (30 and 60 m) (Report No. 4.2.4-10).

Observations of waterfowl from onshore wind facility sites, particularly the Top of Iowa project, indicate that collisions with wind turbines can be extremely low, even in areas with very high waterfowl use (Koford et al., 2005). Tulp (1999) found that waterbirds diverted their daytime and nighttime movements away from turbines at even greater distances. Results from offshore wind facilities in Denmark and Sweden showed that flocks of migrating eiders (and other waterfowl) change their flight path around the wind facility and/or avoided turbines by flying between the rows or by changing height (Desholm and Kahlert, 2005; Desholm, 2006; Pettersson, 2005).

Survey results from offshore European facilities provide additional evidence that waterfowl can detect and avoid offshore turbines at night. Observations from a study conducted in the North Sea off of Denmark suggest that divers, gannets, and scoters actively avoided the wind farm area and only occasionally entered the wind farm (Christensen and Houninsen, 2005). Eiders at that facility often deflected their flights away from the turbines beginning at distances of 1,300 to 1,640 ft (400 to 500 m) from the turbines (Christensen and Houninsen, 2005 *as cited by* Maclean et al., 2006).

The lighting mounted on nacelles as well as natural sources of nighttime lighting are expected to decrease the risk of bird collisions if their migratory movements result in nighttime crossings of the area of the proposed action. At the Nysted and Horns Rev wind farm in Denmark, all the wind turbines are equipped with yellow navigational lighting. In addition, all wind turbines positioned at the outer edge of the wind farm are equipped with two medium intensity flashing red lights on the top of the nacelles. The lights operate at a frequency of 20 to 60 FPM (Petersen et al., 2006). Radar observations suggest that birds approached the turbines at closer distances at night than during the day, and that more birds entered the wind farm at night than during the day; however, observations indicated avoidance behavior of the turbines by nighttime migrants. The typical distance at which an avoidance reaction occurred was 1,640 ft (500 m) from turbines at night and 1.8 miles (3 km) during the day (Petersen et al., 2006). It may be that that migrating birds react later to the turbines at night due to decreased visibility, but are eventually able to detect the turbines due to lighting mounted on the nacelles or natural sources of night lighting. Another study conducted with a vertically oriented radar suggests that migrating birds may also react to turbines by 'vertical deflection' at night instead of the linear avoidance primarily observed during the day (Blew et al., 2006 as cited by Petersen et al., 2006).

During periods of inclement weather, however, lighting may result in increased avian collisions. A mortality study conducted at a potential wind farm site in the North Sea found that collisions occurred at a radar platform that was illuminated at night, and that 50 percent of these collisions occurred on two nights with conditions of fog and drizzle during a heavy migration period (Huppop et al., 2006). The species composition of the 442 birds believed to have collided with the lit research platform include mainly thrushes, common starlings (*Sturnus vulgaris*), and sky larks (*Alauda arvensis*), as well as 1 dunlin, four gulls, and one pigeon (*Columba livia*). It was believed that the birds may have been attracted to the lighting on the platform during inclement conditions. However, the data indicated no mortality of sea duck or waterfowl. Petersen et al. (2006) observed a substantial decrease in the volume of migrating waterbirds during weather periods of elevated collision risk. Fewer waterbirds migrated during periods of low visibility and strong headwinds (Petersen et al., 2006).

For the Nysted offshore wind facility, Petersen et al., (2006) developed a stochastic predictive collision model to estimate numbers of common eiders likely to collide with turbine blades each autumn. Using data derived from radar studies and infrared video monitoring, they predicted with 95 percent certainty that 0.018 to 0.020 percent of 235,000 passing birds (41 to 48 individuals) would collide with all 72 turbines in a single autumn (one eider/turbine/year). Collision mortality predicted by Hatch and Brault (2007) (Report No. 5.3.2-1) for sea duck at the proposed facility was estimated to be lower than the fatalities predicted for the facility in Denmark due to the relatively fewer migrants along the Atlantic Coast. The number is estimated to be well below the annual hunt of 15 to 20,000 eider and long-tailed duck along Atlantic Coast states (USFWS 2006 *as cited in* Report No. 5.3.2-1).

Potential impacts may be associated with increased collision mortality due to perching opportunities under turbines. Cormorants, in particular, are a bird group that may be attracted to the WTG area for perching opportunities. However, above water foundations are not anticipated to create perching habitat or result in increased risk of collision. The above water foundations, WTGs, and the ESP would be equipped with stainless wire and vision restriction perch deterrent devices. Each turbine foundation would have a deck which would be covered by aluminum chain link fencing to discourage access on the sides (and the deck overhangs the access ladder). There would be a taught 0.12 inch (3 mm) stainless steel wire on top of the railing, and a 25 inch (0.65 m) solid panel to restrict the view of birds from the deck (species such as cormorant prefer perches with views). The spacing between the wire and the rail would be 1.2 inch (3 cm). The ESP would have a perimeter railing and the ladders and railing would be equipped with stainless steel wire, chain-link fence, and panels similar to the WTG foundations. The use of tubular towers instead of lattice towers also discourages perching under the rotors. Vibrations and low level noise created by operating WTGs may also deter birds from perching.

Although certain species may fly within the rotor zone of the proposed turbines, sea duck and waterfowl have demonstrated turbine avoidance behavior. These birds likely have reduced movements during periods of darkness and inclement weather, therefore, this bird group is at a lower risk of collision with turbines than other species groups. In general, populations of many of these species are relatively large, and could likely sustain low levels of collision-related fatalities. Therefore, collision mortality is anticipated to result in minor impacts to sea duck and waterfowl species.

Conclusions on Operation Impacts

Based on research cited and information discussed herein, with respect to affects resulting from habitat modification, human disturbance, and risk of collision, the overall operational impacts of the proposed action to non T&E avifauna would be minor.

5.3.2.5 Subtidal Offshore Resources

5.3.2.5.1 Construction/Decommissioning Impacts

Impacts on Hard Bottom Benthic Communities

Potential impacts to hard bottom benthic communities that have been reported in limited areas of the proposed action locale would be associated with indirect affects from sediment suspension and deposition resulting from cable jetting, the vessel anchoring process associated with jetting, and the introduction of new and additional hard substrate due the presence of the monopiles and rock scour armor, if that is used. Sessile epifauna and macroalgae noted to occur in these areas could be subject to effects of sediment suspension and deposition and filter feeding organisms may experience clogging of feeding and respiration organs. These effects are expected to range from negligible to minor and be temporary. Such sediment would be expected to be removed by natural processes occurring in the adjacent mobile and dynamic sandy substrate environment. Although not anticipated, a thick layer of deposited sediments could permanently cover hard substrate areas, such as glacial till/cobble surfaces.

Impacts on Soft-Bottom Communities

Potential impacts to soft bottom communities relate to areas of the seafloor that are temporarily disturbed by geotechnical investigation methods such as coring and boring, and construction/decommissioning activities such as cable jetting, monopile and ESP pile installation, HDD of the shoreline crossing, and scour protection installation. Indirect impacts would occur from water withdrawals associated with construction vessels and jetting, which entrain the planktonic larvae of benthic species, assumed to result in 100 percent mortality of the entrained organisms.

Soft-Bottom Benthic Invertebrate Communities

Direct Seafloor Disturbance

Potential areas where seafloor impacts may occur were determined based on the proposed action design and construction methodologies. The length of cable needed for linking all the wind turbine towers to the ESP is approximately 66.7 miles (107.3 km). A zone of disturbance between 4 and 6 ft (1.2 and 1.8 m) wide is anticipated for burial of the inner-array cables to a target depth of 6 ft (1.8 m). Thus, the seafloor area anticipated to be disturbed during the inner-array cable installation is between approximately 1,408,704 and 2,113,056 ft^2 (32.34 and 48.51 acres or 130,872 and 196,309 m^2). Also, two 3 ft (0.9 m) wide skid pontoons would ride on the substrate surface on either side of the jet plow to help control the depth of cable embedment. Pontoon impacts that result from installation of the inner-array cables would be 2,113,056 ft^2 (48.51 acres or 196,309 m^2). Combined temporary disturbance would be up to 4,226,112 ft^2 (97.02 acres or 392,618 m^2) of sea bottom within the perimeter of the WTGs, or approximately 0.61 percent of the 25 square miles (64.7 km^2) area defined as the total area of the proposed action (see Table 5.3.2-2).

Approximately 12.5 miles (20.1 km) of offshore transmission system cable is required for joining the ESP to the mainland. A disturbance zone of 4 to 6 ft (1.2 to 1.8 m) wide is expected for burial of each of the two offshore transmission cable circuits to a target depth of 6 ft (1.8 m). Thus, the seafloor area that would be disturbed during installation of the offshore transmission cable system along the proposed route would be approximately 792,000 ft^2 (18.18 acres or 73,579 m^2). The two skid pontoons would impact another approximately 792,000 ft^2 (18.18 acres or 73,579 m^2). The resulting combined temporary disturbance is expected to be up to 1,584,000 ft^2 (36.36 acres or 147,158 m^2) of sea bottom or approximately 0.228 percent of the area of the proposed action (see Table 5.3.2-2).

Since there are shallow water depths in Nantucket Sound, shallow draft vessels/barges are necessary for installation. These types of vessels/barges commonly use anchors for positioning. The processes of positioning, anchoring and movement of cable installation barges are expected to result in impacts occurring along cable installation paths. The impact area would vary with water depth, weather and sea conditions, and the type of bottom substrate. Average impact areas for each anchor deployment can be made using properties of anchor behavior that have been described by the U.S. Navy (NAVFAC, 1985; NCEL, 1987; Taylor, 2002). Using the width of an anchor (10.6 ft [3.23 m] including stabilizer bar), the number of anchors necessary for securing and moving a vessel (6), and the required setting drag length for deep water (20 ft [6.1 m]), the estimate is that up to 7,230 ft^2/mile (0.17 acre/mile or 420 m^2/km) would be disturbed from the deployment and retrieval of anchors. Anchors would disturb the substrate to a depth of 4 to 6 ft (1.2 to 1.8 m) for each anchor deployment and leave a temporary irregularity to the seafloor with localized mortality of infauna. In addition, the seafloor area that would be swept by anchor cable as the jetting barge moves along the cable routes was calculated to be 311,880 ft^2 (7.16 acres or 28,975 m^2) per linear mile (1,609 m) of cable. Use of mid-line anchor buoys would minimize potential impacts but cannot eliminate them entirely. Anchor cable sweep impacts would be expected to disturb sediment to a depth of up to 6 inches (15.2 cm) (Algonquin Gas Transmission Company, 2000). Organisms that may be subject to impacts from anchor line sweep include mollusks such as soft shell clams, surf clams, and whelks and other sessile species such as tube dwelling polychaetes or mat forming amphipods which make up a large portion of the taxa occurring in the area of the proposed action. Organisms that are mobile, such as certain polychaete species, amphipods, Tanaidacea, Mysidacea, and crabs could be expected to avoid impacts from the anchor line sweep.

Total anchoring and anchor sweep impacts that are part of the installation of 66.7 miles (107.3 km) of inner-array cables would be approximately 21,030,177 ft^2 (482.79 acres or 1,953,768 m^2), or approximately 3.02 percent of the area of the proposed action (see Table 5.3.2-2). Vessel anchoring and anchor sweep impacts that are part of the installation of the 115 kV transmission system that would span the approximately 12.5 mile (20.1 km) route between the ESP and the mainland are anticipated to impact approximately 7,979,925 ft^2 (183 acres or 741,359 m^2), or approximately 1.15 percent of the area of the proposed action.

In addition to temporary construction impact from installation of offshore transmission cable systems, it is expected that there would be temporary impacts to the seafloor in the proposed wind turbine tower locale from placement of jack-up barges that would be used for installing each tower. These jack-up barges would not require any anchoring. However, jack-up barges that have a range of four to six jacking legs are expected to have pads that contact the sea floor over an area of 172 ft^2 (0.0039 acres or 19 m^2) each. The maximum expected temporary impact area related to the jack-up barge for installation of the WTG and ESP pilings (136) would be 140,352 ft^2 (3.22 acres or 13,039 m^2).

After pilings are in place, a second vessel would need to jack-up at each piling for installation of turbines, blades and other equipment. A second vessel would also need to jack-up near the ESP pilings for construction of the ESP platform. In order to connect inner-array cables to the WTGs and the ESP platform, a third vessel would need to jack-up at each tower and the ESP. A vessel would also need to be located at each piling for installation of the scour control mats or rock armor that are to surround each piling.

According to the calculations and assumptions described, it is anticipated that total combined temporary impact from the jack-up barge use related to installing turbine towers and association equipment, the ESP platform, connection of inner array-cables (using J-tubes) to WTGs, and installation of scour control mats would be approximately 411,133 ft^2 (9.4 acres or 38,195 m^2), or 0.06 percent of the total area of the proposed action (see Table 5.3.2-2).

In the locale where temporary disturbance of the seafloor occurs due to cable and monopile placement substantial mortality of benthic organisms is expected; however, the impacts are expected to be minor since the area disturbed is somewhat limited, abundant area of similar habitat type occurs in the surrounding vicinity, and the sand bottom community typical to the area is adapted to frequent natural sediment movement that creates localized temporary impacts. Information reported in the scientific literature indicates that certain benthic invertebrate species opportunistically invade substrate areas that are unoccupied after disturbances have occurred (Hynes, 1970; Rhoads et al., 1978; Rosenberg and Resh, 1993; Howes et al., 1997).

Suspended Sediment and Deposition Impacts

For determination of volume of suspended sediments from the jet plow embedment process SSFATE modeling was conducted (Report No. 4.1.1.2). The results of the SSFATE model indicated that sediments suspended by the jet plow would settle alongside the cable route, primarily because of the relatively coarse nature of the sandy sediments. Depending on horizontal distance from the trench, trench geographic orientation, and tidal current direction deposition of sediment is predicted to range from 0.04 to 0.2 inches (1.0 to 5.0 mm) thick. Depositions that range in thickness from 0.4 to 1.8 inches (10 to 45 mm) are expected to occur in isolated locations when tidal currents are in slack water (Report No. 4.1.1.2).

Sediment suspension times vary according to particle size, distance from the cable route and tidal current strength. Sediments may remain suspended approximately 2 to 18 hours. Gravel and sand settle more quickly than silts and clays. Sediment transport modeling studies concluded that sediment deposition from the jet plow embedment operations would be minimal compared to active sediment transport that has been observed in Nantucket Sound during natural tidal and weather conditions (Report No. 4.1.1.2).

Results from sediment transport modeling indicate that benthic organisms would suffer some mortality due to the temporary disturbance from jet plowing activities. Species-specific responses to suspended sediments and sediment deposition have been studied and vary depending on a particular species' feeding mode and mobility (see Table 5.3.2-3). Benthic organisms that are mobile and species that can burrow can evade areas with sediment deposition. This includes species such as crabs and lobsters. Sedentary organisms, such as the northern quahog and the eastern oyster, not able to evade sediment deposition may be subject to mortality or impact to reproduction and growth. Due to the highly dynamic environment in Nantucket Sound and that most naturally occurring species are adapted to settle and move in the sandy environment and recover from burial, the expected sediment deposition is expected to have minimal adverse impacts to benthic resources. Since sediments expected to be suspended by jet plow operations are minimal in comparison to active sediment transport known from Nantucket Sound, filter and deposit feeding benthic organisms are not expected to be substantially impacted from suspended sediments from the jet plow installation. Compared to the Horseshoe Shoal locale, impacts may be greater from the jet plowing activities in nearshore areas of Lewis Bay since weak currents and finer sediments may remain in an elevation of suspended sediments as long as 48 hours.

Benthic community recovery rates have been studied by Dernie et al. (2003) who has shown that sediment particle size and rate of disturbance infilling have an effect on recovery rates. Disturbed areas that infill under natural circumstances have longer recovery rates than areas that are infilled after installation of cables. Also, benthic communities adapted for surviving in high-energy types of environments recover more quickly after disturbances (Dernie et al., 2003). Since the WTG area is a naturally dynamic environment, benthic organisms that occur are adapted to fluctuations in concentrations of suspended sediments in the water column. These organisms are not expected to be impacted substantially by sediment resuspension occurring on a short-term basis and could be expected to recover as quickly as they have reproductive mechanisms allowing for rapid colonization. Thus, benthic invertebrate populations occurring at the site of the proposed action could be expected to recover fully in a timeframe of one to two years (Rhoads et al., 1978; Hall, 1994; C-CORE, 1995; Rhoads and Germano, 1986; Newell et al., 1998; Whitlatch et al., 1998; Byrnes et al., 2004).

Moderate long-term (permanent) impacts related to installation of the pilings that support the wind turbine towers and the ESP would be anticipated to affect the soft-bottom benthic communities in the area of the proposed action. Round pilings to be constructed include 130 for the wind turbine towers and six for support of the ESP. Dimensions of each wind turbine piling depend on the depth of water in which it is located. Dimensions would be 16.75 ft (5.1 m) diameter at the seafloor for a piling that is situated in water depths ranging from 0 to 40 ft (0 to 12.2 m), and 18.0 ft (5.5 m) diameter for pilings situated in water depths ranging from 40 to 50 ft (12.2 to 15.2 m). The diameter of ESP pilings would be 42 inches (106.7 cm) at the seafloor. Thus, there is a direct impact area that is equal to 220 ft^2 (0.005 acre or 20 m^2) for each 16.75 ft (5.1 m) diameter wind turbine tower piling (111 pilings) and 255 ft^2 (0.005 acre or 21 m^2) for each 18 ft (5.5 m) diameter wind turbine tower piling (19 pilings). The impact of the ESP would be expected to be approximately 9.6 ft^2 (0.0002 acre or 0.9 m^2) per piling. This would result in a total area of permanent impact of approximately 29,351 ft^2 (0.67 acre or 2,727 m^2) for the 130 wind turbine towers and the 6 ESP pilings. This is approximately 0.004 percent of the area of the proposed action and an even smaller percentage of similar habitat within Nantucket Sound (see Table 5.3.2-2).

Permanent Alteration of Habitat

Scour protection would be placed at the base of each of the pilings to minimize scour related to prevailing currents. Synthetic fronds that mimic seafloor vegetation were determined to be an option that would provide needed scour protection but minimize possible changes to the soft-bottom and fish communities that are associated with the Horseshoe Shoal locale. When they are attached to the bottom as a network, these synthetic fronds trap sediments and eventually become buried. As a result of this sediment trapping mechanism, this form of scour protection provides a low bottom relief similar to that which exists on Horseshoe Shoal rather than traditional boulder revetment. A scour control mat has an area of 135 ft^2 (0.003 acre or 13 m^2), and it is estimated that six mats would be required to protect a wind turbine piling. The area around a piling protected with scour control mats would be 810 ft^2 (0.02 acre or 75 m^2), which results in a total scour protection area of 105,534 ft^2/2.4 acres (9,804 m^2) for all 130 wind turbine towers and 4,871 ft^2 (0.11 acre or 452 m^2) for the 6 ESP pilings. Thus, scour protection using mats would alter approximately 0.015 percent of the area of the proposed action (see Table 5.3.2-2).

Permanent colonization of the scour control mats by attached benthos is expected to be minimal since the scour control mats are designed to capture and retain sediment from the surrounding sea floor. The sediment that these mats trap is expected to be colonized by the benthos typically found in the shifting mobile sands of Nantucket Sound. Although it is expected that the trapped sediment would be scoured from the mat during periods of intense current movement or storm driven wave action, it is unlikely that the mat would be utilized by any attached benthic organisms. Evidence from the Field Report on Seabed Scour Control Mats (Report No. 4.1.1-8) showed photos of crabs on the mats. Crabs are not attached to the mat and are likely to be opportunistically utilizing the mat as a stable substrate during a period when the mat was exposed. Crabs were also present on the meteorological tower pilings, as previously described in Section 4.2.5.3, and common in benthic samples collected and analyzed from sandy substrates of Horseshoe Shoal and Nantucket Sound (Report Nos. 4.2.5-1 and 4.2.5-2). Since the scour control mats are designed to trap sediment and regularly be buried, no permanent colonization by epilithic fauna would be expected.

Rock armor scour control has also been considered as an option to provide scour protection at the base of each of the pilings to reduce scour related to prevailing currents. This type of scour control involves use of geosynthetic fabric overlaid by rock armor stones. These materials would be placed so that final elevations would approximate bottom contours similar to those prior to installation of the monopiles. The filter layer material serves to fill most of the scour hole that may be expected to form after the monopile installation. It would also reduce the possibility of wave action to remove natural underlying sediments and reduce possible settlement of the rock armor into the natural underlying sediments. Armor stones would be large enough to deter removal by current conditions and wave effects and small enough for prevention of removal of stone fill material that is placed beneath them. This would result in total scour protection area of 2,064,964 ft^2 (47.41 acres or 191,841 m^2) for all 130 wind turbine towers and 17,664 ft^2 (0.41 acre or 641 m^2) for the 6 ESP pilings. Thus, rock armor scour protection would alter approximately 0.298 percent of the area of the proposed action (see Table 5.3.2-2).

If rock armor were used for scour control, it would be only as fill in a scoured area around the turbine piling and would not appreciably change the local seafloor topography. This design would promote deposition of a sand/silt matrix in the interstices of the boulder framework with the eventual burial of all the rock armor. Tidal currents may expose portions of the rock armor at the surface for short periods of time. However, the bi-directional nature of these currents should lead to establishment of a dynamic equilibrium, allowing the average condition of the scour-protected zone to be buried by sand. Thus, the faunal composition around the base of wind turbines at the site of the proposed action could be similar to that found pre-construction.

In the case that a portion of the rock armor becomes permanently exposed above the sandy seafloor, the fauna that colonize it would likely be similar to that found on the turbine pilings. As previously described in Section 4.2.5.3, macroinvertebrate sampling on support pilings of a meteorological tower in June 2005 yielded 26 taxa including seven species that were not observed during other baseline surveys at Horseshoe Shoal. These seven species, as previously described in Section 4.2.5.3, are likely to be within the site of the proposed action, but would be expected to inhabit hard substrates such as rocky shoals or boulders.

Oil Spills

During construction there is the potential for spills and accidental releases of material such as diesel fuel, lubricants, and hydraulic fluid. Commitment to careful construction practices to minimize potential for spills and accidental releases and having a SPCC Plan that includes rapid spill response and clean-up capabilities are measures that should minimize the potential for harm to benthos and benthic habitats relative to spills and accidental releases during construction activities.

Decommissioning Specific Impacts

Impacts related to removal and decommissioning (refer to decommissioning procedure details in Section 2.0) of proposed action-related structures including wind turbine towers, foundations, scour control mats, ESP and offshore cables, would be expected to result in temporary seafloor impacts comparable to those that have been described above for construction activities during installation.

Monopiles would be decommissioned by removing sediments from inside the pile, cutting and removing the pile 15 ft (4.6 m) below the seabed, and then returning sediments to the sea floor to re-establish pre-proposed action seabed conditions. For each WTG constructed in water depths less than 40 ft (12.2 m), approximately 3,744 ft^3 (106 m^3) of material would be moved and returned. For each WTG constructed in water depths greater than 40 ft (12.2 m), approximately 4,324 ft^3 (122 m^3) of material would be moved and returned. During removal it is anticipated that any sediment plume would be minimal due to sediments being contained in the monopile and pump hoses. After cutting of the monopile, best practices available would be employed to minimize any sediment plume. Once removed, sediments inside monopiles would be suctioned out to a depth of approximately 15 ft (4.6 m) below existing sea bottom. Sediments would be pumped and stored on a barge and then returned to the excavated pile site using a vacuum pump and diver assisted hoses to minimize sediment disturbance and turbidity. Impacts related to removal and return of sediments from inside the monopile are anticipated to be temporary and localized.

Removal of the wind turbine tower foundations and ESP piles would result in a local shift from structure-oriented habitat to the original shoals type of habitat that was present prior to installation of the proposed action. There would be a return to pre-construction conditions. Decommissioning activities would also include removal of the network of inner-array cables and offshore transmission cable system linking the ESP to the mainland. These actions 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 those described above for the construction phase.

Impacts to Shellfish and Lobsters

The activities that would affect shellfish include installation of monopile foundations, inner-array cables, and the offshore transmission cable system and HDD activities in Lewis Bay, which is similar to those described above for general benthos.

In the locale where temporary disturbance occurs some mortality is expected. However, the impacts are expected to be minor since the area disturbed is somewhat limited and areas of similar habitat type occur in the surrounding vicinity. However, certain shellfish species can be long lived, such as quahogs, and recovery of similar aged species would take longer.

As described in Section 4.2.5.4.2, the lobster fishery in Nantucket Sound does not appear to be a major fishery. In a Survey of Commercial and Recreational Fishing Activities (Report No. 4.2.5-6) it was commented that the Horseshoe Shoal locale was too sandy for support of a viable lobster fishery. Direct impacts to lobsters are anticipated to be minor and any possible mortality limited to individuals that are less mobile and may be in the immediate post lease geological and geophysical assessment and proposed action construction activity area. Use of the hydraulic jet-plow installation method would reduce impacts to the immediate construction corridor. Sediment suspension during installation of both the cable and monopiles is not anticipated to result in significant indirect impacts since the sediments settle relatively quickly. Review of the literature has indicated that lobsters have been described as having high tolerance to sediment deposition and suspended sediment (Stewart, 2000) (see Table 5.3.2-3). In addition, lobsters have a rapid retreat response when threatened and the mobility and sensory capabilities of adult lobsters would allow them to largely avoid areas sediment disturbance is actively occurring (Jury et al., 1995).

Interpretation of results from sediment transport modeling indicate that shellfish would suffer some mortality due to the temporary disturbance from jet plowing activities. Species-specific responses to suspended sediments and sediment deposition have been studied and vary depending on a particular species' feeding mode and mobility (see Table 5.3.2-3). Species such as crabs and lobsters may be able to avoid areas of heavy sedimentation. Sedentary organisms, such as the northern quahog and soft shell clam, not able to evade sediment deposition may be subject to mortality or impact to reproduction and growth. Due to the highly dynamic environment in Nantucket Sound and that most naturally occurring species are adapted to settle and move in the sandy environment and recover from burial, the expected sediment deposition is not anticipated to have more than minor adverse impacts to shellfish resources. Since sediments expected to be suspended by jet plow operations are minimal in comparison to active sediment transport known from Nantucket Sound, filter and deposit feeding shellfish are not expected to be substantially impacted from suspended sediments from the jet plow installation.

The proposed cable route has been located to avoid privately licensed shellfish areas or grants in Lewis Bay. The proposed cable route would cross approximately 600 ft (182.9 m) of the recreational shellfish bed in Lewis Bay. The HDD would be used for crossing the area that is 200 ft (61 m) closest to shore. Moderate impacts to the benthic community are likely to occur from the placement of the pre-excavation pit that would be necessary for the transition from the seaward terminus of the HDD conduit to the offshore transmission cable system. Temporary impacts from the pre-excavation pit would involve 2,925 ft^2 (0.07 acre or 272 m^2) of seafloor which is approximately 0.0004 percent of the area of the proposed action. Thus, approximately 12,525 ft^2 (0.29 acre or 1,164 m^2) would be directly disturbed in the recreational shellfish bed 2,925 ft^2 (0.07 acre or 272 m^2) from the pre-excavation pit and 9,600 ft^2 (0.22 acre or 892 m^2) from jet plow embedment of the offshore transmission cable system. The applicant has committed to providing the town of Yarmouth with funds for mitigation of direct impacts to shellfish resources in accordance with the Town's shellfish mitigation policy.

Impacts on Meiofauna and Plankton

Meiofauna

The meiobenthic community is likely to be adversely affected in a very similar manner to the sessile or less mobile soft bottom benthos discussed above. Because benthic meiofauna are extremely small and live in the interstices between sediment particles they are susceptible to bottom disturbing activities and sediment deposition. Recovery of the meiobenthic community from sediment disturbance is expected to be as fast as or faster than that of the macrobenthos. Past studies of meiofauna and sediment disturbance have generally documented quick recolonization following disturbance, with predisturbance densities usually reached in a few hours to a few days (Alongi et al., 1983; Fegley, 1988; Ingole et al., 2005). In some instances, the rapid recovery may be attributable to an increase in food availability (Ingole et al., 2005). However, even in experiments where the sediment was completely defaunated, recolonization occurred in a few weeks (Alongi et al., 1983). Meiobenthic assemblages also recover quickly, with predisturbance species compositions achieved within 90 days (Alongi et al., 1983). Thus, temporary and highly localized disturbance of sandy substrate during post lease G&G investigations, and construction and decommissioning activities should have minor long-term impacts on the meiobenthos. Also, the nature of the construction and decommissioning activities are such that work progresses in sequence over a period of several months. Thus, impacts to the meiofauna that could potentially impact the marine food web would only be expected to occur on a localized level as the work takes place. An example of the ability of the meiofauna community to survive frequent sediment disturbance is evidenced by the continued use of large benthic organisms and fish of areas that experience regular and repeated bottom fishing. Further evidence of this community's ability to survive disturbed sediments is reflected in the abundance of these organisms within those portions of Nantucket Sound experience high movement of bottom sediments, visible as sand waves, due to natural conditions.

Plankton

Phytoplankton and zooplankton are not expected to be affected by post lease geotechnical and geophysical investigations nor construction or decommissioning activities. These activities are anticipated to temporarily increase suspended sediment concentrations in the area of activity. This may limit depth of maximum light penetration and thereby reduce ability of phytoplankton to photosynthesize. However, due to Nantucket Sound's intense tidal flushing, suspended sediment concentrations would be flushed away from the offshore cable route and are expected to settle approximately three hours after the jet plow passes. At most, this could result in small-scale, temporary reduction of primary production by phytoplankton, which could in turn suppress grazing zooplankton populations for a short time. During jet plow installation activities, direct mortality is expected for those phytoplankton and zooplankton that are entrained into the jetting system and injected into the sediments at high pressures. However, the hetting water withdrawal volumes represent a small fraction of the water in Nantucket sound at any one time and loss of these individuals would not be detectable in their populations nor have any adverse affect on the marine food web.

Similar negligible impacts to plankton would occur due to the water withdrawals and subsequent entrainment of plankton into the engine cooling and other water use system on board the construction and decommissioning vessels. Because this mostly occurs while ships are underway, the impacts are diffuse and temporary, spread along the transit route of the vessels. Hundreds of similar water withdrawals occur throughout Nantucket Sound and adjacent waters due to the operation of recreational boats, and commercial shipping, such as the ferries between the islands and Cape Cod and commercial fishing vessels. There is no reported harm to plankton communities due to these existing water withdrawals, and the short period, a year or two each, during which construction and decommissioning would occur, is unlikely to measurably alter or reduce the plankton community.

Sediments found in the area of the proposed action have been reported to be mainly sand and chemical constituent concentrations have been noted to be below the established thresholds that are in applicable reference sediment guidelines. Sediment core samples that were obtained at the proposed WTG site locale and along the proposed offshore cable routes had chemical constituent concentrations that were all below Effect Range-Low (ER-L) and Effect Range-Median (ER-M) marine sediment quality guidelines (Long et al., 1995). Disturbance and suspension of the sediments associated with the monopile foundation, inner-array and offshore transmission cable system installation activities are not anticipated to cause phytoplankton and zooplankton to be exposed to such contaminants during proposed action activities.

In the event of an unplanned activity, such as an oil spill during construction, the plankton community within the plume area would experience toxic affects of the released hydrocarbons. The applicant would construct and decommission the proposed action with an OSRP in place that should serve to minimize the harmful affects of an accidental oil spill.

Conclusion

Overall the post lease G&G investigation, and construction and decommissioning impacts on soft-bottom benthic invertebrate communities, shellfish, meiofauna, and plankton are expected to range from negligible to minor as these impacts would be for the most part temporary in nature and localized. Furthermore, much of the Nantucket Sound benthos in shoal areas, have adaptive mechanisms for surviving in and on sediments that experience regular and ongoing disturbance due to the energetics of tidal currents and wave action in shallow water ecosystems.

5.3.2.5.2 Operational Impacts

Potential impacts to benthic communities that are associated with operation of the proposed action relate to areas of the seafloor that remain altered by the proposed action’s features, or that could be affected by accidental and unplanned activities.

Soft-Bottom Benthic Invertebrate Communities

The vertical structures introduced by the installation of the wind turbine towers would be a source of new hard substrate with vertical orientation. These structures would be present during the full time of the operation of the proposed action. The Horseshoe Shoal area of Nantucket Sound has limited amounts of this type of habitat. Monopile foundations that were selected for this proposed action are smooth and lacking in complexity in comparison to scaffolding that is often used for oil platforms (MMS, 2000). Substrates that are irregular and rough offer organisms structural complexity for protection from predation and/or exposure to high current velocities and scour. Thus, the new substrate is not favorable for colonization or reef formation because of its low complexity and rugosity (CARPG, 1998). Organisms that may settle on such structures include algae, sponges, tunicates, anemones, hydroids, bryozoans, barnacles, and mussels. These organisms are known to occur on other hard substrate areas in Nantucket Sound. Organisms including polychaetes, oligochaetes, nematodes, nudibranchs, gastropods, and crabs are expected to occur as fouling organism growth develops. Results from the 2005 Macroinvertebrate Survey of the Meteorological Tower (described previously in Section 4.2.5.3.2) indicated that a benthic macroinvertebrate community similar to the surrounding sea floor community had colonized the support pilings. Noted were seven species not observed during other baseline surveys at Horseshoe Shoal. These new taxa were noted to likely be in the site of the proposed action, but would be expected to inhabit hard substrates such as rocky shoals or boulders. It was expected the pilings would support more taxa since they may attract organisms from both sandy substrate habitats and those that would be attracted to fixed structures.

Although use of the monopile structures is expected by some hard-bottom and fouling organisms, individual monopiles are not anticipated to act as true artificial reef structures that would significantly change benthic or fish communities in Nantucket Sound. Research that has been conducted on design of artificial reefs indicates that major design features affecting artificial reef function are, as previously described, complexity and rugosity (material used and roughness), and, in addition, surface area, shape, profile, size, and orientation (CARPG, 1998). Adequate interstitial spaces are also a factor in establishment of a diversity of mobile invertebrates and numerous cryptic fish species (CARPG, 1998). The monopiles would not have interstitial space and their wide spacing (0.34 to 0.54 mile (629 to 1,000 m) apart) does not create collectively sizeable interstitial space beneficial for benthic organisms or most fish. Additional amounts of surface area that are being introduced, approximately 1,200 ft^2 (0.03 acre or 111 m^2) per tower with 30 ft (9.1 m) as an assumed average water depth, for a total of about four acres, would be minor. The addition of rock scour armor would significantly increase this acreage compared to that of the monopiles alone, but representing a small fraction of change in the overall site of the proposed action.

Observations that are similar to those made at the meteorological tower in Nantucket Sound have been made at the monopile foundation installations at existing European wind farms such as Denmark's Horns Rev and Nysted offshore wind farms (Birklund and Petersen, 2004; Bio/consult as., 2005). At these wind farms, hard-bottom attachment sites are created habitat for the benthic organisms that require a fixed (non-sand) substrate. Two annual post-construction/operation surveys of monopile communities at the Horns Rev wind farm identified taxa of seaweeds and faunal invertebrates, some of which were mobile species. Some epifaunal species had not previously been reported at the mostly sandy habitat. It was noted that the monopiles and scour control devices (raised hard-bottom platforms) had changed the substrate from all sand to one with foundations of steel, gravel, and stones. The monitoring reports noted further that native infaunal communities had been replaced with epifaunal communities usually found in the hard-substrate type of environment. In the year between the two surveys significant species and population variations were noted along with variation in spatial and temporal distribution. Such changes may have occurred because of regular scouring and recolonization due to severe storms and winter conditions. Studies have noted that though heavily populated fouling communities can establish themselves in as short a time as a year with placement of new hard-bottom habitat, stability of such a community is not reached till five to six years after a structure's establishment (Bio/consult as., 2005).

A post-construction survey at Nysted windpark found blue mussels, barnacles, bryozoans, and macroalgae at various depths on the monopile. Macroalgae were found on the monopile foundation and anti-scour concrete and stone base platform. Other invertebrate species noted along the base of the monopile foundation and raised scour protection platform included polychaetes, amphipods, gastropods, and bivalves (Birklund and Petersen, 2004). The raised hard-bottom platforms used at the Horns Rev and Nysted wind farms had greater substrate complexity than that proposed for this proposed action with scour control mats, although the alternative proposed rock armor backfill would increase substrate complexity around monopiles. In comparison to the Danish wind farms that provided greater surface area for colonization, hard-bottom colonization is anticipated to be less at the site of the proposed action in Nantucket Sound.

In addition, post-construction monitoring results from these European wind farms documented that a significant alteration to the food-chain basis (benthic organisms) did not occur. Therefore, it is not anticipated that the proposed action would impact the food chain or greatly impact predator-prey relationships supported by the benthic resources.

The presence of the ESP, with a surface area of 20,000 ft^2 (0.46 acre or 1,858 m^2), may affect the soft-bottom benthic invertebrate communities in its immediate locale due to shading. It is expected these possible effects would be negligible since the ESP structure is to be located approximately 39 ft (12 m) above the MLLW datum plane in 28 ft (8.5 m) of water. The shadow from the structure is expected to move rapidly across the seafloor during the daylight hours.

Impacts from Unplanned or Accidental Events

In addition to the referenced operational impacts on benthic resources, there are potential impacts that could result from the unlikely requirement for repair of the electric cable. Such impacts would include temporary turbidity and some localized deposition of sediments during the repair process. Turbidity would be caused by the jetting of sediments to uncover the damaged portion of the cable, hoisting of the cable after it is cut, laying the cable back down, and then jetting of sediments for reburial of the repaired cable. Cable repair procedures are discussed in more detail in Section 2.4.6. Temporary impacts would also occur in the area where anchors were deployed or anchor cable sweeps the bottom. Impacts on benthic resources as a result of cable repair would be temporary, occupy a very small area of the seafloor and would therefore be negligible overall.

Other accidental situations, such as vessel collision or monopile collapse are most likely only going to have an affect on the benthos in the immediate area around the damaged monopile. Impacts would be consistent with and similar to those discussed above for construction and decommissioning, although in reverse occurrence, since the damaged monopile would be removed and a new one installed. Because of the temporary nature and localized impacts from sediment disturbance and vessel activities associated with this type of event, impacts to benthic resources would be negligible.

Shellfish

Potential impacts to shellfish due to operation of the proposed action are similar to those described above for soft-bottom benthic invertebrate communities.

In addition, with cable installation involving burial with a minimum of 5 ft (1.8 m) of cover below the seafloor possible interference with lobster or other shellfish migration or use of nursery or habitat areas is not expected. Use of submarine cable installation methods may result in temporary depressions in the seafloor, but since these are similar to natural topographic relief there is not expected to be interference with lobster, crab, gastropod or other mobile benthos movement or migration (Fogerty, 2000).

No adverse impacts from heat associated with submarine cables are expected for benthic and shellfish resources. Burying of cables below the seafloor and proper cable system design, serve to minimize potential thermal impacts during the operation of the proposed action.

During operational related activities there is the potential for spills and accidental releases of material such as diesel fuel, lubricants, and hydraulic fluid. Commitment to careful operational related practices to minimize potential for spills and accidental releases and having an SPCC Plan that include rapid spill response and clean-up capabilities are measures that should minimize the potential for harm to benthos and benthic habitats relative to spills and accidental releases during operation of the proposed action.

Impacts on Meiofauna and Plankton

Meiofauna

The meiobenthic community may be affected from sediment disturbance from maintenance activities during operation. Recovery of the meiobenthic community from sediment disturbance is expected to be as fast as or faster than that of the macrobenthos, as previously described in the construction/decommissioning impacts. Thus, temporary and highly localized disturbance of sandy substrate during periodic maintenance activities should have minor impacts on the meiobenthos.

Plankton

Phytoplankton and zooplankton are not expected to be significantly affected by operational activities. Temporary and localized disturbance of sandy substrate during periodic maintenance activities should have minor impacts on phytoplankton and zooplankton.

Wind turbine operation would shade small areas of water which may result in minor reduction of photosynthesis by phytoplankton. This potential for shading is expected to be inconsequential since water in Nantucket Sound typically moves rapidly through the site of the proposed action due to tidal currents. Thus, there should be minor potential for phytoplankton disturbance.

Conclusion

Wind Turbine operations are expected to have negligible impacts on soft and hard bottom benthic invertebrate communities, shellfish, meiofauna, and plankton. Since the proposed action's operation does not involve planned activities resulting in seafloor disturbance, only those unplanned or accidental events that occur would result in the potential to impact these species. It is inherent in an activity that is unplanned that if have a low probability of occurrence, and for this proposed action, any such activity is likely to involve on a short duration and a small area.

5.3.2.6 Non-ESA Marine Mammals

5.3.2.6.1 Construction/Decommissioning Impacts

Non-ESA listed marine mammal species may be impacted by activities associated with proposed action construction, operation/maintenance and decommissioning. This section discusses the impacts on the specific species mentioned in Section 4.2.6. These species are all protected under the MMPA. The applicant would be required to abide by any measures required by NOAA Fisheries under the terms of its review and approval process under the MMPA. Threatened or endangered marine mammals protected under the federal ESA are presented in Section 5.3.2.9 and Appendix C.

The NMFS has established acoustical guidelines that set thresholds to prevent acoustic injury (Level A) and acoustic harassment (Level B) to marine mammals. The Level A threshold is 190 dB for pinnipeds and 180 dB for cetaceans, and the Level B threshold is 160 dB.

Pinniped Species

Acoustical Harassment

Short-term noise level measurements of underwater noise were collected at Buoy G5 in the North Shipping Channel and at Buoy R20 at the edge of the Main Channel. Measured L_{eq} underwater sound levels were found to be 90 dB and 93 dB at Buoys G5 and R20, respectively. The sound level at Buoy R20 is slightly higher due to the shallower water and greater current. The depth at this location is also more representative of the water depth on Horseshoe Shoal, and accordingly, the Buoy R20 data were used as a baseline for the proposed action.

Underwater sound levels with higher wind speeds (as would occur with proposed action operation) would be higher. Studies conducted in other coastal water areas indicate that the sound level increases 7.2 dB per doubling of wind speed. Accordingly, the estimated underwater L_{eq} sound level for the design wind speed of the proposed action would be 107.2 dB. The frequency spectrum for the existing condition is provided in Figure 4.1.2-12.

Underwater sound level measurements conducted on Horseshoe Shoals at the site of the SMDS at the time that three support piles were driven into the seabed were also utilized for this study. The weather conditions at the time of the measurements included moderate winds of less than 12 mph and moderate seas of less than 5 ft (1.5 m). The measured existing underwater L_{max} level (without pile driving) was 123 dB.

Modeling Methodology

Underwater sound effects from construction and operation of the proposed action were evaluated by utilizing the results of the ambient measurements and a noise modeling study (Report No. 5.1.5-1). The design wind speed corresponds to the maximum underwater sound levels for the proposed action. 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 for the proposed action used standard methods for representing how sound waves spread out underwater (spherical wave spreading) and diminish in intensity and for seawater absorption effects. Research has shown this method provides a reasonable fit to measured underwater sound levels under a wide variety of conditions. The acoustic model consisted of utilizing a spreadsheet type model that accounted for spherical spreading and standard seawater sound absorption factors.

Sound source data for construction and operational effects underwater were provided by GE Wind Energy from recent tests at the Utgrunden and Gotland Projects (Report No. 4.1.2-1) which have similar environmental conditions to Nantucket Sound and provide the best available data. Data obtained during pile driving at the Utgrunden Project revealed L_{max} sound levels of 177.8 dB at 1,640 ft (500 m). Noise levels of pile driving at the SMDS were found to range from 145 dB to 167 dB at a distance of 1,640 ft (500 m). The higher Utgrunden pile driving sound level data were utilized in the modeling analysis because the monopile foundations for the proposed action would be similar in size to those used at Utgrunden, and because of similarities in environmental conditions between Nantucket Sound and the Baltic Sea. Baseline underwater sound levels under the design wind condition are 107.2 dB.

Underwater Construction Impacts

The underwater sound effects of construction would be associated with the installation of 130 16 to 18 ft (4.8 to 5.5 m) diameter monopiles (one for each WTG), installation of six smaller 4 ft (1.2 m) diameter piles for the ESP, vessel traffic for transporting equipment, piles, and workers to the site and vessel traffic associated with installation of offshore 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.

The NMFS has established acoustical harassment guidelines that set thresholds to prevent acoustic injury (Level A) and acoustic disturbance (Level B) to marine mammals. The Level A threshold is 190 dB for pinnipeds and 180 dB for cetaceans, and the Level B threshold is 160 dB. The hearing threshold is the minimum sound level in a 1/3-octave band that can be perceived by an animal in the absence of significant background noise. The hearing bandwidth for an animal is the range of frequencies over which an animal can perceive sound. Calculated underwater pile driving noise levels were shown to be below the NMFS Level A acoustic harassment threshold at and beyond the 1,640 ft (500 m) safety radius. However, sound levels would be above the Level B 160 dB threshold. It is currently anticipated that 10 WTGs would be installed per month, with all WTGs being installed in two seasons. While pile driving noise would be temporary and intermittent, it would occur over a two season period.

Pile Driving

Pile driving noise is most concentrated in the lower frequencies, below 1000 Hz, and in particular below 250 Hz. The calculated maximum underwater sound levels (L_{max}) from pile driving in the proposed action would range from 172 dB at a distance of 1,640 ft (500 m) to 170 dB at a distance of 4,002 ft (1,220 m) and down to 145 dB at a distance of 13 miles (21 km). In the near-shore waters of Cape Cod and Martha's Vineyard, the L_{max} levels would range from 140 to 155 dB. Levels would be lower in Lewis Bay due to the barrier attenuation provided by the land-mass of Great Island in Yarmouth. Figures 5.3.2-1 and. 5.3.2-2 show the temporary underwater L_{max} sound levels throughout Nantucket Sound for pile driving at the southwest and northeast corners of the proposed action, respectively. The frequency spectrum of the underwater sound at a distance of 1,640 ft (500 m) from a monopile is given in Figure 5.3.2-3. Vessel underwater noise has been measured at 162 dB at one meter, and its energy peak is below 1000 Hz.

The hearing threshold sound level (dB_{ht}) of protected species were calculated by passing the frequency spectrum of the expected underwater sound through a filter that mimics the frequency dependent hearing threshold of the species. This allows for a single dB number to be used to describe the effects of a sound on a species. This methodology is similar to that used to calculate dBA levels, which are used to determine how humans perceive sound. The hearing bandwidth for an animal is the range of frequencies over which an animal can perceive sound. Pinnipeds (hair seals) have a hearing bandwidth of from 100 Hz to 100 kilohertz (kHz), but their most sensitive hearing is at the middle frequencies of 1 kHz to 30 kHz where their hearing threshold is 60 to 80 dB re 1 μPa (Richardson et al., 1995). In the low frequencies where pile driving noise is concentrated, pinnipeds have a high hearing threshold of 80 to 100 dB.

A hearing threshold sound level (dB_{ht}) was calculated for several species of seals to determine the actual underwater sound level that is heard by seals from monopile installation at different distances from construction activities. The results of the dB_{ht} analysis show that no physical injury to seals are predicted if an individual were to approach as close as 98 ft (30 m) to the pile driving because all dB_{ht} values at this minimum distance are well below 130 dB. Therefore, although the animal may hear the underwater construction sounds they are not expected to cause physical harm to pinnipeds.

Research has shown that marine mammal avoidance reactions occur for 50 percent of individuals at a 90 dB_{ht} (e.g., when the sound level exceeds the species' hearing threshold by 90 dB). The 90 dB_{ht} threshold is consistent with NOAA Fisheries Service guidelines defining a zone of influence (e.g., annoyance) for marine mammals as a sound level of 80 to 100 dB above a species hearing threshold. Using the hearing threshold data, sound levels were calculated for seals for the project's loudest construction noise (pile driving). If seals are in the construction area, they are likely to temporarily avoid the zone of behavioral response around the monopile being driven. Behavioral effects (avoidance) would occur at a range of 820 to 4,593 feet (250 to 1,400 m) when dB_{ht}=90 dB re 1 µPa. Marine mammals may experience limited and temporary noise harassment, as the anticipated noise levels will be slightly greater than the NMFS Level B standard, but is not expected to be greater than the NMFS Level A standards, and thus not result in any injury to marine mammals. MMS recommends that the applicant contact NMFS to determine if an Incidental Harrassment Authorization (IHA) under the MMPA is warranted. If an IHA application is submitted, the final IHA would need to be issued prior to the commencement of any activities that may "take" marine mammals.

Vessels

Maximum hearing threshold levels for proposed action vessels were calculated for seals at a distance of 150 ft (45.7 m). A level of 44 dB_{ht} was calculated, well below the injury threshold of 130 dB_{ht} and the harassment threshold of 90 dB_{ht}.

The jet plow embedment process for laying the offshore transmission cable system circuits and inner-array cables produces no sound beyond that produced by typical vessel traffic and the cable installation barge would produce sound typical of vessel traffic already occurring in Nantucket Sound. Furthermore, no substantial underwater sound would be generated during HDD.

Given the known areas that the seals within Nantucket Sound inhabit, minor impacts would be anticipated for seals due to proposed action construction generated noises, and any noise should not affect the migration, nursing/breeding, feeding/sheltering or communication of seals. If seals are in the proposed action construction area, they are likely to temporarily avoid a given area around the construction.

Noise produced by the decommissioning of the proposed action is expected to be similar to those produced during proposed action construction. Proposed action decommissioning would not require pile driving activities, which cause the highest sound levels of any activities associated with the proposed action. Pile driving only takes place during the construction phase of the proposed action. Decommissioning would involve the use of similar vessels, cranes, jet plow, cutting and welding equipment and other tools that were involved in construction, but would not include any pile driving, blasting or activities which approach the noise level of pile driving. During decommissioning, the monopiles and transition pieces would be cut off at approximately 15 ft (4.6 m) below the seabottom. As such, the noise impacts from decommissioning activities would appear to be less than the worst case impacts already presented for construction and would be minor.

In addition to noise associated with boat traffic and pile driving, the proposed action would result in noise associated with the post lease G&G field investigation, which would include vibracores and drilling of bore holes to acquire subsurface geological information on the sea bottom. The vibracores would be accomplished via a small gasoline motor and the drilling of cores would be accomplished via a truck mounted drill rig on a barge. Both of these activities would be very short term, and these devices generate sound levels that are much lower than sound levels associated with pile driving. Sound levels from a small gasoline motor would be comparable to that associated with a small motorized boat. Sound levels from a truck mounted drill rig would be comparable to those on a small ship or large boat. These types of sounds occur regularly in the area. Thus impacts to marine mammals are expected to be negligible with respect to the G&G activity.

Increased Vessel Traffic

As previously mentioned, the proposed action would temporarily increase the number of vessels within the vicinity of the area of the proposed action, especially in the route between Quonset, Rhode Island and the area of the proposed action. The additional traffic from construction and decommissioning vessels may increase the chance of a strike or harassment of seals.

Vessel Strikes

Collisions between proposed action vessels and seals may cause severe damage or even mortality to the animal. Vessel strikes were determined to be the cause of death in some stranded harbor seals and other species in New England waters (Waring et al., 2006).

Seals are agile and aware of their surroundings in the water; at the sight or sound of an approaching vessel seals are known to dive into the water and swim away. The proposed action's vessels, such as the tugs and barges used for proposed action construction and decommissioning, would be clearly audible and can be detected easily by seals. Seals have been known to both avoid vessel traffic and approach vessels, especially fishing vessels, and appear to habituate to most anthropogenic noises and activities, such as those at harbors and coastal airports (Vella et al., 2001). Gray seals were observed to habituate to construction activities, including pile installation, during construction of the Näsrevet Wind Farm in Sweden (Westerberg, 1999).

The assumed risk of vessel strikes to seals is considered minor, as seal haul-out and breeding sites, where the highest densities of seals have been observed are not in close proximity to proposed action activities and proposed action vessels would be traveling at slower speeds (less than 14 knots [7.2 m/s]).

Vessel Harassment

Any impact on MMPA protected seal species due to the physical presence of the proposed action's vessels are expected to be minor. MMS recommends that the applicant contact NMFS to determine if an IHA under the MMPA is warranted. If an IHA application is submitted, the final IHA would need to be issued prior to the commencement of any activities that may "take" marine mammals.

The central portion of Nantucket Sound and the vessel routes proposed to be used by the proposed action vessels are not within what is considered a high use area for listed seal species. If any seals are present in the area of the proposed action, potential behavior changes in response to the proposed action-related vessel traffic would be short-term and would likely be similar to the behaviors observed during regularly occurring activities in Nantucket Sound such as the personal boat use, whale watching cruises, ferry traffic and fishing. However, as seals are coastal marine mammals, and readily habituate to vessels in locations of high vessel traffic, they may be more susceptible to vessel strikes.

The effects of vessel harassment on the migration, breeding and feeding behaviors of seals are expected to be minor. Important coastal habitat for gray and harbor seals exists in Nantucket Sound, but at distances from the area of the proposed action that would result in minor harassment from the proposed action-related vessel traffic. Some displacement of seals from feeding grounds due to an increase in vessel traffic may occur if the vessel makes repeated approaches or if vessel traffic is heavy. However, prey for all seal species is prevalent in Nantucket Sound and foraging can occur in locations less disturbed by proposed action vessels. In addition proposed action vessels would be similar to typical vessel traffic occurring in Nantucket Sound on a regular basis, to which seals are already acclimated.

If seals are present in the area of the proposed action or along the vessel routes, potential behavioral changes in response to vessel traffic would be short-term, and would likely be similar to the behaviors observed during activities that regularly occur in Nantucket Sound.

Both construction and decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction. Seals in the Nantucket Sound area are accustomed to substantial amounts of suspended sediment on an irregular basis, and would be minimally impacted by a temporary increase in turbidity from proposed action decommissioning activities.

Temporarily Reduced Habitat

Activities related to proposed action construction and decommissioning may cause a temporary reduced availability of habitat for seals in the vicinity of the area of the proposed action. The main anticipated impact would be part or complete avoidance of areas of high traffic mainly the route the proposed action-vessels would use to and from the proposed action. However, as under normal conditions the seals are exposed to high volumes of vessel traffic due to commercial and recreational ships within Nantucket Sound, the increase in traffic is not anticipated to displace the seals for long periods of time. Some avoidance may also occur during construction activities due to acoustical harassment from pile driving, as mentioned previously. However, this disturbance would be temporary and would not result in any major effects on the listed seals. Studies conducted throughout the construction of offshore projects in Denmark, showed that only during pile driving activities was there a slight change in seal behavior or distribution, reducing haul-outs on nearby landfalls and temporary avoidance of the general area at great distances. Normal behavior and distribution returned quickly after pile driving activities ceased and continued through the operation of the Wind Farm (Danish Offshore Wind – Key Environmental Impacts, 2006).

As most seals forage and inhabit areas inshore, the HDD operations within Lewis Bay may cause temporary displacement from near-shore foraging areas. Studies do show that seals can rapidly habituate to construction activities, including pile construction, only showing alarm when support vessels moved within hundreds of meters of the seals (Westerberg, 1999). Some disturbance from vessel traffic and construction noise may occur, temporarily displacing seals from feeding or haul-out sites, but this impact would be minor and would terminate when proposed action construction concluded.

Known breeding and haul out sites for seals do not coincide with the proposed action in Nantucket Sound. Since the proposed action's proposed location is approximately 8 to 12.7 miles (13 to 20.4 km) from haul-out and breeding sites; Monomoy, Muskeget and Tuckernuk Islands; seals utilizing these breeding and haul-out grounds would be minimally impacted by proposed action construction.

The proposed action may cause some displacement of prey during construction and decommissioning activities; however, seals that may feed on fish would be able to find suitable prey in areas adjacent to the area of the proposed action. Construction activities may result in an increased availability of seal prey species, especially during winter construction periods when fish may experience higher levels of injury or mortality, providing a short-term increased opportunity to feed on injured fish and macroinvertebrates (Report No. 4.2.5-5).

Habitat Shift (Non-structure Oriented to Structure)

As seals do not often utilize the waters within the vicinity of the area of the proposed action for foraging, but rather remain closer inshore, the change of habitat structure with the addition of the WTGs would have minor impacts on seal populations. However, as the proposed action has the potential for the establishment of "fouling communities", the hard substrate may have minor impacts for seals.

Habitat Shift (Structure to Non-structure Oriented)

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 to the proposed action. However, as the addition of the monopiles would be a minor addition to the hard substrate that was present prior to the construction of the proposed action, the removal of the WTGs and ESPs would not cause a great impact in the overall habitat structure. Therefore, any seal that may have been attracted to the WTGs for feeding would have to forage in other locations within Nantucket Sound, which has ample supplies of prey species and impacts from the habitat shift would be minor.

Turbidity and Total Suspended Solids

The increase of TSS would impact the foraging abilities of the seals, decreasing visibility within the water. As with sea turtles, seals within the area of Nantucket Sound and Lewis Bay are accustomed to substantial amounts of suspended sediment on an irregular basis, from storms and strong tidal currents, and should not be substantially impacted by a temporary increase in turbidity from proposed action activities. Further, seals are mobile and can move away from any disturbance, including any increases in suspended sediments. The total expected impacts of increased turbidity and TSS are minor for seals within Nantucket Sound.

Seals bioaccumulate contaminants from their ocean environment almost exclusively through their food sources. The potential mechanism by which sediments suspended during proposed action construction can harm seals is through bioaccumulation of sediment-associated chemicals through ingestion of contaminated prey (indirectly).

Analysis of sediment core samples obtained from the area of the proposed action indicate that sediment contaminant levels were below established thresholds in reference ER-L and ER-M marine sediment quality guidelines (Long et al., 1995). Therefore, the temporary and localized disturbance and suspension of these sediments during proposed action construction activities are not anticipated to result in increased contaminants in lower trophic levels. Thus, seals are unlikely to experience increased bioaccumulation of chemical contaminants in their tissues from the consumption of prey items in the proposed action vicinity, and any impacts are expected to be minor.

During the nearshore installation, the release of contaminants from the HDD operation within Lewis Bay would be minimized through a drilling fluid fracture or overburden breakout monitoring program, minimizing the potential of drilling fluid breakout into the water.

