5 POTENTIAL IMPACTS OF ALTERNATIVE ENERGY DEVELOPMENT ON THE OCS AND ANALYSIS OF POTENTIAL MITIGATION MEASURES

5.1 DEFINITIONS OF IMPACT LEVELS

The conclusions for most analyses in this Environmental Impact Statement (EIS) use a four-level classification scheme to characterize the impacts predicted if the proposal or an alternative is implemented and activities occur as assumed.

5.1.1 Impact Levels for Biological and Physical Resources

Impact levels for biological and physical resources are used for the analysis of water quality, air quality, marine and terrestrial mammals, marine and coastal birds, fish resources, sea turtles, coastal and seafloor habitats, and areas of special concern (such as Essential Fish Habitats [EFHs], marine sanctuaries, parks, refuges, and reserves). For biota, these levels are based on population-level impacts rather than impacts to individuals.

Negligible

- No measurable impacts.

Minor

- Most impacts to the affected resource could be avoided with proper mitigation.

- If impacts occur, the affected resource will recover completely without any mitigation once the impacting agent is eliminated.

Moderate

- Impacts to the affected resource are unavoidable.

- The viability of the affected resource is not threatened although some impacts may be irreversible, OR

- The affected resource would recover completely if proper mitigation is applied during the life of the project or proper remedial action is taken once the impacting agent is eliminated.

Major

- Impacts to the affected resource are unavoidable.
- The viability of the affected resource may be threatened, AND
- The affected resource would not fully recover even if proper mitigation is applied during the life of the project or remedial action is taken once the impacting agent is eliminated.

5.1.2 Impact Levels for Societal Issues

The following impact levels are used for the analysis of demography, employment, and regional income; land use and infrastructure; fisheries; tourism and recreation; sociocultural systems; environmental justice; and cultural resources.

Negligible

- No measurable impacts.

Minor

- Adverse impacts to the affected activity or community could be avoided with proper mitigation.
- Impacts would not disrupt the normal or routine functions of the affected activity or community.
- Once the impacting agent is eliminated, the affected activity or community will return to a condition with no measurable effects without any mitigation.

Moderate

- Impacts to the affected activity or community are unavoidable.
- Proper mitigation would reduce impacts substantially during the life of the project.
- The affected activity or community would have to adjust somewhat to account for disruptions due to impacts of the project, OR
- Once the impacting agent is eliminated, the affected activity or community will return to a condition with no measurable effects if proper remedial action is taken.

Major

- Impacts to the affected activity or community are unavoidable.

- Proper mitigation would reduce impacts somewhat during the life of the project.

- The affected activity or community would experience unavoidable disruptions to a degree beyond what is normally acceptable, AND

- Once the impacting agent is eliminated, the affected activity or community may retain measurable effects indefinitely, even if remedial action is taken.

5.2 WIND ENERGY ACTIVITIES ON THE OCS

5.2.1 Ocean Surface and Sediments

This evaluation considers both project impacts to and the hazards posed by particular geologic features and processes. Potential impacts include acceleration of geologic processes (e.g., erosion or mass movement on the seafloor), alteration of seafloor topography, and changes in sediment transport along the coast.[1] Locating the wind facility on the basis of site-specific studies that would characterize the seafloor (Section 3.5.2) and assess wave and current baseline conditions, as would be done during a project-level EIS, would minimize these impacts.

Potential hazards are associated with the scouring action of ocean currents and seafloor instability, which can undermine foundation structures and undersea transmission cables and lead to failure (as described in Sections 4.2.1.5, 4.3.1.5, and 4.4.1.5). Submerged structures on the seafloor increase wave turbulence, causing localized erosion of bottom sediments (scouring) in the immediate vicinity of the structures. Scouring can also be expected to occur on a larger scale, in the areas between multiple structures. It is important to note that the changes to seafloor topography caused by scouring can affect the wave climate, leading to potential impacts to sediment transport processes along the coast. While proper siting of the wind facility can eliminate or minimize the hazards associated with the reduced load-bearing capacity of water-saturated and gaseous sediments, bottom sediments of variable density, and irregular topography,

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1 Changes in sediment transport along the coast are important potential impacts to consider when developing technologies offshore. When waves hit the coastline at an angle, they create a longshore current (also called littoral drift) that, on a regional scale, transports sediment from updrift coastal areas to downdrift coastal areas. In an evolved littoral system, an equilibrium is established between the processes of erosion and deposition—the result is that beaches, which lose sediment (sand) to downdrift coastal areas via the longshore current are also nourished by new sediment (sand) from updrift coastal areas via the same longshore current. When these processes are interrupted, either by activities offshore (which reduce wave energy) or by structures like jetties along the shoreline (which capture littoral sediment), deposition becomes the dominant process. The effect of increased deposition in one coastal area, however, usually results in accelerated erosion in downdrift coastal areas.

the risk of seafloor collapse and subsidence triggered by episodic geological and meteorological events (earthquakes, tsunamis, and storm surges) would remain.