Pollution/Potential Spills

Seals have thick layers of blubber that prevent them from becoming hypothermic if they were to become coated in oil as result of a spill. While in the water, seals are most vulnerable when they surface for air, at which time they may inhale hydrocarbon vapors which can damage lungs. Contact with eyes and skin can also cause irritations.

Because the seals rely on coastal areas to haul-out and some to reproduce, they have the potential to be exposed on land as well as at sea. Seal pups are most vulnerable if oil reaches the shoreline, because they have not developed the protective blubber. Pups are also more likely to ingest oil while nursing on contaminated teats. The gray seal, which breeds in Nantucket Sound during the winter, is most susceptible to impacts from an oil spill. Seals can also become impacted by an oil spill through bioaccumulation of the pollutants from their prey species. In the event of an oil spill during construction or decommissioning, the impacts on seals are expected to be minor.

Impacts to Cetaceans

The MMPA protected cetacean species that could occur in the site of the proposed action may be impacted by activities associated with proposed action construction and decommissioning. This section discusses the impacts on the specific species mentioned in Section 4.2.6.2.2.

Acoustical Harassment

Pile Driving

In general, toothed whales have a hearing bandwidth of 100 Hz to over 100 kHz, with the most sensitive hearing in the HF range of 10 kHz to 65 kHz where their hearing threshold is 40 to 60 dB (Richardson et al., 1995). Baleen whales react primarily to sounds at low frequencies below 1 kHz, which is consistent with the fact these whales usually communicate at frequencies in the 20 Hz to 500 Hz range (Richardson et al., 1995). The hearing threshold for baleen whales ranges from 82 dB at 500 Hz to 88 dB at 20 Hz (Nedwell et al., 2004).

A dB_{ht} was calculated for several species of cetaceans to determine the actual underwater sound level that is heard by cetaceans from monopile installation at different distances from construction activities. The results of the dB_{ht} analysis show that no physical injury to cetaceans are predicted if an individual were to approach as close as 30 m to the pile driving because all dB_{ht} values at this minimum distance are well below 130 dB. Behavioral effects (avoidance) would occur at a range of 1,050 to 4,626 feet (320 to 1,410 m) when dB_{ht}=90 dB re 1 μPa. Therefore, although marine mammals may hear the underwater construction sounds they are not expected to cause physical harm to cetaceans. Marine mammals may experience limited and temporary noise harassment, as the anticipated noise levels will be slightly greater than the NMFS Level B standard, but is not expected to be greater than the NMFS Level A standards, and thus not result in any injury to marine mammals. MMS recommends that the applicant contact NMFS to determine if an IHA under the MMPA is warranted. If an IHA application is submitted, the final IHA would need to be issued prior to the commencement of any activities that may "take" marine mammals.

Vessels

Maximum cetacean hearing thresholds for vessels were calculated for a distance of 100 ft (30.5 m). Levels of 42 dB_{ht} and 45 dB_{ht} were calculated for whales and for toothed whales, respectively. These levels are well below the injury threshold of 130 dB_{ht} and the harassment threshold of 90 dB_{ht}. In this range, the animal would be able to hear the vessel, but no physical harm or behavioral effects would occur.

The jet plow embedment process for laying the two offshore transmission cable system circuits and inner-array cables produces no sound beyond that produced by typical vessel traffic and the cable installation barge would produce sound typical of vessel traffic already occurring in Nantucket Sound. Furthermore, no substantial underwater sound would be generated during HDD.

Any cetaceans are likely to temporarily avoid a given area around the construction, and only minor impacts would be anticipated due to proposed action construction generated noises. Any noise should not affect the migration, nursing/breeding, feeding/sheltering or communication of cetaceans.

Noise produced by the decommissioning of the proposed action is expected to be similar to those produced during proposed action construction. Proposed action decommissioning would not require pile driving activities, which cause the highest sound levels of any activities associated with the proposed action. Pile driving only takes place during the construction phase of the proposed action. Decommissioning would involve the use of similar vessels, cranes, jet plow, cutting and welding equipment and other tools that were involved in construction, but would not include any pile driving, blasting or activities, which approach the noise level of pile driving. During decommissioning, the monopiles and transition pieces would be cut off at approximately 15 ft (4.6 m) below the seabottom. As such, the noise impacts from decommissioning activities would appear to be less than the worst case impacts already presented for construction and would be minor.

Increased Vessel Traffic

As mentioned above, the additional traffic from construction and decommissioning vessels may increase the chance of a strike or harassment of cetaceans.

Vessel Strikes

Vessel strikes to listed cetaceans can result in injury or death of the animal. The potential risk to listed whale and dolphin species from collisions with proposed action-vessels is evaluated below.

Ship collisions are a significant threat to large cetaceans and is considered the single important source of human-caused mortality in some species (Jensen and Silber, 2003; Waring et al., 2006). While ship strikes occur throughout the world, several studies document that the greatest number of incidents occur within the North American east coast (Laist et al., 2001; Jensen and Silber, 2003; Waring et al., 2006). Along the North American east coast there is a high concentration of large cetaceans and a significant volume of vessel traffic, enabling a greater chance of a collision but also the greater likelihood of reporting of any strikes possibly biasing any assumptions (Jensen and Silber, 2003).

The majority of vessels that have documented whale strikes are large, fast moving vessels such as container ships, tankers or military vessels (Jensen and Silber, 2003). There are several documented collisions of cetaceans with smaller vessels (less than 65 ft [19.8 m]); however all of these collisions were with boats traveling at higher speeds (Right Whale News, 2005). Collisions with vessels that are moving at slower speeds (less than 14 knots [7.2 m/s]), such as the construction vessels to be used for the proposed action, are less likely, and there have been no recorded ship strikes from vessels traveling less than 10 knots (5.1 m/s) (Laist et al., 2001).

The humpback, North Atlantic right and fin whales are the most often documented victims of ship strikes. Ship strikes of the other whale and dolphin species mentioned in Section 4.2.6.2.2 are less common, and general assumptions and impacts discussed for these three whales would apply to other MMPA protected cetaceans. Detailed discussion of these three whale species is presented in Appendix C, which provides information on T&E species and potential effects to T&E species.

Humpback, right and fin whales should be able to detect any tugboat, barge and other slow-moving vessels within the area of the proposed action, as baleen whales can easily detect and respond to sounds of the frequency range and intensity of those produced by tugboats and barges (Miles et al., 1987; Richardson et al., 1991; McCauly, 1994). Humpback whales are relatively tolerant of boats, but, due to this habituation they may be more susceptible to ship collisions. Whale response, however, are unpredictable and may depend on the activity of the whale at the time, or its previous experience with other motor vehicles.

Despite the expected ability of right whales to hear approaching vessels, they continue to die from vessel collisions (Richardson et al., 1995; Nowacek et al., 2004). A study by Nowacek et al., (2004), reported that right whales did not respond to the sounds of approaching vessels or the actual vessels. Some anecdotal observations suggest that right whales only respond when vessels approach to within a very close range. Right whales off the eastern coast of North America are frequently exposed to vessels, and they may have habituated to the sounds of approaching vessels at great distances (Richardson et al., 1995; Terhune and Verboom, 1999; Laist et al., 2001).

The other species of whales and dolphins discussed in Section 4.2.6.2.2 should also be able to hear approaching vessels, as the noise associated with the vessel fall within their hearing range.

Vessel Harassment

Any impact on marine species due to the physical presence of the proposed action-vessels is expected to be minor. MMS recommends that the applicant contact NMFS to determine if an IHA under the MMPA is warranted. If an IHA application is submitted, the final IHA would need to be issued prior to the commencement of any activities that may "take" marine mammals.

There have been many studies of the effects of vessels on cetaceans, particularly the underwater noises they make (Richardson et al., 1985, 1991). It is likely that whales and dolphins react primarily to the sound generated by vessels, and not their physical presence (NMFS, 2001; NMFS, 2002). Moreover, the central portion of Nantucket Sound and the vessel routes proposed to be used by the proposed action vessels are not within what is considered a high use area for listed whale species. If any MMPA protected animals are present in the area of the proposed action, potential behavior changes in response to proposed action-related vessel traffic would be short-term and would likely be similar to the behaviors observed during regularly occurring activities in Nantucket Sound such as the personal boat use, whale watching cruises, ferry traffic and fishing. Close encounters between proposed action vessels and species are likely to be rare and result in minimal physical disturbance to the animals.

The effects of vessel harassment on the migration, breeding and feeding behaviors of cetaceans are expected to be minor. Based on the undeveloped source of whale prey in Nantucket Sound, it is highly unlikely that cetaceans would be migrating through, nursing or feeding in Nantucket Sound, but further offshore. The physical presence of vessels associated with proposed action construction would not contribute to the harassment of migrating, nursing or feeding humpback, fin or right whales. These large migratory whales are only expected to be within the vicinity of New England waters during the spring and summer feeding seasons. However, preferred whale prey is not found abundantly within Nantucket Sound, rather most feeding grounds for these species are further offshore and would not be directly impacted by proposed action construction. Some seasonal residents of Nantucket Sound, such as harbor porpoises, may experience some displacement from traditional feeding grounds, however this should be temporary and most species found within the vicinity of the proposed action are habituated to high volumes of vessel traffic.

As mentioned previously, vessel strikes have caused mortality in cetaceans in New England waters (Waring et al., 2006). During decommissioning activities, as during construction activities, it is estimated that 4 to 6 stationary or slow moving vessels would be present in the general vicinity of the pile removal. Vessels delivering demolition materials or crews to the site would also be present in the area between the mainland and the site of the proposed action. The barges, tugs and vessels carrying materials would be limited to speeds below 10 knots (5.1 m/s) and may range in size from 90 to 400 ft (27.4 to 122 m), while the vessels carrying crews would be traveling at a maximum speed of 21 knots (10.8 m/s) and would typically be 50 ft (15.2 m) in length. The vessels used for the decommissioning of the proposed action would be smaller, slower moving vessels than those that regularly cruise Nantucket Sound, with expected impacts on cetacean populations in Nantucket Sound to be minor.

Temporarily Reduced Habitat

Activities related to proposed action-construction may cause a temporary reduced availability of habitat for cetaceans in the vicinity of the area of the proposed action. The main anticipated impact would be avoidance of areas of high traffic mainly the route the proposed action vessels would use to and from the proposed action. However, as under normal conditions the cetaceans are exposed to high volumes of vessel traffic due to commercial and recreational ships within Nantucket Sound, the increase in traffic is not anticipated to displace cetaceans for long periods of time. Some avoidance may also occur during construction activities due to acoustical harassment, as mentioned previously. However, this disturbance would be temporary and would not result in any major effects on the listed cetaceans. Studies at off-shore Danish wind farms showed that harbor porpoises temporarily avoided the area in the vicinity of the turbines only during construction, and mainly during pile-driving activities (Danish Offshore Wind – Key Environmental Impacts, 2006). Abundances for harbor porpoises slowly returned to close to pre-construction values for most of the area, with only a limited area with strong negative impacts that continued through the operation of the wind farm. Therefore any impacts are expected to be minor for the cetaceans in Nantucket Sound, and any changes would be temporary.

Proposed action construction and decommissioning are not anticipated to result in changes in cetacean prey abundance or distribution. Some temporary displacement may occur during periods of noise or high suspended sediments, but this would be limited to areas directly surrounding the given activities, causing both prey species and cetaceans moving to an undisturbed area. Pelagic prey tends to be highly variable and animals foraging on these sources move with the food source, as seen with many cetaceans and their prey species. Any temporary disturbance to pelagic prey is likely to mimic typical temporal and spatial variability, and is likely available in other areas of Nantucket Sound and surrounding waters for foraging by cetaceans. Therefore, proposed action construction is anticipated to have minor impacts on cetaceans in regards to reduced habitat and prey availability.

Habitat Shift (Structure to Non-structure Oriented)

The presence of 130 monopile foundations, six ESP piles and their associated scour control mats in Nantucket Sound has the potential to shift the area immediately surrounding each monopile from soft sediment, open water habitat system to a structure-oriented system, with minor effects to cetaceans.

Habitat Shift (Structure to Non-structure Oriented)

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 to the proposed action. However, as the addition of the monopiles would be a minor addition to the hard substrate that was present prior to the construction of the proposed action, the removal of the WTGs and ESPs would not cause a great impact in the overall habitat structure. Therefore, any cetacean that may have been attracted to the WTGs for feeding would have to forage in other locations within Nantucket Sound and surrounding waters, which have ample supplies of prey species.

Turbidity and Total Suspended Solids

Cetaceans within the area Nantucket Sound are accustomed to substantial amounts of suspended sediment on an irregular basis, from storms and strong tidal currents, and a temporary increase in turbidity from proposed action activities would have minor impacts.

Cetaceans bioaccumulate contaminants from their ocean environment, almost exclusively through their food sources. The potential mechanism by which sediments suspended during proposed action construction can harm cetaceans is through bioaccumulation of sediment-associated chemicals through ingestion of contaminated prey (indirectly).

Analysis of sediment core samples obtained from the site of the proposed action indicate that sediment contaminant levels were below established thresholds in reference ER-L and ER-M marine sediment quality guidelines (Long et al., 1995). Therefore the temporary and localized disturbance and suspension of these sediments during proposed action construction activities are not anticipated to result in increased contaminants in lower trophic levels. Therefore, cetaceans are unlikely to experience increased bioaccumulation of chemical contaminants in their tissues from the consumption of prey items in the proposed action vicinity, and any impacts are expected to be minor.

During the nearshore installation, the release of drilling fluid from the HDD operation within Lewis Bay would be minimized through a drilling fluid fracture or overburden breakout monitoring program, minimizing the potential of drilling fluid breakout into the water.

During the post lease G&G field investigation, vibracores and drilling of bore holes would take place to acquire subsurface geological information on the sea bottom. This would result in turbidity, which would be localized and temporary, and impacts on marine mammals would be negligible.

Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction. The suspension of solids are expected to be temporary and localized, as the removal technology that would be used to install the monopile foundations and the offshore cables, respectively, were selected specifically for their ability to keep sediment disturbance to a minimum. Further, the physical composition of the sands and the physical characteristics of the Sound environment provide reason to assume that any localized turbidity would settle back to the sea floor within a short period of time (one to two tidal cycles) and distance.

Cetaceans in the area are accustomed to substantial amounts of suspended sediment on an irregular basis, and would be minimally impacted by a temporary increase in turbidity from proposed action decommissioning activities.

As discussed previously in proposed action construction impacts, there is little potential for cetaceans to bioaccumulate chemical contaminants in their tissue from consuming prey within the area of the proposed action. The suspension of the sediments due to proposed action decommissioning activities is not anticipated to increase the amount of contaminants found within lower trophic levels.

The preliminary assessment is that those activities associated with the proposed action's construction and decommissioning would have minor impacts on the cetaceans species that may be found in that area. Some temporary avoidance of the area of the proposed action may occur due to elevated acoustic and vessel harassment, however this should be short-lived and normal conditions are expected to resume once construction and decommissioning activities have ceased.

Pollution/Potential Spills

As they rely on blubber for insulation, cetaceans are less vulnerable to oil spills than fur-coated marine mammals, such as seals. Cetaceans are most vulnerable to oil spills when they are surfacing for air when skin and eyes can be irritated. Direct exposure to oil spills can result in the inhalation of harmful fumes, lethargy, poor coordination and difficulty breathing which can lead to drowning (Hammond et al., 2001). Migratory cetaceans may limit their exposure to a persistent oil slick in a small geographic area by avoiding that area. Of the three listed large whale species, the right whale population should be considered at greatest risk to being negatively impacted by an oil spill because of the small population size and slow recovery of their numbers from earlier depletion events. Due to the low probability of an oil spill and limited cetaceans in the area, impacts during construction and decommissioning from an oil spill would be minor.

Conclusion

The overall impacts on marine mammals from construction and decommissioning activities associated with the proposed action are expected to range from negligible to moderate (for pile driving). The moderate impacts would be limited to the construction phase of the proposed action. Marine mammals may experience limited and temporary noise harassment, as the anticipated noise levels will be slightly greater than the NMFS Level B standard, but is not expected to be greater than the NMFS Level A standards, and thus not result in any injury to marine mammals. It is anticipated that marine mammals would avoid the WTG locations while pile driving is occurring. A recent study by Thomsen et al. (2006) revealed that seals and porpoise left the area of the proposed action during pile driving. Seals subsequently returned although porpoise had not as of the study's publication. Negligible impacts would be confined to the duration of the proposed action and the area of the proposed action activities. MMS will work with NMFS through the NEPA comment process to further refine, if needed, its assessment on the impacts of pile driving on marine mammals as well as any mitigation or monitoring measures that will reduce the potential for these impacts to occur. MMS has also advised the applicant that MMS believes there is a potential for pile driving and other activities under the proposal for behavioral harassment to marine mammals and that the applicant should contact NMFS to determine if an Incidental Harrassment Authorization under the MMPA is warranted. If an IHA application is submitted, the final IHA would need to be issued prior to the commencement of any activities that may "take" marine mammals. In addition, MMS is consulting with NMFS under Section 7(a)(2) of the ESA to address impacts of the proposed activities on ESA-listed marine mammals or ESA-designated critical habitat for listed species. A discussion of mitigation is provided in Section 9.0.

5.3.2.6.2 Operational/Maintenance Impacts

Pinniped Species

Vessel Strikes/Harassment

The proposed action's operation and maintenance activities are expected to require two vessel trips per working day for 252 days of the year. The vessels are anticipated to consist of small crew boats and slower moving vessels, as were used in proposed action construction.

As mentioned previously, vessel strikes have caused some mortality in seals in New England waters (Waring et al., 2006). Because of the ability of seals to habituate to vessels and because seals inhabit coastal shores, they may be more susceptible to ship collisions. However, seals are extremely agile and aware of their surroundings in the water, and able to detect approaching vessels in time to swim away. The vessels used for the operation and maintenance of the proposed action would be smaller and slower moving than those that regularly cruise Nantucket Sound. As a result, impacts on seal populations in Nantucket Sound would be minor.

It is possible that some increased recreational fishing effort may occur after the proposed action is operational due to the "fouling potential" of the WTGs. Seals may be attracted to the WTGs for foraging purposes, but would be minimally impacted by increased fishing vessel traffic to the site of the proposed action since vessels approaching or operating near the WTGs would be traveling at slow speeds.

Acoustical Harassment

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Existing underwater sound levels for the design condition are 107.2 dB. The calculated sound level from operation of a WTG is 109.1 dB at 65.6 ft (20 m) from the monopile (i.e., only 1.9 dB above the baseline sound level), and this total falls off to 107.5 dB at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 361 ft (110 m).

An analysis of predicted underwater sound levels perceived by seals from proposed action operation show that no injury or harassment to seals are predicted even if an individual were to approach as close as 65.6 ft (20 m) to a monopile when the proposed action is operating at the design wind speed as all dB_{ht} values at this minimum distance are well below 90 dB. In fact, proposed action operation would be inaudible for all hair seals at the close distance of 65.6 ft (20 m). Therefore, it is anticipated that underwater operation sounds from the proposed action would result in negligible impacts on hair seals in Nantucket Sound.

Electro Magnetic Fields (EMF)

Potential impacts to seals during the normal operation of the inner-array cables and the offshore transmission cable system circuits are expected to be minor, as the electric field would be completely contained within the shields surrounding the cables. The magnetic fields associated with the operation of the cables are not anticipated to result in an adverse impact to seals or their prey. The burial depth of 6 ft (1.8 m) below the seabed would also minimize potential thermal impacts from the operation of the cables. Therefore, it is anticipated impacts to seals or their prey species during the normal operation of the cable systems are expected to be negligible.

Pollution/Potential Spills

Seals have thick layers of blubber that prevent them from becoming hypothermic if they were to become coated in oil as result of a spill. While in the water, seals are most vulnerable when they surface for air, at which time they may inhale hydrocarbon vapors which can damage lungs. Contact with eyes and skin can also cause irritations.

Because the seals rely on coastal areas to haul-out and some to reproduce, they have the potential to be exposed on land as well as at sea. Seal pups are most vulnerable if oil reaches the shoreline, because they have not developed the protective blubber. Pups are also more likely to ingest oil while nursing on contaminated teats. The gray seal, which breeds in Nantucket Sound during the winter, is most susceptible to impacts from an oil spill. Seals can also become impacted by an oil spill through bioaccumulation of the pollutants from their prey species. In the event of an oil spill, the impacts are expected to be minor to moderate depending on the location and amount of oil released.

"Fouling Communities"

Seals may be attracted to the WTG fouling communities as a source of food once fish and invertebrate communities are established. Atlantic herring (*Clupea harengus*) and alewife (*Alosa pseudoharengus*) are the only two species of seal-preferred prey anticipated to potentially forage within the area of the proposed action. However, seals will pursue other fish species if necessary and readily available. Since the preferred fish species of migratory seals are not likely to aggregate at the proposed action structures, the attractiveness of the WTGs to seals for foraging purposes and any impacts associated with the additional hard substrate are expected to be minor.

The preliminary assessment is that those activities associated with operation and maintenance would have minor impacts on the pinniped species that may be found in that area. Those that would have the greatest effect on the pinniped species are the concepts of "fouling communities" that may attract seals to that proposed action site that are not normally present there, and only in the unlikely chance of an oil spill would any impacts be greater. Any operational related impact would be minor.

Impacts to Cetaceans

Vessel Harassment/Strikes

As previously discussed, cetaceans do not appear to be exceedingly disturbed by the physical presence and sound produced by vessels, and the vessel traffic itself (NMFS, 2001; NMFS, 2002). Cetaceans should be able to detect and move away from any proposed action vessel by diving into deeper waters. Any impact would be limited to temporary avoidance of an area; however, this is unexpected due to the high volumes of vessel traffic that normally travel the waters of Nantucket Sound. Therefore, the impacts of increased vessel traffic should have minor impacts on listed cetaceans.

It is possible, yet difficult to predict, whether there would be increased fishing activity after the proposed action is operational. Such fishing efforts would mainly be by private and recreational charter boats using hook and line fishing gear, which should not adversely impact any whale or dolphin species.

Acoustical Harassment

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Existing underwater sound levels for the design condition are 107.2 dB. The calculated sound level from operation of a WTG is 109.1 dB at 20 m from the monopile (i.e., only 1.9 dB above the baseline sound level), and this total falls off to 107.5 dB at 50 m and declines to the baseline level at a relatively short distance of 110 m.

An analysis of predicted underwater sound levels perceived by cetaceans from proposed action operation show that no injury or harassment to cetaceans are predicted even if an individual were to approach as close as 20 m to a monopile when the proposed action is operating at the design wind speed as all dB_{ht} values at this minimum distance are well below 90 dB. In fact, proposed action operation would be inaudible for toothed whales, and only slightly audible to baleen whales at the close distance of 20 m. Therefore, no behavioral effects to cetaceans are anticipated even if an individual were to approach within 20 m of the structures. Proposed action operations would result in negligible acoustic impacts on cetaceans in Nantucket Sound.

Electro Magnetic Fields (EMF)

Potential impacts to cetaceans during the normal operation of the inner-array cables and the offshore transmission cable system are expected to be negligible, as the electric field would be completely contained within the shields surrounding the cables. The weak magnetic fields associated with the operation of the cables are not anticipated to result in an adverse impact to cetaceans or their prey. The burial depth of 6 ft (1.8 m) below the seabed would also minimize potential thermal impacts from the operation of the cables. Therefore, it is anticipated impacts to cetaceans or their prey species during the normal operation of the cable systems are expected to be negligible.

"Fouling Communities"

The WTG monopile foundations would represent a source of new substrate with vertical orientation in an area that has a limited amount of such habitat, and as such may attract fish and benthic organisms. Of the cetaceans that may be found within the vicinity of the proposed action, only the prey of humpback whales, Atlantic herring (*Clupea harengus*) and menhaden (*Brevoortia tyrannus*) may potentially occur within the proposed action area. However, as these species are migratory fish they are not anticipated to aggregate around the WTGs. The remaining whale and dolphin species do not rely, but may occasionally feed, on the fish or benthic organisms that may be attracted to the WTG as prey and therefore would not be attracted to the structures for feeding purposes. Any impact to cetaceans with respect to changes in the fouling community would be expected to be negligible to minor.

Pollution/Potential Spills

As they rely on blubber for insulation, cetaceans are less vulnerable to oil spills than fur-coated marine mammals, such as seals. Cetaceans are most vulnerable to oil spills when they are surfacing for air when skin and eyes can be irritated. Direct exposure to oil spills can result in the inhalation of harmful fumes, lethargy, poor coordination and difficulty breathing which can lead to drowning (Hammond et al., 2001). Migratory cetaceans may limit their exposure to a persistent oil slick in a small geographic area by avoiding that area. Of the three listed large whale species, the right whale population should be considered at greatest risk to being negatively impacted by an oil spill because of the small population size and slow recovery of their numbers from earlier depletion events. Due to the low probability of an oil spill and limited cetaceans in the area, impacts during construction and decommissioning from an oil spill would be minor.

The preliminary assessment is that those activities associated with operation and maintenance would have minor impacts on the cetacean species that may be found in that area. Those that would have the greatest effect on the cetacean species are acoustical harassment from the operation of the turbines, and only in the unlikely chance of an oil spill would any impacts be greater.

Turbidity and Total Suspended Solids

There are potential impacts related to turbidity and total suspended solids that could result in the unlikely requirement for repair of the electric cable. Such impacts would include temporary turbidity and some localized deposition of sediments during the repair process. Turbidity would be caused by the jetting of sediments to uncover the damaged portion of the cable, hoisting of the cable after it is cut, laying the cable back down, and then jetting of sediments for reburial of the repaired cable. Cable repair procedures are discussed in Section 2.4.6. Impacts on MMPA resources as a result of cable repair would be temporary and result in only minor impacts.

Conclusion

The operation of the proposed action is expected to have negligible to minor impacts on MMPA listed pinnipeds and cetaceans. Maintenance vessels would generally operate at slower speeds (less than 14 knots) and maintenance activities should not result in water quality, benthic, or water column affects that alter the habitat. Under the MMPA, the applicant is required to abide by any measures required by NOAA Fisheries under the terms of its review and approval process to reduce the potential for harassment, injury or mortality to marine mammals. A discussion of mitigation is provided in Section 9.0.

5.3.2.7 Fisheries

5.3.2.7.1 Construction/Decommissioning Impacts

Potential Impacts on Commercial and Recreational Fisheries

There would be impacts to fisheries resources as a result of construction and decommissioning including post lease G&G investigations). The magnitude, extent, and duration of these impacts would be highly variable. Possible direct and indirect impacts on the fishery resource and fish habitats during the various phases of the proposed action are discussed below. A discussion of possible impacts on gear types and fishing techniques used by recreational and commercial fishermen is presented along with information on possible effects related to fishery usage activities.

Fish Habitat Disturbance and Loss

Permanent loss of benthic habitat from the installation of WTG and ESP monopile foundations would involve an area that is approximately 0.67 acres or approximately 0.0042 percent of the total area of the proposed action (see Table 5.3.2-2). Temporary impacts to the benthic habitat would be expected from activities including jet plow embedment of the inner-array cables, jet plow embedment of two circuits that comprise the 115 kV offshore transmission cable system, installation of scour protection devices, construction vessel positioning, anchoring, and the anchor line sweep that is associated with the construction of the proposed action structures. Temporary disturbance could be approximately 812 acres or approximately 5.1 percent of the total area of the proposed action with the use of scour control mats (see Table 5.3.2-2). Temporary disturbance could be approximately 866 acres or approximately 5.4 percent of the total area of the proposed action with use of rock armoring for scour control (see Table 5.3.2-2).

Sediments disturbed during cable jetting are anticipated to settle out soon after cable embedment and refill the cable trench and the immediate surrounding area. Temporary bottom impacts are anticipated at the post lease geotechnical boring and coring locations but the area disturbed is a negligible amount of the entire site of the proposed action. Temporary impacts along the cable installation paths are associated with other components of cable installation activities such as barge positioning, anchoring, anchor cable sweep, and the pontoons on the jet plow. Impacts that are associated with the anchor cables used for positioning of the cable lay vessel are anticipated to be temporary and localized, since the invertebrate prey community would recover and the physical characteristics of the sediments would not be altered. It is anticipated that sediments would be affected to a depth of up to 6 inches (15.2 cm) (Algonquin Gas Transmission Company, 2000). Impacts would be minimized with the use of mid-line buoys. Frequent anchor re-positioning would occur with each anchoring location having disturbances that could be up to five feet deep, but covering a small area of the seafloor. Jet plow embedment would directly disturb sediments to deeper depths of approximately 8 ft (2.4 m), through the process of injecting high pressure water. Since the jetting does not result in excavation of a trench, and the biologically active portion of the sediments are within the top 1 ft, jetting results in a narrower zone of impact to the benthic habitat of demersal fish species than mechanical or hydraulic dredging where sediments are physically removed from the seafloor and either sidecast or loaded on barges for disposal.

Benthic habitat disturbance associated with the post lease geotechnical investigations would result in a negligible and one time loss of demersal fish eggs, such as those produced by winter flounder if they occur during the time of post lease geotechnical investigations. Temporary impacts to benthic habitat may cause mortality or displacement of benthic organisms that serve as prey for fish. Thus, there may be some disruption of feeding of some fish species. During construction/decommissioning activities, the greatest area of impacts to surficial benthic habitat would be due to anchor positioning and anchor line sweep. Total expected temporary impacts to upper sediments from these activities would make up approximately 4.2 percent of the area of the proposed action (see Table 5.3.2-2). During construction and decommissioning activities demersal fish species are likely to find suitable benthic habitat in areas in proximity to the area of the proposed action. When construction activities are completed fish species are expected to return to the area of the proposed action.

Water withdrawals are another impact factor that would occur within the water column, and would affect the pelagic egg and larval lifestage of certain fish species. Water pumped through the cable jetting device would entrain fish eggs and larvae and cause mortality as this water is jetted at high pressures into the sediment. Other water withdrawals would occur in association with the operation of the construction and decommissioning vessels, which need engine cooling water, hoteling water, and ballast water. Fish eggs and larvae entrained with this water are assumed to suffer mortality because of mechanical stresses associated with passing through pumps, temperature affects, and holding time.

The HDD operation would involve HDD borehole exit hole dredging activities in Lewis Bay that are expected to directly affect benthic habitat. Dredging activity would involve either sediment disturbance or sediment removal volume of approximately 840 yd^3 (642.2 m^3). This material would either be contained in a cofferdam structure measuring approximately 2,925 ft^2 (0.067 acre or 272 m^2) (see Table 5.3.2-2) or transported to an approved onshore disposal site. With removal of the cofferdam sheeting the sediment surface would potentially have a depression area that is several feet deep. Clean fill material would be placed as needed to fill this area to match natural bottom contours. These activities are expected to have minor impacts due to the contained nature of the dredging activities in the cofferdam and small area disturbed.

Potential impacts from decommissioning activities are expected to be similar to the impacts described above for the construction phase. Decommissioning efforts, however, would not include pile driving or HDD activities. Monopiles would be decommissioned by removing sediments from inside the pile, cutting and removing the pile 15 ft (4.6 m) below the seabed, and then returning sediments to the sea floor to re-establish pre-project seabed conditions. For each WTG constructed in water depths less than 40 ft (12.2 m), approximately 3,744 ft^3 (106 m^3) of material would be mechanically dredged from inside the base of the monopile, loaded on a barge for storage until the monopile is cut and removed, and then returned into the depression. For each WTG constructed in water depths greater than 40 ft (12.2 m), approximately 4,324 ft^3 (122 m^3) of material would be moved and returned. During removal it is anticipated that the sediment plume at a WTG would be minimal due to the sandy nature of the sediments and the short duration. After cutting of the monopile, best practices available would be employed to minimize any sediment plume.

Fish Mortality or Displacement

The post lease G&G investigations and proposed action construction/decommissioning activities would have negligible direct mortality to juvenile or adult pelagic fish. These life stages have mobility within the water column, and therefore have the ability to move from or avoid areas of active construction where elevated suspended sediment concentrations are created or where increased sound levels occur. The juvenile and adult lifestages of these species would temporarily occupy the water column in nearby areas and other portions of Nantucket Sound. It is possible that displacing fish from one area to another could lead to increased competition or predation, however the zone of avoidance around construction vessels and equipment is likely to range from a few dozen feet to a few hundred feet and it is unlikely that many fish would be impacted in the small area around a WTG under construction or removal or around the jetting vessel. Details on avoidance due to sound and increased suspended sediments are discussed below.

Demersal fish species may be subject to some injury or mortality due to slower avoidance response, particularly in the colder winter construction timeframe. To protect sensitive fish species, such as winter flounder, the applicant has committed to avoid in-water construction in Lewis Bay between January 15 and May 31 of any year. Demersal eggs and larvae of fish may be subject to moderate impacts from anchor line sweep and anchor placement due to a lack of or limited mobility. Temporary impacts to demersal fish habitats related to construction stage anchoring activities are anticipated to make up less than 4.2 percent of the total area of the proposed action (see Table 5.3.2-2). As with pelagic species, displacement of demersal fish may make them more susceptible to competition and predation, when they are forced to avoid construction areas and move into adjacent habitats that are already occupied or that are less preferred. This type of displacement affect is likely to have negligible impacts on the populations of demersal fish in the site of the proposed action.

Elevated Total Suspended Solids

The post lease geotechnical investigations and proposed action construction or decommissioning activities that include installation or removal of monopile foundations, scour control mats or rock armoring, the inner-array cables and the offshore transmission cable system would cause localized and temporary increases in suspended sediment concentrations (see Section 5.3.1.6 for more information on water quality impacts). The ability of some fish to forage, navigate and find shelter can be negatively affected when suspended solid concentrations become elevated (Wilber and Clarke, 2001). Any turbidity associated with the post lease geotechnical and geophysical assessment program would include a negligible amount of sediment and is expected to be confined to immediate sampling areas. Localized turbidity related to proposed action construction or decommissioning activities is expected to be limited to the immediate area around the monopiles, inner-array cables and offshore transmission cable system circuits since sediments in the area of the proposed action of Nantucket Sound are mainly fine to coarse-grained sands. Impacts to fish species are anticipated to be minor due to temporarily elevated TSS levels that would be caused by proposed action construction and decommissioning activities.

Simulation studies related to sediment transport and deposition resulting from jet plow embedment of the inner-array cables and the offshore transmission cable system circuits were performed (Report No. 4.1.1-2). The effect of grain size was shown since the finer sediments occurring in Lewis Bay stayed in suspension longer than sediments in Nantucket Sound, primarily because they have higher silt and clay fractions. Also, because the tidal currents in Lewis Bay are weak, the model results indicated a build up of suspended sediments since dilution and dispersal was less than the Sound. The modeling revealed that sediments may remain suspended approximately 2 to 18 hours. Gravel and sand settle more quickly than silts and clays. In some locations, such as near the Yarmouth landfall, due to weak currents and occurrence of fine sediments, particles can remain in suspension for up to 48 hours. Sediment transport modeling concluded that sediment deposition from the jet plow embedment operations would be minimal compared to active sediment transport that has been observed in Nantucket Sound during natural tidal conditions (Report No. 4.1.1-2). In addition to the suspended sediment affects in the water column, deposition of these sediments can result in indirect affects at distances further away from the source. This process can result in harm or mortality of dermesal fish eggs, but can also result in changes in benthic habitat characteristics, depending upon the nature and extent of the deposition. However, throughout much of the Horseshoe Shoal area, continuously shifting sandy substrates are in evidence, and the incremental increase of sediment reworking due to proposed action activities is likely to have negligible to minor adverse affects on substrate characteristics and the demersal fish inhabiting this area.

During the excavation of the HDD exit holes in Lewis Bay, suspension of sediments is expected to be limited since these activities would be contained within a cofferdam. To help contain turbidity that would be associated with dredging for the HDD exit hole, the sheet piles used for the cofferdam would extend approximately 2 ft (0.61 m) above MHW.

Sound Impacts

It has been noted (Vella, 2002) that certain sounds related to the construction activities of an offshore wind farm can affect local fish populations and cause them to temporarily move from an area. The main sound from construction activities that could adversely affect fish would be the pile driving of monopiles. Use of the jet plow embedment process for laying the inner-array cables and the offshore transmission cable system does not produce sound other than that associated with vessels that are part of that operation (Center, 2003). Information on underwater sound anticipated from such vessels is discussed below in the section on "vessel traffic." Fish in the vicinity of the post lease geotechnical and geophysical assessment activities are anticipated to either not be affected by underwater noise or exhibit a very localized avoidance behavior, since these activities only generate low and intermittent noise. Impacts are expected to be minor and may be similar to behavior that might occur around a commercial fishing vessel, or an anchored charter or party fishing boat.

Fish are anticipated to avoid areas in proximity to monopiles while they are being driven. Using information on species-specific hearing thresholds the zone of behavioral response for pile driving activities was calculated for the site of the proposed action. Distances from the monopiles where significant avoidance reactions could be expected (where dB_{ht} = 90 dB re 1 μPA) were determined for several species. Avoidance reactions to pile driving could be expected for tautog at 591 ft (180 m), for bass at 328 ft (100 m), for cod at 1,148 ft (350 m), and for Atlantic salmon at 197 ft (60 m). Injury to fish is not anticipated even if individuals were to approach as close as 98 ft (30 m) to pile driving activities since species specific hearing threshold values are below 130 dB re 1 μPa at this distance. Potential impacts to fish would be reduced with use of a "soft start" of pile driving equipment that the applicant has committed to for protection of marine mammals. This would allow fish to move out of the pile driving activity area at non-harmful sound levels before the full energy of pile driving is employed.

The HDD methodology used for the transition of the offshore transmission cable system to onshore cable in Lewis Bay is anticipated to have temporary minor impacts on fish. Drilling would be conducted through unconsolidated material and it is not expected that there would be transmission of vibration from sediment to water. A low vibratory method rather than impact pile driving would be used during sheet steel installation for the cofferdam. The cofferdam installation is anticipated to have temporary, localized and minor impacts on fish in the proximity of the cofferdam.

Vessel Traffic

When the post lease G&G assessment and proposed action and construction and decommissioning activities are occurring there would be an increase of vessel traffic between the WTG array locale and the offshore transmission cable system route. Fish have been noted to exhibit various types of avoidance behavior when noise-emitting vessels are detected. Response to noise coming from ocean vessels includes lateral movement by demersal species and diving to greater depths in the water column by pelagic species. Increase in swimming speed has also been noted as a response to vessel noise by most fish species. Underwater sound from vessels has its peak energy below 1,000 Hz (Richardson et al., 1995). Information indicates that fish species have a narrow hearing bandwidth. The bandwidth is in the range of 16 to 1,600 Hz in which the hearing threshold ranges from 80 to 130 dB re 1 μPa. Table 5.3.2-4 (Table 5 in Report No. 5.3.2-2) shows data from several sources that have been combined to provide maximum likelihood estimations of hearing thresholds for several fish species including Atlantic salmon, bass, cod, and tautog. The sound source level for barges or tugs, typical types of construction/maintenance vessels that may be used is 162 dB re 1 μPa at 3.3 ft (1 m) (Malme et al., 1989). Maximum hearing-threshold sound levels (dB_{ht} re 1 μPa) for fish at a 10 ft distance from a proposed action vessel were calculated to be 73 dB_{ht} re 1 μPa. Thus, fish could hear vessels but sound levels would be well below the 130 dB_{ht} re 1 μPa threshold for prevention of harassment or injury. Proposed action vessels that are a 10 ft or greater distance from fish are not expected to cause physical harm to fish species. The 73 dB_{ht} re 1 μPa sound level expected at 10 ft (3.05 m) exceeds the 70 dB_{ht} re 1 μPa threshold for avoidance by very sensitive fish individuals. Therefore, fish in the vicinity of the post lease geological and geophysical assessment, construction, decommissioning, and cable repair procedure vessels are anticipated to display avoidance behaviors when these vessels are in operation. Impacts are expected to be minor and may be similar to behaviors associated with the existing vessel activity, such as ferry traffic, pleasure boat activities, or fishing activities.

Prey Mortality and Displacement

During the post lease geotechnical investigations and construction and decommissioning activities some impacts to benthic habitat are anticipated to cause mortality to benthic organisms that are prey for some species of fish (see Section 5.3.2.5 for presentation of impacts on benthos). The greatest extent of area affected would include locations where anchor cable sweep occur. However, the areas of greatest impact severity are associated with the WTGs where habitat would be permanently altered and there would be extensive bottom disturbance associated with multiple visits by jack up construction/decommissioning vessels The total area that would be directly disturbed during construction activities makes up less than approximately 5.0 percent of the total area of the proposed action (see Table 5.3.2-2). Similar benthic habitat in the proposed action locale would be available for foraging fish species. The benthic habitat disturbance would largely be short-term, with recolonization commencing shortly after the disturbances are over, through movement from adjacent less disturbed areas, as well as through recruitment via planktonic eggs and larvae. Various benthic invertebrate species have been noted to recolonize benthic sediments following disturbances such as these construction activities (Hynes, 1970; Rhoads et al., 1978; Rosenberg and Resh, 1993; and Howes et al., 1997). As recolonization of benthos occurs, fish species would be expected to return to previously disturbed areas for foraging.

Mobile fish prey species such as herring, alewife, or menhaden are anticipated to exhibit similar responses to construction and decommissioning activities as other pelagic fish. In fact, since these are planktivorous feeding fish, they are more likely to avoid areas of elevated suspended sediments than predatory fish since the sediments interfere with the feeding mechanism. When construction and decommissioning activities are completed in a particular location, these fish species are expected to return to the area of the proposed action.

Bioaccumulation from Consumption of Contaminated Prey

Sediments found in the area of the proposed action have been reported to be mainly sand and chemical constituent concentrations have been noted to be below the established thresholds that are in applicable reference sediment guidelines. Sediment core samples that were obtained at the proposed WTG site locale and along the proposed offshore cable routes had all chemical constituent concentrations that were below ER-L and ER-M marine sediment quality guidelines (Long et al., 1995). Thus, fish are not anticipated to be subject to an increased bioaccumulation of contaminants from consuming prey present in the area of the proposed action.

Oil Spills and Other Discharges

During construction and decommissioning, there is a possibility that an accidental oil spill could occur, either during refueling operations, as lubricants are introduced into WTGs, or as transformer cooling oil is installed on the ESP. The applicant would be required to have an OSRP that addresses containment and clean up procedures in the event of an oil spill. However, the accidental release of fuel or oils into the marine environment would have adverse affects on fish resources in and near the proposed action location. Low concentrations of hydrocarbons have been shown to have negative affects on survival and maturation of fish eggs and larvae, lifestages that are particularly vulnerable to such spills. Depending on the type of fluid, an accidental spill could also affect benthic habitats and demersal fish should some form of the fluid sink to the bottom or wash up onto shorelines. Given the low probability of occurrence for a large spill, the potential impacts on fishery resources are negligible. However, given the duration of construction and decommissioning, and the need for refueling, there is a higher probability that some small fuel spills would during the refueling process, in which case only a small area would be affected and it could be cleaned up more rapidly, resulting in only a minor impact on fishery resources.

Vessels operating during post lease G&G investigations, construction, and decommissioning would result in various forms of wastewater discharges, as described in Section 5.1.1.1. Given that these are relatively small volumes, often occurring while vessels are underway when dilution and dispersion is rapid and extensive, and would not contain toxic or contaminating elements, the impacts to fish resources would be negligible. In addition, while these discharges would represent an increase over existing levels of vessel discharges associated with the hundreds of other vessels that operate on the Sound, but only temporarily.

Conclusion

Post lease G&G investigations, construction, and decommissioning impacts on fisheries in general are expected to be minor as they would be short term and localized. Also, many fish would able to avoid disturbed areas. Demersal eggs and larvae of fish may be subject to moderate impacts in very discrete locations due to limited mobility, but the extent of this is not likely to affect recruitment levels or future population size. Mitigation being considered at this time includes the use of "soft start" procedures for monopile installation to allow fish that may be in the area to move away as a response to construction sounds, time of year restrictions to avoid sensitive periods when spawning takes place; and post-construction monitoring for documentation of habitat disturbance and recovery progress. More discussion of mitigation is provided in Section 9.0.

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

During proposed action development, several potential concerns were identified that relate to the commercial fishing industry. These concerns included potential restriction on fishing activities, potential construction impacts, and potential gear conflict due to presence of the offshore cable systems or WTGs.

During construction and decommissioning, the proposed action would not place restrictions on commercial or recreational fishing activity or create fishing exclusion zones in the proposed action locale. For protection of public safety there may be limited temporary vessel restrictions in proximity to construction sites and vessels, but these would not involve large enough areas or be in place long enough to reduce fishing opportunities. The only exception to this is the placement of fixed gear in the immediate area where WTGs, the ESP, or the cables are scheduled to be installed. The applicant would need to coordinate with lobstermen to make sure that lobster gear is not placed along a section of the cable routes that is going to be installed, since gear damage or loss would occur from the jetting equipment. Once installed, lobstermen would be able to resume placing gear within the cable routes. Similarly a short term exclusion of fixed gear would be required around a WTG to prevent damage or loss due to jack up barge operations. Once a WTG is completely installed, fixed gear could be placed in proximity to it, at the fisherman's discretion, and in a manner that does not affect maintenance vessel access.

Conclusion

Commercial fishing activities may be subject to temporary disruption in close proximity to construction activities. Potential impacts of construction activities are expected to be minor with regard to commercial fishing activities and commercial fishing gear. Impact minimization measures that the applicant has already incorporated into development of the proposed action, includes the relocation of several WTGs away from popular commercial fishing areas, and burying the inner-array cables and the offshore transmission cable system circuits to a minimum of 6 ft (1.8 m) below the seabed to avoid the potential for conflicts with fishing vessels and gear operation. More discussion of mitigation is provided in Section 9.0.

5.3.2.7.2 Operational Impacts

Potential Impacts on Commercial and Recreational Fisheries

Sound and Vibration from WTGs

Fish species are sensitive to vibrations (underwater sound waves). Fish have two main organs for detection of underwater vibrations, the inner ear and the lateral line system (Thomsen et al., 2006). Hearing capabilities among fish species have been noted to vary greatly (Fay and Popper, 1999). Thomsen et al., 2006 has indicated that more precise information on turbine emissions (particle motion and sound pressure), in situ attenuation measurements, and on hearing capabilities of different fish species are needed for detailed assessments. Research that has been conducted at offshore wind farms in Europe suggests that very low vibrations coming from wind turbines have minor impacts on fish in the region. Dolphins (marine mammals) have been noted congregating for feeding around turbines at Blyth Offshore in Northumberland (Great Britain's first wind farm) (AMEC, 2002). Since dolphins were noted engaged in feeding behavior around the turbines, fish (i.e., prey of the dolphin) also may have been present.

At a Swedish wind farm, the Näsrevet Windfarm, Westerberg (1999) noted that cod appeared to be more numerous in the waters immediately around wind turbines than in areas nearby. Westerberg postulated a possible habituation by this fish species to increases in the decibel level during normal operation. Such habituation has also been noted in proximity to oil rig platforms (Vella, 2002). Westerberg (1999) also noted that normal wind farm operational sounds did not greatly impact eel migration.

Modeling simulations that were conducted to evaluate underwater sound during the proposed action phases (Report No. 5.3.2-2) suggest that possible impacts to fish species due to normal operation of WTGs would be negligible. Background sound levels are reached within approximately 328 ft (100 m) from an individual WTG, and levels that are a distance of 66 ft (20 m) from a WTG are usually less than 2 dB from the baseline conditions (see Table 5.3.2-5). Sound would not be emitted from inner-array cables or the offshore transmission cable system when the proposed action is operating. Based on the modeling simulations and observations noted from existing offshore wind farms in Europe (Vella, 2002; Westerberg, 1999), it is anticipated that sound emissions from the WTGs for this proposed action may have minor or negligible impacts and would not substantially affect fish populations in the area.

It is not anticipated that prey for fish species would be displaced due to submarine vibration while WTGs are in operation. Surveys conducted at operating European wind farms (Elsam Engineering A/S and ENERGI E2 A/S, 2005) have reported various species of fish in the turbine site areas indicating that prey organisms may be available in proximity to operating turbines.

Vessel Traffic

Potential vessel impacts on fish during maintenance activities are expected to be similar to the impacts previously described for vessels during the construction/decommissioning phases. During operation and maintenance activities, an increase of vessel traffic can be expected in the WTG array area. Fish are anticipated to display avoidance behaviors when these activities occur. Impacts are expected to be negligible and may be similar to behavior noted when there is ferry traffic, pleasure boat activities, or fishing activities.

Electromagnetic/Thermal Emission from Submarine Cables

EMF/thermal emissions from normal operation of the inner-array and the offshore transmission cable system circuits are expected to have negligible direct impacts to fish species. A review of scientific literature concerning detection of EMF by marine organisms including elasmobranchs (sharks, skates and rays) was conducted. Though high levels of sensitivity were demonstrated for weak electric fields, the sensitivity was limited to steady, slowly-varying fields. Evidence indicates that some marine organisms use the geomagnetic field for orientation, but this response is limited to steady and slowly-varying fields. The mechanism underlying this sense is not expected to respond to rapid varying (e.g., 60 Hz) AC fields. Power-line EMF was not reported as disrupting marine organism orientation, behavior or migration (Report No. 5.3.2-3). The cable system to be used for this proposed action is a three-core solid dielectric AC cable design. This cable system was selected since it minimizes potential environmental impacts and reduces any EMF. The proposed action's cable system would have grounded metallic shielding that can block an electric field generated by the cable system. With the electric field fully shielded, impacts to fish would be related to the magnetic field emitted from the cable systems, but in both situations, impacts would be negligible.

The inner-array cables and the offshore transmission cable system circuits that would connect the WTGs to the landfall would be buried 6 ft (1.8 m) below the seafloor. Thus, there would be no barrier to fish passage. Demersal fish could utilize the surface sediments and benthic organisms could colonize surface sediments. This burial depth also minimizes potential thermal impacts of the offshore cable circuits, since the heat dissipated into the surrounding sediments would result in no perceptible increase in temperature at the sediment surface.

Shading

Potential impacts on fish from shading from WTGs on water areas are anticipated to be negligible Shadows from the WTG structures are anticipated to move rapidly across the water surface during daylight hours. The WTGs are spaced approximately 0.39 by 0.63 miles (629 by 1000 m) apart. Presence of the ESP, with a surface area of 20,000 ft^2 (1,858 m^2)/0.46 acre, may affect the soft-bottom benthic invertebrate communities in its immediate locale due to shading. It is expected these possible effects would be negligible since the ESP structure is to be located approximately 39 ft (12 m) above the MLLW datum plane in 28 ft (8.5 m) of water and sunlight would pass under the ESP, particularly at lower sun angles.

Lighting

Lighting for the proposed action components would include the following: FAA navigation lighting on the tops of the WTGs (257 ft [78 m] above the water, flashing red, oriented to be conspicuous to pilots in the air with negligible ground spread) and USCG navigation lighting on the WTG platforms (32 ft [9.8 m] +/- above the water, flashing low intensity amber, oriented outward to be conspicuous to mariners). The ESP would have utility lighting (in addition to navigation lighting) that would only be in operation when the platform is occupied. The platform would not often be occupied at night except during weather emergencies when crews may not be able to get off the platform. Any lighting on the ESP would be focused on the deck and work areas, and not on the water surface. There would be no steady burning illumination and no lighting focused on the water from any of the proposed action components, therefore there is negligible anticipated impact on fish from proposed action lighting.

Alterations to Waves, Currents and Circulation

Effects to waves, currents and circulation are not anticipated beyond the immediate locale of individual WTGs in the operating WTG array due to the spacing of the structures (Swanson et al., 2005; Report No. 4.1.1-9). The WTGs are spaced approximately 0.39 to 0.63 miles (629 to 1,000 m) apart and modeling has shown there to be no interaction between individual WTGs. Potential limited changes to waves, currents and circulation that may occur in close proximity to each WTG are anticipated to have negligible impacts to fish populations.

Habitat Change from Non-Structure Oriented to Structure Oriented System

The introduction of 130 WTG monopile structures and six ESP piles in Nantucket Sound would result in an increase of hard substrate that sessile organisms may colonize. Thus, there is a change expected in the immediate localized area around each monopile from a non-structured to a structure oriented system. The diversity of benthic communities that may colonize the monopiles is influenced by characteristics of the substrate and various environmental factors affecting colonization of most marine habitats, such as such as current, waves, scour, etc. The attached community is anticipated to include sessile animal and plant species and small invertebrates. The presence of this fouling community is expected to attract small fish species and in turn attract both larger demersal and pelagic fish species (Elsam Engineering A/S and ENERGI E2 A/S, 2005). Monopile foundations selected for the proposed action are smooth and devoid of complexity, unlike scaffolding that is often used for oil platforms (MMS, 2000). Though the monopiles would provide vertical habitat and are expected to be colonized by organisms, the degree of the colonization is expected to be minimal since they have a smooth cylindrical form.

Based on macroinvertebrate species observed during a survey on pilings of the meteorological tower (refer to Section 4.2.5.3.2 in this document) results indicated that a benthic macroinvertebrate community similar to the surrounding sea floor community had colonized support pilings. Seven species not observed during other baseline surveys at Horseshoe Shoal were noted. These new taxa are likely to be in the area of the proposed action, but would be expected to inhabit hard substrates such as rocky shoals or boulders. It is expected that pilings would support organisms from both the sandy substrate habitat and those that would be attracted to hard substrates.

In addition, should the applicant select the use of scour mats consisting of synthetic fronds for scour protection at the base of the monopiles, which are designed to mimic seafloor vegetation, the potential alteration of the fish community around the monopiles would be reduced compared to the use of rock armor for scour protection. Use of the scour mats is more consistent with the sandy bottom relief of Horseshoe Shoal rather than rock armor scour protection that may introduce additional hard substrate supporting an invertebrate and fish rocky bottom community.

Although both demersal and pelagic fish species are anticipated to congregate around the monopiles the fouling community that may form is anticipated to support organisms that already occur in Nantucket Sound. Impacts from this habitat change are anticipated to be minor and the fish species composition in the area of the proposed action is not anticipated to substantially change from the pre-project conditions.

Removal of the WTG monopile foundations and ESP piles during decommissioning would result in a local shift from structure-oriented habitat in proximity to the WTGs and ESP to the original shoals type of habitat that was present prior to installation of these structures. Impacts as a result of WTG and ESP removal are anticipated to be minor and short term, as this would be a return to the pre-construction conditions.

WTGs Acting as Fish Attracting Devices

As discussed above, the introduction of 130 WTG monopile structures and six ESP piles in Nantucket Sound would result in an increase of hard substrate that sessile organisms may colonize. Thus there is a change expected in the immediate localized area around each monopile from a non-structured to a structure oriented system. When a stable fouling community becomes established that supports certain fish species, it could be expected that fish eating birds such as great black-backed, herring, and ring-billed gulls, cormorants, several species of ducks, and terns may feed in the areas around monopiles (Report No. 4.2.5-4). It has been noted that fish species likely to benefit from artificial structures, such as monopiles include species that have territorial, demersal and reef-obligate life histories (Bohnsack, 1989). Some fish species occurring within the area of the proposed action and other shoal areas within Nantucket Sound display such characteristics in all or some of their life stages. These species include Atlantic cod, cunner, tautog, black sea bass, and scup. Research that has been conducted (Alessi, 1996) regarding artificial reef design provides some information on potential effects on fish species. Effects of different types of reef designs and spacing patterns on artificial reef populations were tested and results indicated that spacing and design are important factors. It was noted that reefs that are too close together or too far apart are not as effective (Alessi, 1996). Investigations concerning varying reef dispersion for management of targeted fishery assemblages found that approximately the same numbers of fish species were attracted to dispersed reefs and clumped reefs although higher numbers of fish were attracted to clumped reefs (Lindberg et al., 1989 – 1990). From information noted in the described research and the fact that the WTGs would be spaced approximately 0.39 by 0.63 miles (629 by 1,000 m) apart, impacts are anticipated to be minor and the overall environment and fish species composition in the proposed action locale is not anticipated to substantially change from the pre-Project conditions.

As a result of decommissioning, removal of the structure-oriented type of habitat is anticipated to cause these species to disperse to other areas, or be eaten. If there had been any increase of fishing pressure for these species during the operational period, such fishing pressure would decline with a return of the area of the proposed action to pre-construction conditions.

Cable Repair

Procedures used to repair a segment of the inner-array or offshore transmission cable system are anticipated to be similar to those used in construction activities. The cable section would be jetted so the cable is exposed and can be cut. Then a new cable segment is spliced in and the cable section jetted into the seafloor. Potential impacts to the local fish habitat and species from repair activities are expected to be similar to the impacts previously described for the construction phase but much more limited in extent and duration, and would therefore be negligible.

Oil Spills and Other Discharges

As described above during construction and decommissioning, there is the potential for oil spills and vessel discharges to occur during project operation. Since vessel re-fueling would not happen offshore during maintenance activities, a fuel spill is unlikely. However, should a vessel collide with a monopile or the ESP, it is possible that fuel would be released. If an oil or fuel transport barge or commercial transport vessel collide with a monopile, there is the potential for a larger release. Smaller spills could occur as lubricants are raised or lowered from the nacelles during maintenance, or when material is transferred from the maintenance vessel to the storage tank on the ESP. The project would be operated with an OSRP designed to provide rapid response and clean-up in the event of a spill. Regardless, should a spill occur during operations, impacts on fish and fish habitats could range from negligible to moderate, depending upon the specific characteristics of the spill and environmental conditions at the time of the spill. Given the low probability of a major spill, the probability of moderate levels of impact are also low.

During normal operation of maintenance vessels there would be other discharges associated with engine cooling water, ballast water, and other hoteling water uses. These discharges would all be performed in accordance with applicable laws and regulations, and represent a small incremental increase over existing levels of similar discharges that occur from the hundreds of other commercial vessels that operate in Nantucket Sound every year, such as the ferries. Given the mobile nature and small volume of these discharges, impacts to fish species and habitats would be negligible.

Monopile Collapse

In the event of a monopile collapse, there would a small release of lubricating fluid and other fluids (about 210 gallons total) from the nacelle, but more importantly, there would be localized bottom disturbance similar to what would occur for decommissioning and construction of a WTG, just in reverse order. While the impacts would be as described above for these types of activities, they would only occur at this one location for a short duration, and impacts to fish habitats and fish populations would be negligible.

Vessel Collisions

As indicated under Oil Spills, collision of a vessel with a monopile or the ESP could result in the accidental release of fuel or lubricants. Oil spill plume modeling was undertaken with the scenario involving accidental release of all 40,000 gallons of oil from the ESP (Report No. 4.1.3-1). Modeling results are described in Section 5.2.3. In addition, depending upon the extent of damage, a monopile may need to be removed and replaced. Given the variety of scenarios involved in a vessel collision, it is difficult to definitely state the impact level, but when the probability of occurrence is factored in, fish and fish habitat impacts would be negligible to minor.

Conclusion

Wind turbine operations are expected to have negligible to minor impacts on fisheries. Under normal operations, the offshore cable systems should not require maintenance resulting in impacts to benthic habitats or the water column. Remote monitoring of the cable routes would occur periodically to make sure they remain buried. Maintenance of the WTGs and ESP would require daily vessel operations, weather permitting, but no planned activities resulting in disturbance of benthic habitats or the water column. Several accidental or unplanned events with low probability of occurrence could have localized minor to moderate impacts on fish or fish habitats.

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

Proposed action operation is not expected to have substantial impacts to commercial or recreational fishing activities in the area. Measures for minimizing potential impacts include having no restrictions on fishing related activities in the area of the proposed action when the proposed action is in operation. Additional measures include avoiding possible conflicts with fishing vessels and their gear operation by maintaining the burial of the cables below the seafloor. Commercial fishing vessels would have to avoid the WTGs and ESP when trawling or placing pot or trap lines. However, the affects are minor due to the WTGs being spaced 0.39 by 0.63 miles (629 by 1,000 m) apart. Slight course corrections may be required to avoid them.

To minimize or avoid impacts to commercial fishermen who use mobile gear, a number of proposed WTG sites that were in deeper water along the eastern portion of the array have been relocated to shallow water locations in the northwestern portion of Horseshoe Shoal. Commercial fishermen who use mobile gear had identified the deeper as an area they frequently fish.

5.3.2.8 Essential Fish Habitat

Details on EFH impacts are provided in a separate EFH report in Appendix D. A short summary of EFH impacts is provided below.

5.3.2.8.1 Construction/Decommissioning Impacts

During construction, impacts to EFH and EFH species would arise from activities that disturb the seafloor, that alter water quality conditions, and alter physical characteristics of the ocean environment such as noise. Activities that could disturb the seafloor include post lease geotechnical sampling (refer to post lease geotechnical and geophysical sampling procedure details in Section 2.0); installation of the monopile foundations for the WTGs and ESP within the WTG array; placement of seabed scour control systems at the base of the monopiles; installation of the inner-array cables connecting each WTG to the ESP and installation of the offshore transmission cable system circuits connecting the ESP with the landfall location that use the hydraulic jet-plow embedment technology, associated anchoring required for cable installation barge positioning; and activities related to construction of a temporary cofferdam associated with HDD installation methods.

Construction activities that could alter water quality include post lease geological and geophysical sampling, installation of the monopile foundations for the WTGs and ESP and barge activities associated with this aspect construction; installation of seabed scour control systems at the base of the monopiles; installation of inner-array cables and the offshore transmission cable system circuits that connect the proposed action and landfall location that use hydraulic jet-plow embedment technology and associated barge anchoring, pontoon and anchor line sweep effects; and construction of a temporary cofferdam associated with HDD installation methodology.

Construction activities or proposed action features that could alter the physical characteristics of the marine environment include installation of the monopile foundations, which introduce hard, vertical substrate areas, and introduction of seabed scour control systems.

An additional potential impact to early lifestages of some EFH species is entrainment along with water that is used by construction vessels for engine cooling or for operation of the jet plow during cable burial. Entrainment of eggs and larvae, as well as zooplankton that are food for juveniles and adults of species such as herring, alewife, and shad, would result in the loss of individuals to these species local populations. The water withdrawn for the jet plow is injected into the sediments under high pressure. Survival of entrained eggs, larvae, and zooplankton can be assumed to be essentially zero, because of the pressure and mechanical forces that these organisms would experience. However, unlike a fixed point withdrawal, such as for cooling water at a power plant, the jet plow would typically advance at 3 to 5 miles (4.8 to 8.0 km) per day such that no portion of the water column would be affected for very long. Thus, the dispersed nature of this impact is likely to only have a minor affect on EFH species.

During decommissioning, impacts to EFH would arise from activities that disturb the seafloor, that alter water quality conditions, and alter physical characteristics such as noise. These activities would be similar to the construction phase described above, except no pile driving would occur and no HDD activities would take place. In addition, the monopiles as substrate for a fouling community would be removed, and fish associated with these small reef-like settings would disperse.

Impacts to Benthic EFH

The potential impacts to benthic EFH are described based on the anticipated duration of the impact. While the total area of the seafloor encompassed within the boundaries of the proposed action is large, there are extensive areas that would not be impacted by the proposed action activities and there is an even smaller area that would be impacted in a long term manner. For example, while more than 80 miles (129 km) of cable jetting are proposed in order to bury the cables, these areas would be temporarily disturbed, whereas each of the monopile locations represent a long term alteration of the benthic habitat.

The total permanent direct area of benthic habitat disturbance from construction activities is summarized in Table 5.3.2-2. Permanent benthic habitat loss would result from installation of the WTG and ESP monopile foundations. This permanent loss due to occupation of structures would be approximately 0.67 acres (0.003 km^2) or 0.0042 percent of the total proposed action area (see Table 5.3.2-2). Similar habitat conditions are present in areas adjacent to the site of the proposed action.

The installation of the scour control, inner-array cables, and the offshore transmission cable system would physically displace sediment at specific locations. The total temporary direct area of benthic habitat disturbance from construction activities is summarized in Table 5.3.2-2.

Temporary impacts to benthic habitat would result from jet plow embedment of the inner-array cables, jet plow embedment of the two circuits comprising the 115 kV offshore transmission cable system, and installation of the scour protection devices, as well as from vessel positioning, anchoring, and anchor cable sweep associated with construction (see Table 5.3.2-2). This temporary disturbance could total up to approximately 812 acres (3.3 km²) (5.1 percent of the total proposed action area) with scour protection mats or 866 acres (3.5 km²) (5.4 percent of the total proposed action area) with rock armoring (see Table 5.3.2-2). Decommissioning-related impacts would be short-term and localized and are expected to be similar to impacts during construction (see Section 5.3.2.5.1).

The temporary benthic habitat disturbance of between 812 and 866 acres (3.3 to 3.5 km²) from construction could result in the temporary loss of functions and values provided by the benthic EFH. Impacts during construction are temporary, occur over small areas, and the benthic habitat is expected to recover thus restoring the functions and values to EFH and EFH fish species.

The impact from jet plow embedment of the inner-array cables and the offshore transmission cable system 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 5.3.1.1). Impacts associated with cable installation barge positioning, anchoring, anchor line sweep, and the pontoons on the jet plow device would also be localized and temporary. Impacts from anchor line sweep has the greatest areal impact, but 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) and impacts would be minimized through the use of mid-line buoys. Anchoring locations would have disturbances to the sediment to a depth of 4 to 6 ft (1.2 to 1.8 m) at each anchor deployment, leaving a temporary irregularity to the seafloor with localized mortality of infauna. While numerous anchor re-positionings would occur, the cumulative area is still small (see Section 5.3.2.5). Jet plow embedment would directly disturb sediments to a depth of approximately 8 ft (2.4 m), deeper than the anchoring or anchor line sweep depth disturbances.

Modeling was used (see Section 5.3.1.1) to estimate seabed scar recovery from jet plow cable burial operations. Using the assumption that 3 percent of the sediments in the jetted cross section could be injected back into the water column and that the coarse sediment volume is returned to the trench, it was estimated that the dimensions of the scar left along the cable routes would be 6 ft (1.8 m) wide and from 0.75 to 1.7 ft (0.23 to 0.53 m) deep. Information from a number of relevant studies at similar sites was reviewed, and by applying those findings to site specific conditions for Nantucket Sound and Horseshoe Shoal, approximate recovery times were estimated for the trench scars. The methodology of van Rijn (1993) was used to calculate bedload sediment flux at core locations along the proposed 115kV cable outside the Horseshoe Shoal area. Bedload transport rates at the core locations range from 0.18 to 25 ft^3/day per foot (0.017 to 2.3 m^3/day per meter) of seabed. Together the flux rates from Horseshoe Shoal and the rates calculated using the method of van Rijn represent the range of sediment flux throughout Nantucket Sound. Based on these transport rates, recovery rates for jetting scars along the cable route are estimated to be between 0.2 and 38 days. Recovery of jetting scars on Horseshoe Shoal is anticipated to occur within a few days. Areas of low wave and tidal current energy and a predominately mud bottom such as Lewis Bay are typically dominated by suspended sediment load. In these areas it is likely that seabed scars from cable burial would last months or until a major storm (hurricane or major nor'easter) occurs. Deposition rates in estuaries in southern New England typically range from 0.079 to 0.79 in/yr (0.2 to 2.0 cm/yr) (King, 2005). Refer to Section 5.3.2.5 for further details on benthic substrate recovery.

Egg and larval stages of demersal EFH species would be temporarily affected by benthic habitat disturbance if present during the time of year of construction. EFH species with pelagic eggs and larvae would be less affected by temporary benthic habitat disturbance. The temporary displacement of benthic habitat would also likely result in the mortality and/or dispersal of some benthic organisms (i.e., prey for some EFH species) in the footprints of the construction activities, thereby temporarily disrupting feeding for some benthic-oriented juvenile and adult EFH species in the area. Pelagic-oriented juveniles and adult EFH species would be less affected by permanent and temporary benthic habitat loss. The greatest areal impacts to surficial benthic habitat and therefore to early demersal life stages and benthic prey species of demersal adults and juvenile EFH species would occur from anchor positioning and anchor line sweep. As discussed in Section 5.3.2.5, the total anticipated temporary impact to the upper sediments from anchoring would comprise less than 4.2 percent of the total proposed action 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 the nearshore Lewis Bay environment, benthic EFH could be directly affected by the HDD borehole end dredging activities within Lewis Bay; however, dredging would be limited to a volume of 840 yd^3 (642.2 m^3) and would be contained within the cofferdam. The area enclosed by the cofferdam would be approximately 2,925 ft^2 (272 m^2), a minimal area compared to surrounding habitat in Lewis Bay. The dredged sediments from within the cofferdam pit would be temporarily removed and replaced upon completion of the offshore transmission cable system. Due to the limited and contained nature of the HDD installation activities within the cofferdam and the limited area affected by the backfilling of the dredged material, no substantial impacts to benthic EFH are expected. These activities would not be required during decommissioning. See Section 2.3.6 for additional information on HDD construction and installation methodologies.

Disturbance of the benthic environment from 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). It has been found that benthic communities that are adapted for survival in high-energy environments would recover more quickly following disturbance (Dernie et al., 2003). The naturally dynamic environment of the proposed action 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 proposed action area are adapted to relatively wide fluctuations in water column suspended sediment concentrations and are not expected to be substantially impacted by short-term sediment resuspension associated with construction and decommissioning. Therefore, affected benthic invertebrate populations are expected to recover as quickly as they are capable of reproducing. Many shellfish species generally spawn on an annual basis; however, depending on the water temperature and time of year, shellfish may spawn more than once per year. Therefore, benthic invertebrate populations at the proposed action's site are expected to fully recover within a time period of 1 to 2 years (Byrnes et al., 2004; C-CORE, 1995; Hall, 1994; Newell et al., 1998; Rhoads and Germano, 1986; Rhoads et al., 1978; Whitlatch et al., 1998).

In addition, because benthic habitats similar to those in the proposed action area are present in Nantucket Sound, similar benthic communities (i.e., prey organisms) would be located in many areas and EFH species would be able to find suitable prey in areas adjacent to the proposed action area and other regions of the Sound. Pelagic species are likely to be able to occupy the water column in other parts of the Sound. As disturbed benthic habitat is recolonized by benthos, as discussed above, EFH species would resume foraging in those areas as prey items become more abundant. Therefore, impacts to EFH species from mortality or displacement of prey species would be expected to be negligible to minor.

During decommissioning activities, benthic EFH would be disturbed once again. Temporary impacts to that habitat would be similar to those described above. In addition, benthic communities that have recolonized sediments initially disturbed during construction, such as along the inner-array cable and the offshore transmission cable system and over the filled-in scour control mats, would be disturbed once again. Post-decommissioning recolonization is expected, and in the interim, EFH species in the proposed action area are likely to be able to find similar prey items in adjacent areas or in other areas of the Sound, and impacts would be expected to be legible to minor.

Potential for Sediment Contamination of Benthic EFH

Recent studies indicate that sediments in the proposed action 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 array site and along the offshore transmission cables system, route had concentrations below ER-L and ER-M marine sediment quality guidelines (Long et al., 1995) (see Section 4.1.6.3). Therefore, the temporary and localized disturbance and suspension of these sediments during construction and decommissioning is not likely to result in increased incorporation of contaminants in the benthic substrate or at low trophic levels. EFH species are thus unlikely to experience increased bioaccumulation of contaminants via consumption of prey items or exposure to benthic substrate classified as EFH.

During the near shore installation in Lewis Bay, the HDD operation 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. The drilling fluid would consist of water (approximately 95 percent) and an inorganic, bentonite clay (approximately 5 percent). 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 2.3). 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 EFH or EFH species. 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. In summary, sediment contamination of benthic EFH is expected to be negligible to minor.

Impacts to Eelgrass Habitat in Lewis Bay

As discussed in Section 4.2.2.4 of this DEIS, one SAV eelgrass bed has been mapped within Lewis Bay, located to the west of Egg Island in the Town of Barnstable. To avoid impacts to this habitat which also serves as EFH for several EFH species in the proposed action's area (black sea bass, scup, summer flounder), the offshore transmission cable system would be no closer than 70 ft (21.3 m) from the edge of the eelgrass bed located near Egg Island.

In the area of the eelgrass bed in Lewis Bay, the bottom sediments are relatively coarse. Simulations of sediment transport and deposition from jet plow embedment predict that sediments suspended by the jet plow would fall along the route with bottom deposition predicted to be in the range of 0.04 to 0.1 inches (1.0 to 3.0 millimeters) at the western edge of the eelgrass bed (Report No. 4.1.1-2). The majority of the eelgrass bed is predicted to experience little or no deposition as a result of the jet plow embedment operations. Suspended sediment concentrations in this area are predicted to be in the range of 50 to 500 mg/L, depending on proximity to the cable route. Suspended sediment concentrations of 10 mg/L are predicted to remain for approximately 9 to 18 hours after the jet plow has passed this point on the route.

At the western end of the eelgrass bed, suspended sediment concentrations of 100 mg/L are predicted to remain for up to 4 hours.

Many sessile or bottom-oriented aquatic organisms (including eelgrass) encounter some level of sedimentation under natural conditions as a result of tidal currents, waves, and storms. As a result, many organisms have morphological, behavioral, and/or physiological means of dealing with exposure to deposited sediments. Regrowth of seagrasses such as eelgrass can occur if sediment deposition only results in a light covering of sediment material and if the rhizome system is not damaged (USACE DOER, 2005). Since the majority of the eelgrass bed is expected to experience little or no deposition as a result of jet plow operations, it is anticipated that the natural means of seagrass adaptation to changing sedimentation conditions would allow the eelgrass bed to withstand the short-term jet plow operations that would pass the eelgrass bed, and impacts would be negligible to minor.

Impacts to Submerged Aquatic Vegetation on Horseshoe Shoal

Potential impacts to SAV on Horseshoe Shoal as a result of the construction and decommissioning of the proposed action are expected to be limited in nature. Section 4.2.2.4 summarizes the extent of SAV within Horseshoe Shoal. Field surveys have shown the proposed action area to include only sparse areas of SAV. Most of the habitat surveyed within Horseshoe Shoal was shown to be bare sand and the areas that did include SAV assemblages were mostly comprised of macro-algae, not eelgrass. Impacts to the limited SAV assemblages in the proposed action area are expected from activities associated with installing the inner-array cables, the offshore transmission system cables, the WTGs, the ESP, and the scour control around the monopile foundations. Overall, these activities are anticipated to impact a total of 678 acres (2.7 km^2) of Nantucket Sound although only a fraction of this area has the potential for SAV to occur (see Table 5.3.2-2).

Impacts to SAV resulting from the above listed activities (including anchor cable sweep) are expected to be temporary and similar to impacts seen during coastal storm events. These impacts would include the damage and/or displacement of SAV found within the specific working areas for these individual components.

The only permanent impacts to SAV anticipated are those associated with the installation of the WTGs, ESP, and the scour control mats. The physical presence of the monopile towers would result in a loss of available habitat within the tower footprint for the duration of the proposed action. Once installed however, the towers themselves would provide a substrate area greater than that being impacted for the attachment and subsequent growth of macro-algae.

Once construction has moved to a new site, natural re-colonization of the disturbed areas, by both eelgrass and macro-algae, should begin immediately. However, complete recolonization of disturbed areas by seagrass may take a decade or longer (Neckles et al., 2005), while macro-algae would recolonize considerably faster due to their reproductive dispersal mechanisms, fast growing nature, and opportunistic growth strategies. Based upon the species composition observed during the ground-truthing field study (Report No. 4.2.2-2), it is expected that within 12-24 months of installation (Villard-Bohnsack, 2003), macro algae would have significantly re-colonized areas which previously supported these communities, as well as the monopile foundations of the WTGs. As a result, SAV impacts are expected to be minor.

Impacts to Water Column EFH

Impacts to EFH from Degraded Water Quality

Construction activities associated with installing the monopile foundations, scour control mats, and the inner-array cables and the offshore transmission cable system would result in a temporary and localized increase in suspended sediment concentrations which could affect EFH that is defined as within the water column. Decommissioning-related impacts would be short-term and localized and are expected to be similar to impacts during construction. Elevated 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 offshore 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 construction or decommissioning is anticipated to be minimal and confined to the area immediately surrounding the monopiles, the inner-array cables, and the offshore transmission cable system circuits. Sediments disturbed by construction or decommissioning activities are expected to settle back to the sea floor within a short period of time (see Section 5.3.1.1). In addition, the proposed action 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, including EFH species, in this area are accustomed to periodic increases in suspended sediments and should not be substantially impacted by a temporary increase in turbidity from construction and decommissioning activities.

Simulations of sediment transport and deposition from jet plow embedment of the offshore transmission cable system and the inner-array cables were performed (Report 4.1.1-2). These simulations, which used two models (HYDROMAP to calculate currents and SSFATE to calculate suspended sediments in the water column and bottom deposition from the jet plow operations), estimated the suspended sediment concentrations and deposition that could result from jet plow embedment of the cables. The model results demonstrate that concentrations of suspended sediment in the water column resulting from jet plow embedment operations (i.e., concentrations above natural background conditions) are largely below 50 mg/L. The effect of grain size distribution is evident since the finer sediments present in portions of the Lewis Bay area, the area at the southern half of the north-south portion of the route, and the area just northwest of the ESP, remain in suspension longer due to higher silt and clay fraction.

In Lewis Bay, suspended sediments are predicted to remain in suspension considerably longer than in Nantucket Sound as a result of weak tidal currents. As a result, water column concentrations are predicted to build-up rather than quickly disperse. The model results demonstrate that concentrations of suspended sediment in the water column resulting from jet plow embedment operations (i.e., concentrations above natural background conditions) in Lewis Bay are largely below 500 mg/L. Suspended sediment concentrations in excess of 100 mg/L are generally predicted to remain for less than 2 hours with the exception of some sections along the offshore transmission cable system route showing durations at 6 hours. Suspended sediment concentrations in excess of 10 mg/L are generally predicted to remain for less than 24 hours after the jet plow has passed a given point along the route, except near the Yarmouth landfall where concentrations in excess of 10 mg/L are predicted to remain for up to 2 days after the jet plow passes as a result of very weak currents and fine bottom sediments.

These TSS concentrations are still minimal when compared to the active bed load sediment transport known to exist in Nantucket Sound (between 45 and 71 mg/L under natural tidal conditions and up to 1,500 mg/L as a result of trawling operations. Sediment suspension during construction and decommissioning activities are not anticipated to result in long-term or environmentally significant elevations in water column TSS. Demersal eggs and larvae of EFH species in the immediate vicinity of construction and decommissioning activities may experience mortality or injury through burial and smothering. Pelagic eggs and larvae of EFH species may be temporarily affected or displaced from elevated TSS in the immediate vicinity of construction and decommissioning activities. Juvenile and adult EFH species are mobile and capable of moving away from disturbed areas and elevated TSS concentrations. Zooplankton or fish species may be temporarily affected or displaced in the immediate vicinity of the area of the activity; however, they are likely to rapidly return to these areas once construction in the specific area ceases or is completed. As a result, impacts to EFH resources in the water column are expected to be minor.

Sediment suspension during excavation of the HDD borehole ends in Lewis Bay is expected to be minor since these activities would be partially contained within the cofferdam and the top of the sheet piles for the cofferdam would help contain turbidity associated with dredging for the HDD borehole end transition and subsequent backfilling. Therefore, impacts to EFH species would be minor. These activities would not be required during decommissioning.

EFH Species Mortality/Injury/Displacement

Construction/decommissioning is not expected to result in measurable direct mortality or injury to adult and juvenile pelagic EFH finfish species since these life stages are mobile in the water column, capable of avoiding or moving away from the disturbances associated with construction, and not as closely associated with the bottom as demersal finfish. Adult and juvenile demersal EFH finfish species and adult and juvenile benthic EFH invertebrate species in the direct path of bottom disturbing construction and decommissioning activities may experience some direct mortality or injury. 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. However, no measurable effects on populations would be expected. Displacement of juvenile and adult EFH finfish species 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. Displacement of juvenile and adult EFH finfish species is likely to primarily result from increased turbidity.

Because they lack motility, demersal EFH eggs or larvae that lie within the direct footprint of construction disturbance would likely experience mortality. Demersal EFH eggs and larvae may also experience localized increases in physical abrasion, burial or mortality from elevated suspended sediments during construction. 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 would comprise less than 4.2 percent of the total proposed action area. Larvae in the latter stages of development are capable of some motility, which may allow for movement from the construction area. Pelagic EFH eggs and larvae are likely to be less affected than demersal early life stages since they are not as closely associated with the bottom; however, those in the immediate area of construction could experience some injury or mortality. Eggs within the water column would be transported by prevailing currents, with larvae being transported to a lesser degree. 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. Decommissioning-related impacts are expected to be similar to impacts during construction.

Potential Impacts from Impingement/Entrainment of Fish Eggs/Larvae from Vessel Water Withdrawals/Water Withdrawals Associated with Cable Jetting

Vessel water withdrawals during jet plow embedment of the offshore cable systems are anticipated to be minimal, consisting only of periodic withdrawal of near-surface water for ballast water exchange and for engine cooling. Such vessel water withdrawals would also occur during decommissioning activities and during operation when any maintenance activities would be required. Construction vessels withdrawing surface water for ballast water exchange would be required to adhere to all USCG regulations and requirements for water withdrawal and discharge. This process of withdrawing water for ballast water exchange is commonly practiced and is no different than the processes practiced by other vessels already operating in the area. Water withdrawals associated with engine cooling occur for essentially all motor vessels, and this would be the case for construction vessels, tugs, crew boats, etc.

For vessels underway, the water withdrawals occur along the transit route, and would include entrainment of small marine organisms, which typically occur in a patchy manner throughout the ocean. A certain percentage of these organisms would be injured or suffer mortality as a result of passage through pumps and heat exchangers, both from mechanical forces as well as possibly thermal increases.

The jet plow itself would require additional water withdrawals in order to operate. The intake for the jet plow is expected to be located off of the surface vessel that supports jet plow operations. Water withdrawals for use in the jet plow embedment operation would be withdrawn from the near-surface area. Any early life stages of fish (eggs or larvae) that may be present in the immediate area of water withdrawal have the potential to be entrained during this process. Those eggs or larvae entrained during water withdrawal would likely suffer 100 percent mortality as the water is forcefully injected into the sediments to loosen and liquefy them. Millions of fish eggs and larvae may be present in the withdrawn water, depending on the season. However, given the fecundity of fish, the loss of eggs and larvae only represents a small fraction of equivalent adults of the species that are present. Given that commercial fishing vessels and ferries have traversed Nantucket Sound for years with engine cooling water withdrawals occurring, impacts from the incremental increase from the jetting is short term and minor.

The species that could potentially be impacted by these water withdrawals include those with planktonic egg and/or larval stages at the time of jet plow operation. Early life stages that are benthic or demersal in nature are not expected to be impacted since water withdrawal would occur at or near the water surface. Since the jet plow process is expected to progress relatively rapidly, impacts are expected to be short-term and minimal in any one area. Impacts to these early pelagic life stages that have designated EFH in the proposed action’s area would also be limited to those months of the year where jet plow operation coincides with the occurrence of particular life stages in the area. In general impacts from these water withdrawals would be minor.

Acoustical Impact

Information on the hearing thresholds for finfish and potential risk of acoustic disturbance that could result in injury or disturbance to finfish is evaluated below for sounds emitted during monopile construction, other construction, and vessel transit.

Hearing Thresholds for Fish

The hearing threshold is the minimum sound level in a 1/3-octave band that can be perceived by an animal in the absence of significant background noise (Report No. 5.3.2-2). The hearing bandwidth for an animal is the range of frequencies over which an animal can perceive sound. Finfish have a relatively narrow hearing bandwidth, in the range of 16 to 1,600 Hz, in which their hearing threshold is 80 to 130 dB re 1 μPa. Data from nine sources (Nedwell *et. al*., 2004; Hastings and Popper, 2005) have been combined to produce maximum likelihood estimates of hearing thresholds, summarized in Table 5.3.2-4 for tautog, bass, cod, and Atlantic salmon.

Monopile Pile Driving

The maximum submarine sound generated during offshore construction would occur during installation of the monopile foundations. Sound levels measured during impact pile driving operations at the Utgrunden Wind Park in Sweden were used to model underwater sound expected from installation of the monopiles since the size of the monopiles and the installation techniques proposed are the same as for the Utgrunden Wind Park (Report No. 4.1.2-1). The Utgrunden data show a maximum sound level of 178 dB at 1,640 ft (500 m). 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.

In order to determine the actual underwater sound level that is heard by finfish from monopile installation, a hearing threshold sound level (dB_{ht}) was calculated for three fish species for which data were available. The dB_{ht} for a given species is calculated following the method developed by Nedwell and Howell (2004) by passing the frequency spectrum of underwater sound produced by a source through a filter that mimics the frequency-dependent hearing thresholds of that species. The benefit of this approach is that it enables a single number to describe the effects of sound on that species, thereby allowing one to compare acoustic effects among species. The dB_{ht} represents the level of sound perceived by a certain species by taking into account its frequency-dependent hearing thresholds. For estimating the zone of injury for marine species, a sound pressure level of 130 dB_{ht} re 1 µPa (i.e., 130 dB above an animal's hearing threshold) is recommended (Nedwell and Howell, 2004; University of California, 2005). Of the five groups of marine animals considered in the underwater sound analysis, toothed whales (dolphins, porpoises, pilot and minke whales) have the lowest hearing thresholds in the frequency range where construction sounds would occur. Those thresholds are around 50 dB re 1 µPa, and 130 dB above that hearing threshold level is a sound level of 180 dB re 1 µPa, which is the present NMFS guideline for preventing injury or harassment to all marine species (Kurkul, 2002). The 180 dB re 1 µPa sound level guideline is also highly protective to finfish since it is equal to 100 dBht re 1 µPa (180 minus the 80 dB minimum finfish hearing threshold) and is thus 30 dB below the 130 dB_{ht} re 1 µPa threshold for injury.

Note that since the NMFS 180 dB re 1 µPa guideline is designed to protect all marine species from high sound levels at any point in the frequency spectrum, it is a very conservative criterion. The dB_{ht} calculated for each combination of proposed action activity and marine species is a more accurate measure of acoustic effects than simply comparing the sound level to the NMFS 180 dB criterion because the dB_{ht} method takes into account the frequency distributions of both the sound source and the receiving animal's hearing thresholds.

Research shows significant marine animal avoidance reactions occur and mild behavioral reactions occur at 70 dB_{ht} re 1 µPa (Nedwell and Howell, 2004; Nedwell et al., 2004). Using the hearing threshold data from Table No. 5.3.2-4, dB_{ht} sound levels were calculated for finfish for the proposed action's loudest construction noise (pile driving) and the results are provided in Table 5.3.2-6. Construction noise results are given for the NMFS safety radius of 1,640 ft (500 m) and two closer distances, 1,050 ft (320 m) and 98 ft (30 m), where source measurements were made at the Utgruden wind park (Report No. 4.1.2-1). Pile driving sound levels cannot be reliably estimated for distances closer than 30 m (98 ft) due to near-field effects. The 1,640 ft (500 m) safety radius is based on a condition in the USACE Permit granted to the applicant for construction and operation of a SMDS [Permit No. 199902477]. The condition requires that sound level monitoring during pile driving procedures be conducted at an initial safety zone radius of 1,640 ft (500 m) 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 (Illingworth & Rodkin, Inc. 2001; SRS Technologies, 2004).

The results of this dB_{ht} analysis (Report No. 5.3.2-2) show that no injury to finfish are predicted if an individual were to approach as close as 98 ft (30 m) to the pile driving because all dB_{ht} values at this minimum distance are well below 130 dB re 1 µPa. Fish that remain in immediate proximity to the monopile 0 to 30 feet (0 to 9 m) have a greater likelihood of injury at the start of pile driving.

The dB_{ht} data presented in Table 5.3.2-6 were then used to calculate the zone of behavioral response for pile driving at the proposed action site. These results, summarized in Table 5.3.2-7, give the distance from the monopile where a significant avoidance reaction would occur for each species, i.e., where dB_{ht} = 90 dB re 1 µPa. Avoidance by a minority of individuals would be expected at lower levels and hence at slightly greater distances than those listed in Table 5.3.2-7. If finfish are in the proposed action's construction area, they are likely to temporarily avoid the zone of behavioral response around the monopile being driven. Table 5.2.3-7 reveals that behavioral effects (avoidance) would occur at a range of 60 to 350 m (197 to 1,148 ft) by finfish.

Acoustical impacts to fish within 1,640 ft (500 m) would be minimized by using a "soft start" of the pile driving equipment (use of a low energy start) to allow fish to move away from the area in response to construction sound. Avoidance effects are temporary, limited to a relatively small area around the one monopile being driven at any one time, and avoidance effects disappear only hours after pile driving ceases. Only two pieces of pile driving equipment would be present at any one time, and they are unlikely to be operating simultaneously in close proximity to each other.

As an added protection measure, underwater sound monitoring would be performed during initial monopile construction (the first three monopiles - as was done to ensure protection of marine mammals during the installation of the SMDS foundation piles). Underwater sound pressure level measurements would be made at an Initial Safety Zone radius of 1,640 ft (500 m) to determine compliance with the 180 dB NMFS threshold. Hydrophone measurements would use the Lmax RMS "fast" setting, and data would be analyzed on a real-time basis to ensure continuing compliance. The SMDS permit stipulated that if measured levels exceeded the threshold, a site-specific Safety Zone radius corresponding to the 180dB threshold would be established and the NMFS approved observer would be advised of the expanded action area for observation of marine mammals. Similar measures would be followed for the installation of the monopiles. These measures would also have benefits to any finfish species in the vicinity of the proposed action. During installation of the SMDS, measured sound levels did not exceed the 180dB threshold at or beyond the initial Safety Zone radius.

Effects of pile driving noise on marine invertebrates are expected to be negligible. An evaluation of the BATHOLITHS airgun seismic surveys off the coast of British Columbia predicted only minor, short-term, sub-local and insignificant impacts on invertebrates (LGL Ltd. and JASCO Research Ltd., 2006). It should be noted that airguns produce some of the loudest peak human-made underwater noises (NMFS) and are designed to penetrate to great depths; therefore predicted impacts to invertebrates from local monopile driving are expected to be much less than that anticipated from the BATHOLITHS program.

Other Construction Sounds

The jet plow embedment process for laying the offshore transmission cable system circuits and inner-array cables produces no sound beyond that produced by typical vessel traffic and the cable installation barge would produce sound typical of vessel traffic already occurring in Nantucket Sound. No substantial underwater sound would be generated during HDD operations used to transition the offshore transmission cable system to the upland cable system in Lewis Bay. Due to the sound-insulating qualities of saturated sedimen**ts**, 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.

Vessel Sounds

Construction would result in increased vessel traffic between the WTG array site, the transmission cable system route, and Quonset, RI (where construction laydown is planned to occur). The sound source level for a tug and barge traveling at low speed, the typical construction vessels for the proposed action is 162 dB re 1 μPa @ 1 m (3.3 ft) (Malme et al., 1989). Using the reported sound source level for tugs and barges, the maximum perceived underwater sound level was evaluated at 10 ft (3 m) for finfish using the hearing-threshold data presented in Table 5.3.2-4. The maximum hearing-threshold sound level (dB_{ht} re 1 μPa) for finfish at a distance of 10 ft (3 m) from a vessel was calculated as 73 dBht re 1 μPa. Finfish would be able to hear the vessel but the sound levels are safely below the 130 dB_{ht} re 1 μPa threshold for preventing injury or harassment. Therefore, vessels that are 10 ft (3 m) or greater from finfish should not cause physical harm. The 73 dBht re 1 μPa sound level at 10 ft (3 m) is above the 70 dBht re 1 μPa threshold for avoidance by the most sensitive finfish individual, and thus finfish in the vicinity may display avoidance behaviors to vessels. These behaviors, however, would be short-term and would likely be similar to the behaviors observed during activities that regularly occur in Nantucket Sound such as pleasure boat use, ferry traffic, and fishing. Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction. Vessel traffic generated by proposed action activities is not expected to have a significant effect on the early life stages of fish species, as it would be typical of vessel traffic already occurring in Nantucket Sound.

Conclusion

Post lease geotechnical and geophysical sampling, and construction/decommissioning activities, are expected to have negligible to minor impacts on EFH. The applicant and MMS would continue to work with NOAA Fisheries and MassDMF to ensure that impacts to EFH and EFH species are minimized and mitigated if necessary. Mitigation being considered at this time includes performing surveys to delineate eelgrass beds, avoidance of anchoring in locations with eelgrass beds and developing a Before After Control Impact (BACI) plan. More discussion of mitigation is provided in Section 9.0.

5.3.2.8.2 Operational Impacts

During operation of the proposed action, impacts to EFH and EFH species would arise from activities that disturb or alter the seafloor, that alter water quality conditions, and alter physical characteristics such as noise. Such activities may include cable repairs, maintenance of scour protection, and associated vessel activity where water withdrawals and discharges occur and noise is produced. Other impacts include the continued presence of a vertical structure which would alter the benthic environment and habitat in the area.

Unplanned and accidental events have the potential to adversely affect EFH and EFH species. Vessel collisions and collapse of a monopile would necessitate repair and/or replacement activities, including mobilization of similar vessels and equipment used to construct a WTG. Oil spills could occur if a monopile collapses or the storage containers on the ESP are ruptured. Small spills could occur during handling of lubricants and fuels during maintenance activities. In general, the low probability of these events occurring results in a negligible potential for impact on EFH and EFH species.

Impacts to Benthic/Demersal EFH

Impacts from Creation of Vertical Structure

Research on the potential effect of the monopile foundations on fish species, including those with designated EFH in the area, was conducted. This research included in-depth discussion of possible fish aggregation, reef effects, and spacing considerations for the monopiles. 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 proposed action area or to Nantucket Sound. Although 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, this new substrate is not favorable for colonization or reef formation due to its low complexity and rugosity (CARPG, 1998).

Despite the anticipated utilization of the monopile structures by certain fouling and hard-bottom benthic organisms (see Section 5.1.5.11), the individual monopiles are not expected to serve as true artificial reef structures that would serve to significantly alter the benthic or finfish communities within Nantucket Sound. Historical and recent research conducted on the design of artificial reefs indicates that the major design features that affect the function of artificial reefs are complexity and rugosity (the material used and roughness), as well as surface area, profile, shape, orientation and size (CARPG, 1998). The quantity and nature of interstitial spaces in reef structures are important in determining the degree and complexity of the biological community developing on and around the reef. Adequate interstitial spaces are necessary to establish a rich diversity of motile invertebrates as well as numerous cryptic fish species (CARPG, 1998). The monopiles would not have any interstitial space and given the wide spacing between the individual monopiles (0.39 to 0.63 miles (629 to 1,000 m) apart), there would not be creation of interstitial space among the monopiles collectively at a scale that would be beneficial to benthic organisms or most fish.

The proposed monopile structures would provide a high profile but cylindrical structure of poor complexity and low rugosity. Thus, fish attraction to the monopile structures is not expected to be as marked as that for planned artificial reefs or complex steel structures such as oil and gas platforms (Wilson et al., 2003) which have a high profile, open latticework structure. Certain demersal EFH species in Nantucket Sound that show territorial or reef-obligate life histories may be attracted to the monopiles including, but not limited to: Atlantic cod, black sea bass, and scup. In addition, it should be noted that the distance between the monopile structures is within the sensory range for flatfish. Flatfish such as flounder, sole and dab have been shown to be attracted to submarine structures at distances of 1,969 ft (600 m) and flounder have been shown to move between 2 reef structures at a distance of 2,953 ft (900 m) (Grove et al., 1989). Because of their relatively high mobility between underwater structures, these species may become more vulnerable to fisheries, increasing the exploitable biomass. In addition, flatfish species have been found to be attracted to artificial reefs (Polovina and Sakai, 1989), although it is believed that they visit the reefs primarily to forage.

In general, it is not likely that the addition of new hardened structures in Nantucket Sound would introduce species that aren't currently there, because artificial hard substrate can already be found throughout the harbor and port areas within the Sound in the form of pilings associated with wharfs and breakwaters. Some studies have shown that artificial reefs simply redistribute the resources without increasing the biomass (Polovina & Sakai, 1989). A conclusion more specific to wind parks may be drawn from research done in support of the Horns Rev windmill park in Denmark. A study was conducted to describe the possible artificial reef impact on fish of the monopile foundations of the planned marine windmills (DIFR, 2000). The Horns Rev project is on a smaller scale than the proposed action, being only 80 units forming an 8 x 10 grid, 1,804 ft (550 m) apart. However the two projects are similar enough to draw conclusions on potential reef effect impacts. The Horns Rev project concluded that "Considering the hydrography and material and design of the Horns Rev structures, there is no indication that the windmill foundations would provide a significant food-chain basis" even though monopiles at the Horn's Rev wind farm were found to be colonized by bryozoans, sea anemone, sea squirts, starfish and the common mussels (*Mytilus edulis*) within 5 months of its construction (S.E Ltd., 2002). Based on the design similarities of the proposed action and the Horns Rev project, it would be reasonable to conclude that the proposed action, a comparable project, would not have significant impact on the food-chain or the ecology of Nantucket Sound.

In addition, 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 ft^2 (0.03 acre or 111 m^2)) per tower, assuming an average water depth of 30 ft (9.1 m)) would be a minor addition to the hard substrate that is already present. Therefore, it is likely that these isolated structures would generate a relatively small amount of additional patch reef type habitat, common in the Sound, further supporting the conclusion that the monopiles would have a minor impact on the fish community or 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.

Removal of the monopiles would eliminate the vertical structure-oriented habitat offered by the monopiles that some 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 proposed action, removal of the monopiles may allow subsequent dispersal of the aggregated fish, thereby reducing fishing pressure on these species in the area.

Impacts to Benthic EFH from Repair of Submarine Cable

In the unlikely event a submarine cable has to be repaired, a segment of the cable would have to be excavated, repaired and then backfilled again (See construction procedures for repairs at Section 2.4.6). Impacts associated with submarine cable repair work would be similar to those benthic EFH impacts described above for installation of the submarine cable in Section 5.3.2.8.1. Such impacts are expected include disturbance to the seafloor and benthos, which would be localized, temporary, and result in negligible to minor impacts.

Impacts to Benthic EFH during Maintenance Work

Maintenance work on the WTGs would require vessels to operate in the area to deliver maintenance workers and or supplies to the WTGs. This work would result in anchoring of vessels that would cause temporary and localized disturbance to the benthic EFH, which would result in minor impacts. Maintenance of scour mats and or riprap if needed, would result in temporary and localized impacts to benthic resources in the vicinity of the work, and such impacts would be minor.

Impacts from Underwater Electromagnetic Fields (EMF)

Potential impacts to fish species, including those with designated EFH in the proposed action area, from electromagnetic/thermal emissions during the normal operation of the inner-array cables and the offshore transmission cable system circuits are expected to be negligible. The cable system (for both the inner-array cables and the offshore transmission cable system circuits) is a three-core solid dielectric AC cable design. The proposed inner-array and offshore transmission cable systems would contain grounded metallic shielding that effectively blocks any electric field generated by voltages on the conductors within the cable systems. Since the electric field would be completely contained within those shields, impacts are limited to those related to the magnetic field emitted from the offshore transmission cable system and inner-array cables. As described in Report No. 5.3.2-3, the magnetic fields associated with the operation of the inner-array cables or the offshore transmission cable system are anticipated to result in negligible impacts to marine organisms, including EFH species and their prey.

Water Column Impacts

Impacts from Suspended Sediments

In the event a cable repair is required, impacts to the water column would be similar to those experienced during installation of the cable as described above in Section 5.3.2.8.1. Impacts would include temporary turbidity as a result of suspended sediments caused from excavation of the cable and or backfilling of the cable, plus anchoring impacts and anchor line sweep impacts. Marine organisms, including EFH species, in the water column are accustomed to periodic increases in suspended sediments and should not be substantially impacted by a temporary increase in turbidity that cold be caused by repair work or other maintenance work, and thus impacts to the water column as a result of suspended sediments are expected to be negligible to minor.

Acoustical Impacts

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Acoustic modeling of underwater operational sound at the offshore proposed action area was performed for the design wind condition (see Section 4.1.2.3). Baseline underwater sound levels under the design wind condition are 107.2 dB re 1 μPa (see Section 4.1.2.3 for more information on baseline sound data). The predicted sound level from operation of a WTG is 109.1 dB re 1 μPa at 65.6 ft (20 m) from the monopile (i.e., only 1.9 dB re 1 μPa above the baseline sound level), and this total sound level falls off to 107.5 dB re 1 μPa at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 361 ft (110 m). Since the WTGs would be spaced farther apart than 361 ft (110 m), cumulative impacts from the operation of the 130 WTGs are not anticipated.

In order to determine the actual underwater sound level that is heard by finfish during operation, a dB_{ht} was calculated. Using the hearing threshold data from Table 5.3.2-4, dB_{ht} sound levels were calculated for proposed action's operation. Operation sound results are given for the two distances where source measurements were made in the Utgruden and Gotland wind parks, 65.6 ft (20 m) and 328 ft (100 m) (Report 4.1.2-1). Operation sound levels cannot be reliably estimated for distances closer than 65.6 ft (20 m) due to near-field effects._ The results indicate that at 328 ft (100 m) and 65.6 ft (20 m), perceived operational sound levels for finfish were 7 dB_{ht} re 1 μPa and 21 dB_{ht} re 1 μPa, respectively. Since operational sound would be only barely audible to finfish at the extremely close distance of 65.6 ft (20 m), it is also unlikely to have any adverse effect on fish eggs or larvae.

The results of this dB_{ht} analysis (Report No. 5.3.2-2) show that no injury or behavioral effects to EFH finfish species are predicted even if an individual were to approach as close as 66 ft (620 m) to a monopile when the proposed action is operating at the design wind speed because all dB_{ht} values at this minimum distance are well below 130 and 90 dB re 1 μPa. Operational sounds would only be slightly audible to finfish at the extremely close distance of 66 ft (20 m). Research conducted at offshore wind farms in Europe suggest that the very low vibration from wind turbines does not impact fishes in the region (AMEC, 2002). At the Näsrevet Windfarm in Sweden, Westerberg (1999) reported that the normal operational sounds of a wind farm did not greatly impact the migration of eels.

Based on the dB_{ht} analysis and observations from offshore wind farms in Europe (Vella, 2002; Westerberg, 1999), underwater sound levels from the WTGs for the proposed action are not anticipated to cause physical harm or behavioral changes to finfish, including those with designated EFH in the area.

Impacts to EFH from Rotor Shadows

As fish swim into the area affected by rotor shadow, they are unlikely to be startled because they would be able to see the periodic motion of the shadows ahead of time. Furthermore, shadows cast by wind turbine blades are unlikely to be perceived by fish as rapidly growing shapes, which is the primary cause of their startling (Webb, 1982) since this does occur with avian predation. Rather, the shadow shape should remain fairly constant at any given point in the water, even as the blades spin. When the blades are not spinning, the shadow would be relatively static. As the blades spin faster, the shadows of each individual rotor blade would become less distinct and harder to perceive. Additionally, the speed of the rotor shadow, as perceived by finfish, would remain fairly constant over short periods of time. This should preclude a sense of shadow acceleration (the looming threshold), as might be expected with avian predation from above (Paglianti and Domenici, 2006). As such, the number of energy-intensive predator evasion responses due to rotor shadow movement is expected to be minimal, and impacts from rotor shadows on EFH species would be negligible.

In addition, the fact that water is denser than air causes light to be refracted toward the water surface. Because the surface of marine water is inevitably wavy, this leads to a dappling effect of light and dark through the water column and on the seafloor. Marine fishes are accustomed to these shifting patterns of light from above—in fact, many fish species (e.g., whale shark and lanternfish) have developed camouflage that mimics these patterns (Harcourt and Stanley, 2007; Shedd, Aquarium 2007). Therefore, the relatively thin, shifting shadows cast by wind turbine rotors are not expected to significantly contribute to a sense of top-water predation.

Impacts to EFH as a result of Spills and Accidental Releases of Potential Contaminants

The WTGs have been configured to contain any fluid leakage and prevent overboard discharges. Well-maintained equipment and training of personnel would help prevent any spills from occurring. However, in the case of a spill, all service vessels would be equipped with spill handling equipment to minimize and mitigate any impacts. In addition, waste collection systems would be installed on board each WTG. The waste would be separated for proper disposal once the containers are off-loaded at the dock.

The ESP would have sealed, leak-proof decks, which would serve as fluid containment. In addition, spill containment kits would be available near all equipment. Furthermore, the applicant would develop a SPCC Plan in accordance with MMS regulations.

Oil would be stored in greater quantities than any other potential contaminant. To address this, a comprehensive OSRP is under development. The OSRP is likely to provide finfish with a level of protection that is equal to or greater than marine mammals or sea turtles. This follows from the fact that, in the unlikely case of an oil spill, finfish are generally less likely than marine mammals and sea turtles to surface and come into direct contact with the spill. Unlike marine mammals and sea turtles, finfish do not surface in order to breathe and many marine finfish species never surface during the free-swimming stages of their life history.

The areal extent of an oil spill associated with the wind turbines or maintenance vessels would be small such that a significant ecological impact would be unlikely. The only significant source of oil is associated with the ESP. If an oil spill were to occur within the proposed action area, including a mineral oil spill from the ESP, juvenile and adult finfish would be likely to avoid the area directly affected by oil spills, thereby minimizing direct mortality from contact with oil. Some commercial finfish species have floating egg and larval life stages, which are more susceptible to injury or mortality from oil spills than the free-swimming juvenile and adult stages. However, these species also typically spawn over large areas and produce hundreds of thousands to millions of eggs per fish each season. Therefore, a small oil spill from the turbines, maintenance vessels or the ESP in Nantucket Sound would be unlikely to have a significant impact on recruitment from early life stages. Finfish with demersal eggs and larvae are even less likely to be affected by oil spills.

Conclusion

Wind turbine operations are expected to have negligible to minor impacts on EFH, other than the very low probability occurrence of an accidental scenario, such as a commercial oil transport vessel colliding with a monopile and spilling a large quantity of cargo.

Species Specific Impact Summary

Potential impacts discussed above that may affect the benthic and pelagic fish and invertebrate species with designated EFH in the proposed action area are summarized in Tables 5.3.2-8 through 5.3.2-10. In order to assess impacts more efficiently, target species were grouped into four categories: early life stages (eggs and larvae) of benthic-oriented species (Table 5.3.2-8), early life stages of pelagic-oriented species (Table 5.3.2-8), older life stages (juveniles and adults) of benthic-oriented species (Table

5.3.2-9) and older life stages of pelagic-oriented species (Table 5.3.2-9). Since potential impacts to all species is highly dependent on the time of year that activities occur, Tables 5.3.2-8 and 5.3.2-9 also describe the potential season(s) when these life stages may be present in Nantucket Sound. Potential impacts to species with designated EFH in the proposed action area are summarized by the four categories described above in Table 5.3.2-10. This table describes the level of impact to each category using the MMS definitions of impact levels and provides a brief description of the potential impact. This table serves to address impacts to the fish and invertebrate species with designated EFH by categorizing them into four groups for comparison. As can be seen in Table 5.3.2-10, all impacts are projected to be minor or negligible.

5.3.2.9 Threatened and Endangered Species

This section provides an overview of the impacts on threatened and endangered species protected under the ESA that have the potential to occur in the site of the proposed action as well as two candidate species, the red knot and the eastern cottontail rabbit.

5.3.2.9.1 Construction/Decommissioning Impacts

Sea Turtle Species

The ESA/MESA protected sea turtle species may be impacted by a number of activities associated with proposed action construction, operation/maintenance and decommissioning.

Acoustical Harassment

Noise measurements and modeling are discussed in Section 5.3.2.6.1, which was done to help with the impact assessment of both marine mammals and sea turtles. Little published data were available regarding the hearing threshold for sea turtles. Unpublished data from the Office of Naval Research regarding a hearing threshold study being done at New England Aquarium on Green Turtles were obtained and combined with other available information in order to develop a hearing threshold for sea turtles. The hearing bandwidth is relatively narrow, ranging from 50 to 1,000 Hz, with a maximum sensitivity at around 200 Hz. The hearing threshold is very high, over 100 dB in the low frequencies where construction noise occurs.

A dB_{ht} was calculated for sea turtles to determine the actual underwater sound level that is heard by sea turtles from monopile installation at different distances from construction activities. The results of the dB_{ht} analysis show that no injury to sea turtles are predicted, if an individual were to approach as close as 30 m to the pile driving because all dB_{ht} values at this minimum distance are well below 130 dB re 1 µPa. In fact, sea turtles were found to be the least sensitive to noise of all the species evaluated.

A maximum sea turtle hearing thresholds for vessels was calculated for a distance of 100 ft (30.5 m). A level of only 17 dB_{ht} was calculated, well below the injury threshold of 130 dB_{ht} and the harassment threshold of 90 dB_{ht}. The animal would be able to hear the vessel, but no physical harm or behavioral effects would occur.

The jet plow embedment process for laying the offshore transmission cable system circuits and inner-array cables produces no sound beyond that produced by typical vessel traffic and the cable installation barge would produce sound typical of vessel traffic already occurring in Nantucket Sound. Furthermore, no substantial underwater sound would be generated during HDD.

Any sea turtles are likely to temporarily avoid a given area around the construction, and, given the known areas that the sea turtles inhabit within Nantucket Sound, only minor impacts would be anticipated due to proposed action construction generated noises. Any noise should not affect the migration, nursing/breeding, feeding/sheltering, or communication of sea turtles.

Noise produced by the decommissioning of the proposed action is expected to be similar to those produced during construction. Proposed action decommissioning would not require pile driving activities, which cause the highest sound levels of any activities associated with any phase of the proposed action.

In addition to pile driving noise, the post lease G&G investigation would result in noise associated with vibracores and drilling of bore holes to acquire subsurface geological information on the sea bottom. The vibracores would be accomplished via a small gasoline motor and the drilling of cores would be accomplished via a truck mounted drill rig on a barge. Both of these activities would be very short term, and these devices generate sound levels that are much lower than sound levels associated with pile driving. Sound levels from a small gasoline motor would be comparable to that associated with a small motorized boat. Sound levels from a truck mounted drill rig would be comparable to those on a small ship or large boat. These types of sounds occur regularly in the area. Thus noise impacts on T&E species are expected to be negligible with respect to G&G activity.

Increased Vessel Traffic

The proposed action would temporarily increase the number of vessels within the vicinity of the construction/decommissioning work areas, especially in the route between Quonset, Rhode Island and the area of the proposed action. Several shipping lanes and two navigational channels exist within the vicinity of the area of the proposed action. During construction activities, especially during pile driving activities, it is estimated that 4-6 stationary or slow moving vessels would be present in the general vicinity of the pile installation. Vessels delivering construction materials or crews to the site would also be present in the area between the mainland and the site of the proposed action. The post lease G&G field investigation would also require the use of vessels in the area (see Section 2.7). The barges, tugs and vessels delivering construction materials would be limited to speeds below 10 knots (5.1 m/s) and may range in size from 90 to 400 ft (27.4 to 122 m), while the vessels carrying construction crews would be traveling at a maximum speed of 21 knots (10.8 m/s) and would typically be 50 ft (15.2 m) in length. The additional traffic from construction vessels may increase the chance of a strike or harassment of sea turtles.

Prey and Habitat Reduction

Activities related to construction may cause a temporary and local reduction of available habitat for sea turtles within the greater area of the proposed action. The main anticipated impact would be avoidance of work areas around WTGs. Proposed action construction is not anticipated to result in permanent changes in sea turtle prey abundance or distribution. Some temporary displacement may occur during periods of noise or elevated suspended sediment concentrations, such as near the cable jetting, but this would be limited to areas directly surrounding the given activities, causing both prey species and sea turtles to move away. Benthic habitat disturbance due to construction activities may cause mortality to benthic organisms in the disturbed area, but similar benthic communities are found throughout Nantucket Sound, enabling sea turtles to find suitable prey in other areas, and the effect is temporary as the disturbed areas would become recolonized.

Habitat Shift (Non-structure Oriented to Structure)

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, open water habitat system to a structure-oriented system with a hard substrate fouling community, with potential localized changes in use of the area by benthic feeding sea turtles. The WTG monopile foundations would represent a source of new substrate with vertical orientation in an area that has a limited amount of such habitat, and as such may attract fish and benthic organisms, potentially affecting sea turtles by causing changes to prey distribution and/or abundance. While the aggregation of fish around the monopiles would not attract sea turtles, loggerhead and Kemp's ridley turtles may be attracted to the WTGs for the fouling community and epifauna that may colonize the monopiles as an additional food source. All four species may be attracted to the monopiles for shelter, especially loggerheads that have reported to commonly occupy areas around oil platforms (NRC, 1996).

Habitat Shift (Structure to Non-structure Oriented)

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. However, as the addition of the monopiles would be a minor addition to the hard substrate that was present prior to construction of the proposed action facilities, the removal of the WTGs and ESPs would not cause a great impact in the overall habitat structure. Therefore, sea turtle populations that consume colonizing benthic invertebrate prey are not likely to increase due solely to the presence of the monopiles and hence would not be greatly affected by their removal.

Turbidity and Total Suspended Solids

An increase in the TSS within the water can impact the foraging abilities of the sea turtles, decreasing the visibility of prey species. The suspension of sediments produced by proposed action construction is expected to be temporary and localized, as pile driving does not generate much suspended sediments and jet plow technology in sandy sediments results in minimal sediment release. The post lease G&G field investigation would also result in negligible sediment disturbance associated with the taking of vibracores and drilling of boreholes. Further, the physical composition of the sands and the physical characteristics of the sound environment provide reason to assume that any localized turbidity would settle back to the sea floor within a short period of time (one to two tidal cycles). Simulations of sediment transport and deposition for the proposed action demonstrate that jet plow embedment operations would result in a sediment plume below 50 mg/L, and would settle in less than 2 to 3 hours. Within Lewis Bay, suspended sediments are expected to remain in suspension for longer periods due to the weak tidal currents, with a plume in excess of 100 mg/L remaining for 2 to 6 hours depending on location and period of cycle. Decommissioning-related impacts would be short-term and localized and are expected to be similar to or less than impacts during construction.

Sea turtles that forage within the area of Nantucket Sound are naturally accustomed to substantial amounts of suspended sediment on a regular basis, from storms and strong tidal currents, and should be minimally impacted by a temporary increase in turbidity from proposed action activities, including the sea turtles that may inhabit or forage within Lewis Bay. Further, sea turtles are mobile and can move away from any disturbance, including any increases in suspended sediments. The impacts of increased turbidity on the foraging abilities of sea turtles are expected to be minor.

Cetaceans

Potential impacts to endangered and threatened cetaceans are described in more detail in Appendix C and will be covered in the Biological Assessment. In addition, impacts to endangered and threatened cetaceans are in many instances similar to those described for MMPA marine mammals (see Section 5.3.2.6). Vessel strike, underwater noise, and habitat shift are some of the potential adverse impacts that could occur during and after construction.

Vessel Traffic and Strikes

According to a recently published large whale ship strike database based on public information collected by NOAA Fisheries from 1975 to 2002 (Jensen and Silber, 2003) for the western North Atlantic, finback whales are the most often reported species hit by ships (75 records of strike) followed by humpback (44 records), North Atlantic right (38 records), gray (24 records), minke (19 records), southern right (15 records), and sperm whales (17 records).

As discussed above in the species descriptions for humpback, fin, and right whales, respectively, each of these species are known to seasonally migrate between their fall/winter mating, birthing, and nursing grounds in the southern waters of the West Indies and the mid- and south-Atlantic states (including the Carolinas, Georgia, and Florida), and their spring/summer feeding grounds in the western North Atlantic (Clapham 1992; Baraff and Weinrich 1993; Waring et al., 2006; NMFS 2005; CeTAP 1982; USEPA Region 1, 1988). Therefore, whales are only expected to be within the vicinity of New England waters during the spring and summer feeding seasons.

Although vessel collisions are a primary cause of large whale mortality in the western North Atlantic, the proposed action is not expected to put whales at increased risk for vessel collisions. Vessels moving at slower speeds (less than 14 knots [26 km/h]), such as the construction vessels to be used, are less likely to cause collisions (Laist et al., 2001). In addition, the vessel routes proposed to be used do not occur in areas where there have been high concentrations of whale sightings. Based upon the underdevelopment of whale prey species in Nantucket Sound, it is highly unlikely that whales would be migrating through, nursing, or feeding in Nantucket Sound. Therefore, the physical presence of vessels associated with the construction, operation, and decommissioning of the proposed action will not contribute to the harassment of migrating, nursing, or feeding humpback, fin, or right whales. Therefore, overall the impacts of increased vessel traffic should have minor impacts on listed whales.

Noise

The maximum submarine sound generated during construction will occur during installation of the monopile foundations. Sound levels measured during impact pile driving operations at the Utgrunden Wind Park in Sweden were used to model underwater sound expected from installation of the monopiles since the size of the monopiles and the installation techniques proposed for the proposed action are the same as for the Utgrunden Wind Park (Report No. 4.1.2-1). The Utgrunden data show a maximum (L_{max}) sound level of 178 dBL at 1,640 ft (500 m). 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.

The jet plow embedment process for laying the offshore transmission cable system circuits and inner-array cables produces no sound beyond that produced by typical vessel traffic and the cable installation barge will produce sound typical of vessel traffic already occurring in Nantucket Sound. No substantial underwater sound will be generated during horizontal directional drilling (HDD) operations used to transition the offshore transmission cable system to the upland 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 sound source level for a tug and barge traveling at low speed, typical construction vessels, is 162 dB re 1 μPa @ 1 m (Malme et al,. 1989).

In general, toothed whales have a hearing bandwidth of 100 Hz to over 100 kHz, with the most sensitive hearing in the high frequency range of 10 kHz to 65 kHz where their hearing threshold is 40 to

60 dB (Richardson et al., 1995). Baleen whales react primarily to sounds at low frequencies below 1 kHz, which is consistent with the fact these whales usually communicate at frequencies in the 20 Hz to 500 Hz range (Richardson et al., 1995). The hearing threshold for baleen whales ranges from 82 dB at 500 Hz to 88 dB at 20 Hz (Nedwell et al., 2004).

A dB_{ht} was calculated for several species of whales to determine the actual underwater sound level that is heard by whales from monopile installation at different distances from construction activities. The results of the dB_{ht} analysis, provided in Table 6 in Report 5.3.2-1 of the DEIS, show that no injury to whales are predicted if an individual were to approach as close as 30 m to the pile driving because all dB_{ht} values at this minimum distance are well below 130 dB.

Maximum whale hearing thresholds for vessels were calculated for a distance of 100 ft (30.5 m). Levels of 42 dB_{ht} and 45 dB_{ht} were calculated for whales and for toothed whales, respectively. These levels are well below the injury threshold of 130 dB_{ht} and the harassment threshold of 90 dB_{ht}. The animal would be able to hear the vessel, but no physical harm or behavioral effects would occur.

The jet plow embedment process for laying the offshore transmission cable system circuits and inner-array cables produces no sound beyond that produced by typical vessel traffic and the cable installation barge will produce sound typical of vessel traffic already occurring in Nantucket Sound. Furthermore, no substantial underwater sound will be generated during horizontal directional drilling.

Any whales are likely to temporarily avoid a given area around the construction, and only minor impacts would be anticipated due to construction generated noises. Any noise should not affect the migration, nursing/breeding, feeding/sheltering or communication of whales.

Noise produced by the decommissioning is expected to be similar to those produced during construction. However, decommissioning will not require pile driving activities, which cause the highest sound levels of any activities associated with construction.

Habitat Shift or Alteration

Activities related to construction may cause a temporary reduced availability of habitat for whales in the vicinity of the proposed action. The main anticipated impact would be avoidance of areas of high traffic. However, as under normal conditions the whales are exposed to high volumes of vessel traffic due to commercial and recreational ships within Nantucket Sound, the increase in traffic is not anticipated to displace whales for long periods of time. Some avoidance may also occur during construction activities due to acoustical harassment, as mentioned previously, however this disturbance will be temporary and will not result in any major effects on the listed whales.

Construction and decommissioning are not anticipated to result in changes in whale prey abundance or distribution. Some temporary displacement may occur during periods of noise or high suspended sediments, but this will be limited to areas directly surrounding the given activities, causing both prey species and whales moving to an undisturbed area. Pelagic prey tends to be highly variable and animals foraging on these sources move with the food source, as seen with many whales and their prey species. Any temporary disturbance to pelagic prey is likely to mimic typical temporal and spatial variability, and is likely available in other areas of Nantucket Sound and surrounding waters for foraging by whales.

Red Knot

The red knot is not a listed threatened or endangered species, but since it is a Candidate species and there is a possibility that it may be listed as one in the near future, it has been included in this section to allow for full consideration of impacts.

In North America, the red knot breeds in arctic zones of Alaska and Canada. The red knot does not breed in Massachusetts; however it occurs as a migrant at stop-over locations, and some individuals over-winter in Massachusetts. Staging areas are known to occur along the mainland shores of Cape Cod during migration, however patterns of activity in Nantucket Sound are poorly understood. The preferred foraging habitat of red knot is associated with inlets to estuaries and bays and in proximity to salt marshes. The closest known staging area in the general vicinity of the proposed action is Monomoy Island, approximately 20 miles (12 km) east of HSS (USFWS, 2006).

The red knot spring migration occurs from mid-February to mid-June. Fall migration occurs from mid-July to mid-November. Red knot peak occurrence in the region during the spring is mid-May, and mid-July in the fall, when the birds may occur at staging locations after long distance, non-stop flights from breeding or wintering grounds. The birds would remain at coastal stop-over locations for a few weeks to build up their fat reserves before resuming their dispersal (O'Brien et al., 2006).

The red knot may occur over areas of Nantucket Sound during migration. One red knot was observed during one boat survey during the 2002 to 2006 survey periods. No other individuals were observed in the study area during aerial or boat surveys conducted by the applicant or by MAS.

The potential impacts to red knot during construction and decommissioning include habitat loss or modification and disturbances associated with increased vessel activity.

Changes in sediment drift and deposition processes caused by construction may affect inter-tidal habitat structure and prey bases onshore. Any type of sediment removal, or disruption of normal coastal erosion and redeposition processes, may impact suitable habitat available within and adjacent to the area of the proposed action. Since it is only the offshore transmission cable system that would be constructed near shore, and it would be buried beneath the seabed, it is unlikely that a measurable change in coastal erosion or deposition processes due to construction activities would occur.

Habitat loss or Modification

The shoreline where the offshore transmission cable system would make landfall is primarily artificial shoreline, comprised of concrete and stone with minimal sandy areas. Habitat loss for the red knot is not expected because the inter-tidal area directly impacted by the offshore transmission cable system landfall in Yarmouth would be drilled under for installation of the cables. This area is not likely to provide habitat for red knot during migration and/or wintering periods. The beach habitat on Great Island represent the closest potential stopover habitat near the cable landfall construction area, and these beaches are not expected to be impacted by any of the construction or decommissioning activities as the shoreline would be drilled under for cable installation. These beaches occur in a developed area and experience high human activity.

The landfall site of the offshore transmission cable system in Lewis Bay is not known to provide stopover or wintering habitat for red knot. Specific construction techniques, including horizontal drilling, would minimize the impact of the proposed action on the inter-tidal community within the vicinity of the landfall site. The laying of submarine cables in Lewis bay and near the inlet of the bay are not expected to cause long term changes in inter-tidal habitat structure or prey availability. The increase in suspended solids and the relocation of sandy sediments would be temporary and would result in no lasting changes in the coastal areas of interior Lewis Bay, or the beaches on either side of the inlet.

Because of the inherent dynamic nature of all marine environments within the area of the proposed action, including the inter-tidal zone, disturbances created during construction and decommissioning are not expected to cause lasting or harmful effects. Small mortality events of infaunal organisms are likely to occur, but effects on local inter-tidal assemblages would be negligible. Disturbance of the sea floor within Lewis Bay may provide for opportunistic colonization by disturbance tolerant benthos after construction, and similarly after decommissioning activities; however, these changes are not expected to influence inter-tidal areas. Impacts associated with changes in inter-tidal habitat during installation of the offshore transmission cable system in Lewis Bay are anticipated to be negligible.

Vessel Traffic

There would be an increase in vessel activity associated with construction and decommissioning activities. A large vessel(s) would be used to transport and install the monopiles, towers, nacelles, hubs, and blades during construction and decommissioning. The vessel would be loaded in Quonset, Rhode Island, and would be anchored near the monopiles that are undergoing construction. During installation and decommissioning of the WTGs, the large vessel would make several trips from Quonset to the area of the proposed action. Additionally, smaller support vessels would make regular trips from nearby ports to HSS during the construction period.

A study investigating shorebird roost site selection at an important shorebird staging and over-wintering site in South Carolina indicated that out of 8 species studied, red knots were relatively sensitive to vessel traffic. The authors determined that red knots avoided roosting at sites that experienced high average boat activity, and red knots responded to boat activity within 1,000 m (Peters and Otis, 2007). Disturbances associated with increased boat traffic could deplete red knot energy reserves during critical pre-migratory periods. However, boat and other construction activities would mainly occur at offshore locations greater than 5 miles (8 km) from potential staging habitats along the mainland coast or along island shores. The closest distance of the offshore transmission cable system to potential staging habitat on the seaward side of Great Island is 0.8 miles (1.3 km). Near shore construction activities in Lewis Bay would be temporary and would occur outside of the known 1000 m vessel disturbance distance.

Therefore, construction and decommissioning vessel activity is expected to have negligible impacts to red knot.

Piping Plover

The following provides a summary of the proposed action construction and decommissioning impacts on the Piping Plover. Federally Threatened piping plover breed along the mainland and island shores of Nantucket Sound. Potential impacts to piping plover associated with construction and operation of the proposed action may include loss of habitat, disturbances associated with the presence or activity of construction or decommissioning equipment, disturbances such as barriers to flight paths due to the presence of the turbines, and risk of collision. Additional sources of impact include oil spills and disturbances associated with submarine cable repair.

Habitat Loss or Alteration

Habitat loss or alteration associated with construction/decommissioning or operation is not anticipated. The proposed WTGs would be located offshore, at least 5 mi (8 km) from the nearest nesting or staging habitat (Figure 5.3.2-4). The proposed landfall of the offshore transmission cable system would not occur within breeding habitat. The proposed action would not impact critical habitat as there are no designations in Massachusetts.

The proposed location of the landfall of the offshore transmission cable system is on the northeastern side of Lewis Bay at the end of New Hampshire Avenue in Yarmouth. Neither the proposed cable nor landfall would cross piping plover breeding habitat. The closest nesting location to the proposed landfall is approximately 1.5 mi (2.4 km) at Kalmar Beach/Dunbar Point in Hyannis. The closest distance of the offshore transmission cable system to the nearest piping plover nest site on the seaward side of Great Island is 0.8 mi (1.3 km) (Figure 5.3.2-4). The buried cables at their closest point would occur approximately 820 ft (250 m) from Kalmar Point/Dunbar Beach and approximately 1,210 ft (369 m) from Great Island. In addition, since the shoreline would be drilled under for cable placement, there would be no disturbance of beach areas.

Disturbance

High disturbance levels around nest sites can result in the abandonment of nests, and ultimately, decreased breeding success. Causing parents or juveniles to flush while foraging may stress juveniles enough to negatively influence critical growth and development. Potential disturbances during construction and decommissioning associated with increased human activity, the presence and operation of large equipment, and increased boat traffic offshore of nesting sites located closest to the proposed landfall, would be temporary and are not anticipated to impact breeding piping plover. It is possible that a tracking system consisting of a wire, for the operation of the drill head may be placed across the beach. This would be a minor, temporary activity that would not disturb the area more than a person walking on the beach.

Available data on disturbance distances suggest that flushing distances of incubating birds vary among sites and individuals. Disturbances resulting in flushing occurred as far away from nests as 689 ft (210 m), 984 ft (300 m), and 571 ft (174 m) at Nova Scotia, Virginia, and Maryland beaches, respectively (USFWS, 1996). The recommended disturbance buffer around nest sites is typically a 164 ft (50 m) buffer; however, at Maryland sites it is 738 ft (225 m) (USFWS, 1996). The mean flushing distance at Massachusetts nest sites is 24 m (USFWS, 1996). For non-incubating birds, the maximum disturbance distances reported for pedestrian, vehicles, pets, and kites are 197 ft (60 m), 230 ft (70 m), 328 ft (100 m), and 394 ft (120 m), respectively (USFWS, 1996).

Due to the 820 ft (250 m) (or greater) separation of the offshore transmission cable system from the nearest nesting beaches, disturbances associated with offshore construction or operation activities are not anticipated for nesting piping plover. In addition, since the shoreline would be drilled under for cable placement, there would be no disturbance of beach areas. The placement of a wire on the beach (and seafloor) to help guide and track the drill head would result in disturbance essentially equal to a person walking on the beach. The proposed landfall site is 1.5 mi (2.4 km) from the nearest nesting beach and, therefore, onshore construction or decommissioning activities are not anticipated to impact nesting piping plover.

Roseate Tern

The following provides a summary of proposed action construction and decommissioning impacts on the roseate tern. For a detailed analysis, refer to Appendix C, which provides information on T&E species and potential effects to T&E species. The potential impacts associated with the proposed action construction, and decommissioning include loss of habitat, habitat modification or prey displacement during construction, barriers to flight paths due to the presence of WTGs, collisions with proposed action structures, increased predation, and/or disturbances associated with increased vessel traffic during construction and decommissioning.

Habitat Loss or Modification

Terns traveling or foraging in the proposed action area could potentially be impacted by habitat loss or modification during construction and decommissioning activities. Some species of birds are more sensitive to disturbances than others and can be displaced up to hundreds of meters from the source of the activity (Gill 2005). Breeding terns would be most sensitive to construction and operation disturbances during the breeding season when they have increased energy demands.

There is no available breeding habitat within or in close proximity to the proposed action area boundary, and the offshore transmission cable system and proposed landfall would not cross breeding locations. All points along the transmission cable would be greater than 15 mi (24 km) to the nearest breeding location in Nantucket Sound on Monomoy Island. The center of the turbine array in HSS would be greater than 19.8 mi (31.8 km) to Monomoy Island and 11.5 mi (18.5 km) from the closest potential breeding habitat on Muskeget Island. Therefore, construction and decommissioning activities would not result in the loss of breeding habitat. However, terns travel substantial distances (16 to 19 mi [25.8 to 30.6 km]) from their breeding locations to access foraging habitat and terns may be affected as they travel or forage in the vicinity of the proposed action area. Because of the small footprint of the actual development area (individual WTGs and the ESP), minimal habitat loss is anticipated during proposed action construction and decommissioning activities.

Construction and decommissioning activities could directly deter roseate terns or their prey from the proposed action area resulting in the temporary or permanent loss of habitat. Baseline surveys conducted in Nantucket Sound, documented minimal tern use of the HSS area in relation to other locations in the Sound. Most terns were observed traveling, fewer were seen actively foraging. Terns are known to regularly forage near recreational fishing boats, ships, and other man-made structures. Terns and gulls are among species of birds that have been observed in the vicinity of operating turbines at European offshore facilities (Everaert and Stienen, 2006; Petersen et al., 2006; Pettersson, 2005). Roseate terns would likely continue to forage and travel in the vicinity of construction activities, assuming that their food sources are not displaced. Impacts associated with displacement of prey fish during construction are anticipated to be minimal and temporary. The natural benthic substrate and prey fish communities would be maintained following a period of recovery from the construction or decommissioning disturbances.

Vibrations from pile-driving could startle and temporarily displace prey fish from the proposed action area. Increases in turbidity from offshore cable trenching could temporarily impede fish foraging and navigation in disturbed areas (Jarvis, 2005). Construction activities could affect fish and benthic communities up to 328 ft (100 m) from the activity (Nedwell et al., 2004 *as cited by* Gill, 2005). However, impacts to foraging habitat are anticipated to be minimal as construction activities would be temporary and localized. A jack-up barge with a crane would be used to install the monopiles. There would be a total of two pile driving rams used to fix the 130 monopile structures into the seabed and it is unlikely that both rams would be used simultaneously. The hollow monopiles are expected to trap the majority of sediment displaced during pile driving.

Sediment suspended by trenching during offshore cable installation is expected to be localized (20 milligrams/liter within 1,500 feet [457 m] from the trench) and is expected to quickly resettle (within minutes or up to a few hours) (Report No. 4.1.1-2). Jet plow embedment would allow for simultaneous plowing and cable-laying to minimize impacts. As a result of disturbances to sediment during trenching and pile driving, small benthic organisms would be stirred up and prey fish may be attracted to the area to forage. This in turn could attract roseate terns to forage. However, this is likely to be a very localized event and is unlikely to represent anything more than a minor potential benefit for foraging terns.

Vessel Traffic

Increases in vessel traffic could result in impacts to roseate terns during the construction, operation, and decommissioning phases. A large vessel(s) would be used to transport and install the monopiles, towers, nacelles, hubs, and blades during construction and decommissioning. The vessel would be loaded in Quonset, Rhode Island, and would be anchored near the monopiles that are undergoing construction.

During installation and decommissioning of the WTGs, the large vessel would make several trips from Quonset to the proposed action area. Additionally, small vessels from Falmouth, Massachusetts, and a maintenance support vessel from New Bedford would make regular trips to HSS during the construction period. While the proposed turbines are in operation, there would be regular vessel trips made from Falmouth and New Bedford harbors to the proposed action area. The expected maintenance schedule would be approximately 2 vessel trips per day for 252 days per year (5 maintenance days per turbine per year) (see Section 2 of the DEIS for a description of maintenance activities).

During high surf conditions, workers may be transported by helicopter to the platform on the ESP. There may also be occasional helicopter landings at the ESP in association with some regular maintenance activities. An increase in recreational fishing may occur around the WTGs if fish populations aggregate around foundations. The arrival of vessels and helicopters could temporarily displace terns from localized areas within the larger proposed action area. This type of disturbance already occurs to some extent within and adjacent to the proposed action area due to existing levels of vessel activity, and the temporary incremental increase is likely to have only a minor affect on roseate tern use of the construction areas.

New England Cottontail

Small populations of New England cottontails were observed in Barnstable County during a 2000 - 2003 survey (MDFW, 2003). The upland work associated with the installation of the underground cable would be located within either streets or an existing previously disturbed utility ROW. As such, construction impacts to eastern cottontail rabbits are expected to be negligible. Construction of the WTGs would not have an impact on New England cottontails as the WTGs would be located far offshore.

Conclusion

The overall impacts from construction and decommissioning activities associated with sea turtle species, cetacean species and the red knot are expected to range from negligible to minor as these impacts would be for the most part confined to the duration of the proposed action and the area of the proposed action activities. Impacts associated with the piping plover would be negligible to minor, and impacts associated with the roseate tern would be minor. These impacts are principally related to habitat disturbance, vessel movement and construction activities. Some mitigation measures being considered at this time include construction techniques, requiring a NMFS-approved observer on-site during all pile driving activities, the use of a bubble curtain, and restricting construction to less sensitive periods. Construction impacts associated with the New England cottontails are expected to be negligible since upland work associated with the installation of the underground cable would take place in streets or an existing utility ROW.

5.3.2.9.2 Operational/Maintenance Impacts

Sea Turtle Species

Vessel Harassment/Strikes

The proposed action operation and maintenance activities are expected to require two vessel trips per working day for 252 days of the year. The vessels are anticipated to consist of small crew boats and slower moving supply vessels, similar to the smaller vessels to be used during proposed action construction.

As previously discussed, sea turtles do not appear to be exceedingly disturbed by the physical presence and sound produced by vessels, and the vessel traffic itself (NMFS, 2001; NMFS, 2002). Sea turtles should be able to detect and move away from any proposed action vessel by diving into deeper waters. Any impact would be limited to temporary avoidance of an area; however, this is unexpected due to the high volumes of vessel traffic that normally travel the waters of Nantucket Sound. Therefore, the impacts of increased vessel traffic should have minor impacts on listed sea turtles. One exception to this is that if the loggerhead and Kemps Ridley sea turtles selectively feed around the monopiles, they may interact with the maintenance vessels. However, as the maintenance vessels approach the monopile, they would be at very low speeds and unlikely to strike a sea turtle.

Acoustical Harassment

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Existing underwater sound levels for the design condition are 107.2 dB. The calculated sound level from operation of a WTG is 109.1 dB at 20 m from the monopile (i.e., only 1.9 dB above the baseline sound level), and this total falls off to 107.5 dB at 50 m and declines to the baseline level at a relatively short distance of 110 m.

An analysis of predicted underwater sound levels perceived by sea turtles from proposed action operation show that no injury or harassment to sea turtles are predicted, even if an individual were to approach as close as 20 m to a monopile. When the proposed action is operating at the design wind speed as all dB_{ht}, values at this minimum distance are well below 90 dB. In fact, proposed action operation would be inaudible for sea turtles.

Electromagnetic Fields

Potential impacts to sea turtles during the normal operation of the inner-array cables and the offshore transmission cable system circuits are expected to be minor, as the electric field would be mainly contained within the shields surrounding the cables. The magnetic fields associated with the operation of the cables are not anticipated to result in an adverse impact to sea turtles or their prey. The burial depth of 6 ft (1.8 m) below the seabed would also minimize potential thermal impacts from the operation of the cables. Therefore, it is anticipated impacts to sea turtles or their prey species during the normal operation of the cable systems are expected to be minor.

Pollution/Potential Spills

While improbable, an oil spill would have minor to moderate impacts on sea turtles within Nantucket Sound. The type of oil, length of exposure, condition of the oil in terms of weathering and life stage at which the sea turtle is exposed to the spill would all play a role in the impact on the animal. While some oil products would be present within the proposed action structures, the relatively small amount of oil being used would tend to produce a small plume in the event of a spill.

Sea turtles are vulnerable at all life stages, with the most vulnerable stages being the eggs, embryos and hatchlings, which do not occur in Nantucket Sound or in the Northeast. Adult sea turtles are also extremely vulnerable to oil spills. Sea turtles can be harmed if they surface in an oil slick to breath. Oil can affect their eyes and damage airways or lungs, can absorbed through their skin and can be ingested through contaminated foods. Sea turtles also seem unable to distinguish between food and tar balls, and show no avoidance behavior when encountering oil slicks (Report No. 5.2.1-1). Of the species that may occur within the vicinity of the area of the proposed action, Kemp's ridley sea turtles may be most impacted by an oil spill, as it has a small population size and limited nesting distribution. However, the overall potential for an oil spill from the proposed action is very low, and the amount of oil being used and the distance to shore would lead to less severe impacts in any case of oil spill from proposed action facilities.

The exception to this is in the event of a commercial oil transport vessel collision with a WTG, should a cargo container rupture. In such an event, tens of thousands of gallons of oil could be released. Recent experience with the *Bouchard No. 120* grounding in Buzzards Bay provides an example of the extent of dispersal that can occur. However, the low probability of such an event would suggest that the potential for harm or injury to sea turtles would be minor.

Turbidity and Total Suspended Solids

During operation, there are potential impacts related to turbidity and total suspended solids that could occur in the unlikely event of a cable repair. Such impacts would include temporary turbidity and some localized deposition of sediments during the repair process. Turbidity would be caused by the jetting of sediments to uncover the damaged portion of the cable, hoisting of the cable after it is cut, laying the cable back down, and then jetting of sediments for reburial of the repaired cable. Cable repair procedures are discussed more thoroughly in Section 2.4.6. Impacts on listed sea turtle species as a result of cable repair would be minor because of the temporary and localized water quality effects.

Cetacean Species

The impacts from proposed action operations on endangered and threatened cetaceans are essentially the same as those described for MMPA marine mammals in Section 5.3.2.6.

Wind Turbine Operational Noise

Once installed, the operation of the WTGs is not expected to generate substantial sound levels above baseline sound in the area. Acoustic modeling of underwater operational sound at the Wind Park was performed for the design wind condition (see Section 3.13 of ESS, 2007). Baseline underwater sound levels under the design wind condition are 107.2 dB re 1 μPa. The predicted sound level from operation of a WTG is 109.1 dB re 1 μPa at 65.6 ft (20 m) from the monopile (i.e., only 1.9 dB re 1 μPa above the baseline sound level), and this total sound level falls off to 107.5 dB re 1 μPa at 164 ft (50 m) and declines to the baseline level at a relatively short distance of 110 m (361 feet). Since the WTGs will be spaced farther apart than 360 ft (110 m) (approximately 629 to 1,000 m or 0.39 to 0.63 miles apart), no cumulative impacts from the operation of the 130 WTGs in the Wind Park are anticipated.

An analysis of predicted underwater sound levels perceived by whales during operations show that no injury or harassment to whales are predicted even if an individual were to approach as close as 65.6 ft (20 m) to a monopile when the turbines are operating at the design wind speed as all dB_{ht} values at this minimum distance are well below 90 dB. In fact, operation sounds will be inaudible for toothed whales, and only slightly audible to baleen whales at the extremely close distance of 65.6 ft (20 m). Therefore, no behavioral effects to whales are anticipated even if an individual were to approach within 65.6 ft (20 m) of the structures.

Habitat Shift

The presence of 130 monopile foundations, 6 ESP piles and their associated scour control mats or rock armor in Nantucket Sound has the potential to shift the area immediately surrounding each monopile from soft sediment, open water habitat system to a structure-oriented system, with minor effects to whales.

Unplanned and Accidental Events

Accidental and unexpected events associated with the proposed action could impact whales. Such impacts would primarily be the result of oil spills, but may also relate to cable repair, collapse of a monopile, and vessel collision with a project structure.

Oil spills could occur either as a release from the ESP storage tank or from a vessel collision with a monopile. Little species-specific information is available regarding the effects of oil spills on whales. Past studies suggest that large whale species do not seem to be particularly sensitive to oil spills. Because they rely on blubber for insulation, whales are less vulnerable to oil spills than fur-coated marine mammals which can die from hypothermia when coated in oil. In addition, humpback whales, fin whales and right whales are all migratory which may limit their exposure to a persistent oil slick in a small geographic area. Although most research suggests that whales do not appear to be especially sensitive to spills, other studies have shown that there are negative long-term effects to whales from exposure to oil. When surfacing, oil may irritate whale's eyes and skin and they may breathe in harmful fumes. Other symptoms of acute exposure to oil include lethargy, poor coordination and difficulty breathing which can lead to drowning (Hammond et al., 2001).

Many of the types of disturbances that would occur during cable repair activities are smaller and shorter duration, but of similar type, to those that would occur during cable installation. A relatively short distance along the sea floor would be disturbed by the jetting process used to uncover the cable and allow it to be cut so that the ends could be retrieved to the surface. In addition to the temporary loss of some benthic organisms, there would be increased turbidity for a short period, and a localized increase in disturbance due to vessel activity, including noise and anchor cable placement and retrieval. Given the small area, short duration, and infrequency of occurrence of listed whales in the proposed action area, potential adverse impacts from cable repair activities on the listed whales would be negligible.

The extent of potential impacts that could result from a vessel collision with a monopile largely depends on the extent of damage to the monopile or vessel, as well as the nature of the vessel. Some smaller vessels would merely strike a glancing blow and suffer some hull damage but not sink. Other vessels may suffer enough damage to sink, causing a small release of fuel and debris. A larger vessel, such as an oil tanker, would most likely cause a collapse of the monopile, also resulting in a small release of lubricating fluid. If oil being transported were to be released, then depending upon the quantity released, an oil spill that escapes Nantucket Sound could directly affect listed whales (see section 5.2.1.1). Repair of a damaged or collapsed monopile would create short term and localized disturbances to the benthos, water column, and pelagic organisms similar to the construction and decommissioning of a single monopile, albeit in reverse order and combined in a single event. Since these disturbances are localized to the monopile they are unlikely to adversely affect listed whale species, and therefore potential adverse impacts resulting from a vessel collision with a monopile and the associated repair activities on the listed whales would be negligible.

Red Knot

The potential impacts to red knot during proposed action operation may include impacts associated with disturbance from vessel activity during any necessary cable repair, impacts associated with oil spills or WTG structure or ESP fluid spills, and the risk of collision of migrant red knots with WTG structures.

Vessel Traffic

There would be an increase in vessel activity within the Horseshoe Shoal area associated with maintenance of the WTGs during the operational period. During operation, maintenance vessels would mainly operate out of Hyannis or similar Cape Cod ports. These ports have adequate facilities for berthing and loading of the maintenance vessels. These ports occur in developed areas and currently experience similar uses. There are no known important staging areas in the vicinity of these ports; therefore, the increase in vessel activity in these areas is anticipated to result in negligible impacts to red knot.

There may be an increase in vessel activity associated with offshore cable repair during the operation phase. However, the cable is designed under normal conditions to last the life of the project. The closest distance of the offshore transmission cable system to potential staging habitat on the seaward side of Great Island is 0.8 miles (1.3 km). Near shore construction activities in Lewis Bay would be temporary and would occur outside of the 1000 m vessel disturbance distance for red knot. Therefore, vessel disturbances associated with cable repairs are anticipated to result in negligible impacts to red knot

Oil Spills

The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. Oil spills may result in the release of contaminants from vessels or from the WTG or ESP foundations themselves. Depending on the location and the size of a spill, red knots may be impacted. If the feathers of birds become coated with oil, birds loose their ability to repel water and to insulate, and in some instances, loose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening (Jarvis, 2005).

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2003). Shorebird habitat was impacted by the oil spill, particularly at Barney's Joy, Dartmouth, and shorebird mortality was a resulting impact.

Monopile collapse, vessel collisions, or storm damage to the ESP or WTG structures could result in oil or other fluid contamination. The total maximum oil storage on the ESP is expected to be approximately 42,000 gallons at any given time. The total oil storage at each WTG is expected to be approximately 214 gallons at any given time (27,820 gallons for all 130 WTGs). In the unlikely event that an oil spill was to occur, the oil is most likely to travel toward the south shore of Cape Cod and the eastern shore of Martha's Vineyard (20 percent to 30 percent). It has a 90 percent chance of impacting any shoreline in the area.

The potential impacts of oil spills associated with the operation of the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in the mortality of red knot if staging areas were to be impacted. Oil spills that occur outside of dispersal, staging periods, or wintering periods could result in no impacts to red knot. Due to the distance between the WTG area and the closest known red knot migratory and wintering habitat on Monomoy, the potential for impacts are reduced, and when the probability is considered, oil spills should be considered to represent a minor impact.

Risk of Collision

There is the potential for red knot collisions with the proposed WTGs. The risk of collision is dependent on the frequency of occurrence of red knots within the site of the proposed action, visibility during potential red knot encounters with WTGs, and the flight behaviors of red knots within the area of the proposed action.

Red knots may occur with the area of the proposed action during migration, however, no red knots were observed in HSS during aerial and boat surveys conducted during 2002 to 2006. One individual was observed during one of the applicant's boat surveys near Cape Poge off of Martha's Vineyard on September 13, 2002. The individual was in a mixed flock of sandpipers and was observed flying low over the water.

Red knots undertake one of the longest known migrations and may travel thousands of kilometers without stopping (Harrington, 2001). Departure for migration for most shorebirds, including red knots, tends to occur on sunny days in the few hours before twilight (Harrington, 2001). Red knots tend to occur in larger flocks than most other shorebirds with flocks sizes at over one hundred individuals; the average size of red knot flocks consisted of roughly 50 individuals at one study location (Harrington, 2001). Observations suggest red knots fly in v-formations, and mixed flocks eventually segregate according to species after departure from beaches (Harrington, 2001). Flocks observed departing for migration, gained altitudes at relatively high rate of 0.91 m/s compared to 7 other species observed (Harrington, 2001). Limited migration behavior information suggests that red knots mainly migrate during periods of good visibility and that they may travel at relatively high altitudes. These behaviors may put red knot at a low risk of collision with the proposed turbines, however, more site specific information is required to assess their risk.

Red knot are known to occur regularly during migration on Monomoy Island (USFWS, 2006), especially during the late summer and early fall. Migration paths and flight altitudes used to access Monomoy are not known. The observation of one individual near Cape Poge off of Martha's Vineyard may indicate that red knots also utilize beach and inter-tidal areas associated with the islands of Nantucket Sound, or that some individuals may pass Martha's Vineyard while accessing staging habitat. No other individuals were observed in the study areas and no individuals were observed within HSS during the 2002 to 2006 boat and aerial surveys. However, aerial and boat surveys were conducted during the day, and therefore it is not known whether red knot may cross HSS during nighttime migration movements. Additionally, there are limitations to visual observations of shorebirds flying near the surface of the water from aerial surveys, as well as visual observations of high flying shorebirds from the surface of the water during boat surveys. More information is needed to access red knot occurrence and flight behavior in HSS during the day and at night, during a variety of weather conditions. However, the results of available surveys indicate a low chance of occurrence of red knot in the area of the proposed action. The risk of collision is low and therefore, collision mortality associated with the proposed action is anticipated to result in negligible impacts to red knot.

Piping Plover

Minor adverse impacts to piping plover are anticipated during operation of the proposed action. The site of the proposed action does not occur within breeding or staging habitat, or within a known migration or movement corridor. Therefore, the effects of loss of habitat or habitat modification would be negligible. There are no features that would funnel piping plover across the site of the proposed action if their movements were to result in crossings of Nantucket Sound during the breeding season or migration season. Therefore, the presence and operation of the WTGs is not expected to present a major barrier to the flight paths of transient plovers. Piping plover that encounter turbines during crossings of the Sound are generally expected to avoid collisions with WTG structures depending on visibility. These avoidance behaviors are expected to result in minor changes to piping plover flight behavior and minimal increases in energy expenditure. Therefore, the presence of WTGs in HSS may affect piping plover, but minor adverse impacts are anticipated.

WTG Presence and Rotor Movement

During the breeding season, piping plover remain in close proximity to nests as they forage on invertebrates in the inter-tidal zone near nest sites. During this period, plovers mainly travel by walking or running between foraging and nearby breeding sites. Their regular daily movements would not result in crossings of the proposed action area. However, there have been some observations of plovers during the breeding season departing land and heading for the horizon. There are no known flight corridors for plovers over the Sound during the breeding season. There are no topographical features such as shortest crossings that would direct occasional flights over the Sound into HSS. Therefore, the presence and operation of turbines is not anticipated to present a major barrier to the flight paths of piping plover.

Other unusual crossings of Nantucket Sound during the breeding season could include the crossings of failed breeders or unpaired birds seeking alternate habitat or a mate. However, aerial and boat surveys conducted in 2002, 2003 and 2004 in Nantucket Sound did not detect such movements in any of the study areas. There is no data available that suggest piping plover would cross HSS during such movements; therefore, the WTGs are not anticipated to create a major barrier to the flight paths of piping plover.

The majority of Atlantic Coast piping plover migratory movements is believed to take place along the outer beaches of the coastline (USFWS, 1996). Most movements are believed to occur along a narrow flight corridor, and offshore and inland observations are rare (USFWS, 1996). Some birds may occur inland or offshore if blown off course by weather events. The birds that breed or stop-over on islands in Nantucket Sound and Vineyard Sound would make over-water crossings while accessing these locations. Therefore, there is a potential that piping plover could occur in the proposed action area during migratory or post-breeding dispersal movements. However, there are no topographical features that would funnel piping plover through HSS. Therefore, the presence of the WTGs is not expected to present a major barrier to the flight path of migrating piping plover.

Risk of Collision

Piping plover cross areas of Nantucket Sound to access breeding locations during migration or dispersal, and may sporadically cross the Sound during the breeding period. However, the flight paths of piping plover through the Sound are not known. The migration flight paths of piping plover along the Atlantic Coast are expected to occur within a narrow corridor along the coast but some birds may occur offshore or inland. Piping plover migrate both day and night and could travel during periods of inclement weather when visibility is reduced. However, studies suggest that migration of birds is reduced during periods of inclement weather (Petersen et al., 2006). Birds have demonstrated turbine avoidance behaviors both during the day and at night. If piping plover were to occur within the area of the proposed action, they would generally be expected to visually detect and avoid collisions due to FAA lighting on the nacelles as well as sources of natural lighting. More information is required to assess the effects of refracted light during periods of rain or fog to traveling piping plover. There are no topographical features that would funnel piping plover through HSS, therefore, crossings of the site of the proposed action are expected to be few in relation to the number of birds that could potentially cross Nantucket Sound over the course of a year.

Hatch and Brault (2007) (Report No. 5.3.2-1) estimated the number of piping plover turbine encounters per crossing of the wind turbine array, assuming all turbines were aligned perpendicular to each bird's path, based on three different flight height scenarios: If all individuals fly below 30 m, the expected encounters per crossing would be 0.07; if all birds fly in the rotor swept zone (75.5 to 440 ft [23 to 134 m]), there would be 0.67 encounters; and if flights are evenly distributed from 30 to 600 m then there would be 0.13 encounters. The authors suggest that, based on high avoidance rates estimated for other species, the likelihood of collision resulting from encounters is low (see Collision Probability

Modeling for description of avoidance rates). The authors assume that all encounters with stationary monopiles would be avoided.

Hatch and Brault (2007) (Report No. 5.3.2-1) used the Band Collision Risk Model to estimate a 91 to 99 percent plover turbine avoidance rate based a range of known avoidance rates calculated for other species. These avoidance rates are consistent with rates calculated at a few existing wind farms in the U.S. where mainly geese and raptor species were estimated to have avoidance rates greater than 95 percent. Fernley et al., (2006) calculated the avoidance rates of geese at four operating land-based wind farms in the U.S. using the Band Collision Risk Model. The avoidance rates calculated at the four facilities ranged from 99.82 percent to 100 percent despite high usage by geese at these wind farm sites. Whitfield and Madders (2006) used the Band Collision Risk Model to estimate the avoidance rate of hen harriers (*Circus cyaneus*) at eight wind farms in the U.S. Estimates were: 100 percent at 6 sites, 99.8 percent at 1 site, and 93.2 percent at 1 site. Other avoidance rates reported include: 99.62 percent mainly for gull species at Blyth Harbor in Northeast England, 99.5 percent for golden eagle (*Aquila chrysaetos*) at a U.S. facility, and 99.98 percent for passerines at the Oosterbierum wind farm in the Netherlands (Chamberlain et al., 2006). There are, however, limitations to the Band Collision Risk Model, as it does not account for differences among bird activities and behaviors under a range of conditions, and because avoidance rates exhibited by a range of species are understudied (Chamberlain et al., 2006).

Chamberlain et al., (2006) warned against the inaccuracies that can result in collision models that are based on the avoidance rates calculated for other species. Hatch and Brault (2007) (Report No. 5.3.2-1) provided an estimate of the number of plover crossings of the proposed action area per year. This estimate was based on the number of breeding plovers from Massachusetts northwards, including the Atlantic Canada population. It was estimated that 2,458 plovers cross the Massachusetts coastline over the course of a year (based on adults in spring and fall, and fledglings). MassWildlife suggested that less than 200 piping plover would cross HSS in a year (Report No. 5.3.2-1). This figure was applied to the model with varying scenarios of flight height and collision probability. Based on an avoidance rate of 98 percent, if all flights occurred in the rotor zone, one piping plover collision would occur in 5.5 years; if all flew below 98 ft (30 m), there would be one collision in 50 years; if flight heights were distributed between 98 to 1,968 ft (30 to 600 m), there would be one collision in 28 years. Using the avoidance rate of 91 percent, there would be 1.2 collisions per year if birds flew exclusively in the rotor zone, 1 collision in 12 years if all birds flew below 98 ft (30 m), and 1 collision in 6 years if flight heights were distributed between 98 and 1,968 (30 and 600 m). The authors emphasize the uncertainties surrounding the model including the lack of information regarding piping plover occurrence and flight behavior in HSS, as well as the lack of a species-specific avoidance rate.

A population viability analysis (PVA) was developed by Brault (2007) (Report No. 5.3.2-4) using the most recent breeding population trends of both the Atlantic Canada and New England population. The model estimated a range of mortality associated with the proposed action that could be tolerated by the population without increased risk of extinction or decreased probability of recovery goals (the author used 600 breeding pairs for New England, although the current recovery goal is 625 pairs; the correct recovery goal of 400 pairs was used as the Atlantic Canada threshold). The author modeled varying kill rates with no growth and intermediate growth scenarios. It was estimated that a take of up to 5 piping plover per year would not influence the likelihood of achieving Atlantic Coast recovery goals, or influence the probability of extinction. It was estimated that the increase in the risk of extinction was low over a period of 50 years with wind farm fatalities up to 20 birds per year, given that there are no changes in available breeding and wintering habitat. It was determined that changes in the annual survival rate had 2.25 times the effect on population dynamics than did changes in productivity. The author emphasized that the potential impacts associated with the proposed action are greatly dependent on the level of management efforts. The PVA used a New England recovery goal of 600 breeding pairs instead of the actual 625 breeding pairs. This discrepancy in 25 birds is likely an insignificant factor to the wide range of parameters factored into the model; however, it represents a flaw in the model.

Assuming the estimated worst case scenario of 1.2 wind farm-related piping plover fatalities per year with the low turbine avoidance rate of 91 percent, calculated by Hatch and Brault (2007) (Report No. 5.3.2-1), the recent PVA model suggests that the proposed action would not significantly impact the probability of achieving recovery goals or the influence the probability of extinction. However, there is a large range of uncertainty surrounding the collision mortality estimate. The actual number of crossings of the proposed action area per year, the average height of flight during crossings, and the turbine avoidance rates specific to piping plover are not known. The estimate of 1.2 wind farm-related fatalities is conservative because it assumed that piping plover exhibit a low turbine avoidance rate and that all birds fly through HSS at rotor height. The assumption that all piping plover would cross the proposed action area at rotor height is likely inaccurate; however, it is appropriate to be conservative until more data is available.

Non-Routine, Unplanned and Accidental Events

Piping plover may be impacted by oil spills, monopile collapse, cable repair, and pre-construction geotechnical and geophysical investigations. Depending on the season, and the size and location of the area affected by an oil spill, a spill in Nantucket Sound could result in the decreased breeding success or mortality of piping plovers. However, an oil spill is an unlikely event and due to the distance of the area of the proposed action from the major breeding areas, negligible impacts are anticipated to result form oil spills. Furthermore, if a spill were quickly detected and contained, negative impacts could be minimized or avoided. Most potential affects from monopile collapse would occur offshore and not affect shoreline areas used by the piping plover.

The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions, and possibly oil spills. Contamination may result from the release of fluids from vessels, or from the WTG or EPS structures themselves. Depending on the size and location of an area impacted by an oil spill, spills could result in the direct mortality or decreased breeding success of piping plovers. If the feathers become coated with oil, birds loose their ability to repel water and to insulate (Jarvis, 2005). Potential impacts include mortality from heat loss, starvation, or drowning. Some birds may loose their ability to fly. Mortality can result if toxins are ingested through water or during preening. Also, nesting birds can transfer oil to their eggs resulting in decreases in hatching success, developmental problems, or the mortality of embryos (Jarvis, 2005).

Oil spills can impact large areas if the spills are not immediately contained. The coastline of Buzzards Bay was impacted when the *Bouchard No. 120* collided with rocks off the coast of Westport in 2003. Oil was reported as far as Block Island and Middleton, Rhode Island (BBNEP, 2003). Piping plover were impacted by the oil spill, particularly at Barney's Joy, Dartmouth. Two piping plover were reported dead as a result of oil slicking. However, overall nesting success that year was not believed to be adversely impacted (BBNEP, 2003).

The potential impacts of oil spills associated with the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in the loss of piping plover adults or could lead to decreased nesting success. Oil spills that occur outside of the breeding or dispersal periods could result in no impact to piping plover. Due to the distance between the WTG area and the closest piping plover nesting location (approximately 5 miles [8 km]), as well as the low probability of occurrence, the potential for impacts from an oil spill are minor.

The disturbances associated with cable repair activities are expected to be of a similar type but shorter and less extensive than during cable construction. Regular maintenance activities are not anticipated for the submarine cables. Due to the 250 m (or greater) buffer of the offshore transmission cable system from the nearest nesting beaches, disturbances including increased human presence and vessel traffic associated with offshore maintenance activities are not anticipated for nesting or foraging piping plover, and overall cable repairs would have a negligible affect on piping plover.

Roseate Tern

The Federally Endangered roseate tern breeds at limited colony locations within Buzzards Bay and Nantucket Sound (see Appendix C, which provides information on T&E species and potential effects to T&E species). The potential impacts associated with proposed action operation include habitat loss or modification, barriers to flight paths due to the presence of WTGs, collisions with proposed action structures, increased predation, and/or disturbances associated with increased vessel traffic. Additional sources of proposed action impacts include oil spills, monopile collapse, cable repair, and geotechnical and geophysical investigations.

Habitat Loss or Modification

There is no available breeding habitat within or in close proximity to the proposed action area boundary, and the offshore transmission cable system and proposed landfall would not cross breeding locations. All points along the transmission cable would be greater than 15 mi (24 km) to the nearest breeding location in Nantucket Sound on Monomoy Island. The center of the turbine array in HSS would be greater than 19.8 mi (31.8 km) to Monomoy Island and 11.5 mi (18.5 km) from the closest potential breeding habitat on Muskeget Island. Therefore, operation of the project would not result in the loss of breeding habitat. However, terns travel substantial distances (16 to 19 mi [25.8 to 30.6 km]) from their breeding locations to access foraging habitat and terns may be affected as they travel or forage in the vicinity of the proposed action area.

Operation theoretically could directly deter roseate terns or their prey from the proposed action area resulting in the temporary or permanent loss of habitat. Baseline surveys conducted in Nantucket Sound, documented minimal tern use of the HSS area in relation to other locations in the Sound. Most terns were observed traveling, fewer were seen actively foraging. Terns are known to regularly forage near recreational fishing boats, ships, and other man-made structures. Terns and gulls are among species of birds that have been observed in the vicinity of operating turbines at European offshore facilities (Everaert and Stienen, 2006; Petersen et al., 2006; Pettersson, 2005). Roseate terns would likely continue to forage and travel in the vicinity of operating WTGs, assuming that their food sources are not displaced.

The boundary of the proposed action area would include approximately 25 square miles (6474 hectares) of WTGs and ESP (electrical service platform) foundations, and 5.89 acres (2.4 hectares) of transmission cable. The total area represents 11 percent of Nantucket Sound (Jarvis, 2005). However, the total area of seabed that would permanently be disturbed would be less than 1 percent of the total wind farm area including approximately 1 acre (0.4 hectares) for the 130 turbines, 100 by 200 ft (30.5 to 61 m) for the ESP platform, and over 45 acres (18 hectare) for rock scour protection (Jarvis, 2005). The additional amount of surface area (approximately 1,200 square feet [111 square meters] per tower would result in a minor addition to the substrate that is currently available. Due to the small amount of additional surface area in relation to the total proposed action area in Nantucket Sound, and the spacing between WTGs, the proposed structures are not expected to have a significant affect on the benthic community, the presence of prey fish, or foraging terns.

WTG Presence and Rotor Movement

The presence of wind turbines and the spinning of the blades could present barriers to the flight paths of birds and could potentially affect or restrict access to breeding, staging, or foraging habitat. A wind farm could potentially lead to significant impacts if it were to occur in an area of high use by birds (Drewitt and Langston 2006). Barriers can result in increases in energy expenditure if birds are forced to travel greater distances while accessing foraging habitats or while undertaking migration movements. However, there are no known situations where a wind farm has created a 'barrier effect' resulting in an avian population level impact (Drewitt and Langston 2006).

Terns have been observed to continue to use WTG areas at existing offshore facilities during both migration and breeding periods. Post-construction radar studies during migration at the Nysted and Horns Rev wind farms in Denmark indicate that, although the greatest levels of movement occurred outside of the wind farms, terns continued to migrate through the wind farm areas (Petersen et al., 2006). The facility is located 8.7 mi (14 km) offshore and is comprised of 80 turbines with a rotor zone of 98 to 360 ft (30 to 110 m). The turbines are spaced 1,640 ft (500 m) apart, half the distance of the proposed turbines. Visual data collected at the Nysted and Horns Rev facility indicate that the majority of terns generally avoided the direct wind farm area but increased their use of the 1.2 mi (2 km) zone surrounding the facility (Petersen et al., 2006). Terns were observed foraging at the outer edges of the facility around turbine structures. Small flocks flew into the farm, but then exited the area after passing through the second row of turbines (Petersen et al., 2006). Sandwich terns (*S. sandvicensis*) entered the wind farm between two turbines more frequently when one or both of the turbines were not active (Petersen et al., 2006). Common and artic terns (*S. paradisaea*), observed flying in the vicinity of turbines at a facility in Kalmar Sound, Sweden, flew between turbines or right next to the turbines instead of veering off in wide curves as waterfowl species were observed to do (Pettersson, 2005). The Kalmar facility is located 1.9 to 7.8 mi (3 to 12.5 km) from the shore with 12 turbines spread out over two locations positioned 20 to 30 km apart. The rotor zone is 115 to 328 ft (35 to 100m) above the water surface. The facility is located along a major migration corridor for water birds. Most birds were observed making slight alterations to their flight paths while traveling past turbines to avoid approaching individual turbines. It was estimated that the presence of the turbines resulted in a minor increase (0.2 to 0.5 percent) to the overall distance traveled by most birds during migration (Pettersson, 2005).

A more local tern-turbine interaction study was conducted at the MMA campus turbine. The MMA turbine has a maximum height of 74 m (243 ft) (85 to 243 ft [26 to 74 m] rotor zone) and is located at the western entrance of the Cape Cod Canal. The turbine is situated 328 ft (100 m) from the water's edge on a landmass adjacent to a popular common and roseate tern foraging location, the Mashnee Flats Shoal located 5.3 mi (9 km) from one of the largest roseate tern breeding colonies, Bird Island. Visual surveys and mortality searches were conducted from April 24 to November 30, 2006, during the breeding, staging, and fall migration periods (see Section 5.3.2 Risk of Collision for information regarding mortality searches). Terns were most abundant in the area during the post-breeding period when they were foraging in large, mixed-species flocks. Terns were most abundant in the turbine airspace (within 164 ft [50 m] of turbine tower, rotor, and blades) during the chick-rearing period and least abundant during the nesting period. The average flight height of terns in the turbine airspace was 83 ft (25.3 m) and the mean flight height was 50 ft (15 m). The one positively identified roseate tern observed in the turbine airspace flew at 26 ft (8 m). In summary, of the terns observed in the 164 ft (50 m) airspace surrounding the turbine: 17 percent flew within, 74 percent flew below, and 9 percent flew above the rotor zone. The study demonstrated that terns continued to use the 50 m [164 ft] airspace around the turbine while traveling between foraging locations (Vlietstra, 2007). However, the operating rotors and spinning blades were observed to deter terns from flying directly within the rotor zone of the turbine when the rotor velocity was greater than 1 rpm. Under these conditions, terns were found to be 4 to 5 times less abundant in the turbine airspace. Therefore, it was assumed that the terns visually and acoustically detected the spinning blades when the rotor was operating (Vlietstra, 2007). Despite the turbine's location in between foraging locations, terns continued to use the area and their access to habitat was not evidently restricted.

Risk of Collision

As terns are known to travel and forage in the vicinity of other man-made structures, including wind turbines, it is likely that roseate terns would continue to use the area of the proposed action after construction. Although the majority of terns are expected to avoid the direct WTG rotor swept area, it is anticipated that terns would continue to travel and forage in the vicinity of the turbine array. Tern surveys in HSS documented minimal use of the area of the proposed action, therefore, the proposed action is not anticipated to present a major barrier to the flight paths of terns. The proposed action is not expected to substantially increase energy expenditure as terns travel around the direct area of WTGs. Also, because turbines would be widely spaced (0.39 to 0.63 miles [0.63 to 1.0 km] apart), it is anticipated that some terns would occur between turbines while traveling or foraging as they have been observed to do at existing offshore facilities with smaller spacing between turbines. Therefore, the presence of the turbines may affect roseate tern behavior to some extent, but is not anticipated to adversely affect the population of roseate terns.

Roseate terns are anticipated to continue minimal foraging and traveling activities in the vicinity of the proposed action with a low risk of collision given the turbine-avoidance behavior exhibited by terns at the majority of existing offshore and near-shore facilities. The exception is the high collision mortality observed at the Belgium facility located adjacent to a tern colony where terns exhibited high risk flight behaviors and frequent flights through the turbines which put them at a greater risk of collision. Because no colony is located adjacent to HSS, this data is not particularly relevant to the proposed action's potential impacts. Roseate terns would be expected to make direct flights while traveling through HSS to access foraging or breeding locations. The majority of flight heights observed in the area of the proposed action occurred below the rotor zone. During conditions of good visibility, roseate terns would be expected to visually detect and react to turbine structures. Roseate terns are not expected to frequent the area of the proposed action during those periods of inclement weather or at night, however, surveys have not been conducted under these conditions and therefore the potential for collision under these conditions can not be ruled out. However, if flying into strong headwinds, terns would be expected to fly closer to the water's surface. If flying at night, they would be expected to avoid encountering the proposed turbines due to FAA lighting mounted on turbine nacelles as natural sources of lighting, based on the observed turbine avoidance behavior observed by other waterbirds at night. These factors decrease the risk of roseate tern collisions with proposed action structures.

Hatch and Brault (2007) (Report No. 5.3.2-1) calculated a median value of 0.8 roseate terns fatalities per year as a result of collision with the proposed turbines. Arnold (2007) (Report No. 5.3.2-5) developed a PVA to demonstrate the range of mortality that the Northeast population of breeding roseate terns (excluding the Canada population) could tolerate without an increased risk of extinction. Under the most updated survival and productivity parameters at the time of modeling, it was determined that there is a 95 percent chance that the population would fall below the threshold of 500 males after 50 years in the absence of additional mortality resulting from the proposed action (the risk of extinction at 15 and 25 years without additional proposed action associated mortality is 9 percent and 42 percent, respectively). The results of the population viability analysis indicate that a take of 0.8 individuals per year would lead to a minimal increase in the risk of population extinction. For a 20 year operational period, the take of the maximum uncertainty parameter of 8.2 individuals per year after 15, 25, and 50 years would result in the risk of population extinction of 11 to 12 percent, 46 to 50 percent, and 95 to 96 percent, respectively. These extinction probabilities are only slightly higher than the probability of extinction in the absence of the wind farm. The PVA suggests that the proposed action would result in a minimal increase in the risk of population extinction. Therefore, the potential for collision may result in minor adverse impacts to roseate terns, but is not anticipated to jeopardize the population.

While the collision probability model and the PVA suggest that the development of the proposed action would result in minor adverse impacts to the population of roseate terns, there is uncertainty surrounding the collision risk probability model because the actual number of roseate terns that occur in the area of the proposed action each year and the turbine-avoidance rates for roseate terns factored into the model are estimates only. There is uncertainty surrounding the population viability analysis because of the unpredictability of stochastic events. However, these models are based on the most current life history data and were developed in consultation with roseate tern experts.

Increased Predation

It is unlikely that development of the proposed action would result in additional hunting habitat for predatory species. Peregrine falcons aerial and perch hunt, and are known to take species of tern although this is much more likely to happen in proximity to land than around Horseshoe Shoals and their seasonal occurrence in the area of the proposed action does not overlap with roseate terns. Additionally, proposed action structures would be equipped with perch deterrents and modern tubular towers do not provide perch habitat as do older, outdated lattice towers common at some land based projects. Therefore, there is a negligible chance that increased predation due to the presence of proposed action facilities may adversely effect roseate terns.

Vessel Activity

Terns appear to be less sensitive to human disturbances than other species of birds, and are also thought to be attracted to some areas of human activity (Borberg et al., 2005; Drewitt and Langston, 2006; Sadoti et al., 2005a). Terns are known to habituate to some levels of human presence and disturbance. Terns are regularly observed traveling and foraging in the vicinity of vessels and other man-made structures. The major northeast roseate tern breeding colonies on Ram and Bird Islands in Buzzards Bay are located near the entrance of the Cape Cod Canal which receives frequent recreational boating and commercial shipping activity, yet terns continue to colonize these islands. Biologists frequently visit the large roseate tern colonies on the Atlantic Coast and consequently, roseate terns have become habituated to their presence and their handling of eggs, chicks, and adults (Nisbet et al., 1999). An increase in the presence of terns and gulls observed in areas around the Horns Rev offshore facility in Denmark was believed to be associated with increased boat activity for maintenance activities (Petersen et al., 2006). Therefore, roseate terns are expected to continue their traveling and foraging activities despite the presence of increased boat traffic and the few anticipated helicopter landings in HSS. Terns would be expected to return to the area after the departure of the vessels.

Roseate terns are expected to be among those species of bird that would habituate to the presence of increased boat traffic associated with maintenance activities. Therefore disturbances associated with the operation of the facility are anticipated to have minimal effects on roseate terns.

Unplanned and Accidental Events

Roseate terns may also be impacted by oil spills, monopile collapse, cable repair, and pre-construction geotechnical and geophysical investigations. The presence of WTG and ESP foundations in the vicinity of oil tanker shipping lanes increases the risk of ship collisions and possibly oil spills. Because terns forage at the water's surface, they are among those species of birds that are particularly vulnerable to oil spills (Jarvis, 2005). If the feathers become coated with oil, birds loose their ability to repel water and to insulate, and in some instances, loose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening. Also, nesting birds can transfer oil to their eggs resulting in decreases in hatching success, developmental problems, or the mortality of embryos (Jarvis, 2005). The potential impacts of oil spills associated with the proposed action would be situational depending on the location and size of the area affected by a spill. Large spills or spills that are not quickly contained could result in the loss of roseate tern adults or could lead to decreased nesting success. Oil spills could directly impact roseate tern colonies, as the Ram Island colony was impacted in 2003. However, due to the distance of the proposed action from nesting colonies, oil spills associated with the proposed action are unlikely to impact nesting colonies. Therefore, potential oil spills are anticipated to result in minor adverse impacts to roseate terns.

Cable repair activities would be similar to cable installation activities, but would occur for a short period in a small discrete location. Cable jetting, splicing, and re-jetting would result in minor and temporary increases in suspended sediments and would temporarily disturb benthos. Tern foraging in areas of elevated suspended sediments would be reduced. In both instances the habitat and species would recover and no impacts to roseate terns are anticipated from cable repair activities.

In the event of a monopile collapse, recovery and replacement activities would be similar to decommissioning and construction of a single WTG. A very minor amount of benthic habitat would be disturbed with a short term and localized increase in suspended sediments. Foraging opportunities for terns would be reduced in areas of elevated suspended sediments. Some lubricating fluid would likely leak from the submerged nacelle, but would rapidly disperse given the small quantity involved. However, should a tern dive for fish within this small plume, it could be harmed. There is a low likelihood of this occurrence and low probability of it occurring coincidentally with tern use of the immediate area. Potential impacts to roseate tern in the event of a monopile collapse would therefore be negligible.

The geotechnical investigation methods such as borings would result in negligible effects on benthos and water column characteristics, and these activities would be localized and short term, such that no affects on roseate tern habitat or use of the proposed action area are anticipated, even though much of this activity will be focused on the Horseshoe Shoal area. Geophysical investigation methods, such as sidescan sonar, are even less intrusive and have less habitat altering capabilities, and would, therefore, also have no adverse effects on roseate terns.

New England Cottontail

Small populations of New England cottontails were observed in Barnstable County during a 2000-2003 survey (MDFW, 2003). The upland portion of the underground cable would be located within streets and an existing previously disturbed utility ROW, which would be allowed to revegetate after construction. As such, operation of the underground cable would have negligible impacts on the New England Cottontails. Operation of the WTGs would not have an impact on New England Cottontails as the WTGs would be located far offshore.

Conclusion

The operation of the proposed action is expected to have negligible to minor impacts on T&E species of sea turtles, cetaceans, and the red knot (not yet listed as a T&E species but likely). With respect to the piping plover, the results suggest that collision mortality associated with the proposed action would result in a moderate adverse impact. Although the level of collision mortality associated with the proposed action is anticipated to be low, there is great uncertainty surrounding piping plover use of the proposed action area. However, impacts are not anticipated to jeopardize the Atlantic coast population. With respect to the roseate tern, available data suggest a low level of risk of collision with WTG structures. However, there is uncertainty surrounding the available data. The loss of a single breeding individual would be detrimental to the regional population; therefore, a moderate adverse affect on the roseate tern population is anticipated. This impact, however, is not anticipated to jeopardize the Atlantic coast population. Consultations with other Federal agencies through the Section 7 ESA and MMPA authorization processes are being conducted in order to confirm the potential for impact, and to confirm the appropriate mitigation measures to minimize potential impacts. Some mitigation measures may include restricting speeds of crew vessels, utilizing trained marine observers, and monitoring underwater acoustical levels. Operation of the underground cable would have negligible impacts on the New England Cottontails as the cable would be installed in streets and an existing ROW.

5.3.3 Socioeconomic Resources and Land Use

Socioeconomic data provided to describe socioeconomic impacts in this section came from the United States census unless otherwise noted (http://factfinder.census.gov). The most recent available U.S. Census community data for Barnstable County, Massachusetts and Washington County, Rhode Island came from 2005 estimates, and the most recent available community data for Nantucket County, Dukes County, and Bristol County, Massachusetts came from the 2000 census (U.S. Census, 2005 and U.S. Census, 2000).

There would be few and minor adverse impacts on socioeconomics from the construction and operation of the proposed action. In addition, the proposed action would create jobs and require the purchase of goods and services which could benefit the local and regional economies. The applicant would implement a variety of mitigation measure to address impacts on socioeconomics, in which are discussed in Section 9.0.

5.3.3.1 Urban and Suburban Infrastructure

5.3.3.1.1 Construction/Decommissioning Impacts

Housing

The increase in the number of workers to fill the construction requirements of the proposed action would be modest: 391 full-time jobs during the 27-month period, consisting of 316 for the manufacturing and assembly activities (79 and 237 of which would be from Massachusetts and Rhode Island, respectively) and 75 for construction and installation activities (56 and 19 of which would be from Massachusetts and Rhode Island, respectively). Fewer workers would be required to decommission the proposed action as manufacture and assembly activities would not be required. 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. As a result, the proposed action would have a negligible impact on housing in the area. In addition, the relatively small number of workers required relative to the population of Barnstable County indicates that workers coming to live in the area during construction and or operation would have a negligible impact on public services (i.e., school system enrollment, water use, sewer demands, emergency services, etc.). The manufacture and assembly operations slated for Quonset, Rhode Island would also have negligible impact on housing and public services given the relatively small number of employees relative to the number of vacant homes in Washington County.

Construction and Manufacturing Industries

The proposed action would have minor impacts on Barnstable and Washington counties through the resulting temporary increase in construction employment, and associated hirings and purchases that would benefit the construction and manufacturing industries. Refer to Section 5.3.3.2 for further information on economic impacts of the proposed action.

Service Industries

The proposed action would have a minor impact on Barnstable and Washington counties through the temporary increase in demand for service industries during construction (i.e., restaurants, hotels/motel use, hardware, and etc.). Refer to Section 5.3.3.2 for further information on the economic impacts associated with the proposed action.

Waste Disposal and Transit Facilities

The only impact on the Barnstable and Washington county transit facilities would consist of normal work day waste produced by workers who load and unload from boats in Falmouth, and small anticipated small quantities of wasted associated with manufacture and assembly in Quonset. This waste disposal would have negligible impact on the area.

Military Activity and Energy Industry

The proposed action is not anticipated to have an effect on the military activity in the area or the energy industry during its construction/decommissioning phase. Refer to discussion of these issues with respect to operational impacts at 5.3.3.7.

Conclusions

The proposed action is expected to have negligible to minor impacts (both positive and negative) during construction/decommissioning on urban and suburban infrastructure (i.e., impacts on housing, construction and manufacturing industries, service industries, waste disposal, and military activity). This is because the construction workforce required is relatively small relative to the work force in the area, and there is ample availability of necessary housing stock and other infrastructure to accommodate the construction activity.

5.3.3.1.2 Operational Impacts

Housing, Construction and Manufacturing Industries, Service Industries, Waste Disposal

Only 50 workers are required to operate and maintain the facility. These workers would access the site via work boats from Falmouth with a maintenance supply vessel coming from New Bedford, Massachusetts. As the level of employment for operations and maintenance is very small, there will be no significant in-migration of workers from outside of the ROI, and impacts on housing, municipal services and infrastructure in the area would be negligible. The proposed action, once in operation would also have a negligible impact on construction and manufacturing industries and service industries due to the small number of workers required and negligible amount of supplies needed to be purchased to run the facility. Once in operation, the facility would generate a negligible amount of solid waste and thus there would be negligible impact with respect to waste disposal requirements.

Military Activity

Concerns have been raised as to how the proposed action would impact the PAVE PAWS early warning radar site. However, in a memo dated March 21, 2004, the U.S. Air Force stated, “Our experts have reviewed the proposed locations for the Wind Power Plant near Cape Cod AFS and have determined it poses no threat to the operation of the PAVE PAWS radar at Cape Cod AFS. At the nearest proposed location, the main radar beam would clear the towers by more than 4,500 ft (1,372 m)” (Refer to Air Force Letter and PAVE PAWS Report in Appendix E).

Energy Industries

Electrical Generating Capacity, Base and Surge Load Servicing, and Transmission and Relay System

The proposed action represents a new source of generating capacity, which would provide electricity to the region and contribute to the state of Massachusetts's alternative energy portfolio. The electricity from the proposed action would most likely be consumed in the area of the facility (i.e., Cape Cod and the Islands). The proposed action's expected production of 182 MW of electricity in average wind conditions would meet three quarters of the 230 MW average demand of Cape Cod and the Islands, and thus have a substantial positive impact on electrical generating capacity. Negligible impacts are anticipated to base and surge load servicing, as the ISO-NE manages the electrical system to create built in redundancy to address planned and unplanned outages. With respect to transmission cable system impacts, the proposed action has undergone a system impact study by NSTAR and with NSTAR's recommended system upgrades, the proposed action was found to not have an adverse impact on the NEPOOL transmission system and "would improve the Cape area transmission performance particularly when the power plant is producing power" (Tourian, 2005a and Tourian, 2005b).

Conclusion

The proposed action is expected to have a negligible impact during operations on urban and suburban infrastructure (i.e., impacts on housing, construction and manufacturing industries, service industries, waste disposal, and military activity). This is because once the proposed action is in operation it would only require a very small workforce and minor services from the local area, and generate a negligible amount of solid waste. The socioeconomic impact on the energy industry during the operational period would be moderate as the proposed action would result in a substantial contribution to the Commonwealth of Massachusetts' alternative energy portfolio standards.

5.3.3.2 Population and Economics

5.3.3.2.1 Construction/Decommissioning

Impacts on Demographics

Construction would require a small number of workers relative to the population of the area, most of whom would commute to the area (an annual average of 391 full-time jobs during the 27-month period, consisting of 316 for the manufacturing and assembly activities (likely in Quonset Rhode Island), and 75 for construction and installation activities in Barnstable, Massachusetts. As such the proposed action is expected to have a negligible impact on population, as well as other demographic factors including age, race and ethnic composition, and education.

Impacts on Economics

The direct economic impacts in the Region of Impact (ROI) and Massachusetts during manufacture and assembly and construction and installation would consist of the hiring of manufacture, assembly, and construction and installation workers and the purchase of non-labor goods and services. Most of the specialized components of the WTGs, such as the nacelles (i.e., the portion of the WTGs that contain the drive train and the electromotive generating systems), and the rotors would be purchased outside the ROI and very likely outside of Massachusetts (Report No. 5.3.3-1). Other non-labor goods and services would be bought in Massachusetts or Rhode Island such as concrete, steel, and barge services. The temporary increase in economic activity within the ROI and Massachusetts during the manufacture and assembly and construction and installation phase would be the sum of the: (1) direct economic impacts – hiring of manufacture and assembly and construction and installation workers and purchases of non-labor goods and services; (2) indirect effects – the additional demands for goods and services, such as replacing inventory, from the industries that sell goods and services directly to the project; and (3) induced effects – the increases in employment, income, etc. generated by the expenditure of disposable income of the newly hired manufacture and assembly and construction and installation workers. The size of the temporary increase in economic activity in the ROI and Massachusetts during manufacture and assembly and construction and installation and operation would depend on the proportion of direct expenditures that take place within these regions. Once the proposed action begins operating, the direct, indirect and induced economic effects would be permanent changes to the state and ROI economies.

Impacts on Employment

Based on the estimate of total person-months of manufacture and assembly and construction and installation phases labor required, it is estimated that a total of 880 person-years of labor would be required during the manufacture, assembly, construction, and installation phase, 711 for manufacture and assembly operations and 169 for construction and installation activities. Assuming a 27-month manufacture and assembly and construction and installation phase, this translates into an annual average of 391 full-time jobs during the 27-month period, consisting of 316 for the manufacturing and assembly activities (79 and 237 of which would be from Massachusetts and Rhode Island, respectively) and 75 for construction and installation activities (56 and 19 of which would be from Massachusetts and Rhode Island, respectively). However, in actuality the manufacture and assembly and construction and installation activities would not be evenly distributed across the manufacture and assembly and construction and installation phases, but would instead peak during year 2 when the maximum temporary employment at the two locations at one time would be about 600 workers. Given the size of the regional manufacture and assembly and construction and installation labor market, and proximity of manufacture and assembly and construction and installation phase operations to both the Boston and Providence Metropolitan Statistical Areas (MSA), it is estimated that 75 percent of the construction and installation workers would be from Massachusetts, while 25 percent of the manufacture and assembly workers would be from Massachusetts. The latter proportion could rise if some or all of the manufacture and assembly operations are conducted in Fall River, Massachusetts, or possibly southeastern Massachusetts.

In addition to the employment benefits described above, the use of the IMPLAN input/output (I/O) model predicts secondary induced employment benefits resulting in an additional 206 to 622 jobs in Massachusetts and an additional 388 to 1,150 jobs in Rhode Island.

Impacts on Income and Wealth

Impacts on income and wealth would come from new wages associated with construction and operation of the proposed action, as well as purchases of equipment and services locally (i.e., non-labor goods and services). It is estimated that total payments of wages and salaries to Massachusetts' residents hired during the manufacture and assembly and construction and installation phase would be about $17,158,000. In addition, total payments of wages and salaries to Rhode Island residents hired during the manufacture and assembly and construction and installation phase would be about $32,445,000 over the 27-month period.

In order to estimate the temporary increase in economic activity during the manufacture and assembly and construction and installation phase, the IMPLAN input/output (I/O) model was used for Massachusetts. A discussion of the model is provided in Report No. 5.3.3-1. Approximately 20 percent of the Project's total capital cost of $700 million would be needed for labor, while 80 percent would be required for non-labor goods and services, including the WTG components; electric equipment including transmission lines; environmental studies and licensing costs; materials; legal service; construction materials, such as steel; and transportation services. The 80 percent share for non-labor costs means that the temporary increase in economic activity in the ROI and Massachusetts, and even in New England, during the manufacture and assembly and construction and installation-phases would depend primarily on the value of non-labor items purchased within these regions. Based on the location of likely suppliers for the WTG components, it is estimated that between $150 million and $250 million in purchases on non-labor goods and services would occur in Massachusetts during the manufacture and assembly and construction and installation phases. Total output in Massachusetts would increase by between $85.0 million and $137.4 million annually, while the annual increase in value added would range between $43.9 million and $71.0 million (Report No. 5.3.3-1). Total output in Rhode Island would increase by between $180.6 million and $292.0 million annually, while the annual increase in value added would range between $93.3 million and $151.0 million. In addition, between $360 million and $410 million in purchases on non-labor goods and services would occur in Rhode Island during the manufacture and assembly and construction and installation phases.

Other MA property income, comprised of rent, dividends and interest, and corporate profits, would rise by between $9.2 million and $14.8 million annually, producing an annual increase in corporate income taxes of between $434,900 and $702,200 if half of the increase were taxable corporate net income. The total increase in corporate income tax revenues during the manufacture and assembly and construction and installation phases could range between $1.304 million and $2.106 million.

Other Rhode Island property income, comprised of rent, dividends and interest, and corporate profits, would rise by between $19.6 million and $31.5 million annually, producing an annual increase in corporate income taxes of between $924,000 and $1.5 million, if half of the increase were taxable corporate net income. The total increase in corporate income tax revenues during the manufacture and assembly and construction and installation phases could range between $2.8 million and $4.5 million.

Impacts on Business Activity by Industrial Sector

The main impacts of the proposed action would be on the construction sector as a result of construction related job hires and purchase or lease of offshore construction vessels and equipment and related supplies, as described above. Accordingly, the proposed action is expected to have a minor to moderate positive impact on the construction industry in the area.

Conclusion

The proposed action is expected to have a minor impact on population and economics during its construction/decommissioning. The proposed action would generate construction jobs (391 full time, temporary jobs) and generate revenues resulting from construction jobs (approximately $50 million to be spent on construction wages) as well as contribute to the economy via the purchase of materials and supplies, and secondary induced economic effects from construction.

5.3.3.2.2 Operational Impacts

Impacts on Demographics and Employment

Approximately 50 workers would be required to maintain the facility during operation, with approximately $2.64 million spent on salaries. The use of multipliers indicates that as many as another approximately 104 additional indirect jobs may result from the proposed action's operation (Report No. 5.3.3-1). Impacts from operation on demographics and employment would be negligible given the small number of operational workers relative to the area workforce and size of the economy.

Impacts on Income and Wealth

Once the facility begins operation, an estimate of the annual operation and maintenance (O&M) purchases is approximately $16 million to maintain the facility. The annual purchase of O&M services would generate additional permanent increases in economic activity in the ROIs. The combination of the direct, indirect and induced effects as described above would generate an annual increase in Massachusetts' personal income tax revenues of $346,500, while the rise in corporate income tax revenues would be approximately $113,900.

It is estimated that the on-land improvements of the transmission line and related facilities located in Barnstable and Yarmouth would have an assessed value of $26.25 million, and generate annual property tax revenues of $62,500 in Barnstable and $217,200 in Yarmouth. Approximately 25 percent of the onshore transmission facilities would be located in Barnstable and 75 percent would be located in Yarmouth.

The resultant employment and tax revenues would have a minor to moderate positive impact on the tax revenues for the Towns of Barnstable and Yarmouth, but negligible impact when measured against the larger economy of Massachusetts. The resultant employment and tax revenues associated with the maintenance operation out of New Bedford would have a negligible impact when measured against the local economy.

Impacts on Property Values

Currently available information does not support any firm conclusion with respect to the wind facility's effect on property values. A potential purchaser of a piece of property would make an offer to purchase based on his or her own values and sense of aesthetics, which may or may not be affected positively or negatively by the proposed action. A U.S. Government funded study published in 2003 entitled "The Effect of Wind Development on Local Property Values" examined 25,000 real estate transactions within five miles (8.0 km) of ten of the larger wind farms built in the United States between 1998 and 2001. The study found no adverse effect of views of wind turbines on nearby real estate values. Similarly, in 2006 a study entitled "Impacts of Windmill Visibility on Property Values in Madison County, New York" found no negative impact on real estate values from a wind farm there. Thus, there is evidence that some wind projects may not affect property values, though impacts are likely to vary on a proposed action specific basis, and based on the person or persons own interpretation of whether they like or dislike the wind farm.

Impacts on Business Activity by Industrial Sector

Impacts on the ROI during operations of the proposed action would be limited to employment of a small crew for maintenance of the proposed action. This small amount of new employees would have a negligible impact on overall business activity and the local economy.

Public Perception

Many comments were received both in favor and against the proposed action. A recent contingent evaluation study (Seltzer, 2006) concluded that in general people were willing to pay $164.41 per year for a policy that would allow Nantucket Sound to be used for the proposed action. The study attempted to measure peoples attitudes toward the development and included the presentation of visual simulations to help show what the proposed action would look like. Thus, the study attempted to incorporate peoples' attitudes to aesthetic impacts as well as other factors. Yet, contingent valuation studies can be prone to errors depending on how they are carried out, and one review of the study concluded that it was not reliable because the methodology did not follow professional standards for contingent valuation studies (Ward and Niemi, 2007).

Health Impacts

The proposed action would have negligible impacts on public health as its operation would comply with environmental standards to protect public health and the facility would not generate air or water pollution that could affect public health.

Tourism and Recreation

Comments were received on the MMS public notice that the proposed action would have a negative impact on tourism and recreation due to visual impacts, and other comments were received that the proposed action would have a positive impact on tourism and recreation due to the desire of persons to visit the WTGs via boat tours and the potential for additional recreational fishing opportunities as a result of the added hard bottom structure associated with the monopiles. It is difficult to predict the economic impact of the proposed action on tourism and recreation. However, as discussed in the visual section at 5.3.3.4.2, the visual impacts of the proposed action are unlikely to affect the viability of the recreational areas upon which tourism is strongly based (i.e., the general public is not expected to stop using the recreational areas around Nantucket Sound, Cape Cod and the Islands for summer enjoyment including activities like sitting on the beach, viewing the expanse of Nantucket Sound, swimming, fishing, sailing, and other recreational activities). In general, direct impacts to recreation from the WTGs to recreation such as boating and fishing are minor and discussed further in Section 5.3.3.6.

Conclusion

The proposed action is expected to have a minor impact on population and economics during its operation through its operation and maintenance expenditures, tax payments, and the small increase in jobs related to operation. The applicant has provided further economic benefits including payments to the Town of Yarmouth of $350,000 annually or $7,000,000 over twenty years of operation for the on land portion of the interconnection line. Discussion of any mitigation measures proposed by the applicant or being required by MMS is provided in Section 9.0.

5.3.3.3 Environmental Justice

A socioeconomic analysis was conducted and showed that the counties within the ROI (Barnstable County, Nantucket County, Dukes County, Washington County, and Bristol County) had a lower percent minorities than the rest of the State, and a lower percentage of people living under the poverty level than the rest of the state and thus the ROI in a broad sense is not within an environmental justice population (refer to Section 4.3.3.3.1).

Although the statistics for Barnstable County as a whole indicate that the area is not an environmental justice area of concern, the Massachusetts Environmental Justice GIS Map shows that there is a smaller census block group in and around Hyannis, Massachusetts that is an Environmental Justice Population (refer to Figure 4.3.3-1). The on-land cable portion of the proposed action is located outside of this area, but the existing substation where the cable connects is located within this area. The location of the existing substation is outside the population center of Hyannis and work at the substation is expected to be minor with negligible environmental impact.

As discussed in Section 4.3.3, Wampanoag tribes are located in the ROI in the Town of Aquinnah (Gay Head) and in the village of Mashpee, Massachusetts and constitute an environmental justice population. These are discussed below.

5.3.3.3.1 Construction/Decommissioning Impacts

The onshore cable portion of the proposed action would be constructed in streets and in an existing ROW, and thus would result in negligible to minor environmental impacts. Only the area of the cable interconnection with an existing substation is within a State GIS designated environmental justice population area, and the work at this location would be minor and at an existing substation. Construction work is not located near Wampanoag tribal lands and would not affect these areas, though economic benefits including construction jobs, and economic revenues (refer to Section 5.3.3.2.1) could have a minor positive impact on environmental justice populations including the Wampanoag's.

Conclusion

Construction/decommissioning impacts are not expected to result in a disproportionately high adverse environmental and/or health impact on low income or minority populations in the ROI.

5.3.3.3.2 Operational Impacts

The potential visual impact of the proposed action on the Wampanoag Tribe of Gay Head/Aquinnah was raised as a concern during government to government consultations about the proposed action between the MMS and the Tribal Historic Preservation Office.

To address the concern of visual impacts from this location, three line-of-sight profiles were created along transects originating at the approximate highest ground elevation in Gay Head/Aquinnah and extending northeasterly to the maximum height of the nearest proposed WTG along the profile. The three profiles were oriented to represent potential views of the landscape that a person standing at the Gay Head location would see when facing toward the left, middle and right (south side) of the WTG array. The locations of the three profiles (or transects) are shown on Figure 5.3.3-1. Profiles A, B and C are presented in Figures 5.3.3-2 through 5.3.3-4.

The transect lines on each figure are color coded to indicate areas along each profile that would be visible (green) to the person at Gay Head, based only upon screening afforded by the specific Martha's Vineyard topography along that profile. This type of line-of-sight profile does not take into account the additional screening effects of vegetation or intervening structures, if present. Areas not visible to the viewer, again based upon topography only, are indicated in red. As shown in the figures, the profiles indicate that no portions of the offshore turbines in the array would be visible to the viewers at Gay Head/Aquinnah.

The land associated with the Wampanoag tribe of Mashpee is well inland from the coast line, and given the wooded vegetation, and fairly level topography, there would not be a view from this location.

Due to the distances of these two Indian tribal lands from the offshore proposed action site, (Gay Head Wampanoag Tribal Land is 24 miles [38.6 km] away and Mashpee Wampanoag Tribal Land is more than 10 miles [16.1 km] away) no other source of environmental impacts on these areas is associated with the proposed action. During government to government consultations between MMS and the tribes, there was concern expressed that the proposed action would interfere with the tribes' subsistence fishing. However, the proposed action would not preclude fishing from the area around the proposed action and the spacing of the turbines would not have a significant affect on fish populations or trawling and other types of fishing activities at the site of the proposed action. Therefore, environmental justice impacts are expected to be negligible.

Conclusion

In conclusion, operational impacts are not expected to result in a disproportionately high adverse environmental and/or health impact on low income or minority populations in the ROI.

5.3.3.4 Visual Resources

5.3.3.4.1 Construction/Decommissioning Impacts

Visual impacts during construction and decommissioning would be limited to vessels working out in Nantucket Sound and traveling back and forth between Barnstable (for worker staging/supplies) and Quonset, Rhode Island (for manufacturing/assembly). Equipment for installation and decommissioning of the monopiles would require the use of jack-up barges and cranes. The installation of the monopiles is expected to take 8 months and installation of the WTGs is expected to take approximately 9 months. A crane and barge would also be required for near shore dredging work associated with construction of the exit hole associated with the horizontal directional drill operation for the landfall of the offshore transmission cable system. Utility line construction equipment would also be required on land to install the onshore transmission cable system. The onshore portion of the work is expected to take approximately 10 months. Decommissioning is expected to require similar equipment and time requirements. The larger construction/decommissioning vessels would be a visible feature within the area viewshed, more so from boats in proximity to Horseshoe Shoals than from land. And while most construction is expected to occur during daylight hours, these vessels would have nighttime lights in accordance with USCG regulations. In addition, during dawn and dusk periods, particularly on cloudy days, work lights may be required for worker safety as well as to improve visibility on construction vessels. Work lights are generally downward directed lights and would not typically be oriented horizontally where their visibility on shore would be increased.

Conclusion

Visual Impacts associated with construction/decommissioning would be limited to construction equipment and partially built structures depending on phase of construction. Such impacts in general would be minor as construction equipment would only be in use temporarily during the construction and the decommissioning period.

5.3.3.4.2 Operational Impacts

Major Visual Components of the Proposed Action

The proposed action is a 468 MW offshore wind-powered electric generating facility, with associated offshore and onshore transmission cable system. As currently proposed, the proposed action includes 130 3.6 MW GE offshore wind turbines, each mounted on 257 ft tall tubular steel monopile towers. The 3-bladed rotors have a diameter of approximately 364 ft (111 m) and would reach a maximum height of approximately 440 ft (134.1 m) above sea level. Each tower has a service platform located approximately 30 ft (9.1 m) above the water surface. The turbines are arranged in a grid pattern with an approximate separation distance of 0.3 to 0.5 miles (0.6 to 0.9 km).

The 50 perimeter WTGs and the eight WTGs located directly adjacent to the ESP would be lit at night. Every corner would be marked with a medium intensity red light (similar in intensity to FAA L-864) at night with no more than 1.7 miles (2.8 km) between medium intensity lights. The remaining perimeter WTG would be marked with low intensity light fixtures (similar in intensity to FAA L-810), visible from approximately 1.15 miles (1.9 km). The eight interior WTGs adjacent to the ESP would have the low intensity lights. All other interior WTGs would not be lit by red lights at night. The red lights on the perimeter WTGs would be synchronized to flash in unison rather than randomly as previously proposed. The red lighting would flash on for one second, with no lighting for two seconds, for a total of 20 FPM. This lighting design complies with the new FAA guidelines. The FAA lights would be visible from land.

Three USCG amber navigation warning lights would be also installed on the access platforms of each tower approximately 32 ft (9.8 m) above the water's surface. The USCG access platform lights would not be visible from land.

Other visible components of the proposed action include a 20 x 26 ft service platform, which is topped with an FAA aviation warning light. The ESP is an enclosed structure, 100 ft (30.5 m) tall, by 200 ft (61 m) wide, by 100 ft (30.5 m) long, which houses transformers and electrical switching equipment. It is sided with metal panels and supported by cross-braced tubular steel legs, approximately 40 ft (12.2 m) above the water surface. No FAA lights are required on the ESP; USCG lighting would be installed, as described above. Helicopter warning lights would be remotely activated on the helipad as needed. All built components of the facility are proposed to be painted a marine gray color.

The turbine array would be located 13.8 miles (22.2 km) from Nantucket, 9 miles (14.5 km) from Edgartown, 9.3 miles (15.0 km) from Oak Bluffs, 5.6 miles (9.0 km) from Cotuit, 6.5 miles (10.5 km) from Craigsville Beach, and 5.2 miles (8.4 km) from Point Gammon.

Visual Impacts to Historic Structures - Assessment of Effects

The ACHP regulations at 36 CFR 800.5(a) require the MMS to apply the criteria of adverse effect to historic properties within the APEs, which are discussed in Section 4.3.4 and summarized in Table 5.3.3-1. The visual simulation views also are noted in Section 4.3.4 and in Table 4.3.4-1. Three categories of effect are considered for each property identified: adverse effect, no adverse effect, and no effect.

According to 36 CFR Part 800.5(a)(1), "an adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the National Register in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association." Accordingly, for an effect to be considered adverse, it must alter a qualifying characteristic of the property, or "diminish the integrity of the property's significant historic features" (36 CFR Part 800.5(a)(2)(v)).

A finding of no adverse effect is made when there is an effect on the property due to the undertaking, but that visual change in setting does not diminish the property's integrity, and therefore does not negatively affect its historic significance and hence its eligibility for listing in the National Register. In such cases, the change in the setting created by the undertaking does not diminish the integrity of the property's significant historic features that make it eligible for the National Register.

A finding of no effect is made when a clear view of the undertaking from historic properties within the undertaking's APE is not present.

The ocean is an important component of the setting for all of the historic properties within the APE, since many of them were designed as seasonal resort communities to take advantage of the coastal setting, or light houses, designed to warn watercraft of hazards. However, being able to view the WTGs from these properties does not rise to the level of altering a qualifying characteristic of these historic properties in most cases. While the view from some vantage points within these properties may be altered under certain conditions, in many cases this alteration is not such that the property's significant historic features have suffered a loss of integrity. In such cases, there is no adverse effect. In cases where the setting of the property is impacted in such a way as to diminish the integrity of the property's significant historic features, the proposed action is considered to have an adverse effect on the historic property. Table 5.3.3-1 summarizes the assessment of effects considerations for the properties located within the proposed action's APE.

Conclusions on Visual Impacts to Historic Structures during Operation

Based on an analysis of visual effects undertaken in the visual impact assessment, which included both daytime and nighttime visual simulations, MMS concludes that the proposed action would have an adverse effect on one National Historic Landmark (NHL) property (the Kennedy Compound) and two individual historic properties (Wianno Club and Cape Poge Lighthouse). The visual alteration that the WTGs would entail to the setting of these properties, particularly the relatively close, unobstructed views to the WTGs from nearly any vantage point within the properties, would diminish the integrity of these properties' significant historic features.

The proposed action would have no adverse effect on one NHL (Nantucket Historic District), four historic districts (Cotuit Historic District, Wianno Historic District, Hyannis Port Historic District, and Edgartown Village Historic District), and seven individual properties (Col. Charles Codman Estate, Monomoy Point Lighthouse, West Chop Light Station, East Chop Lighthouse, Tucker Cottage, Edgartown Harbor Lighthouse, and Nantucket/Great Point Lighthouse).

The proposed action would have no effect on two NHL properties (the Martha's Vineyard Campground Historic District/Wesleyan Grove-Martha's Vineyard Camp Meeting Association NHL), one historic district (Wouldiam Street Historic District), and four individual properties (the Nobska Point Light Station, the Ritter House, the Arcade, and the Oak Bluffs Christian Union Chapel). These properties are generally within the visual APE defined as 300 ft (91.4 m) from the shoreline, but are screened from water views by intervening structures, vegetation and/or topography, or the view of the WTGs is nearly invisible on the horizon.

At present, the MMS is continuing the Section 106 process, and would continue consultation per 36 CFR 800 to evaluate strategies to mitigate adverse effects and to consider appropriate mitigation measures to minimize impacts.

Visual Resource Impacts to Recreational Areas (Non Historical)

The visual impacts from development of the proposed action on onshore recreational resources would be essentially the same as those described for onshore historic sites. Refer to simulation photographs in Figures 5.3.3-5 and 5.3.3-6. The same daytime and nighttime visual simulations are used to assess the degree of these impacts.

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 visible structures. The visual simulations indicate the greatest proposed action 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 4.3.4-2 and Figure 5.3.3-5).

Falmouth beachgoers would experience views between those simulated at Nobska (VP 1) and Cotuit (VP 5), depending on their respective distances to the wind turbine array. 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 the proposed action were found in the Village of Osterville. The Craigville simulation (VP 7) approximates proposed action 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 ft (10.7 m) above sea level, the simulation provides somewhat more visibility of the built proposed action 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 wind turbine array.

On Martha's Vineyard, open views of the proposed action 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 proposed action would be available from beaches along the entire north shore of Nantucket Island east to Great Point.

Visibility of the proposed action would be affected during the high use season by the degree of haze and fog that develops over the water. According to the U.S. Coast Pilot 2 (NOAA, 2004) for Nantucket Sound "the characteristic advection fog, formed by warm air over cool water, is most frequent from April through August. At this time visibilities drop below 2 miles (3.2 km) 10 to 18 percent of the time. In addition the Coast Pilot provides a climatological table for Nantucket Island which shows that the number of days with fog averages 200 days annually. Thus, there would be a substantial portion of time (at least 10 to 18 percent in the summer months) where the proposed action would not be visible from shorelines.

In addition to the photographic simulations referenced above, daytime photographic renderings from each of the six viewpoints most distant from the proposed action were assessed using two generic waterfront photographs, to try to heighten the contrast and visibility of the WTGs against the sky. These are termed renderings (and each viewpoint is labeled with "B") to differentiate them from the site-specific photographs used to generate the simulations. The six viewpoints are listed below; photo-renderings are shown from each viewpoint respectively in Figure 5.3.3-7, sheets 1 through 6:

- **Viewpoint 1B:** Nobska Lighthouse, Woods Hole in Falmouth, Cape Cod;
- **Viewpoint 26B:** Monomoy Lighthouse, Monomoy Island, Chatham, Cape Cod;
- **Viewpoint 20B:** Lighthouse Beach in Edgartown, Martha's Vineyard;
- **Viewpoint 22B:** Nantucket Cliffs, Nantucket;
- **Viewpoint 23B:** Great Point, Nantucket; and
- **Viewpoint 24B:** Tuckernuck Island, Nantucket.

To develop each rendering, one of the two generic waterfront photographs were selected for each viewpoint, based upon the specific orientation of views toward the proposed action at that viewpoint, and the applicable sun angle that would heighten the visibility of the WTGs to the greatest degree. Both generic photographs were shot into the midday sun, resulting in a light-colored washed-out sky above the horizon. Under these conditions, depending on the orientation of each specific viewpoint toward the wind turbine array, WTGs on the horizon would either be cast into shadow or be strongly front-lit. These lighting conditions heighten the contrast of the WTGs against the sky. The WTGs are front-lit in views from north-facing viewpoints at Nantucket Cliffs and Tuckernuck Island because the sun angles at these locations would rarely back-light the WTGs. The WTGs are shown as back-lit in the remaining far-field viewpoints.

The distances range from almost 9 miles (14.5 km) in Edgartown to approximately 14 miles (22.5 km) at Nobska Lighthouse, Nantucket Cliffs, and Monomoy Lighthouse. Because the WTGs are relatively slim light-colored structures, they are difficult to see at these distances.

Visual impacts at very long distances (15 and 18.8 miles [24.1 and 30.3 km]) were also assessed. These represent distant views of the proposed action that would be experienced by viewers at some shoreline recreational resources, such as beaches and dock areas. For a listing of specific resources at these distances see Table 4.3.4-2 and Figure 4.3.4-3. Both of these photo-renderings represent potential daytime views of the proposed action under clear sky conditions from distant shoreline recreational areas. A visual Simulations has been prepared that shows the proposed action at a distance of 15 miles (24 km), and represents daytime views that would be experienced from south-facing Cape Cod beaches in Dennis Port and Harwich Port, near the border between the two towns (see Sheet 1 of Figure 5.3.3-8). An additional simulation has been prepared that shows the proposed action at a distance of 18.8 miles (30.3 km), representing daytime views that would be experienced from south-facing beaches in the vicinity of East Harwich and Chatham, and west-facing beaches on the northern portions of Monomoy Island (see Sheet 2 of Figure 5.3.3-8). The long viewing distances results in the facility structures looking very small, as a result of perspective, atmospheric clarity, and the curvature of the earth's surface.

Visual Impacts from Boats in Close Proximity

The turbines would obviously appear much larger while viewed close up by boaters traveling or recreating near the site. As such, the turbines would be much larger relative to surrounding features and would be more visible under hazy or foggy weather conditions at these distances. Figures 5.3.3-9 and 5.3.3-10 shows similar sized features from the Nysted Project in the Baltic Sea off of Denmark. Nysted consists of 72 turbines (2.2 MW Siemens), which are 226 ft high (69 m to hub) with 270 ft (82.4 m) rotors (361 ft) (110.2 m overall height) versus the proposed action which has an overall height of 440 ft (134.1 m). The Nysted turbines are spaced in a grid 2,789 ft by 1,575 ft (850 m by 480 m [or 10.4 rotor diameters by 5.8 rotor diameters]). The proposed action has a spacing of 3,281 ft by 2,064 ft (1,000 m by 629 m). Though these are not the same dimensions as the proposed action, the photographs approximate the type of visual impact a viewer is likely to see up close to the wind turbine array.

Conclusions on Visual Impacts to Recreational Areas During Operation

The proposed action represents a large manmade feature in the natural landscape of Nantucket Sound that would be viewed by many people in numerous shoreline areas used for recreation that surround Nantucket Sound. Conclusions as to the significance of visual impact on the people using recreational areas are difficult, as the interpretation of visual impacts is subjective. Many comment letters were received expressing opinions that the proposed action would cause an unacceptable visual impact, and many other comment letters were received expressing views that the proposed action would be beautiful to look at.[5] Visual impacts are important from Cape Cod locations as the proposed action would change the views out to Nantucket Sound from a mostly natural ocean setting, to a setting with manmade features present across a substantial portion of the horizon. Thus, the proposed action would have moderate visual impacts to recreational resources, with major visual impact limited to boaters that are transiting near or within Horseshoe Shoals since they would be located close to the structures. However, the visual impacts are unlikely to affect the viability of the recreational areas (i.e., the general public is not expected to stop using the recreational areas around Nantucket Sound for summer enjoyment including sitting on the beach, viewing the expanse of Nantucket Sound, swimming, fishing, sailing, and other recreational activities). In addition, minimization of visual impacts has occurred through minimization of nighttime lighting, color choice, and facility layout (refer to Section 9.0 for further information on visual impact mitigation).

5.3.3.5 Cultural Resources

5.3.3.5.1 Construction/Decommissioning Impacts

Impacts on Onshore Cultural Resources

Historic

Historic Archaeological Resources

Based on the results of the terrestrial archaeological intensive survey, no significant historic archaeological resources have been identified within the Project's APE for ground disturbance along the onshore transmission cable system route. Therefore, the proposed action is expected to have a negligible impact on onshore historic archaeological sites during construction/decommissioning.

Above-Ground Historic Resources

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 physical impacts to onshore historic structures and districts due to construction/decommissioning. Therefore, impacts are negligible along this portion of the site of the proposed action for historic properties.

Visual impacts to historic properties associated with construction/decommissioning are minor as they are temporary and limited to construction equipment and partially built turbine structures depending on the phase of construction.

Prehistoric

Based on the results of the terrestrial archaeological intensive survey, no significant prehistoric archaeological resources have been identified within the Project's APE for ground disturbance along the onshore transmission cable system route. Thus, construction/decommissioning impacts to prehistoric resources would be negligible.

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[5] A recent contingent evaluation study (Seltzer, 2006) assessed among other things, people's opinions of what the Project would look like. This was performed by showing individuals photo simulations of the Project, and then asking their opinion as to how they think it would look. Overall, the largest group of responders had a neutral opinion toward visual impacts, though a much larger percentage of responders from Cape Cod thought the project would be ugly compared to those questioned who lived in other areas of Massachusetts. Yet, contingent valuation studies can be prone to errors depending on how they are carried out, and one review of the study concluded that this study was not reliable, because the methodology did not follow professional standards for contingent valuation studies (Ward and Niemi, 2007).

Impacts on Offshore Archaeological Resources

Historic

Three targets with moderate probability of representing historic shipwrecks were identified in the vicinity of Horseshoe Shoal. The MMS would require that these three potential shipwreck locations be avoided by all bottom-disturbing activities during all proposed action construction, maintenance and decommissioning activities; therefore, construction/decommissioning impacts are expected to be negligible. If avoidance is not possible, then MMS would require groundtruthing of targets in consultation with MHC and MBUAR. The MBUAR and MHC concurred with these recommendations (see letters dated May 11, 2004 and May 19, 2004, respectively).

Prehistoric

The archaeological analysis of the subbottom profiler and vibracore data collected within the area of the proposed action identified organic material interpreted as paleosols (ancient land surfaces) in limited areas within the easternmost portion of the WTG array. The wind turbine array has been modified to avoid the areas where intact paleosols have been identified. No other areas having a high probability for prehistoric site occurrence were identified from marine remote sensing data collected within the site of the proposed action; therefore, impacts from construction/decommissioning are expected to be negligible.

Conclusion

Based on cultural resource surveys conducted to date and through continued coordination with MBUAR and MHC and compliance with any other future requests for further analysis and or mitigation, the construction/decommissioning impacts are expected to be minor. Should any archaeological resources be encountered during construction/decommissioning, operations would be halted immediately within the area of the discovery and the discovery would be reported to the MMS Regional Director. Mitigation being considered at this time includes avoiding identified sensitive areas, and the development of an Unanticipated Discovery of Cultural Resources and Human Remains Plan.

5.3.3.5.2 Operational Impacts

The Advisory Council on Historic Preservation regulations at 36 CFR 800.5(a) require the MMS to apply the criteria of adverse effect to historic properties within the area of potential effects, which are discussed in Section 4.3.4 and summarized in Table 5.3.3-1. Three categories of effect are considered for each property identified: adverse effect, no adverse effect, and no effect. Table 5.3.3-1 shows that out of the 20 historic places assessed, 3 were identified as having an adverse effect, 12 no adverse effect, and 5 no effect. See Section 5.3.3.4.2 for definitions of these categories.

Operational impacts on cultural resources will be limited to the visual effects of the wind turbine array on onshore Above-Ground Historic Resources. The ocean is an important component of the setting for all of the historic properties within the APE, since many of them were designed as seasonal resort communities to take advantage of the coastal setting, or light houses, designed to warn watercraft of hazards. However, being able to view the WTGs from these properties does not rise to the level of altering a qualifying characteristic of these historic properties in most cases. While the view from some vantage points within these properties may be altered under certain conditions, in many cases this alteration is not such that the property's significant historic features have suffered a loss of integrity. In such cases, there is no adverse effect. In cases where the setting of the property is impacted in such a way as to diminish the integrity of the property's significant historic features, the proposed action is considered to have an adverse effect on the historic property. Table 5.3.3-1 summarizes the assessment of effects considerations for the properties located within the Project's APE.

Conclusions on Visual Impacts to Historic Structures during Operation

See conclusions to Section 5.3.3.4.2 for this assessment. In conclusion, the visual alteration to the historic Nantucket Sound setting caused by the WTGs and related structures would constitute an alteration of the character, setting and viewshed of some historic properties, and MMS would continue to conduct consultation per 36 CFR 800.

5.3.3.6 Recreation and Tourism

This section addresses impacts to recreational activities other than visual impacts. Refer to Section 5.3.3.4 for a discussion of visual impacts to recreational areas.

5.3.3.6.1 Construction /Decommissioning Impacts

Impacts on Tourism

The proposed action is located far offshore and its construction and associated post lease G&G field investigation are not expected to affect tourism, the use of recreational parks, and use of the ocean for recreational activities (Refer to Section 4.3.6 for a presentation of recreational activities of the area). The construction of the onshore cable system would take place during the off season to minimize disruption of the tourist season. Accordingly, impacts to tourism are expected to be negligible during construction. Decommissioning impacts are also expected to be similar to construction impacts; therefore they would also be negligible.

Impacts on Shoreline Activities and Birdwatching

During construction and decommissioning, the noise and activity associated with installation of the onshore cable may temporarily disturb birds that inhabit the area, though this work would occur during the winter months when many migrating birds have vacated the area. In addition, given the altered and developed nature of the shoreline cable crossing location, it is unlikely that this is a high use area for birdwatching or beach recreation. Thus, construction and decommissioning impacts on birdwatching and shoreline use would be negligible.

Impacts on Recreational Boating

Details of the marine-based construction and post lease G&G field investigation would be closely coordinated with the USCG and local Harbor Pilots. During construction and decommissioning, 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 area of the proposed action as the cable embedment process is completed or around WTG or ESP installation. 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. Thus, impacts on recreational boating during construction, the post lease G&G field investigation, and decommissioning would be minor.

Impacts to Recreational Fishing

During construction and decommissioning, 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 area of the proposed action as the cable embedment process is completed or around WTG or ESP installation. 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.

In general, the proposed action would have a minor and localized impact on fishing during construction and decommissioning, as a result of temporary avoidance of disturbed habitat by fish species during these activities. Accordingly, impacts to recreational fishing during operation are expected to be minor.

Conclusion

The proposed action is expected to have a minor impact on recreation during construction/decommissioning. This is primarily because most of the construction and decommissioning activities would be located far from shore and are not expected to significantly impact avian or fish populations (see Section 5.3.2.4 for Avian Impacts and Section 5.3.2.7 for Fishery impacts) or access to these areas by fisherman, birdwatchers, and tourists.

5.3.3.6.2 Operational Impacts

Impacts on Tourism

The proposed action is located far offshore and is not expected to affect tourism and use of recreational parks and use of the ocean for recreational activities. Therefore, there would be negligible impacts to tourism during proposed action operation. Refer to Section 4.3.4 for discussion of how visual impacts could affect use of the area. In fact, there are undocumented reports of increased tourism after some European wind energy projects were constructed.

Impacts on Birdwatching

Since the proposed action would be a minimum of 4.8 miles (7.7 km) from shore and the cable portion of the proposed action onshore would be underground, there would be negligible impacts on recreational birding which primarily occurs along the shorelines of Cape Cod and the Islands.

Impacts on Recreational Boating

The proposed action would impact the Figawi sail boat race that occurs between Hyannis and Nantucket and back every year on Memorial Day. This impact would be moderate, but can be overcome by selecting a race course that does not pass through the site of the proposed action - the overlay of historic race courses shows the race can still be run without crossing the area of the proposed action (refer to Figure 4.4.3-2).

In addition, sail boaters, and to a lesser extent motor boaters, would be faced with a moderate navigational impact as the proposed action would in general make offshore cruising more difficult as the operator would have to take more care to avoid the structures. Navigation in the area would be more difficult during fog conditions and/or at nighttime. Discussions with boaters revealed that many recreational boaters avoid the shallower portions of Horseshoe Shoal, particularly under wavier conditions when the shoals make the seas more choppy. Refer to Section 5.3.4.3 for a complete discussion of recreational boating impacts and to Section 9.6 for navigational impact mitigation. In some instances boaters may benefit from the WTGs since they represent aids to navigation and could allow someone to navigate through the wind turbine array. Overall, operational impacts on recreational boating would be minor.

Impacts on Recreational Fishing

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 0.39 by 0.63 (629 by 1,000 m) apart, the physical presence of these structures should not interfere with recreational fishing activity, including maneuvering of recreational vessels (see Section 5.3.2.7 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 Section 5.1.5.11); such phenomena have been documented at oil rigs in the Gulf of Mexico. The proposed action should not affect other modes of recreational fishing, such as fishing from shore since the shoreline would be drilled under and shoreline areas would remain undisturbed.

Although it appears that charter/party boat companies do not frequently visit Horseshoe Shoal, the operation of the proposed action should not interfere with any recreational fishing conducted from charter or party boats in the area of the proposed action, and once constructed, may, in fact, enhance recreational fishing for certain species discussed above.

The NOAA Fisheries Recreational VTR data for charter and party boats indicated that the portion of fishing reported to occur within the area of the proposed action on Horseshoe Shoal only accounted for approximately 2.8 percent of the total federally-reportable charter and party boats over an eleven year period. A survey of commercial and recreational activities (Report No. 4.2.5-6) indicated that some recreational fishing takes place on Horseshoe Shoal. More specifically, 25 percent of the recreational fishermen surveyed, reported fishing on Horseshoe Shoal some portion of the time.

In summary, the proposed action is not expected to interfere with recreational fishing during operation, as it would not prohibit access or use of existing recreational fishing areas and may in fact enhance fishing as a result of the WTG foundations. Accordingly, impacts to recreational fishing during operation are expected to be minor.

Impacts from Unplanned and Accidental Events

Should a cable failure occur, a Cable Repair Plan would be implemented (see Section 2.4.6 for a description of this plan). Impacts from cable repairs would include localized turbidity around the work area, localized and temporary bottom disturbance from anchoring the work vessels, noise impacts associated with the repair work, and emissions from the work vessels. Overall impacts from cable repair on recreation and tourism would be negligible.

Should an oil spill occur, impacts on recreation and tourism would depend on the location, magnitude, and sea conditions at the time of the spill. The applicant would be required to operate the facilities with an approved OSRP that would be designed to maximize the containment and clean-up of spilled substances. However, should an oil spill reach shoreline areas, there would be a temporary reduction in beach recreation and tourism because of the unpleasant conditions that would be present on the beaches.

Conclusion

The proposed action would have a minor impact on recreation during operation as it is not expected to significantly impact avian or fish populations (see Section 5.3.2.4 for Avian Impacts and Section 5.3.2.7 for Fishery impacts) or access to these areas by fisherman, birdwatchers and tourists. Measures would be implemented to help aid in safe use of the area by recreational boaters such as informing boaters of the proposed action activities in Notice to Mariners and providing the necessary as-built coordinates to allow plotting of the facilities on NOAA nautical charts.

With respect to visual impacts on recreational areas, the proposed action represents a large manmade feature in the natural landscape of Nantucket Sound that would be viewed by many people in numerous shoreline areas used for recreation that surround Nantucket Sound. Conclusions as to the significance of visual impact on the people using recreational areas are provided in Section 5.3.3.4.

5.3.3.7 Competing Uses in the Vicinity of the Proposed Action

5.3.3.7.1 Construction/Decommissioning Impacts

Other Pipelines and Cables

Although a portion of the proposed offshore transmission cable system would cross over one of the existing submarine cable systems already servicing Nantucket Island from Barnstable (Lewis Bay), the effects of this crossing are expected to be negligible since the crossing is over the top of the existing cable and would likely use some form of manufactured “bridging” that would involve a very narrow linear crossing area where the cables would intersect. This is a routine installation technique that results in temporary and localized effects on the seabed and prevents damage to the other utility line. There are also cables that run from Falmouth out to Martha’s Vineyard, though these are well away from the proposed action location and would not be affected. There are no known bottom-founded structures in the vicinity of the site (other than structures associated with coastal marinas, which are located far from the proposed action area), and there are no pipelines in close vicinity to the proposed action area. The onshore portion of the transmission cable system can be constructed with due care to avoid affecting any existing utilities that may be present in the streets, road shoulders, or the NSTAR ROW.

Navigation Features

Maintenance dredging of nearby channels, if initiated at the same time as the jet plow installation of the cable system, could result in additional concurrent uses of the waterway. However, such concurrent uses would only be temporary, and the area affected at any one time during construction of the proposed action is relatively small and would not have a negative impact on navigation. The applicant and the party undertaking the dredging would have to schedule activities and vessel locations so as not to interfere with each others operations.

Sand Mining and Mineral Extraction

There are no sand mining projects proposed within the area of the proposed action or during the scheduled timeframe of the proposed action construction activities. There would not be any space use conflicts between the proposed action installation and sand mining projects. Furthermore, because there is currently a moratorium on oil and gas leasing along the Atlantic coast, these types of projects are unlikely in the timeframe before or during the installation of the proposed action. Therefore, no space conflicts would occur.

Commercial Fishing and Boating

The proposed action would be constructed in phases, and marine traffic would only be restricted in the immediate vicinity of ongoing construction activities for protection of public safety. The applicant estimates that only a few WTG locations would be worked on at any one time. However, cable jetting operations require that fixed gear not be placed in any cable segment schedule for jetting, since the gear could be damaged or lost. Since this would occur in ever changing locations, only small portions of the available fishing area would be restricted at any one time during cable jetting. The remaining areas of the proposed action would be open to unrestricted navigational access. Information updates including daily broadcasts on marine channel 16 would be provided during construction activities. See Section 9.6 for more navigational impact mitigation.

Recreational Fishing and Boating

The proposed action would be constructed in phases, and marine traffic would only be restricted in the immediate vicinity of ongoing construction activities (estimated to be one to two WTG locations at any one time and along the cable jetting vessel) for protection of public safety. The remaining areas of the proposed action would be open to unrestricted navigational access. Information updates including daily broadcasts on marine channel 16 would be provided during construction activities. See Section 9.6 for more navigational impact mitigation.

Military Training

The MMR conducts military training in the vicinity of the proposed action area. They have confirmed that the proposed action would not impact such training (see letter received from the base, in Appendix E).

Other OCS Alternative Energy

Currently there is only one tidal energy project proposed in the general area of the proposed action. This is proposed by Cape and Islands Tidal Energy Company and is located in Vineyard Sound. As the tidal energy project is more than 10 miles (16.1 km) away from the proposed action area, it would not result in a competing use of the area. The wind project in Buzzard's Bay proposed by Patriot Renewables, LLC would compete economically with the proposed action, but it is sited more than 17 miles (27.4 km) from the site of the proposed action and would not represent a competing use to the affected area of Nantucket Sound.

Onshore Activities

The construction and decommissioning of the proposed action would only cause temporary use conflicts due to the construction equipment during the installation of the transmission cable system through existing roadways. This conflict would be minor and temporary and would be minimized through implementation of a Traffic Management Plan.

Removal of Monopiles-Decommissioning

See Section 2.5 for a detailed description of the decommissioning process. Impacts from decommissioning would be similar to those during construction, but the end result would be the removal of navigation obstructions and return of the site of the proposed action to near pre-project conditions. All impacts from decommissioning to competing uses would be temporary and localized and would be negligible.

Conclusion

Overall competing use impacts of the proposed action construction and decommissioning on other existing and proposed uses would generally be minor because of the limited activity that currently takes place or is proposed at the site of the proposed action, the limited ways in which the proposed action would impact those activities, and the proposed mitigation measures.

5.3.3.7.2 Operational Impacts

Other Pipelines and Cables

There are currently no proposed pipeline or cable installation projects proposed within the area of the proposed action in the near future. The existing cables are not within Horseshoe Shoal, therefore there are no space use conflicts.

Navigation Features

Most commercial traffic, such as cruise ships and ferries which have deep drafts (13 to 20 ft [4 to 6.1 m]), are restricted by their draft and for safety reasons to the navigation channels marked by the USCG. Accordingly, cruise and ferry ships do not navigate out of the Main Channel and would not be expected to come close to the WTGs. It is also highly unlikely that any dredging projects would be allowed within the area of the proposed action, but if any were proposed, the presence of the WTGs would require restrictions. 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. Minor restrictions on anchoring would be caused by the monopile structures and the ESP. Overall, competing use impacts on navigational features would be negligible with respect to the Project's operation.

Sand Mining and Mineral Extraction

The monopiles and offshore cables of the proposed action would make future plans of sand mining within Horseshoe Shoal and along cable routes difficult, though there are many other locations to choose from that would be available for sand mining. In the event that the moratorium on oil and gas leasing in the Atlantic is lifted, future leasing within Horseshoe Shoal would be restricted by operation of the proposed action.

Commercial Fishing and Boating

Space use conflicts would occur between commercial fishing and the proposed action due to the establishment of the WTGs and ESP. Small areas would be precluded from commercial fisheries while these structures are in place during operation. (Space requirements are discussed in Section 2.2.) However, the 0.39 miles by 0.63 miles (0.63 by 1.0 km) spacing between the WTGs is far wider than the widths of existing channels in the Nantucket Sound area routinely used by commercial vessels (as shown in Table 4.2 of Report No. 4.4.3-1). Specifically, the existing channel widths in the Nantucket Sound area range from 240 ft in Hyannis Harbor to 700 ft in the Cleveland Ledge Channel. In comparison, the WTG spacing distance is 2,066 ft by 3,281 ft. Mariners are currently able to safely navigate commercial and recreational vessels through these commonly accepted narrow corridors. Therefore, the minimum spacing of 2,066 ft (629.9 m) would not present conditions more restrictive to navigation than presently exist in these channels. Fishing vessels would still be able to trawl within the wind turbine array. However, their operators would have to take the presence of the WTGs into account as they steer their courses. The WTGs on the east side of the array have been relocated to the northwest corner of the array in response to comments received from commercial fishermen who use mobile gear stating that the deep water to the east of Horseshoe Shoal is where they work most (Revised Navigational Risk Assessment, 2006).

The 115 kV offshore transmission cable system is also buried at sufficient depth and would be monitored to avoid upheaval or unburial, such that they would not affect trawling or anchoring in the area. Conflicts with navigation would be mitigated by USCG terms and conditions, such as lighting on the proposed action structures, boating restrictions, and annotated charts with private navigation aids that would be added to the existing network of navigation aids maintained by the USCG.

Analyses and observations of the area of the proposed action indicate Nantucket Shoals is not used by boaters extensively like other near shore areas. Large vessels and commercial vessels would continue to use the channels in the area for safety reasons, and are, thus, not likely to navigate into the area of the proposed action. As such, interruption or change in most vessel traffic patterns as a result of the proposed action would be negligible.

Recreational Fishing and Boating

Space use conflicts would also occur between recreational fishing and boating and the proposed action due to the operation of the Project. Space requirements for proposed action operation are discussed in Section 2.2. Any restrictions that are necessary to protect the safety of mariners would be implemented in coordination with the USCG. Recreational fisherman would also experience aesthetic impacts while fishing within the shoals and in the vicinity of the proposed action during operation. Recreational boaters/fishermen in the waters of Nantucket Sound would experience open views of the visible components of the proposed action during clear days and nights. See Section 5.3.3.6.2 for more recreational fishing impacts. Competing uses associated with recreational motor and sail boating are discussed in detail in the Navigation Section at Section 5.3.4.3.

Military Training

The MMR has indicated that the proposed action would not impact operation of the proposed action (see letter in Appendix E).

Onshore Activities

The transmission cable system onshore could interfere with or prevent future utility development within the onshore area of the proposed action, but typically this merely requires careful design of new facilities, since more developed areas in and near bigger cities have streets and ROWs with many more buried utilities than would exist along the proposed action route. Therefore, only minor impacts would occur to future uses.

Cable Repair

Should a cable failure occur, a Cable Repair Plan would be implemented (see Section 2.4.6 for a description of this plan). Cable repair requires the addition of a loop of spliced in cable, adding a very short distance of the seafloor that is occupied by the cable system, and would prevent future or other bottom disturbing construction or installations in the area. Overall impacts from cable repair on competing uses would be negligible.

Conclusion

Overall competing use impacts of the proposed action operation on other existing and proposed uses would generally be minor except as noted above (i.e., the Figawi Race) because of the limited activity that currently takes place or is proposed at the site of the proposed action, the limited ways in which the proposed action would impact those activities, and the mitigation measures that would be implemented. Some minimization measures include the spacing between the WTGs, the depth of burial of the cable system, and the navigation aids created by the presence of the WTGs and ESP, which minimizes navigational impacts. The onshore portion of the proposed action is proposed within existing roadways and ROWs and would primarily compete with the installation of other utilities, which can be accommodated with adequate designs.

5.3.4 Navigation and Transportation

5.3.4.1 Overland Transportation

5.3.4.1.1 Construction/Decommissioning Impacts

Impacts on overland transportation would be negligible due to the relatively small number of workers used for construction and operation relative to the surrounding population. Both Barnstable, (the worker staging area) and Quonset Rhode Island (Equipment manufacturing/assembly/loading area), have roadways in the area to provide access as needed. The majority of activity including transporting material for the construction of the proposed action would take place on barges from a deep water port in Quonset, Rhode Island.

Transportation impacts associated with the installation of onshore transmission cable system facilities would be temporary in nature. Some combination of road detours or lane closures would be required for cable installation within roadways. A detailed Traffic Management Plan would be prepared in coordination with the Town of Barnstable, Town of Yarmouth, and MassHighway to address road detour and/or temporary closure procedures as well as maintenance of access to abutting businesses and residences. This Traffic Management Plan would also include provisions for coordination with driveway access in construction areas.

Conclusion

Overland transportation impacts of the construction of the proposed action would be minor due to the relatively small number of construction workers and would be mitigated via use of a Traffic Management Plan. Mitigation being considered at this time includes the installation of the onshore cable system would occur outside of the height of the summer tourist season to minimize any vehicular disruption; trenchless technologies would be used at major intersections and railroad crossings in order keep traffic disruptions to a minimum. A more detailed discussion of mitigation is provided in Section 9.0.

5.3.4.1.2 Operational Impacts

Operational impacts on overland transportation would be limited to a very small number of workers associated with the operation and maintenance of the facilities. Maintenance workers would access the site via work boats from Falmouth, and the maintenance supply vessel would access the site from New Bedford. As the number of workers required for maintenance and operation would be very small, the overland transportation impacts during operation would be negligible.

5.3.4.2 Airport Facilities and Aviation Traffic

5.3.4.2.1 Construction/Decommissioning Impacts

The FAA has studied the impact of the proposed action on the airport facilities and aviation traffic in the area and has concluded that the original configuration of the proposed action would "have no substantial adverse effect on the safe and efficient utilization of the navigable airspace by aircraft or on the operation of air navigation facilities" (see correspondence from FAA in Appendix E). As a result of the reconfiguration of the WTG's, design changes that had increased rotor height, and the release of new lighting guidelines by the FAA, the applicant had initiated new Aeronautical Surveys by the FAA for each of the proposed turbine locations. This subsequent determination is pending. Based on the above FAA finding, and assuming a subsequent finding from FAA of no substantial adverse effect on aircraft or on operation of air navigation facilities, the potential impacts during construction would start out as negligible and increase to minor as more and more WTGs are erected. During decommissioning, impacts would start out as minor and drop to negligible as more and more WTGs are removed.

5.3.4.2.2 Operational Impacts

As noted above, the FAA has studied the impact of the proposed action on the airport facilities and aviation traffic in the area and has concluded that the original configuration of the proposed action would "have no substantial adverse effect on the safe and efficient utilization of the navigable airspace by aircraft or on the operation of air navigation facilities" (see correspondence from FAA in Appendix E). The FAA is reviewing the proposed action modifications and would issue another determination.

In March of 2005 the FAA made public a draft report for marking and lighting of wind turbine farms that was developed jointly with the DOE following 4 years of research and flight evaluations of existing wind farms. The FAA formally issued the guidance document in final form in November 2005 (Development of Obstruction Lighting Standards for Wind turbine Farms; DOT/FAA/AR-TN05/50).

As a result of the new FAA guidance, the following revised lighting plan is proposed for operation of the facility:

- Each Perimeter WTG nacelle would be lighted with one red flashing FAA light fixture equipped with automatic bulb changers.
- Medium intensity lanterns (FAA L-864) would be used at corners/points of direction change with intervals of no more than 1.5 miles (2.4 km) between similar intensity fixtures.
- The balance of perimeter WTG's would be marked with low intensity lanterns (similar in intensity to the FAA L-810 with visibility to approximately 1.15 miles).
- The eight turbines adjacent to the ESP would each have one L-810 flashing red fixture.
- The balance of the interior turbines would not have FAA lighting.
- The turbines would be painted off-white (5 percent grey) and no daytime white lighting would be used.
- All FAA lighting would be synchronized to flash as one at a rate of 20 FPM.

These changes would result in the proposed action design being compliant with FAA guidance while minimizing adverse affects on other environmental resources that occur as a result of WTG and ESP lighting.

As described in Section 4.4.2, within the site of the proposed action, aviators are responsible for safe flight under Visual Flight Rules (VFR). While the WTGs do represent obstacles to flight near the ocean's surface, they would be marked on navigation charts and if unsure of safety, aviators would fly over or around the WTG array. This is consistent with the FAA findings.

Conclusion

Given the above lighting plan, and assuming a subsequent finding from FAA of no substantial adverse effect on aircraft or on operation of air navigation facilities, impacts to aviation are expected to be minor.

5.3.4.3 Port Facilities

5.3.4.3.1 Construction/Decommissioning Impacts

With respect to construction and decommissioning impacts on navigational activity, the proposed action would be constructed in phases, and marine traffic would only be restricted in the immediate vicinity of ongoing construction and decommissioning activities (estimated to be one to two WTG locations at any one time or short segments of the cable system) for protection of public safety. The remaining areas of the proposed action would be open to unrestricted navigational access. The WTG that is closest to the Main Channel is approximately 1,190 ft (362.8 m) from the charted Main Channel edge and approximately 6,900 ft (2103.7 m) east of the Main Channel's narrowest point. The work vessels used to construct or decommission the WTGs are approximately 400 ft (122 m) long. This leaves ample room for vessels to transit past any ongoing work. These work vessels would not need to occupy or block the Main Channel during construction and decommissioning. Therefore, no restrictions or closures of the Main Channel to transiting vessels are anticipated. The USCG routinely deconflicts waterways and channels around marine construction activities, and it is anticipated that such procedures could be implemented in Nantucket during construction and decommissioning.

The proposed action would not prohibit vessels from entering or operating in the area of the proposed action and the applicant does not intend to establish exclusionary zones. In addition, the WTGs would be constructed in a grid pattern (minimum 0.39 miles by 0.63 miles [0.63 by 1.0 km] spacing), which would help mariners by allowing them to navigate a relatively straight course through the WTG array. In addition, the 0.39 miles by 0.63 miles spacing between the WTGs is far wider than the widths of existing navigation channels in the Nantucket Sound area routinely used by commercial vessels (i.e., Cape Cod Canal is 480 ft [146.3 m] wide), and thus ample room would be provided for navigation (see Figure 5.3.4-1).

Conclusion on Construction and Decommissioning Impacts

Given the level of navigational impacts discussed above, and proposed mitigation including the lighting of monopiles, lighting of construction vessels, spacing and placement of monopiles to allow for safe navigation, the impacts to vessels navigating in channels during construction and decommissioning would be minor. Note that in the later stages of construction or the early stages of decommissioning, when most of the monopiles are in place, navigational impacts are likely to be the same as those described below in the section on impacts during operations. The USCG has provided Terms and Conditions for the proposed action to help ensure navigational safety of the area during construction and operation (see Appendix E).

5.3.4.3.2 Operational Impacts

Ship, Container and Bulk Oil Handling Facilities

There are no ship and container handling facilities in ports surrounding Nantucket Sound. Containers are carried on SSA ferries as part of a tractor trailer rig and are on and off loaded by driving the rig onto or off the vessel on its vehicle deck. There are bulk liquid facilities at Vineyard Haven and Nantucket for offloading petroleum products that are transported by the T/V Great Gull and other barges. The largest ship handling facilities are those owned and operated by the SSA and the oil transfer facilities in Vineyard Haven and Nantucket. The referenced facilities are located in harbors far away from the proposed action and as such the proposed action would have negligible impacts on these facilities. Impacts to ferries, oil transport barges and other vessels are discussed below.

Navigational Channels

Due to the characteristics of the waterway, most commercial traffic is restricted by its draft and for safety reasons to the navigation channels marked by the USCG. The area is transected by two named channels but only one major channel that provides a route for medium sized vessels to transit in an east/west direction in an area north of the Nantucket Shoals.

The separation distance between the WTGs and the Main Channel is slightly less than that of the Middelgrunden Wind Farm from a shipping channel in Copenhagen, Denmark. The Middelgrunden Wind Farm is located approximately 1,500 ft (0.29 miles M [0.46 km]) from this shipping channel. According to the Royal Danish Administration of Navigation and Hydrography, between 25,000 and 30,000 ships navigate this shipping channel annually, and there have been no reported incidents of collision of ships in this channel with the WTGs (Nielsen, 2005).

In addition, the proposed action has been reconfigured to further distance WTGs from the referenced channels. Several of the southernmost turbines shown in the 2003 Navigational Risk Assessment have been relocated from sites adjacent to the Main Channel to sites in the northwestern portion of Horseshoe Shoal; an area with significantly less deep draft commercial vessel traffic. This relocation further reduces the chance for deep draft vessel interaction, as the nearest WTG is now sited approximately 1,190 ft (0.23 miles [0.37 km]) from the charted edge of the Main Channel, which represents a separation distance increase of approximately 515 ft (0.09 miles[0.15 km]) from that presented in the applicant's 2003 report.

Cruise Ship Traffic

As discussed above, most commercial traffic, such as cruise ships which have deep drafts (13 to 20 ft [4 to 6.1 m]), are restricted by their draft and for safety reasons to the navigation channels marked by the USCG. Accordingly, cruise ships do not navigate out of the Main Channel, and would not be expected to come close to the WTGs. As a result, navigational impacts to cruise ships are expected to be negligible.

Ferry Operations

Ferry operations between Martha's Vineyard and Woods Hole should not be affected by the proposed action as the ferries come no closer than 8 miles (13.0 km) from the closest WGT for the SSA vessels calling on Oak Bluffs and over 9.2 miles (14.8 km) for vessels calling at Vineyard Haven.

Vessels traveling between Hyannis and Woods Hole to Martha's Vineyard use the North Channel from the Hyannis Sea Buoy (HH) through Red Nun 8 and Green Can 7 to Green Can 11 and pass to the north of Horseshoe Shoals. The closest point of approach to a WGT on the north side of Horseshoe Shoal is in the channel gate between Red Nun 8 and Green Can 7, and is approximately 0.86 miles (1.4 km) away.

The SSA vessels traveling from Hyannis to Nantucket proceed to the Hyannis Sea Buoy (HH) and set on a course of 154° True passing Bishop and Clerks Red Nun 4 to Port, over Broken Ground and Red #2 continuing to Green #17 on the Main Channel. Horseshoe Shoal is passed down the starboard side. The closest point of approach this vessel track takes to a WGT is approximately 1.7 miles (2.8 km) in the vicinity of Half Moon Shoal. Based on SSA published vessel schedules and transit times, it is unlikely that a meeting situation between two SSA ferries would be encountered in the immediate vicinity of a WGT.

Ferries using the Main Channel for transits between Woods Hole and Nantucket and between Martha's Vineyard and Nantucket approach the WGT at a distance of approximately 0.69 miles (1.1 km) from a track line at the center of the channel in the vicinity of Red #20 of the Main Channel. Vessels in a meeting situation with a 500 yard closest point of approach between them could potentially come within 0.4 to .46 miles (0.65 to 0.74 km) from the nearest WGT at the Red #20 and Green #21 Gate.

The SSA stated in a letter to USCG Sector Providence that its captains often use tacking maneuvers on the route between Hyannis and Nantucket to provide a smoother ride and to protect vehicles and cargo on board the ferries. This tacking maneuver is postulated to be a course line set at an angle to the sea to allow the vessel to pitch less in a head sea or to wallow less in a trough. Rather than follow a straight course of 154° True, the master varies his course up to 45 degrees either side of the base course. Actual tacking maneuvers by the SSA have not been documented. However, it appears based on channel width and the WTG array offset from channels, that there is ample room for navigation, and the proposed navigational mitigation would make any such impacts minor.

Marinas and Recreational Boating

Marinas are located along shoreline areas far from the proposed action, and as such, would not be affected by the WTGs. The proposed action would impact the Figawi sail boat race that occurs between Hyannis and Nantucket and back every year on Memorial Day. This impact would be moderate, but can be overcome by selecting a race course that does not pass through the site of the proposed action - the overlay of historic race courses shows the race can still be run without crossing the area of the proposed action (refer to Figure 4.4.3-2).

The current proposed action design specifications call for a WTG rotor to clear sailing vessels no larger than 47 ft (14.3 m) (mast heights 72 ft [22 m] or less). Barring any custom design, as a general rule, sailing vessels greater than 47 ft (14.3 m) in length would not be able to clear a rotor due to their mast heights exceeding 72 ft (22 m). Sail boats of this size would tend to stay away from the area due to the shallow shoals and inherent risks of navigating, such a large sailing vessel through the WTG array. This would be a moderate impact and would be mitigated as follows: If a vessel with a mast or structure height of 72 ft (22 m) or higher is in distress and drifting toward a WTG, the WTGs in the path of the vessel can be remotely shut down by the applicant upon receipt of a request to do so by the USCG. Shutting down the WTG prior to the distressed vessel coming close to a WTG would eliminate the potential of the vessel being struck by the rotating blade.

Finally, sail boaters, and to a lesser extent motor boaters, would be faced with a minor to moderate navigational impact, depending on the type of navigational impact on board, as the proposed action would in general make offshore cruising more difficult as the operator would have to take more care to avoid the structures. This would be more difficult during fog conditions or at nighttime.

Commercial Fishing

Commercial fishing is not expected to be significantly impacted. The offshore cables are buried at sufficient depth such that they would not be affected to the extent trawling takes place in the area or by anchoring in the area (A detailed assessment of anchor impacts is provided in the *Revised Navigational Risk Assessment* – (Report No. 4.4.3-1).[6] In addition, the proposed action WTGs are spaced far apart in a straight grid to allow trawlers to navigate in a relatively straight line without danger of colliding with the WTGs. With respect to proposed action mitigation, the revision to the turbine array has resulted in the relocation of a number of WTGs away from the from deeper water areas along the eastern portion of the array to minimize or avoid impacts to commercial fisherman who use mobile gear in this area. The increased separation distance of the turbine array from this area provides a potential positive impact to marine navigation for commercial fishing when compared to the original turbine array configuration.

Search and Rescue (SAR)

The proposed action 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 46.4 square miles [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 area of the proposed action. These incidents occurred between November 1991 and August 2002. The majority of the incidents occurred during daylight hours, with only 22 percent occurring between sunset and sunrise. The majority (81 percent) of the responses to SAR

[6] There is generally little commercial use of anchorages in the area of the proposed action given the dangerous shoal waters and the accessibility of nearby harbors. The Steamship Authority's vessels, work vessels, and cruise ships could potentially anchor in the area, although the likelihood is slim. These types of vessels typically have anchors that would penetrate 3 to 4.5 ft in and around the area of the proposed action. This is 1.5 to 3 ft less than the minimum 6 ft burial depth proposed for the inner array cables and submarine cable interconnection.

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 proposed action 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 proposed action area. A representative of USCG Air Station Cape Cod indicated that USCG aircraft would be able to operate in and around the area of the proposed action 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. The USCG aircraft responding to incidents south of the area of the proposed action would either cruise over or around the WTG array, depending on their destination, and this would not adversely affect USCG response times (USCG, 2003).

The presence of the WTGs within the proposed action area, 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 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 WTG grid pattern and 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 proposed action operations, proposed action work vessels in the proposed action would be conducting routine monitoring and maintenance during daylight hours when the seas are less than 6 ft (1.8 m). These work vessels would be able to assist vessels in distress within the proposed action during these times, and would do so either upon receipt of a request for assistance from the vessel or from the USCG. Proposed action personnel on these vessels would be trained in first aid, CPR, and marine survival skills.

Ice

There do not appear to be historical records on the frequency of sea ice events in Nantucket Sound. The National Weather Service in Taunton, Massachusetts 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. The WTG monopiles have been designed to withstand the forces of up to six (6) inch thick ice floes impacting the monopile.

Although rotor blades would have a slick surface for aerodynamic efficiency, which would allow most ice to slide off prior to any significant buildup, ice may collect on the WTG structure and blades under certain meteorological conditions. This ice usually takes the form of a thin sheet as it attaches to WTG surfaces. Temporary icing of a rotor blade would activate vibration sensors causing turbine shutdown in order to prevent rotor damage or hazard to proposed action maintenance staff or others from falling ice. Conditions conducive to icing would be evaluated by continuous monitoring of meteorological conditions and by monitoring the WTGs remotely (via camera). If conditions warrant, manual shut down of the WTGs experiencing icing conditions would be initiated. The ice would remain attached until meteorological conditions allow it to melt. If the WTG is no longer operating due to icing, the melting ice would break apart into fragments in the same manner as ice falls off building. The risk of ice fragments being thrown from a turning rotor and causing injury is relatively small when one considers the unique weather conditions required for icing and the fact that icing can only occur during the winter months when navigation activity within the site of the proposed action is likely reduced to a few vessels other than the maintenance vessels. Accordingly, impacts from icing are expected to be negligible.

Vessel Impact Analysis

An impact analysis was performed to assess the structural ability of the WTGs to withstand vessel strikes (Report No. 4.4.3-1). The analysis concluded that a drifting vessel of the size that frequents the area of the proposed action would not result in collapse of a WTG after impact. However, it was concluded that the impact of a moving vessel, equal to or larger than a 1,200 metric ton barge, with a WTG could possibly result in collapse of a WTG after impact, and that the impacting vessel and persons onboard could sustain some form of injury. However, such large vessels do not typically operate in the area of Horseshoe Shoals because of inadequate water depths and safety considerations. As well, the mitigation described above reduces the likelihood of such an event from ever occurring.

Conclusion

Impacts related to navigation are expected to be minor with the exception of impacts to sailing vessels which are expected to be moderate in the event of loss of vessel control. Impacts would be minimized through mitigation including lighting of monopiles (see Section 9.0), spacing and placement of monopiles to allow for safe navigation, and the WTG array setback from boating channels. The USCG has provided Terms and Conditions for the proposed action to help ensure navigational safety of the area during construction and operation (These are summarized in section 9.6.2 and attached in Appendix E). A more detailed discussion of mitigation is provided in Section 9.0.

5.3.4.4 Communications

5.3.4.4.1 Construction/Decommissioning Impacts

There are two primary communication issues that arise with regard to the construction of large-scale wind turbine projects: (1) Temporary use of "itinerant" and shared repeater frequencies, point-to-point frequencies, and cell phones by construction crews can possibly cause some amount of radio traffic congestion for other users, especially cell phone users; and (2) Use of construction cranes that could temporarily cause local re-radiation of Low Frequency and Medium Frequency services. These issues are discussed below.

Temporary Use of Radios by Construction Crews

Temporary use of radios by construction crews is seldom an issue because there is very little (although not zero) overlap of private radio frequencies (RFs) with public safety and marine frequency bands (the primary exception is the use of private frequencies by some public entities in cases where public safety frequencies are completely subscribed). The private frequencies that are generally used by construction crews are in the VHF and UHF ranges, and, if properly licensed and maintained, operate completely outside of the marine and public safety bands.

Of primary concern are the emergency calling frequencies, which require the highest degree of protection, as follows:

(1) VHF

- Channel 16 (156.800 MHz) - Distress, safety and calling
- Channel 13 (156.650 MHz) – Inter-ship navigation (bridge-to-bridge)
- Channel 70 (156.525 MHz) - Digital Selective Calling

(2) HF: HF radiotelephone emergency channel 2182 kHz

Private use of the HF frequencies is virtually nonexistent today, because it represents obsolete technology and the antennas are insufficiently compact. It is far more likely that construction crews would use VHF, UHF, or Super High Frequency (SHF) frequencies. Among these three frequency ranges, marine applications are primarily centered on the VHF channels. Besides protection of the emergency channels listed above, additional frequencies are assigned and licensed by the FCC to marine service on a basis that protects them from interference (refer to Table 5.3.4-1). Temporary use of radios by construction crews can have minor impact on radio communications to these frequencies. Avoidance of these frequencies would minimize impact.

Temporary Use of Construction Cranes by Construction Crews

Construction cranes would have a local effect primarily upon low and high RFs. This effect would manifest itself as a distortion of the RF around the crane, which would have a magnitude similar to the wind turbine itself. Since the crane would be relatively close to the turbine position, the differential effect is not expected to be significant with respect to long range navigation (LORAN) broadcast, and HF emergency frequencies.

Conclusion

In conclusion, communication issues resulting from construction and decommissioning of the proposed action would be minor and easily mitigated by avoiding close approach and by utilizing properly licensed and maintained two-way radios.

5.3.4.4.2 Operational Impacts

Wind turbines can have impacts on many types of communications. This section addresses the operational impacts with respect to microwave, HF, cell phone, satellite, TV, AM, FM, and LORAN communications.

Frequently, wind turbines located near RF transmitters or receivers can cause one or more modes of RF impact, such as aperture blockage (shadowing, usually caused by the support structure), time-varying occultation (usually caused by the turbine fan), and multipath reception (usually caused by RF "scattering" of the primary signal).

The turbines have an electrical conductor that runs the length of the leading edge of each blade, and which is grounded through the hub connection. As the turbine rotates through an RF field, it results in a time-varying signal that is displaced in time from the primary (incident) signal. Depending upon the sensitivity of the RF receiver, the frequency involved and the strength of the radiated power, it is possible in some cases that interference could be caused to other services.

Impacts associated with Various Communication Devices

Using industry standard procedures and FCC databases for microwave links, a search was conducted to determine the presence of existing microwave paths crossing the subject property, as well as other RF facilities within or adjacent to the identified area. The turbine layout plan was then prepared as an overlay, showing microwave blackout areas and nearby land mobile (2-way) radio facilities. The resulting maps are shown in Figures 5.3.4-2 and 5.3.4-3. With respect to broadcast facilities, pertinent TV, FM and AM stations were listed and the estimated impact to broadcast consumers in the turbine area was assessed.

The following is a list of communication devices and information on how they may be affected. Table 5.3.4-2 shows a summary of the frequencies of interest with respect to possible adverse effects due to the proposed action.

Entertainment Satellite

Entertainment satellite equipment depends on a stationary earth receiver. If a turbine blade, which has a metal component, turns in front of the receiver dish, the received video can "freeze" or "pixelate" (turn into small squares). This impact would be minor and only apply to a vessel using an entertainment satellite system in very close proximity to the turbines.

Entertainment Broadcasting Services (AM, FM and TV stations)

The frequency used for entertainment broadcasting services is below 1 GHz. For shipboard analog receivers, such as traditional TV, FM and AM, the main effect of a turbine blade would be a small rhythmic variation in the transmitted signal strength that is generally compensated for by the receiver's automatic gain control, even when the receiver is quite close to the turbine. The exception to this statement would be if the particular station was quite distant (depending upon the type of service) or used a directional antenna that reduced coverage over the water. It should be noted that some ships occasionally use AM broadcast stations for positioning. The use of these signals is relatively imprecise and may be subject to a small amount of additional uncertainty when near the turbines. For digital entertainment signals, the indicated effects can be slightly greater; in these cases, the 0.5 miles (800-m) limit may be appropriate. While these entertainment style services can be disrupted within the turbine impact area, mitigation should generally not be required because the influence area is small, being primarily confined to a radius of 0.5 miles (800 m) from each turbine (it is true that there is a small residual effect outside of this distance, but it is generally considered to be insignificant). Based upon FCC database information, no significant impact is expected to the reception of FM or AM broadcast facilities. Direct over-the-air reception of full-power TV stations is unlikely in and near the turbine area, being limited to TV sets mounted in watercraft, and due to the paucity of nearby TV transmitters.

Non-emergency Ship-to-Shore Communications (cellular communications and VHF frequencies in the marine band)

To a first order approximation, the same blockage (more precisely, "re-radiation") effect is experienced by both the receiver and the transmitter of non-emergency ship-to-shore communications, and can disrupt both sides of a conversation or data transfer. A small additional impact is due to antenna aperture blockage of the very large turbine support structures. These effects are primarily limited to paths that pass through the turning blades within approximately 0.5 miles (800 m) of shipboard radios, even though the angles of interception are lower on the horizon compared to the satellite services. Ship-to-ship communications are subject to the same impacts as the ship-to-shore services, as long as either of the ships is within the impact zone (the subject antenna should be approximately 0.5 miles [800 m] from the nearest turbine).

Navigation and Positioning Services

Navigation and positioning services can be critical to ship safety. They include satellite GPS services, LORAN, and shipboard radar. The satellite GPS signals are subject to the same types of anomalies that affect entertainment satellites. Precise timing is the hallmark of accurate positioning, and the receivers used to calculate the ship's position can be "fooled" by the "multipath signals" created if it is "looking" through a wind turbine. For most ships, the 800 m radius should provide sufficient clearance (subtended angle above the horizon of less than 15 degrees).

The situation for long-range radar requires special consideration. Radar operates by sending out a RF "pulse" in the high-Gigahertz range, and then waiting for an "Echo" from a fixed object or a ship. The time delay of the echo, along with the direction of the reflection, establishes the distance and the bearing of the object, which can be another ship or a land obstruction. The higher the frequency, the better the possible resolution (the ability to distinguish two objects close together). At angles close to the horizon, wind turbines can add "clutter" to the radar's display screen, making it difficult to distinguish small objects, even with high resolution. Depending upon the power and sophistication of the radar system, this effect can extend for 57.5 to 92 miles (92.6 to 148.2 km) from the turbine farm, but would be confined to the general region of the turbines. The primary effect would be to make it difficult to resolve each wind turbine separately.

LORAN

If a ship is within a 0.5 miles (800 m) distance from a turbine there is a possibility that a minor error could be introduced into the LORAN receiver. There are no reasonable mitigation techniques, other than maintaining the required distance.

Safety and Emergency Communications

For nearly all voice and low-speed data applications, the effect of the turbines would be confined to the 800 m radius mentioned previously. For some non-standard applications, such as high-speed data above 10 or 20 Megabits per second, the throughput speed may be reduced if the communications path transverses the turbine area, especially near the center of the path. This effect is not deemed to be critical, because the communications would not be completely disrupted, merely slowed, and the geometry required for adverse effects would be a small fraction of usage, especially since communications at these higher speeds is currently quite rare. Based upon reasonable assumptions, there are no serious instances of impact potential to land mobile or public safety facilities.

Impact of Offshore Cables

The possible radiation from offshore cables is confined to power frequencies (60 to 120 Hz, usually 3-phase). The magnitude of the EMF is proportional to the current flowing in the cable(s). The cables are engineered structures with shielding, and are designed not to radiate and electric field. It should be noted that a wavelength at 120 Hz. is over 1,000 miles (1609.3 km); therefore, a significant difference of potential would not be evident from the proposed action to the shore. Therefore, there would be no significant effect.

Micro Wave Communications - Airports

No microwave links are impacted by the present turbine arrangement. However, if turbines are relocated within the Worst Case Fresnel Zone of any other identified path as shown in Figure 5.3.4-2, those paths should be re-studied. If turbines must be re-located closer to the microwave path, the path should be field-verified by GPS survey.

Conclusion

The proposed action is expected to have a minor impact on the communications systems in the area. In addition, to help ensure minimal impact on communications, the USCG has submitted Terms and Conditions, one of which requires the applicant to submit an analysis before the start of construction, to evaluate whether or not the WTGs as designed would interfere with marine communication or navigation systems or produce any adverse impacts to navigational safety (refer to USCG letter in Appendix E).

5.4 ALTERNATIVES EVALUATED FURTHER IN DETAIL

Based on the results of the screening process described above, MMS chose the following alternatives to evaluate in further detail. These include:

- Monomoy Shoals;
- South of Tuckernuck Island;
- Smaller Alternative;
- Phased Development Alternative; and
- Condensed Array Alternative.

The locations for each of these alternatives are shown together in Figure 3.3.5-1. This section also reviews the option of taking no action.

5.4.1 South of Tuckernuck Island Alternative

5.4.1.1 Description of the South of Tuckernuck Island Alternative

The South of Tuckernuck Island Alternative is approximately 3.8 miles (6.1 km) southwest of Tuckernuck Island in Federal waters (see Figure 3.3.5-1). Water depth within the site ranges between 15 ft and 100 ft (4.6 m and 30.5 m) below MLLW, with an estimated average depth of approximately 57 ft (17.5 m). The South of Tuckernuck Island Alternative would be the same generation size as the proposed action (130 WTG's, 3.6 MW machines plus an ESP), but would require an area of approximately 36 square miles (93.2 km^2). The proposed turbine spacing for the South of Tuckernuck Island site is a grid arrangement approximately 9.0 rotor diameters (0.63 miles [1.0 km]) by 5.7 rotor diameters (0.39 miles [0.629 km]).

This site would require foundations to be placed in various water depths ranging from approximately 15 to 100 ft (4.6 to 30.5 m), but still benefits from some sheltering effects from open ocean waves due to Nantucket Island to the east. The South of Tuckernuck Island Alternative would likely require three different sized monopiles and a quad-caisson foundation depending on water depth. Water depths between 0 and 30 ft (0 and 9.1 m) would utilize a 16.75 ft (5.1 m) diameter monopile, water depths between 30 and 45 ft (9.1 and 13.7 m) would utilize an 18.0 ft (5.5 m) diameter monopile, and water depths between 45 and 65 ft (13.7 and 19.8 m) would utilize a 19.0 ft (5.8 m) diameter monopile. The quad-caisson foundation, a fabricated steel structure, would be utilized for all WTGs installed at a depth greater than 65 ft (20 m). This structure would consist of four tower foundations that support the tower interface (see Figure 3.3.5-2). This structure would require more fabrication and installation due to its large size and the more challenging sea conditions off the southern coast of Nantucket Island.

With respect to construction, the South of Tuckernuck Island Alternative is located in a more open ocean setting that presents sea conditions considerably different from the proposed action. Greater precautions for personnel safety would add to the complexity of the construction. The sea conditions would also restrict access to the site for construction and for maintenance to a considerably greater degree than the proposed action as well as some of the other alternatives. Routing for delivery of material to the site from a marshalling area (assumed to be Quonset Rhode Island for purposes of this comparison) would be from south of Martha's Vineyard.

The construction sequencing for this Alternative would be similar to that described for the Nantucket Sound alternatives. However, rather than the mechanical driving of the structure into the seabed as described for the monopiles, the caissons of the deep water foundation would be set on the seabed and then suctioned into place to the appropriate depth.

The 115 kV offshore transmission cable system for the South of Tuckernuck Island Alternative would consist of the same equipment as described in Section 2.3 of this document. The total length of the offshore cable route, from the alternative site of the ESP to the Barnstable Substation, would be 33.4 miles (53.8 km). Of this amount, approximately 14.8 miles (23.8 km) of cable would cross the OCS, 12.7 miles (20.4 km) would cross state submerged lands, and approximately 5.9 miles (9.5 km) of cable would be located in an onshore transmission ROW. The offshore cable would be routed from the ESP in a northwesterly direction for about 6.8 miles (10.9 km) and then turn in a northeasterly for about 20.7 miles (33.3 km) before making landfall.

The location, WTG configuration, and interconnection routing for this alternative are provided in Figure 3.3.5-3.

5.4.1.2 Environmental Resources of the South of Tuckernuck Island Alternative and Comparison with the Proposed Action

5.4.1.2.1 Regional Geologic Setting

Particle analysis of surface grab sediments collected during benthic studies in Nantucket Sound show sand sized particles predominate, derived from relict glacial sediments (Poppe et al., 1989; Theroux and Wigley, 1998). Finer-grained sediments containing silt and clay could be expected south of Tuckernuck Island, which would indicate that depositional sediment environments may occur in some locations. Glacial sediments near the South Tuckernuck Island Alternative site could be about 60 ft (18.3 m) thick (Uchupi et al., 1996).

Approximately 8 to 10 miles (13 to 16 km) west of the South of Tuckernuck Island Alternative, vibracore samples recovered coarse to fine quartz sand and shell fragments in the upper seven ft (2.1 m). At other core locations, sands also contained silt and clay, generally at the base of the vertical section sampled. Borings that were drilled southeast of Nantucket Island encountered approximately 90 ft (27.4 m) of fine sand overlying a silt of unknown thickness (Uchupi et al., 1996). Lenses of gravel to coarse sand and medium to fine silty sand were encountered in another nearby boring. These conditions indicate that alternating sequences of high and low energy sediment deposition during glacial stagnation and retreat occurred.

The geological setting of the South of Tuckernuck Island Alternative is similar to the proposed action with regard to sediment composition (see Section 4.1.1 of this document). Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. The geologic setting at the South of Tuckernuck Island Alternative is comparable and offers no significant environmental advantage over the proposed action.

With respect to coastal geomorphology, the northwest part of the South of Tuckernuck Island Alternative is located south and southeast of Muskeget Channel between Martha's Vineyard and Nantucket. Strong currents in and around this channel and ocean currents continue to shape the geomorphology of the sea bottom in this area. Migrating sand waves and shoals may be present, especially in shallow water on the northwest portion of the alternative site. Coarse-grained armor-type bottom sediments, often encountered in channels swept clean of fine-grained material, can also be expected. The regional geology and coastal morphology of the proposed action and the South of Tuckernuck Island Alternative are similar; however site-specific conditions of the two sites differ (see Section 4.1.1.1 of this document for a discussion of the site-specific conditions at the site of the proposed action). Compared to the proposed action, the geology and coastal morphology of the South Tuckernuck Island Alternative offers no significant environmental advantage over the proposed action with respect to its construction, operation, or decommissioning.

5.4.1.2.2 Noise

The potential impacts from above water and underwater sound related to construction and decommissioning activities at the South of Tuckernuck Island Alternative would be equivalent to the impacts from these activities at the Nantucket Sound Alternative. However, due to the greater number of foundation supports with larger diameters and the greater distance that this site is located offshore, the South of Tuckernuck Island Alternative may require a longer construction timeframe, thereby resulting in longer duration of acoustical impacts during construction and decommissioning compared to the other offshore alternative sites.

The potential impacts from underwater sound related to operation of the WTGs at the South of Tuckernuck Island Alternative would be equivalent to the impacts from these activities at the Nantucket Sound Alternative. Acoustic modeling for the South of Tuckernuck Island Alternative was performed to predict the above-water, broadband continuous sound level L_{eq} (dBA) at the closest sensitive onshore receptors for this alternative. As with the other alternatives, the worst case was assumed with the WTGs operating at their design wind speed and wind directions corresponding to onshore conditions for the sensitive receptors. Sound data for a 3.6 MW GE WTG was used in the calculations.

The onshore receptor used for the South of Tuckernuck Island Alternative in the acoustic modeling is Madaket Beach on Nantucket. The maximum predicted sound level for the South of Tuckernuck Island Alternative is approximately 30 dBA. With respect to the Nantucket Sound Alternative as discussed previously, operational noise South of Tuckernuck Island is less likely to be noticeable than the pile driving noise during construction. Furthermore, wildlife and human receptors are expected to acclimate to the low noise levels and are not likely to be adversely affected. Noise impacts are minor for both the proposed site and the South of Tuckernuck Island Alternative with respect to construction, operation, and decommissioning. Compared to the proposed action, the South of Tuckernuck Island Alternative offers no significant environmental advantage with respect to noise over the proposed action during construction, operation, and decommissioning.

5.4.1.2.3 Physical Oceanography

Water depths for the South of Tuckernuck Island Alternative generally increase in a southwesterly direction. Tidal height and range information specific to the South of Tuckernuck Island Alternative are not available. However, the closest NOAA tide stations, located in similar conditions, are at Wasque Point on Chappaquiddick Island (about 8.0 miles [12.9 km] northwest of the South of Tuckernuck Island Alternative ESP) and Tom Nevers Head on Nantucket (about 18.0 miles [29 km] east of the South of

Tuckernuck Island Alternative ESP). Given the open sea location of the alternative site, it is expected that tidal ranges would be similar to those at the two NOAA tidal stations (see below). The NOAA also has tidal current stations located within and northwest of the South of Tuckernuck Island Alternative.

The fetch at the South of Tuckernuck Island Alternative is restricted to the northwest by Martha's Vineyard and to the north and east by Muskeget, Tuckernuck and Nantucket Islands, and shallow shoals. Since the fetch is open to the Atlantic Ocean to the south and west the largest waves are likely to come from those directions. Oceanographic data for the site is as follows:

Water Depth: The estimated depths within the alternative site is between 60 and 90 ft (18.3 and 27.5 m) at MLLW except at the northwest edge which has water depths of between 10 and 25 ft (3.1 and 7.6 m) at MLLW.

Tide: Average Tides:
- Mean Range = 1.15 ft (0.35 m)
- MHWS = 1.40 ft (0.43 m)

Current: Station ID: 1716
- Avg. Max Flood = 0.5 knots (0.26 m/s) 90˚
- Avg. Max Ebb = 1.0 knots (0.51 m/s) 270˚

Wave Conditions: WIS Station IDs: 87 and 86 Extreme storm waves of approximately 52.5 ft (16 m); larger value of the two WIS stations.

Compared to the proposed action, the oceanography of the South Tuckernuck Island Alternative offers no significant environmental advantage over the proposed action.

5.4.1.2.4 Climate and Meteorology

The weather conditions for the South of Tuckernuck Island Alternative are similar to the site of the proposed action. However, the alternative site is estimated to have a predicted mean wind speed between 19.0 and 20.1 mph (8.5 and 9.0 m/s) in the near shore and between 20.1 and 21.3 mph (9.0 and 9.5 m/s) in the far shore. This is fairly close to the wind speed at the Horseshoe Shoal site which has a mean wind speed of 17.9 to 20.1 mph (8 to 9 m/s). Compared to the proposed action, impacts on climate and meteorology within the South of Tuckernuck Island site, including its offshore and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.5 Air Quality

The existing air quality conditions for the South of Tuckernuck Island Alternative site are similar to the site of the proposed action. Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning, and maintenance would emit, or have the potential to emit air pollutants. However, emission impacts would be minor and overall, impacts on air quality associated with the South of Tuckernuck Island Alternative, including its offshore and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.6 Water Quality

The Massachusetts Surface Water Quality Standards (314 CMR 4.06(3)) categorize surface waters adjacent to Nantucket Island as Class SA coastal and marine water bodies. According to the MassDEP 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". It is expected that water quality at the South of Tuckernuck Island Alternative and along the approximate 33.4 mile (53.8 km) long offshore cable route, would meet this water quality designation, since there are no known major sources of pollutant input or other degrading factors. In approved areas, Class SA waters are "suitable for shellfish harvesting without depuration (Open Shellfish Areas)." Compared to the proposed action, impacts on water quality would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.7 Electric and Magnetic Fields

Electric and magnetic field strength along the offshore cables and onshore cables would have negligible impacts on the marine environment and to humans, and be of the same strength as that for the proposed action. Compared to the proposed action, impacts from electrical and magnetic fields would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.8 Terrestrial Vegetation

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay, landfall site at New Hampshire Avenue, and onshore cable route (see Section 4.2.1 of this document for detailed information on terrestrial vegetation). Compared to the proposed action, impacts on terrestrial vegetation within the South of Tuckernuck Island Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay and landfall site at New Hampshire Avenue (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the South of Tuckernuck Island Alternative, including its offshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.10 Terrestrial and Coastal Faunas Other than Birds

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay, landfall site at New Hampshire Avenue, and onshore cable route. See Section 4.2.2 of this document for detailed information on coastal and intertidal resources. Compared to the proposed action, impacts on coastal and intertidal resources within the South of Tuckernuck Island Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.11 Avifauna

During the winter, seaducks likely to use the South of Tuckernuck Island Alternative area include eiders, scoters, and long-tailed ducks while the summer months attract pelagic species, such as shearwaters, storm-petrels, and jaegers. Other species of waterbirds such as loons and Northern Gannets use the general area for foraging (National Audubon Society, 2002). Tens of thousands of long-tailed ducks leave Nantucket Sound each day on foraging trips (Veit and Petersen, 1993) and many may spend the day foraging in areas south of Tuckernuck, depending on the food availability. Terns and gulls are also likely to forage in the area while seaducks and other waterbirds use the area as a staging area before migrating to their nesting colonies in the spring and to wintering grounds further south. Other migratory birds such as landbird species likely pass over South of Tuckernuck Island typically at high altitudes during spring and fall migrations.

Compared to the proposed action, the South of Tuckernuck Island Alternative would have a greater potential for impacts to terrestrial, coastal, and marine birds, primarily because of the increased area in which the turbines would be located.

5.4.1.2.12 Subtidal Offshore Resources

Since Massachusetts Geographic Information System (MassGIS) data for eelgrass beds is limited to within the 3.5 miles (5.6 km), no eelgrass data is readily available for the proposed action (MassDEP, 2006). However, given the water depths, none would be expected at this location.

Benthic Habitat

As described above, water depths are variable throughout the South of Tuckernuck Island Alternative. The composition of the bottom sediments there has been documented in several studies (Theroux and Wigley, 1998; Poppe et al., 1989). Although no studies focused solely on the South of Tuckernuck Island Alternative, they did encompass the general area. The site is dominated by sand-sized particles (Theroux and Wigley, 1998; Poppe et al., 1989). In marine environments these substrates typically support the highest density and biomass of organisms per square meter, as compared to either larger or finer grained material (Theroux and Wigley, 1998).

The benthic habitat types for the South of Tuckernuck Island Alternative are similar to the site of the proposed action (see Section 4.2.5 of this document). The dominant bottom substrate of the area of the proposed action includes sand (fine- and course grained), mud, and other fine-grained sediments. The SAV (i.e., eelgrass), boulders, and cobbles are not common.

Benthic Community Composition and Abundance

The South of Tuckernuck Island Alternative is generally reported as a moderately productive area for benthic invertebrates. Densities of benthic organisms typically range between 65 and 510 individuals/ft^2 (700 and 5,500 individuals/m^2) and benthic organism biomass typically ranges between 0.01 and 0.1 lbs/ft^2 (50 and 500 grams/m^2) (Wigley and McIntyre, 1964 and Theroux and Wigley, 1998).

This South of Tuckernuck Island Alternative is reported to have slightly higher benthic organism diversity than Nantucket Sound and diversity similar to that found near the proposed action (Sanders, 1968; Theroux and Wigley, 1998). This may be a function of the generally deeper water depths and more stable substrate at this alternative site. The reduced magnitude and frequency of sand movement is believed to be correlated with more diverse benthic communities, since relatively few species have adapted to recover from burial (Pratt, 1973).

The most abundant taxa at the South of Tuckernuck Island Alternative are crustaceans and mollusks, followed by polychaete worms (Theroux and Wigley, 1998). Among the crustaceans, the amphipods are reported to be by far the most abundant, which is similar to the community found in Nantucket Sound. Several taxa are expected to occur at the South of Tuckernuck Island Alternative that would be much less common within Nantucket Sound. These include Amphipoda, Cumacea, and Isopoda, as well as the Nemeitea, Nematoda, and Sipuncula; all within the Crustacean taxa.

Twenty benthic macroinvertebrate taxa were recorded during benthic sampling programs conducted at the site of the proposed action (see Section 4.2.5 of this document). Of the sites sampled, the average faunal density was 1078 individuals/ft^2 (11,589 individuals/m^2). Nematoda were more abundant than any other class (70 percent of the samples) and was followed by Oligochaeta (27 percent of the samples) and gastropod *Crepidula fornicata* (17 percent of the samples).

Compared to the proposed action, the benthic community composition within the South of Tuckernuck Island Alternative is smaller with regards to overall abundance of species and differs with regard to community structure. The site of the proposed action provides habitat preferred by deposit- and suspension- feeding species whereas the alternative site provides habitat preferred by scavenger and predator species.

The additional pilings, cross-braces, and scour protection required at the South of Tuckernuck Island Alternative substantially increase (by more than 10 times) the vertical habitat structure available for colonization by benthos for the life of the Project. However, anchoring impacts associated with construction would be greater at the South of Tuckernuck Island Alternative than the Horseshoe Shoal proposed site. The area of direct impact at the South of Tuckernuck Island Alternative would be nearly twice that of the Horseshoe Shoal site, likely resulting in greater overall impact to benthos at the South of Tuckernuck Island Alternative than at the proposed action. The South of Tuckernuck Island alternative also would have greater impacts on benthic resources as a result of the much longer offshore transmission cable requirement compared to that of the proposed Horseshoe Shoal site. Accordingly, benthic impacts are expected to be greater at the South of Tuckernuck Island alternative than the Horseshoe Shoal site with respect to construction, operation, and decommissioning.

5.4.1.2.13 Non-ESA Marine Mammals

Four federally protected cetaceans, North Atlantic Right, humpback, and fin whales may occur in the vicinity of the proposed South of Tuckernuck Island Alternative (see Table 5.4.1-1), but are typically found in areas of deeper water. The South of Tuckernuck Island Alternative contains some features that favor dense aggregations of whale prey species, but these are not as well developed as other areas farther north (Kenney and Winn, 1986). Although preferred prey species for whales occur in the South of Tuckernuck Island area higher-use areas occur further north. The South of Tuckernuck Island area does not appear to be an important area even though there have been more recorded sightings of Northern Atlantic right whales in the South of Tuckernuck Island area than in Nantucket Sound or Buzzards Bay.

As shown in Table 5.4.1-1, several other species of protected marine mammals may be present within the vicinity of the South of Tuckernuck Island Alternative. These species include harbor, harp, and hooded seals, white-sided and striped dolphins, harbor porpoise, and long-finned pilot whale.

The species identified in Table 5.4.1-1 could also be present at the site of the proposed action (see Section 4.2.6 of this document) as could the Atlantic spotted dolphin, Risso's dolphin, and Kogia species (sperm whale).

With respect to overall impacts on marine mammals, the South of Tuckernuck Island Alternative is in closer proximity to seal haul-out and breeding sites than the proposed action, and therefore, development at this site has a greater potential to impact seals both during construction and operation. In addition, there is somewhat greater potential to impact whales at the South of Tuckernuck Island alternative during construction since the site is proximate to historical sightings of these mammals. There is a potential for greater impact to prey species at the South of Tuckernuck Island Alternative compared to the proposed action given the greater potential benthic habitat disturbance at this Alternative and anticipated longer construction duration. In conclusion, there may be a somewhat greater potential for impacts on marine mammals within the South of Tuckernuck Island Alternative than the site of the proposed action with respect to construction, decommissioning, and operational impacts.

5.4.1.2.14 Fish and Fisheries

Table 5.4.1-2 lists common finfish and shellfish resources which are known to occur within the general offshore vicinity of Cape Cod and the Islands. Section 4.2.7 of this document provides detailed information on fish and fisheries for the proposed action. The South of Tuckernuck Island Site contains a greater number of fish species than the proposed site, since it has habitat that is preferred by species that typically occur in deeper, cooler waters. The South of Tuckernuck Island Site has more species and life stages with designated EFH unique to this Site. There are eight species (common thresher shark, dusky shark, monkfish, ocean pout, ocean quahog, spiny dogfish, whiting, and witch flounder) that have EFH life stage designations at the South of Tuckernuck Island Alternative and not at the proposed action. There are also eight life stages of certain species that only have designated EFH at the South of Tuckernuck Island Alternative. The habitat requirements for these species/life stages typically are waters that have a deeper depth range and cooler temperatures.

Once in operation, the South of Tuckernuck Island Alternative offers a greater surface area for potential fish aggregations compared to the proposed action because of the larger foundations required as a result of the deeper water. However, the South of Tuckernuck Island Alternative would likely require a longer construction timeframe and greater benthic habitat disturbance, resulting in greater impacts to fisheries from sediment disturbance compared to the proposed action. Finally, the South of Tuckernuck Island Alternative has the potential for greater acoustical impacts to finfish compared to the proposed action, because that alternative would require a longer construction/decommissioning timeframe. In conclusion, the South of Tuckernuck Island Alternative would be expected to have a greater impact on finfish than the proposed action during construction, operation and decommissioning.

Shellfish Resources

Since the South of Tuckernuck Island Alternative is, on average, deeper than the proposed action, it is expected that the shellfish community in the area would not contain as many of the suspension (filter) feeding mollusk species. The highest abundance and diversity of suspension-feeding mollusks tend to be associated with water depths of less than 60 ft (18.3 m) in areas south of Cape Cod (Saila and Pratt, 1973). Suspension-feeding species such as northern quahog, bay scallop, sea scallop, surf clam, and soft-shelled clam are reported to be less common South of Tuckernuck Island than at the proposed site (Weiss, 1995; Saila and Pratt, 1973; Gosner, 1978). The channeled whelk (conch) and knobbed whelk are more common in shallow waters (Weiss, 1995) and would therefore be expected to be less common in the deeper waters of the alternative site.

Two species of mussel are common to the region, blue mussel (*Mytilis edulis*) and horse mussel (*Modiolus modiolus*). The blue mussel thrives in shallower waters near low tide attached to rocks and shells (Weiss, 1995). Rocky habitat is not present at the South of Tuckernuck Island Alternative; therefore, it is expected that fewer blue mussels would be found at the alternative site. The horse mussel is far less common in the region, particularly in areas south of Cape Cod. It typically lives in deeper waters to depths of 240 ft (73.2 m) (Weiss, 1995) and would be more common at the South of Tuckernuck Island Alternative than at the proposed action Ocean quahogs are also more common in deeper waters, between 60 and 90 ft (18.3 and 27.5 m), with finer sand to mud substrates (Weiss, 1995; Saila and Pratt, 1973). They too would be more common at the South of Tuckernuck Island Alternative than at the proposed site.

The South of Tuckernuck Site is expected to have somewhat fewer shellfish resources than the proposed action because of its deeper waters. However, this is balanced by the fact that at South of

Tuckernuck, the area of construction impacts is more extensive as a result of the larger foundation, larger area of anchor sweep associated with deep water construction, and longer offshore transmission cable distance. In general, shellfish impacts are expected to be comparable between Tuckernuck Shoal and the proposed site with respect to construction, operation, and decommissioning.

Finfish

Commercial fishing landings data for the specific fisheries in the South of Tuckernuck Island Alternative area are not readily available. This Alternative site is located outside of the three-mile (4.8 km) territorial limit but within a small portion of the MassDMF statistical reporting Area 16 for lobsters. According to McBride and Hoopes (2001), Area 16 has one of the highest landings for lobster of all offshore statistical reporting areas in Massachusetts (1,000,001 to 2,000,000 lbs [453,593 to 907,185 kg] in 1999). Since the offshore area along the northern coast, north of Cape Cod Bay, produced the highest landings of lobsters and because statistical reporting Area 16 is so large, it is difficult to determine if and how much of the South of Tuckernuck Island Alternative contributes to the total lobster harvest.

Recreational fishing in the waters south and east of Cape Cod includes both private recreational vessels and charter services. Due to the weather conditions on Nantucket Sound, the prime season for recreational fishing occurs during late spring to late summer. Main target species for recreational fishing include striped bass, several tuna species, scup, bluefish, bonito, sea bass, sharks, and cod. Section 4.2.7 of this document provides information on commercial and recreation fish and shellfish for the proposed action.

Overall the South of Tuckernuck Island Alternative would be expected to have a greater impact on fish and commercial fisheries than the proposed action as a result of longer construction time frame and the size of the foundation. The larger foundation size is expected to result in increased fish aggregation compared to the proposed action.

5.4.1.2.15 Essential Fish Habitat

Habitat within the South of Tuckernuck Island Alternative has been designated as EFH for 28 federally-managed fish species and 4 federally-managed invertebrate species. Table 5.4.1-3 provides a listing and specific life stage designations of those species within the area of the South of Tuckernuck Island. The proposed action has been designated EFH for 17 federally managed fish and 3 federally managed invertebrates all of which overlap with those listed in Table 5.4.1-3. The EFH species included for the South of Tuckernuck Island Alternative but not the proposed action are the Atlantic sea herring (*Clupea harengus*), Common thresher shark (*Alopias vulpinus),* Dusky shark (*Carcharhinus obscurus),* Haddock (*Melanogrammus aeglefinus*), Monkfish (*Lophius americanus*), Ocean pout (*Macrozoarces americanus),* Ocean quahog *(Artica islandica),* Red hake (*Urophycis chus),* Sandbar shark (*Carcharhinus plumbeus),* Spiny dogfish (*Squalus cubensis),* Whiting (*Merluccius bilinearis),* and Witch flounder *Glyptocephalus cynoglossus).*

The Magnuson-Stevens Act requires an assessment of potential impacts to federally managed fish and invertebrate species when EFH habitat may be affected, as is the case with the proposed action (NOAA, 2006). Section 4.2.8 of this document provides information on EFH for the proposed action. Temporary and localized sediment disturbance from construction vessel anchoring, anchor line sweep, and scour protection are anticipated. The anchoring and scour protection impact for the South of Tuckernuck Island Alternative would likely be more than that of the proposed action. As a result, this alternative would be expected to result in more temporary impact than that of the proposed action during construction and during decommissioning. Greater foundation size at Tuckernuck, and thus increased aggregation, would result in somewhat greater impact during operation.

5.4.1.2.16 Threatened and Endangered Species (T&E)

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the site of the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route. See Section 4.2.9 of this document for detailed information on endangered and threatened species along this cable route. Compared to the proposed action, impacts on endangered and threatened species along the near shore and onshore cable routes associated with the South of Tuckernuck Island Alternative would be comparable to and offer no significant environmental advantage over the proposed action.

The South of Tuckernuck Island Alternative area may provide suitable foraging habitat for the federally-endangered roseate tern (*Sterna dougallii*) and suitable nesting habitat for the federally-threatened piping plover (*Charadrius melodus*) on shorelines on Tuckernuck Island and Nantucket. The Massachusetts Natural Heritage Atlas (2003 edition) indicates that Tuckernuck Islands, approximately 3.8 miles (6.1 km) northeast of Tuckernuck Island, is located within Priority Habitat for State-Protected Rare Species and Estimated Habitat for Rare Wildlife for onshore, nesting areas for shorebirds and terns. Two state species of special concern (common loon and least tern) and one state-endangered species (roseate tern) may use the waters near the South of Tuckernuck Island Alternative as a winter resident (common loon) and/or foraging (Veit and Petersen, 1993).

Potential impacts to listed species at the South of Tuckernuck Island Alternative would be comparable to the proposed action. Piping plover is known to nest on Tuckernuck Island, but is unlikely to visit this offshore area except during migration. There would likely be fewer terns present at the South of Tuckernuck Island Alternative than the proposed action during the breeding season because of the distance from the primary breeding colonies in Buzzards Bay. However, there would be terns present at South of Tuckernuck Island Alternative during other seasons, and potential impacts would be comparable to the proposed action.

As shown in Table 5.4.1-1, three federally and/or state protected sea turtle species may be present within the South of Tuckernuck Island Alternative: loggerhead, leatherback, and Kemp's Ridley sea turtles. Kurkul (2002) reported that these sea turtles are found within Massachusetts waters at varying times of the year. Therefore it is possible that they may utilize the South of Tuckernuck Island area during some portion of the year as well. The federally protected green sea turtle is less likely to be found within Nantucket Sound. Loggerhead, leatherback, and Kemp's Ridley sea turtles may also use Horseshoe Shoal (see Section 4.2.9 of this document). Compared to the proposed action, impacts on sea turtles within the South of Tuckernuck Island Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.17 Socioeconomic Analysis Area

The existing socioeconomic conditions for the South of Tuckernuck Island Alternative are similar to that of the proposed action (see Section 4.3 of this document) as the two locations are within the same general socioeconomic area of the Cape Cod and the Islands of Martha's Vineyard and Nantucket. Compared to the proposed action, socioeconomics impacts associated with the South of Tuckernuck Island Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning.

5.4.1.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route and affect the same urban and suburban infrastructure (see Section 4.3 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure within the South of Tuckernuck Island Alternative, including its submarine and onshore cables, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.19 Population and Economics

The South of Tuckernuck Island Alternative is located in the same general socioeconomic area as the proposed action and is expected to result in negligible impacts on changes to population or the economy of the region. Hence, the South of Tuckernuck Island Alternative would be comparable to and offer no significant advantage in terms of population and economics over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area South of Tuckernuck is in the same general socioeconomic area as the proposed action and not located near any communities of higher than normal minority populations or higher than normal poverty rates nor is it located any closer to the WTGHA or the Wampanoag Tribe of Mashpee. As such, the South of Tuckernuck Island Alternative would be expected to be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.21 Visual Resources

The seascape from Tuckernuck Island southwest towards the South of Tuckernuck Island Alternative consists of panoramic open ocean views of the Atlantic Ocean. The visual impacts toward the South of Tuckernuck Island Alternative would be somewhat more significant as there are no other lands or human structures visible when viewed from Nantucket or Martha's Vineyard. However, generally fewer viewers would see the WTG array at the Tuckernuck area, since it would be beyond or close to beyond visible range from Cape Cod which has the major population density in the area (see Figure 3.3.5-4A and B). As a result, a WTG array would have less visual impact at the South of Tuckernuck Island site than the proposed action for construction, operation, and decommissioning.

5.4.1.2.22 Cultural Resources

To access the Barnstable Substation, both the South of Tuckernuck Island Alternative and the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route and affect the same onshore cultural resources (see Section 4.3.5 of this document). Compared to the proposed action, impacts on onshore cultural resources within the South of Tuckernuck Island Alternative, including its submarine and onshore cables, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts. With respect to visual impacts on cultural resources (i.e., historic homes and historic sites), this site is located further from historic areas of Cape Cod, but closer to the historic area of Nantucket. Thus no difference in impact is expected compared to the proposed action with respect to impact on cultural resources.

No submerged historic properties or archaeological sites are recorded in the South of Tuckernuck Island Alternative area, and there are no shipwrecks charted in the vicinity of the alternative site. Four vessel casualties ranging in date from 1817 to 1969 are reported in the Northern Shipwreck Database. A review of the MHC's records indicates that no marine archaeological investigations have been conducted in the area. The archaeological sensitivity for submerged Euro-American and Native American cultural resources near the South of Tuckernuck Island Alternative is expected to be low because of the area's homogenous bathymetry and exposed location to the open waters of the Atlantic Ocean. Since a detailed marine sensitivity assessment and marine archaeological reconnaissance survey have not been conducted for the South of Tuckernuck Island Alternative, it is difficult to determine whether any subtidal archeological resources (i.e., historic or pre-historic sites) would actually be affected by the proposed action if it were sited at this alternative location. However, if such sites were documented at the alternative site, the applicant would have to implement mitigative measures similar to those for the proposed action (see Section 4.3.5 of this document). Therefore, impacts on subtidal archaeological resources within the South of Tuckernuck Island Alternative would be expected to be comparable to that of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.23 Recreation and Tourism

The South of Tuckernuck Island Alternative is located closer to land (Nantucket Island) and the popular boating and recreational area around Nantucket Island than the proposed action, but it is located further from the popular boating and recreational areas of Cape Cod than the proposed action. In general, impacts on recreational activities within the South of Tuckernuck Island Alternative would be expected to be comparable to that of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.24 Competing Uses of Waters and Sea Bed

The 115 kV offshore transmission cable system from the ESP at the South of Tuckernuck Island Alternative to the landfall site at New Hampshire Avenue, within Lewis Bay, would traverse approximately 12.8 miles (20.6 km) of State waters and sea bed. Competing uses that exist along the offshore cable route include aquaculture, submarine electric transmission cables (2 Nantucket cables would be crossed), recreational and commercial activities, and maintenance dredging activities. Compared to the proposed action, impacts on competing use activities within the South of Tuckernuck Island Alternative would be expected to be comparable to that of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.25 Overland Transportation Arteries

Like the proposed action, the South of Tuckernuck Island Alternative is located offshore and not near any overland transportation arteries and would be expected to have comparable traffic impacts associated with onshore equipment deliveries or commuting of workers as the proposed action. Thus the South of Tuckernuck Island Alternative offers no significant environmental advantage for overland transportation arteries over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.26 Airport Facilities

The South of Tuckernuck site is located closer to the Nantucket Airport but further away from the Barnstable Airport in Hyannis than the proposed action. Regardless, both locations received FAA approval (see Appendix E). The net impact on airport facilities from the South of Tuckernuck Island Alternative would therefore likely be comparable to that of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.27 Port Facilities

The impact on port facilities from the proposed action and its alternatives would primarily be with respect to vessels navigating in the area. Assuming that the spacing of the WTGs remains the same for the alternative locations, the potential impacts to navigation at the South of Tuckernuck Island Alternative would be equivalent to the potential impacts for the proposed action. Installation of the wind turbines would result in structures being present where no structure has previously existed and mariners would need to navigate with consideration of these new structures. The South of Tuckernuck Island Alternative is located closer to land (Nantucket Island) than the proposed action and thus would experience vessel traffic associated with that area and nearby Nantucket Harbor, but it is further away from the popular boating area near Cape Cod and its associated ports, than the proposed action. On whole, the South of Tuckernuck Island Alternative would have an impact on ports and related marine traffic that is comparable to that of the proposed action and offer no significant advantage to Port Facilities over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.1.2.28 Communications: Electromagnetic Fields (EMF), Signals and Beacons

Recreational vessels, commercial fishing and marine cargo ships traverse Nantucket Sound via the nearby Muskeget Channel. All of these vessels use marine radios, which operate at a range of 156.05 to 157.425 megahertz (MHz). Shore radios operate at approximately 156.85 to 162.025 MHz. The NOAA weather service operates at frequencies between 162.4 and 162.55 MHz. In addition, the site is in sufficiently close proximity to allow telecommunications signals from cellular phone towers, local emergency response communication towers, radio towers, and television (TV) towers to be transmitted and received. The FAA has conducted an aeronautical study for each of the South of Tuckernuck Island Alternative turbine locations (See Appendix E). As part of these studies, the FAA has analyzed the potential for the WTGs to affect aviation radar. Based on the completion of the aeronautical studies, the FAA has issued a "Determination of No Hazard to Air Navigation".

5.4.2 Monomoy Shoals (East of Monomoy, Massachusetts) Alternative

5.4.2.1 Description of the Monomoy Shoals Alternative

The Monomoy Shoals Alternative site is 3.5 miles (5.6 km) southeast of Monomoy Island, within the eastern approach to Nantucket Sound (Figure 3.3.5-1). Water depth within the Monomoy Shoals Alternative site ranges between 13 ft and 34 ft (3.9 and 10.4 m) below MLLW, with an estimated average depth of approximately 24 ft (7.3 m) (Navigational Chart No. 13237 – Nantucket Sound and Approaches. Ed. 38, March 3, 2001). The alternative would be the same generation size as the proposed action (130 WTG's, 3.6 MW machines plus and ESP), but would require a slightly larger area (25.9 square miles [67.1 km^2]). The proposed turbine spacing for the Monomoy Shoals Alternative site is a grid arrangement approximately 9.0 rotor diameters (0.63 miles[1,000 m]) by 5.7 rotor diameters (0.39 miles [629 m]).

The construction and decommissioning methods at the Monomoy Shoals Alternative site would be similar to those presented in Section 2.3 of this document for the proposed action. Although driven monopile foundations and jet plow cable embedment are anticipated to be the proposed method of construction, it is possible that bed rock outcroppings and shallow surface bedrock at the Monomoy Shoals Alternative site may necessitate surface laying of the cable or other alternative installation methods. In addition, it is anticipated that the construction and decommissioning timetables for this alternative would be significantly longer than the proposed action, due to more limited accessibility (primarily due to wave conditions).

The 115 kV offshore transmission cable system for the Monomoy Shoals Alternative site would consist of the same equipment as described in Section 2.1 of this document. As shown in Table 3.3.5-2, the total length of the offshore cable route, from the alternative site ESP to the Barnstable Substation, would be 29.8 miles (48 km). Of this amount, approximately 2.9 miles (4.7 km) of offshore cable would be in Federal waters, 21.0 miles (33.8 km) would be in State waters, and 5.9 miles (9.5 km) of cable would be located in an onshore transmission ROW. The offshore cable would be routed from the ESP in a north-northwesterly direction for about 20.6 miles (33.2 km) and then turn north-northeast for about 3.3 miles (5.3 km) before making landfall. The offshore cable would be located approximately 3.0 miles (4.8 km) south of Monomoy Island. The total inner array length of 33 kV cable would be approximately 74 miles (119.1 km). The location, WTG configuration, and interconnection routing for this alternative are provided in Figure 3.3.5-5.

5.4.2.2 Environmental Resources of the Monomoy Shoals Alternative and Comparison with the Proposed Action

5.4.2.2.1 Regional Geologic Setting

The narrow shelf east of lower Cape Cod, south of Chatham, is made up of a wave-built terrace that contains surface sediments composed of coarse sand (Schlee and Pratt, 1970; Schlee 1973; Aubrey and Gaines, 1982). Fragments of rock recovered from the terrace's seaward scarp are coated with manganese oxide suggesting that little or no sediment is being deposited on the scarp present at the Monomoy Shoals Alternative site. High-resolution seismic reflection profiles taken with an EG&G Uniboom in the wave-built terrace area show a prominent reflector about 10 to 30 m below the sea floor and an unconformity shoaling to the north and south (Aubrey and Gaines, 1982).

Offshore from Monomoy Island, and Nauset Beach, the sea floor is dominated by northeast-trending swells that can be traced to a depth of approximately 65 ft (20 m). Beyond 65 ft (20 m), the sea floor roughness diminishes to the near 130 ft (40 m) depth and sea floor declivity increases as it descends to the Wilkinson Basin complex in the Gulf of Maine.

The geological setting of the Monomoy Shoals Alternative differs from the proposed action with regard to surface sediment type (see Section 4.1.1 of this document). Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. Monomoy Shoals is generally composed of coarse sand. Compared to the proposed action, the geologic setting at the Monomoy Shoals Alternative site offers no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning.

With respect to coastal geomorphology, analyses of historical charts show changes at Nauset Beach in front-and east-of the Chatham Lighthouse and north of Monomoy Island. Nauset Beach and Monomoy Island are two barrier beaches with tidal flows between Chatham Harbor and Pleasant Bay Estuary through the South Inlet located south of Nauset Beach. A comparison of maps from 1887, 1940, 1947 through 1953, and 1961 through 1964 with stereoscopic aerial photographs taken in 1969, show that the northern end of Monomoy Island (Shooters Island) has been receding since 1948. During 1971, Oldale et al. estimated that this area could separate from the rest of the island in about 70 to 80 years. However, island separation occurred in 1978, much earlier than was estimated. The southern half of Monomoy Island has been prograding eastward at a rate of about 39 ft (12 m) per year since at least 1853. Growth of Monomoy Island would most likely slow down in the future as it continues to prograde southeast into Butler Hole.

The regional geology and coastal morphology of the proposed action and the Monomoy Shoals Alternative are similar; however specific conditions at the two sites differ (see Section 4.1.1.1 of this document for a discussion of the site-specific conditions at the sites of the proposed action). Compared to the proposed action, the geology and coastal morphology of the Monomoy Shoals Alternative site are more dynamic, since it is closer to the open ocean and the adjacent Monomoy Island is undergoing constant change in its overall structure. The Monomoy Shoals Alternative offers no significant geological advantage over the proposed action with respect to construction, operation or decommissioning impacts.

5.4.2.2.2 Noise

The potential impacts from above background noise related to construction and decommissioning activities at the Monomoy Shoals Alternative would be less than at the Horseshoe Shoal site due to the site's greater distance to sensitive receptors than the Horseshoe Shoal site. Because noise impacts of the proposed action are expected to be minor, those associated with the Monomoy Shoals Alternative should be considered negligible. Noise impacts to marine life are expected to be the same as for the proposed action. In general, the Monomoy Shoals Alternative would be comparable with respect to noise impacts to the proposed action during construction, operation, and decommissioning.

5.4.2.2.3 Physical Oceanography

Monomoy Shoals consists of numerous detached shoals extending about 5.5 miles (8.9 km) in an easterly direction and 9.5 miles (15.3 km) in a southeasterly direction from Monomoy Point. Narrow sloughs separate the many parts of the Shoal. Monomoy Shoals is shifting in character and is subject to change in location and depth.

Bearse Shoal and Pollock Rip extend about 5.0 miles (8.0 km) eastward of Monomoy Point with a series of sand shoal and ridges. The Pollock Rip Channel lies between Monomoy and Bearse Shoal. Stone Horse Shoal, Little Round Shoal, and Great Round Shoal are part of a continuous series of sand shoals and ridges in 4 to 18 ft (1.2 to 5.5 m) of water. These shoals are directly eastward of the entrance to Nantucket Sound and lie between the two main channels. Southward and eastward of these shoals are numerous other shoals, including Orion Shoal in 16 to 19 ft (4.9 to 5.8 m) of water.[7]

The following is background information on physical oceanography at the Monomoy Shoals Alternative:

Water Depth: The estimated average depth within the Monomoy Shoals Alternative site is approximately 24 ft (7.3 m); however the water depth ranges between 13 ft and 34 ft (3.9 to 10.4 m) below MLLW (Navigational Chart No. 13237 – Nantucket Sound and Approaches. Ed. 38, March 3, 2001).

Tide: Station ID: 1015 (41˚33' N, 070˚00' W) Average Tides:
- Mean Range = 3.70 ft (1.1 m)
- MHWS = 4.30 ft (1.3 m)
- Mean Tide = 1.90 ft (0.58 m)

Current: Station ID: 1731 (41˚33.00' N, 070˚01.30' W)
Average Currents:
- Avg. Max Flood = 1.7 knots (0.87 m/s) 170˚
- Avg. Max Ebb = 2.0 knots (1.03 m/s) 346˚

Wave Conditions: Extreme storm waves of approximately 66 ft (20.1 m); shallow waters of the shoal result in breaking waves.

With regard to physical oceanography, the Monomoy Shoals Alternative offers no significant environmental advantage over the proposed action (see Section 4.1.3 of this document).

[7] Chartmaker.ncd.noaa.gov/NSD/CP2/CP2-36ed-Ch04_2.pdf

5.4.2.2.4 Climate and Meteorology

The weather conditions for the Monomoy Shoals Alternative site are similar to the site of the proposed action. However, the alternative site is estimated to have a predicted mean wind speed (at a height of 70 m) of 20.1 to 21.3 mph (9.0 to 9.5 m/s) (MTC /AWS TrueWind map). This is fairly close to the wind speed at the site of the proposed action, which has a mean wind speed of 17.9 to 20.1 mph (8 to 9 m/s). Compared to the proposed action, impacts due to climate and meteorology associated with the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.5 Air Quality

The existing air quality conditions for the Monomoy Shoals Alternative site are similar to the site of the proposed action. Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning, and maintenance would emit, or have the potential to emit air pollutants. Such impacts would be somewhat greater for the Monomoy Shoals Alternative due to the longer distance between Monomoy and the construction staging area at Quonset, Rhode Island, and worker loading area in Falmouth, Massachusetts. However, in both cases, emission impacts would be minor. Overall, impacts on air quality associated with the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.6 Water Quality

The Massachusetts Surface Water Quality Standards adjacent to the Monomoy Shoals Alternative site are similar to the standards described above for the South of Tuckernuck Island Alternative. In addition, the existing water quality conditions for the Monomoy Shoals Alternative site are similar to the site of the proposed action and would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.7 Electric and Magnetic Fields (EMF)

Electric and magnetic field strength along the offshore cables and onshore cables would have negligible impacts on the marine environment and to humans, and would be of the same strength for the Monomoy Shoals Alternative as that for the proposed action. Compared to the proposed action, impacts would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.8 Terrestrial Vegetation

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay, landfall site, and onshore cable route (see Section 4.2.1 of this document for detailed information on terrestrial vegetation). Compared to the proposed action, impacts on terrestrial vegetation within the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay and landfall site at (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the Monomoy Shoals Alternative, including its offshore transmission cable system cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.10 Terrestrial and Coastal Faunas Other than Birds

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route within Lewis Bay, landfall site, and onshore cable route (see Section 4.2.2 of this document for detailed information on coastal and intertidal resources). Compared to the proposed action, impacts on terrestrial and coastal fauna within the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.11 Avifauna

Monomoy Island (including the Monomoy National Wildlife Refuge) provides important resting, nesting and feeding habitat for migratory birds. Specifically, Monomoy Island is an important staging area for roseate terns, provides habitat for roseate, common and least tern nesting colonies, harbors roseate and common tern restoration sites, and is a known piping plover nesting area (Perkins, et. al., 2003). A large post-breeding, pre-migration staging area for terns is located at South Beach/North Monomoy (Trull et al., 1999). Large numbers of terns (more than 10,000) gather in this area from August through September to roost and forage. Some birds stop over or cross Nantucket Sound and may rest by day at several points along the immediate shoreline. All of these birds are believed to return to South Beach each night. Generally, the foraging range is about 3 miles (4.8 km); however, some birds may travel up to 20 miles (30 km). In addition, the Monomoy National Wildlife Refuge has been designated a Western Hemispheric Shorebird Reserve Network Regional Site and an Important Bird Area (IBA).

Due to the proximity to Monomoy Island, the Monomoy Shoals Alternative would have greater potential impacts than the proposed action to terrestrial, coastal, and marine birds during construction, decommissioning, and operation.

5.4.2.2.12 Subtidal Offshore Resources

Since MassGIS data for eelgrass beds is limited to within the 3.5 miles (5.6 km), no eelgrass data is readily available for the Monomoy Shoals Alternative site (MassDEP, 2006).

Benthic Habitat

The shallows within Monomoy Shoals are nearly continuous, forming a broad shelf. The composition of the bottom sediments at the Monomoy Shoals Alternative site has been documented in several studies (Theroux and Wigley, 1998; Poppe et al., 2004). Although no studies focused solely on the Monomoy Shoals Alternative site, they did encompass the Shoals in general. The Monomoy Shoals Alternative site can be characterized as an area dominated by sand-sized particles (Theroux and Wigley, 1998; Poppe et al., 1989), which typically support the highest density and biomass of organisms per square meter, as compared to either larger or finer grained material (Theroux and Wigley, 1998). However, Poppe et al., (2004) note that patches of gravel and gravelly sediments (between 10 and 50 percent gravel) are found locally within the area and these substrates can support a moderate density and biomass of organisms per unit area, as compared to poorly sorted till or finer grained material such as sand-silt or silt-clay (Theroux and Wigley, 1998).

The benthic habitat types for the Monomoy Shoals Alternative differ from the site of the proposed action (see Section 4.2.5 of this document). The dominant bottom substrate of the proposed action includes sand (fine- and course-grained), mud, and other fine-grained sediments. The SAV (i.e., eelgrass), boulders, and cobbles are not common. As a result the benthic community can be expected to differ.

Benthic Community Composition and Abundance

The Monomoy Shoals Alternative site is generally reported as a moderately productive area for benthic invertebrates, with densities of benthic organisms typically ranging between 93 and 465 individuals/ft^2 (1,000 and 4,999 individuals/m$^{2)}$ and benthic organism biomass typically ranging between 0.02 and 0.1 lbs/ft^2 (100 and 499 grams/m^2) (Theroux and Wigley, 1998).

The Monomoy Shoals Alternative site is reported to have a benthic organism diversity similar to Nantucket Sound site as discussed above (Theroux and Wigley, 1998). While only some benthic species have adapted to recover from burial, the abundance of suspended food in sandy shoals suggests that motile filter-feeders would be well-adapted to the shifting sands of the Monomoy Shoals Alternative site (Pratt, 1973).

The most abundant taxa at Monomoy Shoals are crustaceans and annelids, followed by hydrozoans, mollusks and echinoderms (Theroux and Wigley, 1998). Among the crustaceans, amphipods are reported to be by far the most abundant; however, mollusks are the dominant taxon followed by echinoderms and annelids. Bivalves contribute most significantly to the mollusk biomass. This is similar to the community found in Nantucket Sound; however, several taxa are expected to occur at the Monomoy Shoals Alternative site that would be much less common within Nantucket Sound (Theroux and Wigley, 1998). Table 5.4.2-1 lists the dominant benthic taxonomic groups and the corresponding densities (number of individuals/m^2) occurring at Monomoy Shoals.

Twenty benthic macroinvertebrate taxa were recorded during benthic sampling programs conducted at the site of the proposed action (see Section 4.2.5 of this document). Of the sites sampled, the average faunal density was 1078 individuals/ft^2 (11,589 individuals/m^2). Nematoda were more abundant than any other class (70 percent of the samples), followed by Oligochaeta (27 percent of the samples) and the gastropod, *Crepidula fornicata* (17 percent of the samples).

Compared to the proposed action area, the benthic community composition within the Monomoy Shoals Alternative site is comparable to with regard to over all abundance of species but differs with regard to community structure. The site of the proposed action provides habitat preferred by deposit- and suspension- feeding species whereas the alternative site provides habitat preferred by scavenger and predator species. Construction and Decommissioning impacts on benthic habitat are expected to be somewhat more for the Monomoy Shoals Alternative than for the proposed action because of the additional offshore transmission cable length, and the greater wave heights which would tend to prolong the construction time frame. Operational impacts are expected to be the same as the proposed action.

5.4.2.2.13 Non-ESA Marine Mammals

As with the proposed action, four federally protected cetaceans, North Atlantic Right, humpback, long-finned pilot, and fin, may occur in the vicinity of the proposed Monomoy Shoals Alternative, but are typically found in areas of deeper water. The Monomoy Shoals Alternative site is located adjacent to the northwestern extent of a designated Northern Right Whale Critical Habitat (NOAA Chart No. 13200, 2005). Due to the location of this critical habitat, it is possible that Northern Right Whales may pass through the proposed alternative site during their annual migration to and from their summer and wintering grounds.

Several other species of protected marine mammals may be present within the vicinity of the Monomoy Shoals Alternative site. These species are similar to those described for the proposed action and include gray, harbor, harp, and hooded seals, white-sided and striped dolphins, harbor porpoise, and long-finned pilot whale. The Monomoy Shoals Alternative is located due east and southeast of gray seal pupping grounds on Monomoy Island. This pupping ground is known to be used year round with the greatest used occurring during the winter and spring (Natural Heritage and Endangered Species Program (NHESP), 2002). The species identified in Table 5.4.1-1 could also be present as could the Atlantic spotted dolphin, Risso's dolphin, and Kogia species (sperm whale). However, compared to the proposed action, the Monomoy Shoals Alternative site is located close to the designated Northern Right Whale Critical Habitat, and thus there may be a greater likelihood of construction, decommissioning, and operational impacts to Right Whales in this area.

5.4.2.2.14 Fish and Fisheries

Table 5.4.1-2 lists common finfish and shellfish resources which are known to occur within the general offshore vicinity of Cape Cod and the Islands. Section 4.2.7 of this document provides detailed information on fish and fisheries for the proposed action. The Monomoy Shoals Alternative would likely require a longer construction timeframe and greater benthic habitat disturbance as a result of higher waves and longer offshore transmission cable distance, which would result in greater temporary impacts to fisheries from sediment disturbance compared to the proposed action. In addition, the Monomoy Shoals Alternative has the potential for greater acoustical impacts to finfish compared to the proposed action, since that alternative would likely require a longer construction/decommissioning timeframe. In conclusion, the Monomoy Shoals Alternative would have a somewhat greater impact on finfish than the proposed action during construction, and decommissioning, and would be expected to have similar impacts during operation.

Shellfish Resources

Since the greatest abundance and diversity of suspension-feeding mollusks tends to be associated with water depths of less than 60 ft (18.3 m) in areas south of Cape Cod (Saila and Pratt, 1973), suspension-feeding species are likely to be present in suitable habitat on the Monomoy Shoals Alternative site. These species include: northern quahog, bay scallop, sea scallop, surf clam, and soft-shelled clam (Weiss, 1995; Saila and Pratt, 1973; Gosner, 1978). The channeled whelk (conch) and knobbed whelk are also common in shallow waters (Weiss, 1995) and would be expected to be present in the shallower areas of the site.

Two species of mussel are common to the region, blue mussel (*Mytilis edulis*) and horse mussel, (*Modiolus modiolus*) and have been described above. As sand is abundant in the Monomoy Shoals Alternative site area, it is expected that fewer blue mussels would be found at the Monomoy Shoals Alternative site. The horse mussel is far less common in the region. Similarly, ocean quahogs are more common in deeper waters in substrates with finer sand and mud substrates (Weiss, 1995). Saila and Pratt (1973) report that the ocean quahog was found to occur at depths between 60 ft and 90 ft (18.3 and 27.5 m); therefore, it is likely to be less common at the Monomoy Shoals Alternative site.

The shellfish resources for the Monomoy Shoals Alternative site area are similar to the site of the proposed action (see Section 4.2.5 of this document). However, compared to the proposed action, construction impacts on shellfish resources associated with the Monomoy Shoals Alternative may be somewhat more, because of the longer offshore transmission cable distance to shore and longer construction timeframe associated with work in a location with much greater wave heights. Operational impacts would be similar with respect to shellfish.

Commercial and Recreational Fish and Shellfish

Commercial fishing landing data for the specific fisheries in the Monomoy Shoals Alternative area are not readily available. As with the proposed action described above, the Monomoy Shoals Alternative site would be located within a zone where approximately 250,000 to 500,000 lbs of American Lobster are collected annually (MassGIS Lobster Harvest Zones, 1997). Recreational fishing in the area includes both private recreational vessels and charter services. The prime season for recreational fishing occurs during late spring to late summer and the main target species include striped bass, bluefish, bonito, shark, and several tuna species. Section 4.2.7 of this document provides information on commercial and recreation fish and shellfish for the proposed action. Compared to the proposed action, construction impacts on commercial and recreational fish and shellfish may be somewhat more than the proposed action because of the longer offshore transmission cable distance to shore. Operational impacts would be similar to the proposed action.

5.4.2.2.15 Essential Fish Habitat

Habitat within Monomoy Shoals has been designated EFH for 11 federally managed fish and 3 federally managed invertebrates. Table 5.4.2-2 provides a listing and specific life stage designations of those species within Monomoy Shoals. The proposed action has been designated EFH for 17 federally managed fish and 3 federally managed invertebrates of which 12 species overlap with those listed in Table 5.4.2-2. The EFH species included for Horseshoe Shoal but not the alternative site include windowpane flounder (*Scophthalmus aquosus*), yellowtail flounder (*Limanda ferruginea*), shortfin mako shark (*Isurus oxyrhinchus*), king mackerel (*Scomberomorus cavalla*), Spanish mackerel (*Scomberomorus maculatus*), cobia (*Rachycentron canadum*), little skate (*Leucoraja erinacea*), and winter skate (*Leucoraja ocellata*). Since EFH habitat would be affected by both the proposed action and the Monomoy Shoals Alternative, the Magnuson-Stevens Act requires that there be an assessment of potential impacts to the federally managed fish and invertebrate species (NOAA, 2006). No Habitats Areas of a Particular Concern (HAPC) have been identified within the Monomoy Shoals Alternative. Section 4.2.8 of this document provides information on EFH for the proposed action. Compared to the proposed action, construction impacts on EFH may be somewhat more than the proposed action because of the longer offshore transmission cable distance to shore. Operational impacts would be similar.

5.4.2.2.16 Threatened and Endangered Species (T&E)

To access the Barnstable Substation, both the Monomoy Shoals Alternative site and the site of the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route (see Section 4.2.9 of this document for detailed information on endangered and threatened species along this cable route). Compared to the proposed action, impacts on endangered and threatened species along the near shore and onshore cable routes associated with the Monomoy Shoals Alternative would be comparable to and offer no significant environmental advantage over the proposed action.

Monomoy Island and the Monomoy National Wildlife Refuge provide habitat for two federally threatened bird species: bald eagle (*Haliaeetus leucocephalus*) and piping plover (*Charadrius melodus*), and one federally endangered species, the roseate tern (*Sterna dougallii*) (USFWS, 2001a). Since the Monomoy Shoals Alternative site is located outside state waters it is not located in an area identified by NHESP as Estimated or Priority Habitat (USFWS, 2006). However, Estimated and Priority habitat occurs within state waters surrounding Monomoy Island and the Monomoy National Wildlife refuge which are located 4.5 miles (7.2 km) northwest of the alternative site. State listed species known to occur in this area include one state endangered species (roseate tern), one state threatened species (piping plover) and two species of special concern (the USACE, 2004). Six federally and/or state protected species have nested at the Monomoy National Wildlife Refuge (pied-billed grebe, northern harrier, piping plover, roseate tern, and arctic tern (USFWS, 2001a). As the Monomoy Island Alternative is located close to the avian T&E habitat associated with the Monomoy National Wildlife Refuge, avian T&E impacts would be greater than for the proposed action location.

As shown in Table 5.4.1-1, three federally and/or state protected sea turtle species may be present within the Monomoy Shoals Alternative: loggerhead, leatherback, and Kemp's Ridley sea turtles which can be found within Massachusetts waters at varying times of the year (Kurkul, 2002). Therefore it is possible that they may utilize Monomoy Shoals during some portion of the year as well. The federally protected green sea turtle is less likely to be found within Nantucket Sound. Loggerhead, leatherback, and Kemp's Ridley sea turtles may also use Horseshoe Shoal (see Section 4.2.9 of this document). Compared to the proposed action, impacts on sea turtles with the Monomoy Shoals Alternative would be comparable to and offer no significant environmental advantage over the proposed action.

Overall compared to the proposed action, more impacts on endangered and threatened species would occur as a result of the potential impact of T&E avian species in the vicinity of Monomoy Island and Monomoy National Wildlife Refuge (3.0 to 4.5 miles [4.8 to 7.2 km]).

5.4.2.2.17 Socioeconomic Analysis Area

The existing socioeconomic conditions for the Monomoy Shoals Alternative are similar to those of the proposed action (see Section 4.3 of this document). Compared to the proposed action, impacts on social and economic conditions associated with the Monomoy Shoals Alternative would be comparable to and offer no significant environmental advantage over the proposed action, with respect to construction, operation, and decommissioning impacts.

5.4.2.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route and affect the same urban and suburban infrastructure (see Section 4.3.2 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure within the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.19 Population and Economic Background

The Monomoy Shoals Alternative is located in the same general economic area as the proposed action and is expected to result in negligible or changes in population or the economics of the region. Hence, the Monomoy Shoals Alternative would be comparable to for population and economic impacts and offer no significant advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area of the Monomoy Shoals Alternative is in the same general geographic area as the proposed action and not located near any communities of higher than average minority populations or higher than average poverty rates. It is not located near WTGHA or Mashpee. As such, the Monomoy Shoals Alternative would be expected to be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.21 Visual Resources

The seascape from Monomoy Island east-southeast towards the Monomoy Shoals Alternative site consists of panoramic open views of the Atlantic Ocean. The site is located further from the more populated area of Cape Cod than the proposed action and is thus expected to have fewer visual impacts than the proposed action (see Figure 3.3.5-6 for photo simulations).

5.4.2.2.22 Cultural Resources

To access the Barnstable Substation, both the Monomoy Shoals Alternative and the proposed action would utilize the same near shore cable route, landfall site, and onshore cable route and therefore potentially affect the same onshore cultural resources (see Section 4.3.5 of this document). Compared to the proposed action, impacts on onshore cultural resources within the Monomoy Shoals Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts. With respect to visual impacts on cultural resources (i.e., historic homes and historic sites), this site is located further from the populated and historic areas of Cape Cod and is thus expected to have fewer visual impacts on historic structures than the proposed action.

A review of the NOAA Automated Wreck and Obstruction Information System database indicates that numerous shipwrecks are located within state waters, southeast of South Monomoy; however, there are no mapped shipwrecks shown within the Monomoy Island Alternative area (US DOC, 2002). For the proposed action, three targets with moderate probability of representing submerged historic cultural resources were identified in the vicinity of Horseshoe Shoal. However, the applicant has committed to avoid ground disturbing activities around the detectable limits of each of these potentially sensitive targets. Since a detailed marine sensitivity assessment and marine archaeological reconnaissance survey have not been conducted for the Monomoy Shoals Alternative, it is difficult to determine whether any subtidal archeological resources (i.e., historic or pre-historic sites) would be affected if the proposed facilities were sited at this alternative location. However, if such sites were documented at the alternative site, the applicant would implement mitigative measures similar to those for the proposed action (see Section 4.3.5). Therefore, impacts on subtidal archaeological resources within the Monomoy Shoals Alternative would be comparable to those of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.23 Recreational and Tourism Activities

Fishing and boating (power and/or sail), seal-tours, bird watching, and beach-going are common activities among visitors to and off the waters off of Monomoy Island. Public access to state waters is provided at various boat ramps located in harbors and sheltered inlets inside Chatham harbor. The Monomoy Shoals Alternative site is located closer to land (Monomoy Island) and the popular recreational area of Chatham Harbor, but is located further from the popular boating areas around Hyannis and other south Cape Cod harbors than the proposed action. In general, impacts on recreational and tourism activities with the Monomoy Shoals Alternative would be expected to be comparable to those of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.24 Competing Uses of Waters and Sea Bed

The 115 kV offshore transmission cable system from the ESP at the Monomoy Shoals Alternative site to the landfall site at New Hampshire Avenue, within Lewis Bay, would traverse approximately 21.0 miles (33.8 km) of state waters and sea bed. Competing uses that exist along the offshore cable route include aquaculture, submarine electric transmission cables (2 Nantucket cables would be crossed), recreational and commercial activities, and maintenance dredging activities. The Monomoy Shoals Alternative is located further from the Hyannis and nearby Cape Cod areas used for recreational/boating/fishing and are located closer to recreational/fishing/boating areas around Monomoy Island and Chatham Harbor. In general, the impacts on competing uses of the Monomoy Shoals Alternative are expected to be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.25 Overland Transportation Arteries

Like the proposed action, the Momomoy Shoals Alternative is located offshore and not near any overland transportation arteries and would have a negligible effect on such arteries as a result of onshore equipment deliveries or commuting of workers. Therefore impacts from the Monomoy Shoals Alternative on overland transportation arteries would be expected to be comparable to those of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.26 Airport Facilities

The applicant has received an FAA approval for both the proposed action and for the original Monomoy Shoals Alternative described in the USACE draft EIS (located to the west of Monomoy) indicating that airport facilities would not be affected by this alternative or the original Monomoy Shoals Alternative (see FAA Determinations in Appendix E). The current Monomoy Shoals Alternative is located to the east of these locations and offset from the navigational flyways between Nantucket and Cape Cod, and Martha's Vineyard and Cape Cod. Therefore it may not interfere with FAA navigational requirement and is likely comparable to the proposed action for impacts to airport facilities with respect construction, decommissioning and operation.

5.4.2.2.27 Port Facilities

The impact on port facilities from the proposed action and its alternatives would primarily be to vessels navigating in the area. Assuming that the spacing of the WTGs remains the same for the alternative locations, the potential impacts to navigation at the Monomoy Shoals Alternative site would be equivalent to the potential impacts for the Nantucket Sound Alternative. Installation of the wind turbines would result in structures being present where no structure has previously existed and mariners would need to navigate with consideration of these new structures. The Monomoy Shoals Alternative site is located further from Hyannis and nearby Cape Cod and associated ports and vessel traffic, but is located closer to the vessel traffic areas associated with Monomoy Island and Chatham Harbor. Like the proposed action location, the Momomoy Alternative is also located on a shoal and thus setback from navigation channels and in a location where vessel traffic is not likely to occur. The Monomoy Shoals Alternative would be comparable to that of the proposed action and offer no significant advantage to Ports and associated vessel traffic over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.2.2.28 Communication: EMF, Signals and Beacons

Recreational vessels, commercial fishing and marine cargo ships traverse the area of Monomoy Shoals Alternative via channels to the north and south of the Monomoy Shoals Alternative. All of these vessels use marine radios, which operate 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 at frequencies between 162.4 and 162.55 MHz. Impacts on marine radar and other telecommunication devices are expected to be generally the same as for the proposed action and the Monomoy Shoals Alternative and offer no significant advantage to communications over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3 Smaller Project Alternative

5.4.3.1 Description of the Smaller Project Alternative

The Smaller Project Alternative is located in the same general area as the proposed action but contains only half the number of monopiles, and thus has half the generation capacity of the proposed action. Each monopile included in the Smaller Project Alternative is located within a footprint of a monopile of the proposed action. For the proposed Smaller Project Alternative, the monopile locations along the north and south of the turbine array have been removed, making it further from Cape Cod and from Nantucket than the proposed action (See Figure 3.3.5-1, which shows the Smaller Project Alternative superimposed over the proposed action). Further detail on the location of the Smaller Project Alternative is shown in Figure 3.3.6-1.

5.4.3.2 Environmental Resources of the Smaller Project Alternative and Comparison with the Proposed Action

5.4.3.2.1 Regional Geologic Setting

The geological setting of the Smaller Project Alternative is the same as the proposed action though impacts are focused on a smaller geographic area. The area of Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. The geologic setting of the Smaller Project is therefore comparable to and offers no significant environmental advantage over the geographic setting of the proposed action with respect to construction, decommissioning and operation. Geomorphology is also expected to be the same.

5.4.3.2.2 Noise

Noise impacts to humans would be reduced under the Smaller Project Alternative as the alternative would be located further from both Cape Cod and from Nantucket, and because there would be half as many wind turbines to construct and decommission, and hence a shorter construction time. Operational noise would also be reduced due to the smaller number of turbines and further distance to land. Underwater noise during construction would be reduced due to the reduced number of turbines. In summary, the noise impacts of the Smaller Project Alternative are less than the proposed action and therefore provide some reduction in noise impacts due to construction, decommissioning and operation.

5.4.3.2.3 Physical Oceanography

Water depths for the Smaller Project Alternative are the same as for the proposed action since they are at the same location. Tides, current speed and wave conditions are also the same. Overall, the physical oceanography impacts of the Smaller Project Alternative would be expected to be comparable to those of the proposed action with respect to construction, decommissioning and operation.

5.4.3.2.4 Climate and Meteorology

The weather conditions for the Smaller Project Alternative are the same as for the proposed action as they are at the same location. Compared to the proposed action, impacts due to climate and meteorology would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.5 Air Quality

Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning phases of this alternative would emit, or have the potential to emit air pollutants. The vessels and equipment involved in constructing (and decommissioning) the Smaller Project Alternative would emit fewer air contaminants as compared to the original 130 WTG configuration, however the emissions reductions are not anticipated to be proportional to the 50 percent reduction in WTGs for the following reasons:

- The frequency of mobilization and demobilization of major construction vessels for each distinct segment of construction (pile foundation installation; ESP installation; WTG installation; 115 kV cable installation and 33 kV installation) would not change.
- Emissions related to G&G activities are not expected to be significantly different.
- Emissions related to the installation of the ESP would remain the same.
- Emissions related to the installation of the temporary cofferdam at landfall would remain the same.
- The total number of vessel trips and /or the duration of deployment required to complete the small alternative WTGs (pile installation; tower, nacelle and rotor installation; and scour protection installation) would be approximately 50 percent less than those estimated for the proposed action.
- Emissions related to installation of the 115 kV cable system would be a small percentage greater for the Smaller Project Alternative as compared to the proposed action due to an additional one mile (1.6 km) of cable required to connect to the re-sited ESP.
- Emissions related to the installation of the 33 kV inner-array cables for the small alternative would be approximately 55 percent less due to the lower number of cable miles (29.7 miles versus 66.7 miles [47.8 km versus 107.3 km]).

As a result, it is anticipated that the overall emissions from the construction vessels and equipment related to the Smaller Project Alternative would be substantially reduced relative to those estimated for the proposed action. Similarly the emissions due to decommissioning activities for the small alternative would be expected to be reduced relative to those resulting from the proposed action. However, given the normal vessel traffic volumes regularly experienced in the proposed action area, and the limited timeframe of the construction period, the impacts of air emissions from the construction and decommissioning of either alternative would be considered minor on a local and regional scale.

Maintenance activities would consist of small vessels transiting to and from the proposed action area in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic over current levels in Nantucket Sound, and is not expected to impact air quality in the proposed action area or the region.

5.4.3.2.6 Water Quality

A reduction in WTGs from 130 to 65 would not have a strictly proportional reduction in impacts to water quality related to sediment disturbance. By reducing the number of WTGs to 65 under the smaller alternative, the temporary impacts to sediments related to the WTGs are reduced roughly proportional to the number of WTGs. Impacts related to the installation of the 115 kV offshore transmission cable system would increase by one mile (1.6 km) as the Smaller Project Alternative is further from shore. The total temporary impacts related to the construction of the smaller alternative would be less, using rock armor, than the comparable impacts estimated for the proposed action.

Other impacts to water quality associated with the construction/decommissioning of the Smaller Project Alternative would be the potential for oil spills related to work vessels transiting to and from the Project Area. The marine vessels used to transport maintenance workers and equipment would be required to operate under USCG regulations. Also, an OSRP would be in place during construction/decommissioning 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. Because the number of vessels required to transit to and from the Project area during construction would decrease with the Smaller Project Alternative, the probability of marine vessels spilling fuel, lubricating oils or other substances would also decrease.

Operation of the revised 65 WTG layout is not anticipated to impact hydrodynamics or water quality. The only changes in the potential impacts to water quality associated with the operation of the Smaller Project Alternative would be the decrease in the size of the ESP. This would result in a decrease in the total number of gallons of electrical insulating oil utilized on the ESP. The proposed action of 130 WTGs would require the ESP to contain approximately 40,000 gallons (151,400 liters) of naphthenic mineral oil for cooling the ESP transformers. The revised layout would likely decrease to approximately 20,000 gallons (75,700 liters) of oil. Based on analyses conducted for the proposed alternative for oil spill probabilities and impacts which showed that probabilities of a large spill are extremely small, it is anticipated that the smaller alternative would also have small probabilities of a large spill of fluids from the ESP.

Maintenance activities would consist of small vessels transiting to and from the Project area in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic above current levels in Nantucket Sound, and would not impact water quality in the Project area.

Overall, the water quality impacts of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller footprint and smaller impact area.

5.4.3.2.7 Electric and Magnetic Fields

Electric and magnetic field strength of the Smaller Project Alternative would be less than the proposed action as the Smaller Project Alternative has half the generation capacity and thus a smaller amount of electrical current in its interconnection cable and smaller EMFs than the proposed action. However, EMF impacts are negligible under the proposed action and thus reductions in the levels result in no advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.8 Terrestrial Vegetation

Impacts of the Smaller Project Alternative on terrestrial vegetation as a result of cable construction work on land would be the same as those of the proposed action. Therefore the impacts on terrestrial vegetation from the Smaller Project Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the Smaller Project Alternative and the proposed action would utilize the same near shore cable route and landfall site (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the Smaller Project Alternative, including its offshore transmission cable system would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.10 Terrestrial and Coastal Faunas Other than Birds

Impacts of the Smaller Project Alternative on Terrestrial and Coastal Faunas other than birds would be the same as those of the proposed action as work within the terrestrial area and along the coast would be the same. Therefore the impacts on terrestrial and coastal faunas other than birds would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.11 Avifauna

According to research completed for the proposed action, it is expected that some temporary displacement of birds would result from the disturbance associated with construction/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 temporarily displace some avian species. Because the number and size of the proposed action components would decrease as a result of the revised layout, the number of construction/decommissioning events that could potentially displace the birds would similarly decrease over that of the proposed action.

Maintenance activities would consist of small vessels transiting to and from the Project area in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic over current levels in Nantucket Sound, and would not impact avifauna in the Project area.

Overall, the impacts to avifauna of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller size footprint and fewer turbines.

5.4.3.2.12 Subtidal Offshore Resources

The oceanographic conditions and predominantly sandy sediments on Horseshoe Shoal combine to produce a dynamic, shifting substrate that favors benthic communities of relatively low diversity. However, the shallow depths of Horseshoe Shoal also allow for a relatively high density and biomass of benthic organisms. Total invertebrate abundance is highly variable from site to site due to the high degree of environmental variability found on Horseshoe Shoal.

Most of the impacts to soft-bottom benthic communities are expected to occur during the cabling activities of the construction and decommissioning periods. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings for the WTGs and ESP. The total area of permanent benthic impact due to the WTG and ESP piles is 0.33 acres (1,335 m^2) for the Smaller Project Alternative (as compared to 0.67 acres [2,711 m^2] for the proposed 130 WTG layout).

Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor sweep, pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). A reduction in WTGs from 130 to 65 would not have a strictly proportional reduction in impacts to benthic communities for the following reasons.

- The smaller alternative would decrease the length of the 33 kV cable needed to connect the WTGs to the ESP from 66.7 miles to 29.7miles (107.3 km to 47.8 km).

This would result in a reduction of temporary impacts to benthic habitats from 580 acres to 258 acres (2.3 to 1.04 km^2).

- The smaller alternative would increase the length of the 115 kV cable connecting the ESP to the landfall site in Lewis Bay from 12.5 miles to 13.5 miles (20.1 to 21.7 km). This is due to the ESP being sited further to the west in order to provide a more centralized location for connection of the smaller alternative 33 kV cables. This would increase the temporary impacts to benthic habitat from 86 acres to 104 acres (0.3 to 0.4 km^2).
- With the smaller alternative, temporary impacts to benthic habitat from the jack-up barges used to install the WTGs and ESP would decrease from 9.4 acres to 4.81 acres (38,041 to 19,465 m^2). Under the revised layout, temporary impacts to benthic habitat from the construction and placement of scour control structures would be reduced from 3.0 acres to 1.6 acres (12,141 to 6,475 m^2) with scour mats and from 57 acres to 29 acres (0.2 to 0.1 km^2) if rock armor is used.
- For the complete summary of maximum anticipated temporary and permanent impacts to benthic habitat for the Smaller Project Alternative (see Tables 5.4.3-1 and 5.4.3-2).

By reducing the number of WTGs to 65 under the Smaller Project Alternative, the temporary impacts to benthic habitat and resources related to the WTGs are reduced roughly proportional to the number of WTGs. Impacts related to the installation of the 115 kV cable outside of the 3 mile (4.8 km) limit would increase in proportion to the additional one mile (1.6 km) of cable. The impacts inside of state waters would remain unchanged. The total temporary impacts related to the construction of the smaller alternative would be approximately 39 percent less, using rock armor, than the comparable impacts estimated for the proposed 130 WTG alternative.

During operation the number of WTG monopiles, would reduce the number of structures that would provide new localized hard-bottom habitats for benthic resources to inhabit. These benthic macro invertebrates and fouling organisms are anticipated to attract prey and larger finfish to the monopiles.

Overall, the benthic impacts of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller footprint and impact area.

5.4.3.2.13 Non-ESA Marine Mammals

The marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the Smaller Project Alternative area include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale. The two types of potential harassment that may occur during construction are vessel strikes and noise. Both types of harassment are classified as Level A and Level B harassments under the 1994 Amendments to the MMPA. There would be some potential for reduction of impacts to marine mammals with the Smaller Project Alternative as there would be half as many WTGs and thus half as many vessel trips and chances for vessel strikes.

Underwater noise impacts associated with the operation of the WTGs are not expected to cause Level A harassment to non-ESA mammals. The operations and maintenance plan would not be significantly altered with a reduction in the number of WTGs. Similar maintenance intervals would be expected for the smaller alternative, with a reduction in the number of WTGs still requiring approximately 325 maintenance days (5 days/WTG x 65 WTGs). It is assumed that 2 crews would be retained to perform the required maintenance; however the number of vessel trips for maintaining the smaller alternative would be expected to be the same as for the proposed alternative. The crew boat would transport and drop off two crews rather three crews during each deployment.

Overall, the non-ESA mammal impacts of the Smaller Project Alternative would be expected to be less for construction and decommissioning and about the same for maintenance activities.

5.4.3.2.14 Fish and Fisheries

In general, the disturbance to benthic habitats would be short-term and localized because many benthic invertebrates are adapted to high energy environments such as the Smaller Project Alternative area, and are capable of opportunistically re-colonizing benthic sediments after disturbance. Thus, fish species that prey on benthic species would be impacted temporarily during construction. Shellfish species spawn, at a minimum, once per year, and would likely resettle the disturbed areas within one or two years. The changes in temporary impacts to fisheries mirror those outlined in the Benthic discussion of the Smaller Project Alternative, and are as follows:

- Length of 33 kV cable needed to connect the WTGs to the ESP would decrease from 66.7 miles to 29.7 miles (107.3 to 47.8 km) = reduction of temporary impacts to benthic habitats from 580 acres to 258 acres (2.3 to 1.04 km^2).
- Length of the 115 kV cable connecting the ESP to the 3 mile boundary would increase from 4.9 miles to 5.9 miles (7.9 to 9.5 km) = increase in temporary impacts to benthic habitat from 86 acres to 104 acres (0.3 to 0.4 km^2).
- Temporary impacts to benthic habitat from the jack-up barges used to install the WTGs and ESP would decrease from 9.4 acres to 4.81 acres (38,040 to 19,465 m^2).
- Temporary impacts from the construction and placement of scour control structures would be reduced from 3.0 acres to 1.6 acres (12,141 to 6,475 m^2) with scour mats; 57 acres to 29 acres (230,671 to 117,359 2 m^2) if rock armor is used.

The changes in impacts to fish and shellfish with the revised layout are roughly proportional to the reduction in habitat disturbed from construction of the 33 kV cable, scour control structures, and the use of the jack-up barges. The permanent impacts to fish and shellfish from the placement of the WTG and ESP piles would be decreased from 0.67 acres to 0.33 acres (2,711 to 1,335 m^2). Mortality and injury due to cabling activities would be limited to demersal fish and shellfish located in the direct path of the jet plow and or anchoring equipment. The revised 65 WTG layout would potentially increase this impact along the 115 kV route and decrease the impact for the 33 kV route.

Operation of the Smaller Project Alternative would result in half as much new hard bottom substrate associated with the monopiles, which would reduce the area for new reef-like effects that would alter fish or shellfish communities.

The potential impacts to fish from EMF and thermal emissions from the normal operation of the offshore cables are expected to be negligible (These findings are discussed in further detail in the final EIR Appendix Sec. 3.7-C). The burial depth (6 ft) of the offshore cable systems would minimize the EMF and thermal impacts to shellfish resources. By reducing the number of WTGs from 130 to 65, there would be no significant reduction to these negligible impacts that have already been mitigated in the proposed layout.

Overall, impacts on fisheries of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller footprint and impact area.

5.4.3.2.15 Essential Fish Habitat (EFH)

The revised 65 WTG layout under the Smaller Project Alternative would decrease the area of permanent EFH impacts from 0.67 acres to 0.33 acres. Potential temporary impacts to EFH due to construction include physical displacement of sediments due to cable installation and pile driving, suspended sediments in the water column, and acoustical impacts.

The temporary impacts to benthic EFH would result from jet plow embedment of the 33 kV and 115 kV cables, the installation of the scour control mats and/or rock armor, and the vessel positioning and anchoring activities that would be associated with all structures. Temporary disturbances of the proposed action would total up to 812 acres with scour control mats or 866 acres with rock armoring. Under the small alternative layout, these disturbances would decrease to 502 acres with scour control mats or 529 acres with rock armoring. The areas of benthic habitat that would be temporarily affected by construction activities are expected to recover relatively rapidly, allowing for the EFH functions of affected areas to be restored.

The Smaller Project Alternative layout would not alter the route of the 115 kV cable inside Lewis Bay. Therefore, no changes in the potential impacts to these EFH resources would occur (i.e., no changes to winter flounder impacts) with the revised layout).

The operation of the proposed action has the potential to alter EFH due to acoustical interference caused by the WTGs, the "reef effect" associated with placing hardened structures in a soft bottom substrate, EMF, and changes to water flow and sediment transport. The Smaller Project Alternative would reduce the potential for these impacts. For instance, as the Smaller Project Alternative has half the number of piles it would result in reduced duration of pile driving noise, reduced amount of hard area that could create a reef effect, and reduced EMF levels. Overall, impacts on EFH from the Smaller Project Alternative would be expected to be less than the proposed action with respect to construction, decommissioning and operation.

5.4.3.2.16 Threatened and Endangered Species (T&E)

The Smaller Project Alternative would have a smaller affected area and would therefore reduce impacts to T&E species by limiting disturbance during construction compared to the proposed action. Disturbance associated with construction/decommissioning activities such as increased vessel traffic, presence of equipment, human presence, and noise would be reduced as a result of the Smaller Project Alternative scope and shorter duration of pile driving activities. The Smaller Project Alternative would also result in less interconnection disturbance between the individual WTGs and hence reduce the sediment plumes which could cause fish to avoid the construction site and displace some avian T&E species. The Smaller Project Alternative would reduce the number of wind turbines by half and thus could be expected to reduce the amount of avian T&E collisions predicted for the proposed action by half.

Because the number and size of the Smaller Project Alternative components would decrease as a result of the revised layout, the number of construction/decommissioning events that could potentially displace birds would similarly decrease over that of the proposed action.

Maintenance activities would consist of small vessels transiting to and from the WTG array area in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic above current levels in Nantucket Sound, and would not impact avifauna in the area.

Overall, the impacts to avifauna of the Smaller Project Alternative would be expected to be less than those of the proposed action with respect to construction, decommissioning and operation because of its smaller footprint size and fewer WTGs.

5.4.3.2.17 Socioeconomic Analysis Area

The existing social and economic conditions for the Smaller Project Alternative are similar to those of the proposed action as it is in the same geographic location. Compared to the proposed action, socioeconomic impacts associated with the Smaller Project Alternative would be less in terms of number of construction jobs, electricity generated and revenues from taxes, than from the larger proposed action.

5.4.3.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the Smaller Project Alternative and the proposed action would utilize the same near shore cable route, landfall site a, and onshore cable route and affect the same urban and suburban infrastructure (see Section 4.3.2 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure associated with the Smaller Project Alternative, including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.19 Population and Economic Background

The Smaller Project Alternative is located in the same general geographic area as the proposed action and is expected to result in negligible changes in population or the economy of the region. Hence, the Smaller Project Alternative would be comparable to and offer no significant advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area of the Smaller Project Alternative is in the same location, and same socioeconomic area as the proposed action. It is not located near any communities of higher than average minority populations or close to the tribal lands of the WTGHA or the Wampanoag Tribe of Mashpee. As such, the Smaller Project Alternative would be expected to be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.21 Visual Resources

Visual impacts of the Smaller Project Alternative would be less than those associated with the proposed action. The views of the facility show a somewhat reduced breadth of visual impacts when looking out at the horizon and it is somewhat further away from Nantucket and Cape Cod (see Figure 3.3.6-2 which shows visual simulations of the Smaller Project Alternative). Construction impacts would also be reduced due to the shorter period of construction, and less time when large construction vessels would be visible. Compared to the proposed action, visual impacts would be less than the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.22 Cultural Resources

The Smaller Project Alternative has the same monopile locations (though fewer) as the proposed action, though some inner-array cables between the monopiles are located in different areas. This area has been assessed for underwater cultural resources and it was found that this configuration would not impact such resources. The onshore portion of the cable work is in the same location as the proposed action, and therefore there would be no change in archaeological impacts. Visual impacts to historic structures may be reduced due to the more limited area occupied by the turbine array and because it is further away from the Cape Cod and Nantucket shorelines than the proposed action (see Figure 3.3.6-2).

5.4.3.2.23 Recreation and Tourism

The Smaller Project Alternative is located in the same general location as the proposed action but covering a smaller area. Impacts to recreation boating would be reduced as there would be a smaller area of turbines to navigate through by recreational vessels. The breadth of visual impact from Cape Cod would appear somewhat smaller as well, though this change would not likely result in any measurable impact on tourism over that of the proposed action. (Refer to visual resource discussion above). Overall, impacts to recreation and tourism from the Smaller Project Alternative would be comparable to and offer no advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.24 Competing Uses

Competing uses in the vicinity of the Smaller Project Alternative are the same as for the proposed action and are limited to Commercial and Recreational Fishing and Boating, and the potential for maintenance dredging of nearby channels. The impact of the proposed action on these competing uses was determined to be minor. As the Smaller Project Alternative is smaller than the proposed action, it would have even less of a potential to impact competing uses in the area.

5.4.3.2.25 Overland Transportation Arteries

The Smaller Project Alternative is located in the same area as the proposed action and not near any overland transportation arteries. It would have a negligible effect on such arteries as a result of onshore equipment deliveries or commuting of workers. Therefore impacts from the Smaller Project Alternative on overland transportation arteries would be expected to be comparable to those of the proposed action and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.26 Airport Facilities

The Smaller Project Alternative is located in the same area as the proposed action but spread out over a smaller area. The proposed action received FAA approval indicating that it would not affect navigation or associated communication systems (Refer to Appendix E) and therefore the Smaller Project Alternative would also not affect airport facilities. In summary, the Smaller Project Alternative would be expected to be comparable to that of the proposed action with respect to impacts on Airport Facilities and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.3.2.27 Port Facilities

The Smaller Project Alternative is smaller than the proposed action and hence is less likely to impact port facilities and marine traffic related to port facilities. Overall, the impacts on port facilities from the Smaller Project Alternative would be expected to be comparable to those of the proposed action with respect to construction, operation, and decommissioning.

5.4.3.2.28 Communications: Electromagnetic Fields, Signals and Beacons

The Smaller Project Alternative is located in the same area as the proposed action but covers a smaller area. The assessment for the proposed action found that impacts on entertainment satellite, entertainment broadcasting services, (AM, FM and TV stations), non-emergency ship-to-shore communications (cellular communications and VHF frequencies in the marine band), navigation and positioning services, LORAN, safety and emergency communications, sub-sea communication cables, and Micro Wave Communications would be minor (see Section 5.3.4.4). As the Smaller Project Alternative would have less surface area, it would have less effect on communication devices for those navigating in the area. As a result, the Smaller Project Alternative is expected to have comparable or less impacts than the proposed action.

5.4.4 Phased Development Alternative

5.4.4.1 Description of the Phased Development Alternative

In order to facilitate the study of a phased approach to constructing the proposed action of 130 WTGs, it was determined that for illustrative purposes, a 50/50 split would be most effective. A split in the proposed action of 130 WTGs into two phases was accomplished by dividing the proposed action into an eastern half and a western half, each containing 65 WTGs (see Figure 3.3.5-1). The initial 65 WTG phase would be designed to allow expansion to 130 WTGs with as little re-construction as possible. The cabling layouts (both the inner array 33 kV and interconnecting 115 kV transmission system) used in this Phased Development Alternative are the same as presented in the proposed action.

Phase I:

The western half of the proposed action would be constructed during the first phase primarily because the 65 westernmost turbine sites would be located in the shallower waters of Horseshoe Shoal and would be more regularly spaced in closer proximity to each other allowing for the least amount of inner-array 33 kV cable for interconnection to the ESP. This would be the least costly construction of the two phases, thereby reducing interest costs of financing during construction on the overall two phase project. Assuming that assurances were in place for the completion of both phases, the ESP and the complete 115 kV transmission system (both circuits for the offshore and upland components) would be completed during Phase I allowing for power from the first 65 WTGs to be transformed and transmitted into the regional power grid. Both the ESP structure and the complete 115 kV offshore transmission cable system would be the same as those for the proposed action; however some portion of the electrical equipment on the ESP would be delayed until the second phase. The construction of the ESP and the installation of the 115 kV transmission cable along the eastern edge of the first phase eliminates (to the greatest degree possible) the need to conduct Phase II installation activities (eastern half) within the area of the operating first phase of the alternative. Phase I will include 65 turbines connected in 7 full strings (each made up of 8 to 10 WTGs) and one partial string (3 WTGs), requiring approximately 32.7 miles (52.6 km) of 33 kV inner-array cable (see Figure 3.3.6-3).

Phase II:

The eastern half of the WTG array would be constructed during the second phase. In general, a developer would seek to minimize the time between the construction of the first and second phases in order to minimize the lag time and costs associated with:

- Procurement of equipment;
- Staging area acquisition and build out;

- Mobilization of construction and installation equipment and labor; and
- At sea construction.

For analysis purposes**,** Phase II would be scheduled within a reasonable time frame of five to ten years to coincide with the state's continued desire for renewable energy sources should renewable energy still be mandated. Construction of phase two within five years would not be considered a phased approach due to the short length of time between construction cycles. Construction of phase two beyond ten years is not considered reasonable due to anticipated change to the underlying purpose and need for this project.

The balance of the ESP electrical equipment required for the additional 65 WTGs would be installed during Phase II. For the purposes of this analysis it is assumed that the complete 115 kV offshore transmission cable system would be installed during the first phase. Phase II will include 65 turbines connected in 6 full strings (each made up of 9 or 10 WTGs) and the addition of 7 WTGs to one partial string of 3 WTGs that would have been installed in Phase I. Phase II will require approximately 34.0 miles (54.7 km) of 33 kV inner-array cable (see Figure 3.3.6-3).

Decommissioning

Because it is assumed that all of the WTGs will have the same effective useful life (approximately 20 years), the decommissioning of the Phased Development Alternative will also be conducted in phases to correspond to the phased construction and duration of lag time. Phase I of the decommissioning would remove the WTGs, scour protection, and inner-array cables that were installed 20 years prior during Phase I (western half of the WTG array). Following a period of time equal to the lag between construction phases, Phase II of the decommissioning would take place 20 years after the completion of the Phase II construction and would remove the eastern half WTGs, scour protection and inner-array cables, along with the ESP and the interconnecting 115 kV transmission system. Similar to the construction phases, the decommissioning of the Phased Development Alternative will require multiple mobilizations/demobilizations and staging and is expected to have similar impacts as the phased construction.

5.4.4.2 Environmental Resources of the Phased Development Alternative and Comparison with the Proposed Action

5.4.4.2.1 Regional Geologic Setting

The geological setting of the Phased Development Alternative is the same as the proposed action. The area of Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. The geologic setting of the Phased Development Alternative is therefore comparable to and offers no significant environmental advantage over the geologic setting of the proposed action with respect to construction, decommissioning and operation. Geomorphology is also expected to be the same.

5.4.4.2.2 Noise

Noise impacts to humans would be increased under the Phased Development Alternative due to the longer construction and decommissioning time frames resulting from multiple mobilizations, demobilization and staging operations. Operational noise during Phase I would be less, however once the second Phase is completed there will be no difference between the Phased Development Alternative and the proposed action. The duration of underwater noise during construction would be less during each individual phase followed by some period of time with little or no construction activities. In general noise impacts would be comparable and offer no significant environmental advantage with respect to noise impacts compared to the proposed action during construction, operations and decommissioning.

5.4.4.2.3 Physical Oceanography

Water depths for the Phased Development Alternative are the same as for those for the proposed action since they are at the same location. Tides, current speed and wave conditions are also the same. Overall, the physical oceanography impacts of the Phased Development Alternative would be expected to be similar to those of the proposed action with respect to construction, decommissioning and operation.

5.4.4.2.4 Climate and Meteorology

The weather conditions for the Phased Development Alternative are the same as for the proposed action as they are at the same location. The Phased Alternative would result in slightly more CO_2 emissions (a green house gas) than the proposed action due to the added work associated with two construction mobilizations. However, in general impacts to climate and meteorology would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.4.2.5 Air Quality

Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning phases of the proposed action would emit, or have the potential to emit air pollutants. Although the air emissions for much of the Phased Development Alternative would be similar to the proposed action (emissions related to G&G, ESP installation, cable installation, and operations), the vessels and equipment involved in constructing and decommissioning the Phased Development Alternative would emit greater amounts of air contaminants as compared to the proposed action. The increased air emissions would be the result of multiple mobilizations and demobilizations of major construction vessels for pile foundation installation/decommissioning and WTG installation/decommissioning related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete the Phased Development Alternative would also be greater than if the proposed action was constructed and decommissioned from start to finish. As a result, it is anticipated that the overall emissions from the construction/decommissioning vessels and equipment related to the Phased Development Alternative would be greater than those estimated for the proposed action.

5.4.4.2.6 Water Quality

Water quality impacts related to construction (and decommissioning) of the Phased Development Alternative would be greater as the result of multiple mobilizations and demobilizations of major construction vessels for pile foundation installation and WTG installation related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete the Phased Development Alternative would also be greater than if the proposed action was constructed from start to finish. Water quality impacts from the cable installations (both 33 kV and 115 kV) will be the same for the both alternatives.

Other impacts to water quality associated with the construction/decommissioning of the Phased Development Alternative would be the potential for oil spills related to work vessels transiting to and from the area of the proposed action. Because the overall construction (and decommissioning) duration and number of vessel trips required to transit to and from the area of the proposed action would increase with the Phased Development Alternative, the probability of marine vessels spilling fuel, lubricating oils or other substances would increase.

Additionally, the Phased Development Alternative would delay the installation of some portion of the electrical equipment on the ESP until the second phase. This would likely involve the installation of one or more transformers at sea to accommodate the Phase II WTGs, along with an additional at-sea transfer of a significant amount of transformer oil (approximately 10,000 gallons [37,850 liters] per transformer). In comparison the ESP for the proposed action would be outfitted in Port and towed to the site for installation. This additional phased build-out of the ESP presents a greater chance for a potential spill during installation and transfer, thereby further increasing the potential for impacts to water quality during the construction of the Phased Development Alternative.

During operation the temporary water quality impacts of the Phased Development Alternative would be less than those associated with the proposed action following the completion of Phase I and prior to the installation of Phase II. Once the Phased Development Alternative is completed, there would be no difference in water quality impacts related to operations, between the Phased Development Alternative and the proposed action. Overall, the water quality impacts of the Phased Development Alternative would be expected to be greater than those of the proposed action with respect to construction and decommissioning. The impacts would be similar with respect to operation.

5.4.4.2.7 Electric and Magnetic Fields (EMFs)

Electric and magnetic field strength of Phase I would be less than the proposed action because it would have half the generating capacity and thus a smaller amount of electrical current in its offshore transmission cable system and smaller EMF's than the proposed action. However once the second phase of the development becomes operational, there would be no difference in EMF levels between the Phased Development Alternative and the proposed action. As a result, EMF impacts would be comparable and offer no significant environmental advantage with respect to EMF impacts compared to the proposed action during construction, operations and decommissioning.

5.4.4.2.8 Terrestrial Vegetation

Impacts of the Phased Development Alternative on terrestrial vegetation as a result of cable construction work on land would be the same as those of the proposed action. Therefore the impacts on terrestrial vegetation from the Phased Development Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation and decommissioning impacts.

5.4.4.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the Phased Development Alternative and the proposed action would utilize the same near shore cable route and landfall site (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the Phased Development Alternative, including its offshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation and decommissioning impacts.

5.4.4.2.10 Terrestrial and Coastal Faunas Other than Birds

Impacts of the Phased Development Alternative on Terrestrial and Coastal Faunas other than birds would be the same as those of the proposed action as work within the terrestrial area and along the coast would be the same. Therefore the impacts on terrestrial and coastal faunas other than birds would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.4.2.11 Avifauna

According to research completed for the proposed action, it is expected that some temporary displacement of birds would result from the disturbance associated with construction/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 temporarily displace some avian species. Impacts to birds during construction (and decommissioning) of the Phased Development Alternative is expected to be greater than the proposed action as the result of the longer construction/decommissioning time frames and multiple mobilizations and demobilizations of major construction vessels for pile foundation installation/decommissioning and WTG installation/decommissioning related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete/decommission the Phased Development Alternative would also be greater than if the proposed action was constructed from start to finish. Overall, the impacts to avifauna of the Phased Development Alternative would be expected to be greater than those of the proposed action with respect to construction and decommissioning. The impacts would be similar with respect to operation.

5.4.4.2.12 Subtidal Offshore Resources

The oceanographic conditions and predominantly sandy sediments on Horseshoe Shoal combine to produce a dynamic, shifting substrate that favors benthic communities of relatively low diversity. However, the shallow depths of Horseshoe Shoal also allow for a relatively high density and biomass of benthic organisms. Total invertebrate abundance is highly variable from site to site due to the high degree of environmental variability found on Horseshoe Shoal.

Most of the impacts to soft-bottom benthic communities are expected to occur during the cabling activities of the construction and decommissioning periods. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings for the WTGs and ESP. The total area of permanent benthic impact due to the WTG and ESP piles would be the same for both the Phased Development Alternative and the proposed action (0.67 acres [0.003 km^2]).

Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor line sweep, jet plow pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). There would be some increase in anchoring impacts related to the increased overall number of vessel trips and multiple construction mobilization/demobilizations. During operation the WTGs will provide new localized hard-bottom habitats for benthic resources to inhabit. These benthic macro invertebrates and fouling organisms are anticipated to attract prey and larger finfish to the monopiles. Because of the localized, temporary nature of impacts related to the WTGs, there is no anticipated benefit or impact related to the phased approach with respect to operation.

Overall, the impacts to benthic resources of the Phased Development Alternative would be expected to be somewhat greater than those of the proposed action with respect to construction and decommissioning. The impacts would be similar with respect to operation.

5.4.4.2.13 Non-ESA Marine Mammals

The marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the area of the proposed action include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale.

The two types of potential harassment that may occur during the construction of the proposed action are vessel strikes and noise. Both types of harassment are classified as Level A and Level B harassments under the 1994 Amendments to the MMPA. Because of an increased chance for vessel strike due to the increased number of vessel trips and the multiple mobilizations/demobilizations involved with the Phased Development Alternative, there is some potential for an increase of construction and decommissioning impacts to marine mammals from the Phased Development Alternative as compared to the proposed action.

The operations and maintenance plan would not be significantly altered with the phased development approach. Similar maintenance intervals would be expected for Phase I, with the 65 WTGs still requiring approximately 325 maintenance days (5 days per turbine). During the first phase it is assumed that 2 crews would be retained to perform the required maintenance; however the number of vessel trips for maintaining the smaller first phase would be expected to be the same as for the proposed action. The crew boat would transport and drop off two crews rather than three crews during each deployment. Once Phase II is completed and all 130 WTGs become operational the impacts from the Phased Development Alternative will be similar to the proposed action.

Overall, the non-ESA mammal impacts of the Phased Development Alternative would be expected to be somewhat greater for construction and decommissioning, and comparable for operations as compared to the proposed action.

5.4.4.2.14 Fish and Fisheries

In general, the disturbance to benthic habitats would be short-term and localized because many benthic invertebrates are adapted to high energy environments such as the area of the proposed action, and are capable of opportunistically re-colonizing benthic sediments after disturbance. Thus, fish species that prey on benthic species would be impacted temporarily during construction. Shellfish species spawn, at a minimum, once per year, and would likely resettle the disturbed areas within one or two years.

The changes in temporary impacts to fisheries mirror those outlined in the benthic discussion of the Phased Development Alternative. Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor line sweep, jet plow pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). There would be somewhat greater anchoring impacts related to the increased overall number of vessel trips and multiple construction and decommissioning mobilizations/demobilizations. Operation of the first phase of the Phased Development Alternative would result in half as much new hard bottom substrate associated with the monopiles, for some period of time. This would reduce the area for new reef-like effects that would alter fish or shellfish communities. Following the completion of Phase II, these impacts will be similar to the proposed action. With respect to EMF impacts on fish and fisheries, operation of the Phased Development Alternative, once fully constructed, would result in the same EMF levels.

Overall, impacts on fisheries of the Phased Development Alternative would be slightly greater for construction and decommissioning, and similar for operations as compared to the proposed action.

5.4.4.2.15 Essential Fish Habitat

The Phased Development Alternative would have the same area of permanent EFH impacts as the proposed action (0.33 acres [0.001 km^2]). Potential temporary impacts to EFH due to construction and decommissioning include physical displacement of sediments due to cable installation/removal and pile driving / removal, suspended sediments in the water column and acoustical impacts.

The temporary impacts to benthic EFH would result from jet plow embedment and removal of the 33 kV and 115 kV cables, the installation and removal of the scour control mats and/or rock armor, and the vessel positioning and anchoring activities that would be associated with all structures. There will be some increase in anchoring impacts related to the increased overall number of vessel trips and multiple construction/decommissioning mobilizations/demobilizations, the temporary impacts related to the Phased Development Alternative are expected to be similar to the proposed action. The areas of benthic habitat that would be temporarily affected by construction and decommissioning activities are expected to recover relatively rapidly, allowing for the EFH functions of affected areas to be restored.

The Phased Development Alternative layout would not alter the route of the 115 kV offshore transmission cable system inside Lewis Bay. Therefore, no changes in the potential impacts to these EFH resources would occur (i.e., no changes to winter flounder impacts) with the Phased Development Alternative. Because of the same overall number of WTGs and cable lengths, the operation of the Phased Development Alternative would have similar impacts to the proposed action.

Overall, impacts on EFH of the Phased Development Alternative would be greater for construction and decommissioning, and similar for operations as compared to the proposed action.

5.4.4.2.16 Threatened and Endangered Species (T&E)

Impacts to T&E species would be increased under the Phased Development Alternative due to the longer construction and decommissioning time frames resulting from multiple mobilizations, demobilization and staging operations. Impacts to birds during construction and decommissioning of the Phased Development Alternative is expected to be greater than the proposed action as the result of the longer time frames and multiple mobilization and demobilization of major construction vessels for pile foundation installation/ removal and WTG installation/removal related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete and decommission the Phased Development Alternative would also be greater than if the proposed action was constructed from start to finish.

Because of the same overall number of WTGs and cable lengths, the operation of the Phased Development Alternative would have similar impacts for T&E species as compared to the proposed action.

Overall, the impacts to T&E of the Phased Development Alternative would be expected to be more than the proposed action during construction and decommissioning due to the extended construction time frame and multiple mobilizations/demobilizations, and impacts would be the similar for operation.

5.4.4.2.17 Socioeconomic Analysis Area

The existing social and economic conditions for the Phased Development Alternative are similar to those of the proposed action as it is in the same geographic location. Compared to the proposed action, socioeconomic impacts associated with the Phased Development Alternative would be similar except that it would involve multiple mobilizations/demobilizations and procurement of staging areas and equipment. This would not significantly increase the number of construction jobs or revenues going into the local area, and thus socioeconomic impacts of the Phased Development Alternative are expected to be similar to that of the proposed action.

5.4.4.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the Phased Development Alternative and the proposed action would utilize the same near shore cable route, landfall site and onshore cable route and affect the same urban and suburban infrastructure (see 4.3.2 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure associated with the Phased Development Alternative including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.4.2.19 Population and Economic Background

The Phased Development Alternative is located in the same general geographic area as the proposed action and is expected to result in negligible changes in population or the economy of the region. Hence, the Phased Development Alternative would be comparable to and offer no significant population and economic advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.4.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area of the Phased Development Alternative is in the same location, and same socioeconomic area as the proposed action. It is not located near any communities of higher than average minority populations or close to the tribal lands of the Wampanoag Tribe of Gay Head Aquinnah (WTGHA) or the Wampanoag Tribe of Mashpee. As such, the Phased Development Alternative would be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.4.2.21 Visual Resources

Visual impacts of the Phased Development Alternative would be less than those associated with the proposed action following the completion of Phase I and prior to the installation of Phase II. Once the Phased Development Alternative is completed, there would be no difference in visual impacts related to operations, between the Phased Development Alternative and the proposed action.

Construction and decommissioning impacts from the Phased Development Alternative would be greater as the result of multiple mobilization and demobilization of major construction vessels for pile foundation installation/removal and WTG installation/ removal related to each distinct development phase. The total number of vessel trips and/or the duration of deployment required to complete and/or remove the Phased Development Alternative would also be greater than if the proposed action was constructed from start to finish, resulting in more time when large construction vessels would be visible.

Overall, the visual impacts of the Phased Development Alternative would be expected to be more than the proposed action during construction and decommissioning due to the extended work time frame and multiple mobilizations/demobilizations, and impacts would be the same for operation.

5.4.4.2.22 Cultural Resources

The Phased Development Alternative has the same monopile locations as the proposed action and the same inner array cabling layout. This area has been assessed for underwater cultural resources and it was found that this configuration would not impact such resources. The onshore portion of the cable work is in the same location as the proposed action. Therefore, impacts to cultural resources would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.4.2.23 Recreation and Tourism

The Phased Development Alternative is located in the same location as the proposed action. Because of the extended duration of activity, multiple mobilizations/demobilizations and increased number of vessel trips related to construction and decommissioning activities of the Phased Development, it is likely that the impacts to recreational boating, and any related visual impacts, during construction and decommissioning will be greater than the proposed action.

Once the Phased Development Alternative is completed, there would be no difference in recreation and tourism related to operations, between the Phased Development Alternative and the proposed action. Overall, the impacts to recreation and tourism of the Phased Development Alternative would be expected to be more than the proposed action during construction and decommissioning due to the extended work time frames and multiple mobilizations/demobilizations, and the impacts would be the same for operation.

5.4.4.2.24 Competing Uses

Competing uses in the vicinity of the Phased Development Alternative are the same as for the proposed action and are limited to commercial and recreational fishing and boating, and the potential for maintenance dredging of nearby channels. The impact of the proposed action on these competing uses was determined to be minor.

5.4.4.2.25 Overland Transportation Arteries

The Phased Development Alternative is located in the same area as the proposed action and not near any overland transportation arteries. It would have a negligible effect on such arteries as a result of onshore equipment deliveries or commuting of workers. Therefore, impacts from the Phased Development Alternative on overland transportation arteries would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.4.2.26 Airport Facilities

The Phased Development Alternative is located in the same location as the proposed action. The proposed action received FAA approval indicating the proposed action would not affect navigation or associated communication systems (Refer to Appendix E) and therefore the Phased Development Alternative would also not affect airport facilities. In summary, the Phased Development Alternative would be expected to be comparable to the proposed action with respect to impacts on Airport Facilities and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.4.2.27 Port Facilities

The Phased Development Alternative is likely to have greater impacts to port facilities and marine traffic related to port facilities due to the extended duration of activity, multiple mobilizations/ demobilizations and increased number of vessel trips related to construction and decommissioning activities of the Phased Development.

During operation, impacts to port facilities and marine traffic would be reduced slightly, as compared to the proposed action, following the completion of Phase I and prior to the installation of Phase II. Once the Phased Development Alternative is completed, there would be no difference in impacts to port facilities and marine traffic related to operations, between the Phased Development Alternative and the proposed action.

Overall, the impacts to port facilities of the Phased Development Alternative would be expected to be more than the proposed action during construction and decommissioning due to the extended work time frames and multiple mobilizations/demobilizations, and the impacts would be the same for operations.

5.4.4.2.28 Communications: Electromagnetic Fields, Signals and Beacons

The Phased Development Alternative is located in the same area as the proposed action. The assessment for the proposed action found that impacts on entertainment satellite, entertainment broadcasting services, (AM, FM and TV stations), non-emergency ship to shore communications (cellular communications and VHF frequencies in the marine band), navigation and positioning services, LORAN, safety and emergency communications, sub-sea communication cables, and Micro Wave Communications would be minor. As a result, the Phased Development Alternative is expected to have comparable impacts to the proposed action during construction, operation and decommissioning.

5.4.5 Condensed Array Alternative

5.4.5.1 Description of Condensed Array Alternative

In designing an offshore wind energy project, turbine spacing is considered which effectively balances the capture of the wind resource (and ultimately the power production), with a number of site specific physical and economic constraints such as water depth and watersheet use. Pre-project modeling of wind wake[8] effects can be performed by several proprietary computer models. In the case of proposed action, there is a predominately southwest wind direction that dictates the spacing necessary not only to reduce adjacent row wind wake effects (in order to optimize efficiency of operations), but to follow industry practice to reduce structural fatigue from turbulence created by the wake and associated higher maintenance costs. As a general rule, manufacturers of the WTGs recommend a minimum spacing of greater than 5 rotor diameters in order to avoid catastrophic structural fatigue and guarantee efficiencies.

In order to facilitate the study of a condensed configuration alternative with 130 WTGs, a 6 x 6 rotor diameter spacing was chosen (the proposed action has a 9 x 6 rotor diameter spacing). The 6 x 6 rotor spacing was chosen as a reasonable example that falls within the range of some existing offshore wind energy projects (see Table 3.3.6-1). The Condensed Array Alternative would maintain the same ESP location as the proposed action (see Figure 3.3.5-1), and therefore the interconnecting 115 kV transmission system would remain the same in all aspects of design, length, installation and routing as the proposed action. Both the ESP structure and the complete 115 kV offshore transmission cable system would be the same as those under the proposed action. The WTG locations in the proposed action currently are spaced approximately 6 rotor diameters apart in the north-south "columns" of the array. The 130 WTGs of the Condensed Alternative have been arranged with the same central column of WTGs as the proposed action's "F" column (WTGs F1 through F14), maintaining the same location with 6 rotor diameters separation (see Figure 2.1.2-1). The WTGs of the proposed action are separated by 9 WTGs within the east-west "rows." To reduce the spacing within these rows to 6 rotor diameters for the Condensed Alternative, the WTGs to the west of the ESP and the "F" column have been shifted to the east, and WTGs to the east of the ESP and the "F" column have been shifted to the west, providing for a 130 WTG array with 6 x 6 rotor diameter spacing condensed around a similar ESP location as the proposed alternative.

[8] As wind passes through the rotor of a wind turbine generator, it becomes turbulent behind the rotor. This area on the downwind side of the rotor is termed "wind wake". The wind wake dissipates and returns to smooth, laminar flow at some distance beyond the turbine.

The cabling layouts (both the inner array 33 kV and interconnecting 115 kV transmission system) used in this Condensed Alternative are the same as presented in the proposed action (see Figure 3.3.6-4). The WTGs in the Condensed Alternative have been arranged in similar interconnecting strings (14 strings of 8-10 WTGs each) as the proposed action. The overall inner-array 33 kV cable lengths would be reduced to 58 miles (93.3 km) (from 66 miles [106.2 km] for the proposed action). The reduction would not be proportionate to the 25-30 percent east – west reduction of the WTG array because the inner-array cables of the proposed action have been arranged to minimize overall length by maximizing the use of the shorter north – south transects and minimizing the cabling east to west.

The footprint area of the Condensed Array Alternative is approximately 16 square miles (41.4 km^2) (as compared to 25 square miles [64.7 km^2] for the proposed action). The distances to shore are presented in Table 3.3.6-2.

5.4.5.2 Environmental Resources of the Condensed Array Alternative and Comparison with the Proposed Action

5.4.5.2.1 Regional Geologic Setting

The geological setting of the Condensed Array Alternative is the same as the proposed action. The area of Horseshoe Shoal is generally composed of medium sands dominating the shallow water sediments and poorly graded fine and silty sands located in the deeper shoal waters. The geologic setting of the Condensed Alternative is therefore comparable to and offers no significant environmental advantage over the geologic setting of the proposed action with respect to construction, decommissioning and operation. Geomorphology is also expected to be the same.

5.4.5.2.2 Noise

Noise impacts to humans related to construction activities would be slightly less under the Condensed Array Alternative because of the increased distance to shore from the perimeter WTG pile driving. In particular those receptors on Cape Poge would be located further from the WTGs on the western edge of the array. However, this decrease is expected to be of little significance since the temporary construction noise from the proposed action is expected to be inaudible with the possible exception during installation of those WTGs closest to Martha's Vineyard. Underwater noise during construction of the Condensed Array Alternative would be the same as the proposed action.

Impacts from operational noise, both above and below water, from the Condensed Array Alternative are expected to be the same as those of the proposed action. Decommissioning noise, which would not involve pile driving, would be the same as that of the proposed action.

In summary, the noise impacts from the construction of the Condensed Array Alternative are slightly less than the proposed action, but would be the same for operations and decommissioning.

5.4.5.2.3 Physical Oceanography

Water depths for the Condensed Array Alternative are generally the same as for the proposed action since they are at the same area. Tides, current speed and wave conditions are also the same. Overall, the physical oceanography impacts of the Condensed Alternative would be expected to be comparable to those of the proposed action with respect to construction, decommissioning and operation.

5.4.5.2.4 Climate and Meteorology

The Condensed Alternative would emit CO_2, a green house gas. The amount of CO_2 discharged and the impact on climate would be negligible. Accordingly, the Condensed Array Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.5.2.5 Air Quality

Vessels and equipment involved in the pre-construction G&G investigations, construction and decommissioning phases of the proposed action would emit air pollutants. It is expected that the air emissions for construction of the Condensed Array Alternative would be slightly less than those of the proposed action primarily due to the 8 mile (12. 9 km) reduction in the amount of inner-array 33 kV cabling required. Although the distances the construction and maintenance vessels must travel from the proposed staging area in Quonset RI to reach the furthest WTGs on the eastern edge of the Condensed Array Alternative is slightly less than the proposed action, this minor reduction is offset by the increased travel distances to reach the nearest WTGs on the western edge of the Condensed Array Alternative. As a result, there would be no significant change in air emissions between the two alternatives during construction. Emissions related to G&G, ESP installation, 115 kV offshore transmission cable system cable installation, and WTG installation would be expected to remain comparable to the proposed action.

5.4.5.2.6 Water Quality

Water quality impacts related to construction of the Condensed Array Alternative would be less than the proposed action due to the 8 mile (12.9 km) reduction in the amount of 33 kV cabling required. The total number of vessel trips and/or the duration of deployment required to complete the Condensed Array Alternative would also be the same as for the proposed action. Water quality impacts from the cable installation of the 115 kV transmission system will be the same for both alternatives.

Other impacts to water quality associated with the construction/decommissioning of the Condensed Array Alternative would be the potential for oil spills related to work vessels transiting to and from the area of the proposed action. The marine vessels used to transport maintenance workers and equipment would be required to operate under USCG regulations. Also, an OSRP would be in place during construction/decommissioning 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. Although the distances the construction and maintenance vessels must travel from the proposed staging area in Quonset RI to reach the furthest WTGs on the eastern edge of the Condensed Array Alternative is slightly less than the proposed action, this minor reduction is offset by the increased travel distances to reach the nearest WTGs on the western edge of the Condensed Alternative. As a result, there would be no net change between the two alternatives in the probability of marine vessels spilling fuel, lubricating oils or other substances.

During operation there would be no difference in temporary water quality impacts related to operations, between the Condensed Array Alternative and the proposed action. Operation of the 130 WTGs of the Condensed Array Alternative is not anticipated to impact hydrodynamics or water quality.

Overall, the water quality impacts of the Condensed Array Alternative would be expected to be less than those of the proposed action with respect to construction. The impacts would be similar with respect to operation and decommissioning.

5.4.5.2.7 Electric and Magnetic Fields

As a result of the less efficient spacing of the Condensed Array Alternative, there will be less power generated than the proposed action and therefore less electric and magnetic field strength (EMF) levels produced. However, since the EMF impacts are already negligible under the proposed action there is no advantage from the Condensed Array Alternative with respect to construction, operation and decommissioning impacts.

5.4.5.2.8 Terrestrial Vegetation

Impacts of the Condensed Array Alternative on terrestrial vegetation as a result of cable construction work on land would be the same as those of the proposed action. Therefore the impacts on terrestrial vegetation from the Condensed Alternative would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation and decommissioning impacts.

5.4.5.2.9 Coastal and Intertidal Vegetation

To access the Barnstable Substation, both the Condensed Array Alternative and the proposed action would utilize the same near shore cable route and landfall site (see Section 4.2.2 of this document for detailed information on coastal and intertidal vegetation). Compared to the proposed action, impacts on coastal and intertidal vegetation within the Condensed Array Alternative, including its 115 kV offshore transmission cable system, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation and decommissioning impacts.

5.4.5.2.10 Terrestrial and Coastal Faunas Other than Birds

Impacts of the Condensed Array Alternative on Terrestrial and Coastal Faunas other than birds would be the same as those of the proposed action as work within the terrestrial area and along the coast would be the same. Therefore the impacts on terrestrial and coastal faunas other than birds would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.5.2.11 Avifauna

According to research completed for the proposed action, it is expected that some temporary displacement of birds would result from the disturbance associated with construction/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 temporarily displace some avian species. Although impacts to birds from the construction of the WTGs, ESP and 115 kV offshore transmission cable system are expected to be the same, the 8 mile (12.9 km) reduction in inner-array cable installation will slightly reduce impacts. However, construction activities are not expected to take place over the entire area of the proposed action simultaneously; thus the smaller footprint of the Condensed Array Alternative is not expected to result in any greater displacement impacts than would be expected for the proposed action. Overall impacts to birds during construction (and decommissioning) of the Condensed Array Alternative are expected to be slightly less than the proposed action as the result of the reduction in the length of 33 kV inner array cabling.

When compared to the proposed action, an alternative with condensed spacing is expected to have a greater “barrier” effect due to the higher concentration of structures, thereby increasing the potential for avoidance, collision or other impacts during operation. Maintenance activities would consist of small vessels transiting to and from the area of the proposed action in order to service the WTGs and/or ESP. This vessel traffic represents an insignificant increase in traffic over current levels in Nantucket Sound, and would not impact avifauna in the area of the proposed action for either the Condensed Array Alternative or the proposed action. Overall, the Condensed Array Alternative is expected to have increased impacts during operations.

5.4.5.2.12 Subtidal Offshore Resources

The oceanographic conditions and predominantly sandy sediments on Horseshoe Shoal combine to produce a dynamic, shifting substrate that favors benthic communities of relatively low diversity. However, the shallow depths of Horseshoe Shoal also allow for a relatively high density and biomass of benthic organisms. Total invertebrate abundance is highly variable from site to site due to the high degree of environmental variability found on Horseshoe Shoal.

Most of the impacts to soft-bottom benthic communities are expected to occur during the cabling activities of the construction and decommissioning periods. Permanent impacts include the direct mortality to benthic organisms due to jet plowing and the placement and removal of pilings for the WTGs and ESP. The total area of permanent benthic impact due to the WTG and ESP piles would be the same for both the Condensed Array Alternative and the proposed action (0.67 acres [0.003 km^2]).

Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor line sweep, jet plow pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). The Condensed Alternative would decrease the length of the 33 kV cable needed to connect the WTGs to the ESP from 66.7 miles to 58.0 miles (107.3 km to 93.3 km). This would result in a reduction of temporary impacts to benthic habitats from 580 acres to 504 acres (2.3 to 2.0 km^2). The temporary impacts related to the Condensed Array Alternative are expected to be less as compared to the proposed action. Impacts related to decommissioning of the Condensed Array Alternative would also be less due to the shorter inner-array cable.

During operation the WTGs will provide new localized hard-bottom habitats for benthic resources to inhabit. These benthic macro invertebrates and fouling organisms are anticipated to attract prey and larger finfish to the monopiles. There is no anticipated difference in operational impacts between the two alternatives.

Overall, the impacts to benthic resources of the Condensed Array Alternative would be expected to be less than those of the proposed action with respect to construction and decommissioning and would be similar with respect to operation.

5.4.5.2.13 Non-ESA Marine Mammals

The marine mammals that are not listed under the ESA, but are protected under the MMPA, that may be found in the area of the proposed action include the gray seal, harbor seal, harp seal, hooded seal, Atlantic white-sided dolphin, striped dolphin, common dolphin, harbor porpoise, long-finned pilot whale, and minke whale.

The two types of potential harassment that may occur during the construction of the proposed action are vessel strikes and noise. Both types of harassment are classified as Level A and Level B harassments under the 1994 Amendments to the MMPA. Because of a slightly reduced chance for vessel strike due to the shorter inner-array cabling activities involved with the Condensed Array Alternative, there is some potential for a reduction of impacts to marine mammals from the Condensed Array Alternative as compared to the proposed action.

Underwater noise impacts associated with the operation of the WTGs are not expected to cause Level A harassment to non-ESA mammals. The operations and maintenance plan would be the same for the Condensed Array Alternative as for the proposed action.

Overall, the non-ESA mammal impacts of the Condensed Array Alternative would be expected to be somewhat less for construction and decommissioning, and similar for operations and maintenance, as compared to the proposed action.

5.4.5.2.14 Fish and Fisheries

In general, the disturbance to benthic habitats would be short-term and localized because many benthic invertebrates are adapted to high energy environments such as the area of the proposed action, and are capable of opportunistically re-colonizing benthic sediments after disturbance. Thus, fish species that prey on benthic species would be impacted temporarily during construction. Shellfish species spawn, at a minimum, once per year, and would likely resettle the disturbed areas within one or two years.

The changes in temporary impacts to fisheries mirror those outlined in the benthic discussion of the Condensed Array Alternative. Temporary impacts to benthic resources would be caused by anchoring activities associated with cable-laying and decommissioning activities (anchors, anchor line sweep, jet plow pontoons) and the WTG/ESP construction and decommissioning, as well as the installation and decommissioning of scour control structures (scour mats and/or rock armor). The Condensed Array Alternative would decrease the length of the 33 kV cable needed to connect the WTGs to the ESP from 66.7 miles to 58.0 miles (107.3 km to 93.3 km). This would result in a reduction of temporary impacts to benthic habitats from 580 acres to 504 acres (2.3 to 2.0 km^2). The temporary impacts related to the Condensed Alternative are expected to be less as compared to the proposed action. Impacts related to decommissioning of the Condensed Alternative would also be less due to the shorter inner-array cable.

Operation of the Condensed Array Alternative would result in the same amount of new hard bottom substrate associated with the monopiles as the proposed action. Both alternatives would have the same amount of surface area with the potential for new reef-like effects that would alter fish or shellfish communities, and therefore similar impacts.

Overall, impacts on fisheries of the Condensed Array Alternative would be slightly less for construction and decommissioning, and similar for operations as compared to the proposed action.

5.4.5.2.15 Essential Fish Habitat

The Condensed Alternative would have the same area of permanent EFH impacts as the proposed action (0.33 acres [0.001 km^2]). Potential temporary impacts to EFH due to construction include physical displacement of sediments due to cable installation and pile driving, suspended sediments in the water column and acoustical impacts. Because of the reduced amount of 33 kV inner-array cable required with the Condensed Array Alternative the temporary impacts to benthic habitat during construction (and decommissioning) are expected to be less than for the proposed action and thus reduce the extent of temporary impacts to EFH functions of affected areas.

Because of the same overall number of WTGs, the operation of the Condensed Array Alternative would have similar impacts to the proposed action.

Overall, impacts on EFH of the Condensed Array Alternative would be less for construction and decommissioning, and similar for operations as compared to the proposed action.

5.4.5.2.16 Threatened and Endangered Species

The disturbances associated with construction/decommissioning activities, including cable embedment, involve increased vessel traffic, presence of equipment, human presence, and noise. Sediment plumes from jet plowing could cause fish to avoid the construction site, which could also temporarily displace some avian species. Although impacts to birds from the construction of the WTGs, ESP and 115 kV offshore transmission cable system are expected to be the same, the 8 mile (12.9 km) reduction in inner-array cable installation will reduce impacts. Although jet plowing on Horseshoe Shoal is not expected to have any impact on Piping Plovers who forage along the rack line of beaches, there may be some impact on roseate terns that do forage in the area to some degree. Overall impacts to birds during construction (and decommissioning) of the Condensed Array Alternative are expected to be slightly less than the proposed action as the result of the reduction in the length of 33 kV inner array cabling.

Impacts during operation of the Condensed Array Alternative would be increased when compared to the proposed action. This is due to the condensed spacing of WTGs, which would be expected to have a greater "barrier" effect due to the higher concentration of structures, thereby increasing the potential for avoidance, collision or other impacts.

Overall, the impacts to T&E species of the Condensed Array Alternative would be expected to be less than the proposed action during construction and decommissioning, and greater than the proposed action during operations.

5.4.5.2.17 Socioeconomic Analysis Area

The existing social and economic conditions for the Condensed Array Alternative are similar to those of the proposed action as it is in the same geographic location. Compared to the proposed action, socioeconomic impacts associated with the Condensed Array Alternative would be the same in terms of number of construction jobs and revenues from taxes. However, the Condensed Array Alternative would generate somewhat less electricity, producing less downward pressure on electricity costs. Overall, the Condensed Array Alternative does not offer any significant advantage over the proposed action with respect to socioeconomics.

5.4.5.2.18 Urban and Suburban Infrastructure

To access the Barnstable Substation, both the Condensed Array Alternative and the proposed action would utilize the same near shore cable route, landfall site and onshore cable route and affect the same urban and suburban infrastructure (see 4.3.2 of this document). Compared to the proposed action, impacts on urban and suburban infrastructure associated with the Condensed Array Alternative including its submarine and onshore cable, would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.5.2.19 Population and Economic Background

The Condensed Array Alternative is located in the same general geographic area as the proposed action and is expected to result in negligible changes in population or the economy of the region. Hence, the Condensed Array Alternative would be comparable to and offer no significant population and economic advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.5.2.20 Environmental Justice

Concerns about environmental justice typically center on areas with higher than average minority populations and higher than average poverty levels. The area of the Condensed Array Alternative is in the same location, and same socioeconomic area as the proposed action. It is not located near any communities of higher than average minority populations or close to the tribal lands of the Wampanoag Tribe of Gay Head Aquinnah (WTGHA) or the Wampanoag Tribe of Mashpee. As such, the Condensed

Array Alternative would be comparable to that of the proposed action with respect to environmental justice and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.5.2.21 Visual Resources

Potential visual impacts during construction and decommissioning activities of the Condensed Array Alternative would be based on the number, size, and spacing of construction vessels employed during the construction period and would not be expected to be significantly different than construction related visual impacts under the proposed action. With respect to operations, the breadth of the array would likely be reduced as viewed from the north, and remain the same when viewed from the south. Distances to shore will be slightly increased for the Condensed Array Alternative, making the turbines look smaller and reducing the visual impact. Thus in terms of overall breadth of impact, the Condensed Array Alternative would have less of a visual impact than the proposed action. However, the concentration of structures would be increased for the Condensed Array Alternative, and thus the visual intrusion of the portion of the Condensed Array Alternative that is visible, would create more of an impact than the proposed action.

5.4.5.2.22 Cultural Resources

The Condensed Array Alternative has been laid out along the same previously surveyed area transects as the proposed action. This general area of the proposed action of Horseshoe Shoal has been assessed for underwater cultural resources and it was found that the proposed action configuration would not impact such resources. Although the specific cable routes and WTG locations of the Condensed Array Alternative have not been fully surveyed, it is expected that due to the extent and overlap of previously surveyed area incorporated into the Condensed Array Alternative that the impacts would be similar. The onshore portion of the cable work is in the same location as the proposed action. Therefore, impacts to cultural resources would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.5.2.23 Recreation and Tourism

The Condensed Array Alternative is located in the same general location as the proposed action. The smaller overall footprint of construction activities and the shorter inner-array cabling will reduce some impacts to recreational boating. However, this will be offset by the concentration of construction activities within the Condensed Array Alternative footprint as compared to the proposed action resulting in greater impacts to boating. During operation, impacts to recreational boating will be reduced somewhat by the smaller overall size of the turbine array area, but this would be offset by the tighter spacing between WTGs which would make navigation more difficult. Overall, the impacts to recreation and tourism of the Condensed Array Alternative would be expected to be similar to the proposed action during construction, operation and decommissioning.

5.4.5.2.24 Competing Uses

Competing uses in the vicinity of the Condensed Array Alternative are the same as for the proposed action and are largely limited to commercial fishing and boating, and the potential for maintenance dredging of nearby channels. Any vessels involved in commercial fishing (i.e., trawling activities) within the area of the proposed action would experience increased impacts due to the tighter spacing between WTGs. The impact of the Condensed Array Alternative on these competing uses would therefore be greater than the proposed action during construction, operations and decommissioning.

5.4.5.2.25 Overland Transportation Arteries

The Condensed Array Alternative is located in the same area as the proposed action and not near any overland transportation arteries. It would have a negligible effect on such arteries as a result of onshore equipment deliveries or commuting of workers. Therefore, impacts from the Condensed Array Alternative on overland transportation arteries would be comparable to and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.5.2.26 Airport Facilities

The Condensed Array Alternative is located in the same general location as the proposed action. The proposed action received FAA approval indicating the proposed action would not affect navigation or associated communication systems (Refer to Appendix E) and although the new specific locations for the WTGs in the Condensed Array Alternative would need to be evaluated by the FAA, it is assumed that there would be no change in their determination of no hazard. Therefore, it is expected that the Condensed Array Alternative would also not affect airport facilities. In summary, the Condensed Array Alternative would be expected to be comparable to the proposed action with respect to impacts on Airport Facilities and offer no significant environmental advantage over the proposed action with respect to construction, operation, and decommissioning impacts.

5.4.5.2.27 Port Facilities

The Condensed Array Alternative is likely to have similar construction and decommissioning impacts to port facilities and marine traffic related to port facilities as the proposed action. During operations, marine traffic would have to contend with navigating through WTG configuration that is closer together. However, this is offset by the fact that the Condensed Array Alternative is located further away from shipping channels and takes up less water sheet area. Overall, the impacts to port facilities of the Condensed Array Alternative would be expected to be similar to the proposed action during construction, operation and decommissioning.

5.4.5.2.28 Communications: Electromagnetic Fields, Signals and Beacons

The Condensed Array Alternative is located in the same general area as the proposed action. The assessment for the proposed action found that impacts on entertainment satellite, entertainment broadcasting services, (AM, FM and TV stations), non-emergency ship to shore communications (cellular communications and VHF frequencies in the marine band), navigation and positioning services, LORAN, safety and emergency communications, sub-sea communication cables, and Micro Wave Communications would be minor (see Section 5.3.4.4). The Condensed Array Alternative is expected to have comparable impacts to the proposed action during construction, operation and decommissioning.

5.4.6 Assessment of No-Action Alternative and Comparison with Proposed Action

5.4.6.1 Description of the No-Action Alternative

In order to understand the environmental consequences to the region if the proposed action were not constructed, a qualitative cost benefit analysis has been provided that describes impacts of those energy producing technologies that likely would occur to address energy needs in the near future. Given the projected continued need for power in New England (ISO, 2007) it is expected that if the proposed action is not developed, one or more of the generation alternatives discussed above would be developed. As noted in the discussion of these alternatives, each fails to meet one or more of the objectives set forth in the purpose and need for the proposed action. Table 5.4.6-1 shows for each of the 11 No-Action Alternatives, which of the objectives of the proposed action the alternative does not satisfy.

As Table 5.4.6-1 shows, of the 11 No-Action Alternatives only four are feasible, of a comparable scale and able to be developed within the timeframe of the proposed action (i.e., meet both criteria Nos. 3 and 5). These technologies are: (1) New Natural Gas Fired Power Plants; (2) New Oil Fired Power Plants; (3) New Clean Coal Fired Power Plants; and (4) Repowering of Existing Facilities. This section provides a brief comparison of the environmental costs and benefits that would be associated with the development of these No-Action Alternatives, which could provide power otherwise provided by the proposed action. Other No-Action Alternatives that are not feasible in the near future are not assessed.

5.4.6.2 Impacts Associated with No-Action Alternative

5.4.6.2.1 Environmental Cost/Benefit Criteria

Important to an evaluation of environmental costs and benefits is a way of making meaningful comparisons. In a study Assessing the Costs and Benefits of Electricity Generation Using Alternative Energy Resources on the Outer Continental Shelf, Weiss et al. found that for many different types of environmental impacts that were important to describing and distinguishing among offshore alternatives, it was either difficult to quantify the criteria of interest or almost impossible to determine a monetary value. ISO-NE in their recently released report of New England Electricity Scenario Analyses (ISO, 2007) did monetize environmental costs and benefits, but did so for a relatively limited set of environmental variables (i.e., limited to several types of air pollutant emissions). Because of these difficulties in terms of quantifying and comparing environmental impacts, this analysis will use a limited set of criteria that capture the distinguishing features of the No-Action Alternatives and provide a qualitative discussion of the criteria as they relate to each alternative.

Table 5.4.6-2 provides a simplified picture of the energy generation process. Starting with inputs which include fuel supply, fuel transport and water withdrawal, the actual generation facility has associated with it, a certain amount of surface disturbance, the need for on-site chemical management, and various support facilities or processes such as waste water treatment and fuel storage. The environmental outputs from the generation process can be captured by focusing on air emissions, water discharges and waste disposal.

The importance of selecting appropriate criteria is seen by looking at what ISO-NE used to compare alternatives versus the factors that Weiss et. al. used. The ISO report focuses largely on effects associated with the outputs of the alternatives whereas Weiss el al. tried to capture aspects of a project fuel cycle by including consideration of various inputs. This simplified presentation of the generation process highlights that in comparing wind to the no-action alternatives, wind generally has no input related environmental-effects (other than minor impacts associated with manufacturing and transport of wind turbine components). Differences, therefore, in environmental costs and benefits directly associated with these No-Action Alternatives can be addressed by focusing on 5 variables. These are defined as follows:

1. **Land disturbance**. This variable seeks to capture 3 aspects of land disturbance: (1) the area and natural resources (i.e., flora and fauna and wildlife habitat) that would be permanently disturbed by a building footprint; (2) the total area where there would be some land use restriction of activity such as a larger property boundary; and (3) what is often defined for thermal facilities as the “affected area” or the point at which changes in facility-related air concentrations are negligible.

2. **Air emissions**. A principal difference among the No-Action Alternatives is the emissions to the atmosphere resulting from fossil fuel burning. Compounds of interest are the regulated pollutants (NO_x, SO_x and PM) as well as mercury (HG) and CO_2.

3. **Water use**. Water is an important resource in power generation with consumptive use varying depending generally on the type of cooling that the facility uses, type of fossil fuel, and type of generation and pollution control technology. In the case of cooling via surface water sources, entrainment of fish and fish larvae are also an important impact related to water use.

4. **Solid waste generation and waste management**. Depending on the fuel used to generate power, there can be relative little solid waste generated or alternatively there can be large amounts that require use of an onsite or offsite disposal facility.

5. **Water discharge (both amount and quality)**. Depending on the fuel used to generate power and the type of facility cooling, the quantity of water discharged from a facility will vary along with the quality. Important variables include absolute temperature, difference in temperature from the receiving water body; and several chemical constituents regulated by federal and state water quality programs.

Specifically excluded from consideration are such aspects of these facilities such as noise and aesthetic impacts. This does not suggest that these do not exist; rather that they are site-specific and do not distinguish one No-Action Alternative from the other.

Summary of Environmental Costs and Benefits of the No Action Alternatives

Gas Fired Electric Generation Facilities

A natural gas facility burns natural gas to run a combustion turbine to generate electricity. Natural gas would likely be delivered by underground pipeline via a new interconnection line attached to the existing intrastate natural gas pipeline system. The facility could be cited in an already designated industrial area or in an appropriately zoned greenfield site and would have to comply with zoning regarding setbacks, height limits, noise, and landscaping. If the turbines and associated facilities were enclosed, the facility would resemble a commercial 5 story structure with an associated 150 to 250 ft stack for each gas turbine. Ten to 15 employees would operate the facilities which would run 24 hours a day, every day of the year except for scheduled maintenance periods of 1 to 2 weeks. Depending on location, water for facility cooling could be provided by the local municipality, a nearby river or it could use gray water from a publicly owned treatment works (POTW). Likewise, wastewater, with appropriate pretreatment, could be discharged to a POTW or nearby stream. In order to operate, the facility would have to comply with all federal, state and local regulations relative to air pollution, water discharge and waste management. Emissions of regulated pollutants therefore would be at or below levels designed to be protective of human health and the environment.

For a gas fired facility, the principal pollutant of concern is NO_x. Emissions of NO_x result from the combustion of nitrogen contained in fuel and the air supplied for combustion. NO_x contribute to the formation of ground level ozone and acid rain. Natural gas facilities also emit VOC and carbon monoxide (CO) as a result of incomplete fuel combustion, which occurs to some degree even in state-of-the-art CCCT systems being installed today. Although efficient combustion techniques employed in today's combustion turbines combined with the use of relatively clean burning natural gas reduce VOC and CO emissions below any other fossil fuel fired combustion technology, large quantities of these pollutants would still be emitted. SO_2 emissions from natural gas fired facilities are the lowest of all fossil fuel fired combustion facilities due to the low sulfur content of natural gas. PM also forms through incomplete combustion of fuels or using fuels with high noncombustible content (ash).

In addition to the emissions of criteria pollutants, a gas-fired facility would also emit non-criteria pollutants and CO_2. Non-criteria pollutants include Hazardous Air Pollutants (HAPs), which the EPA considers of special concern and for which the EPA has developed national emission standards for specific source categories such as combustion turbines. Some of the hazardous air pollutants emitted by a natural gas fired combustion turbine include formaldehyde, xylene, toluene, and benzene.

CO_2 has been attributed to an increase in average global temperatures. The emission of greenhouse gases and climate change is a concern to many in the scientific community. Natural gas fired energy facilities represent the best method to reduce the total emissions of CO_2 from fuel burning power plants as compared to other combustion technologies because of the combustion efficiency of the CCCT system and the low carbon content of natural gas per MW of energy produced.

Coal Fired Electric Generation Facilities

Coal fired facilities typically use pulverized coal to fire a boiler to produce steam to operate an electric generator. Because of current air regulations a coal facility would likely be a low sulfur, "clean coal" facility. While the turbine building could be similar in size to the gas turbine facility, the overall property area would be larger due to the need for coal delivery (i.e., railroad unloading area or coal wharf), coal storage and ash storage. Again, the project would be developed in an area set aside for industrial use and so would have to comply with local regulations for noise, setbacks, height limits and landscaping. The coal for the facility would be delivered by rail or ship and limestone if used for emissions control could be delivered by truck or rail. Each would be processed prior to firing in the turbine. Waste generated would be a combination of fly ash from the air pollution control device and bottom ash or unburned coal from the combustion turbine. These would be collected and disposed of on or off site or recycled and reused as road bed material or for making concrete.

A coal-fired facility would be either a circulating fluidized bed boiler with a complex emission control system or integrated gasification CCCT in order to meet air emission requirements. Either of these types of facilities would emit significantly more criteria pollutants, non-criteria pollutants and HAPs than a natural gas or oil-fired facility. Emissions of HG, a persistent bioaccumulative toxin, have also been associated with coal combustion and are the focus of new regulations for existing coal-fired power plants. The storage of coal and the likely use of evaporative cooling technology increase the potential for particulate emissions.

A coal facility would emit SO_2, which contributes to acid rain, sulfate deposition and can react with other compounds in the atmosphere to form particulates. PM also forms through incomplete combustion of fuels or using fuels with high noncombustible content (ash). Elevated particulate levels have been attributed to a variety of health effects such as respiratory ailments, especially in the young and the elderly. A coal facility would also emit CO_2, a greenhouse gas.

Coal-fired facilities require significantly more water than natural gas or oil-fired facilities. A coal-fired boiler has a greater heat load than a natural gas fired turbine resulting in increased water consumption. Dry cooling technology can often become too large for this type of unit requiring the use of wet cooling towers that further increase evaporative losses and water consumption. Coal burning facilities consume water within scrubber systems used for the control of SO_2 and acid gas emissions. The source of water would vary depending on the site but could include a surface water body, municipal supply or gray water from a POTW.

Stormwater runoff from coal storage areas can have impacts on wetlands, groundwater quality, and the local environment. The stormwater runoff can contain toxic chemicals found in coal, which can be washed to surrounding surface water bodies through the stormwater collection systems.

Oil Fired Electric Generation Facilities

New oil fired facilities, like new coal facilities, are a cleaner design, specifically designed to use fuels with lower sulfur content than is typical in older oil fired facilities. As with a gas and coal fired power plant, a new oil fired facility would have to meet local zoning requirements and applicable federal, state and local air emission, water discharge and waste management requirements. Oil for the facility would likely be delivered via ship while limestone used for air pollution control would be delivered by truck or rail. Several large tanks would be required to store the oil, and oil fired facilities involve risks of oil spills during delivery, storage and operation, which can affect natural resources and water quality in the area. Like the other fossil fuel based generation facilities, discharges of air emissions to the atmosphere and/or local water bodies would extend beyond the facility property boundary. Types of air pollutants emitted would be similar to that of a coal facility described above. In addition to pollutant concerns, the U.S. currently depends heavily on foreign oil supplies, and this reliance coupled with regional instability in primary oil producing regions presents potential concerns with the long-term reliability and economic stability of an oil-fired energy facility.

Re-Powered Electric Generation Facility

As the name suggests, a repowered facility is one where new equipment is installed, typically for the purpose of improving the facility to make it more efficient or to bring it into compliance with new regulations. The most common repowering is where an oil fired facility is changed to one that uses gas as the main fuel. One of the advantages of repowering is that the original facility property is "reused" along with much of the supporting infrastructure. Repowered facilities can typically be brought on line more quickly than can new facilities. They do not represent a new land use so there are no issues of compatibility with surrounding land uses. By changing to a cleaner burning fuel the facilities typically can demonstrate a reduction in air emissions. Redesign can also result in more efficient operation and decreased use of water.

Conclusions on Cost Benefit Analysis

Projects likely to be constructed in the near future under the no-action alternative to address the bulk of regional energy needs would be fossil fueled electric generation facilities. These facilities would result in substantial emissions of various air pollutants during their operational life span, affecting the air quality in the region and continuing to increase global CO_2 levels.

5.4.7 Transmission Line Siting

5.4.7.1 Results of Environmental Facilities Siting Board Decision on Siting

On September 17, 2002, the applicant and NSTAR jointly filed a petition with the EFSB and a petition with the DTE to construct, operate and maintain two new 115 kV electric transmission lines to interconnect the proposed action with the regional electric grid in New England.

As part of its review process, the EFSB was required to evaluate whether there is a need for additional transmission resources and evaluate the proposed action in terms of its consistency with providing a reliable energy supply to the Commonwealth with a minimum impact on the environment at the lowest possible cost. A project proponent must present to the EFSB alternatives to its planned action which may include: (a) other methods of generating, manufacturing, or storing electricity or natural gas; (b) other sources of electrical power or natural gas; and (c) no additional electric power or natural gas.

The applicant identified and presented four alternatives to the EFSB that would potentially meet its Project need, each of which could provide reliable service for the applicant's proposed action. These approaches included connecting the proposed action: (1) to NSTAR's 115 kV Barnstable Switching

Station; (2) to NSTAR's 115 kV Harwich Substation; (3) to NSTAR's 115 kV Pine Street Substation in New Bedford; and (4) to a new 115 kV substation on Martha's Vineyard, then proceeding on to the mainland.

Upon its review, the EFSB concluded that the Martha's Vineyard Alternative did not warrant further consideration because of the magnitude of increased cost over the Barnstable Interconnect without any offsetting benefits. Although the Harwich and New Bedford Alternatives would be somewhat less costly than the Martha's Vineyard Alternative, each would cost approximately $50 million more than the Barnstable Interconnect. Because the Barnstable Switching Station is the major bulk substation on Cape Cod, with six 115 kV transmission lines available to carry energy to various parts of Cape Cod, interconnection at this location would provide high reliability in that energy from the proposed action could be reliably delivered to the grid even if one of the lines emanating from the Barnstable Switching Station is out of service. Therefore, the EFSB determined that, all other considerations being equal, a direct connection at the Barnstable Switching Station provides greater reliability than an indirect connection through another, smaller substation at a greater distance from the Barnstable Switching Station.

The EFSB found that the Barnstable Interconnect was preferable to both the Harwich and New Bedford Alternatives with respect to providing a reliable energy supply for the Commonwealth, with a minimum impact on the environment at the lowest possible cost. In addition, the EFSB found that, with the implementation of the proposed mitigation and conditions, the environmental impacts of the proposed facilities along the primary route would be minimized with respect to marine construction impacts, land construction impacts and permanent impacts. Therefore, the EFSB approved the applicant and NSTAR's proposal to construct two approximately 18 mile (29 km), 115 kV underground electric transmission lines along the primary route identified by the applicant.

The applicant has conducted a comprehensive analysis to identify the best route to provide the needed transmission interconnection from the facility to the mainland electrical grid system. A detailed assessment of alternative routes was conducted that concluded that the route proposed would be preferable to alternative routes with respect to providing a reliable energy supply for the Commonwealth, with a minimum impact on the environment at the lowest possible cost (EFSB, 2004).

5.4.8 Conclusion

Impacts are summarized for the five economically and technically feasible alternatives relative to the site of the proposed action in Table 3.3.5-1. The South of Tuckernuck Island Alternative would have the same environmental impacts as the proposed action in most categories of impact (22 of 28 impact categories evaluated, would be expected to have somewhat more impact than the proposed action with respect to five categories (avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, and EFH), and would be expected to have less impact than the proposed action in one category (visual impacts). The Monomoy Shoals Alternative would be expected to have the same level of impact as the proposed action in 20 of 28 impact categories, would be expected to have more impact than the proposed action in six impact categories. (Avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, and threatened and endangered species.)[9] The Monomoy Shoals Alternative would be expected to have less impact than the proposed action in two impact categories (visual resources and cultural resources as they relate to visual impacts to historic structures).

[9] Under the Monomoy Shoals Alternative, the impact categories: subtidal offshore resources, fish and fisheries, and essential fish habitat, have impacts that would be greater than the proposed action but only with respect to construction and decommissioning. Operational impacts would be expected to be the same for these impact categories as for the proposed action.

The Smaller Project Alternative has less impact than the proposed action in 13 impact categories: noise, air quality, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, threatened and endangered species, visual resources, cultural resources (as they related to visual impacts) competing uses of waters and sea bed, and port facilities.

The conclusions with respect to Smaller Project Alternative should be considered in light of the actual level of impacts expected for the proposed action. Table E-1, which summarizes the impacts for the proposed action, shows that the impacts in almost all the categories are minor or negligible, indicating that potential environmental savings with respect to impacts of the Smaller Project alternative relative to the proposed action would not be significant. The Smaller Project alternative would reduce visual impacts (ranked as moderate from the shoreline for the proposed action) though the amount of visible area reduced is not proportional to the 50 percent reduction in generation capacity of the Smaller Project (see Figure 3.3.6-2).

The Condensed Array Alternative would have greater impact than the proposed action for the competing uses impact category during construction, operation, and decommissioning. Additionally, the Condensed Array Alternative would have less impact during construction for 8 impact categories: noise, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, and threatened and endangered species. Of these impact categories noise and water quality would be expected to have similar impact as the proposed action during decommissioning while the other 6 would have a lesser impact. There would be greater expected impact compared to the proposed action during operation for the avifauna and threatened and endangered species impact categories. The remaining 19 impact categories would have the same level of impact as the proposed action during construction, operation, and decommissioning.

The Phased Deployment Alternative would have greater impact than the proposed action for 10 of 28 impact categories (air quality, water quality, avifauna, subtidal offshore resources, non-ESA marine mammals, fish and fisheries, essential fish habitat, threatened and endangered species, visual resources, and recreation and tourism). The impacts on these categories would be similar to the impacts of the proposed action during operation. There would be no change in impacts for the other 18 impact categories for the Phased Deployment Alternative compared with the proposed action during construction, operation, or decommissioning.