5.2.1.1 Technology Testing

Potential Impacts. Offshore wind technologies have been demonstrated at several locations in Europe, and several offshore commercial wind facilities have been built and are now generating electricity. Therefore, there should be little need to prove the concept on the OCS except, possibly, in a few demonstration projects for new foundation technologies farther offshore or in deeper waters. As a result, the level of new technology testing activities would be minimal.

Impacts to geologic features and processes would be minimized through the careful siting of the meteorological tower on the basis of data collected to characterize the seafloor in the area of interest. Impacts to coastal sediment transport processes would likely be negligible since the meteorological tower is relatively small and located some distance offshore.

Geohazards. Tower foundations are at risk of adverse impacts associated with seafloor instability since they are driven into the seabed. These structures would be most impacted by sediment characteristics affecting load-bearing capacity, displacement caused by earthquakes, and slope failure (slumping and mudslides). They are also vulnerable to the scouring action of ocean currents, which can undermine structures and cause failure. Undersea transmission cables used to deliver power from the facility to shore would be most impacted by displacement caused by earthquakes and slope failure.

5.2.1.2 Site Characterization

The project site would be characterized to ensure that it can support the installation of a meteorological tower. A meteorological tower deck would be constructed on a foundation consisting of a monopole or several pilings supporting a single steel pile. The piles may be driven into the seafloor to a depth of about 8 to 14 m (25 to 45 ft) below the seafloor. The area of ocean bottom affected by the meteorological tower construction would range from about 26.4 m^2 (284 ft^2), if the tower was supported by a monopole, to 1,450 m^2 (15,600 ft^2), if it was supported by a tripod tower. Although the tripod tower would cover a larger area, the area within the tripod would likely not be disturbed (Elcock 2006).

Site-specific characterization would be conducted to collect data on ocean-bottom characteristics and unidentified hazards, potential environmental impacts and decommissioning activities, potential archaeological impacts, and possible conflicting uses. Activities associated with site characterization, described in Section 3.5.2, may include:

- A deep-tow, side-scan sonar survey to locate shallow hazards, cultural resources, and hard-bottom areas;

- Digital depth sounding to obtain water-depth measurements;

- "Boomer" sub-bottom and GeoStar full-spectrum CHIRP profiling systems to develop a geologic cross section;

- Bottom sampling, Vibracore shallow sampling, and deep boring to obtain physical and chemical data on surface and subsurface sediments; and

- Magnetic surveys to locate buried pipelines, archaeological items, waste dumps, and other metallic debris.

These activities will assist in identifying the most appropriate site for construction to minimize potential environmental impacts and the hazards associated with seafloor instability (for foundation structures and undersea transmission cables). Impacts to geologic features and processes associated with these activities are expected to be negligible since they mainly involve remote studies that would be of short duration and would not disturb the seafloor. Bottom sampling, Vibracore sampling, and deep boring would result in some disturbance to the seafloor. However, once the activity is completed, recovery would occur at a rate proportional to the rate of sedimentation in the area of interest. Sampling would be avoided in areas prone to intense scouring or mass movement (as determined by remote surveys).

5.2.1.3 Construction

Potential Impacts. The primary activity with the potential to adversely affect geologic features and processes on the seafloor or interfere with the recovery of mineral resources would be the construction of the foundations for the wind turbine generators (WTGs). Tower foundations for a wind facility are of three types; the type used would depend on the water depth and seabed morphology. The first consists of a monopole tower about 3.5 to 5.5 m (12 to 18 ft) in diameter on a monopile base that is driven 9 to 18 m (30 to 60 ft) into the seabed. This structure is most common and cost-effective in waters less than 15 m (50 ft). Tripod towers may be more suitable in deeper waters. The second, known as gravity foundations, are steel or concrete structures that sit on the seabed and are stabilized by their weight or additional ballast. Gravity foundations have a larger footprint than monopiles, typically measuring about 15 by 15 m (50 by 50 ft) at the base (Elcock 2006). Because of the expense involved in moving them, gravity foundations are generally used in water depths of 10 m (33 ft) or less. For waters deeper than 45 m (150 ft), floating platforms—originally developed for the offshore oil and gas industries—may be used. In each case, undersea collection cables would take the power from the individual turbines to an electric service platform (ESP) for transmission to a land-based substation. In the next 5 to 7 years, it is expected that the maximum depth at which a wind facility would be constructed on the OCS would be about 45 m (150 ft).

Site preparation would mainly involve the removal of boulders. A scour protection system, consisting of boulder mounds, cement bags, or seagrass mattresses would likely be needed for the monopile and gravity foundations. The area of ocean bottom affected by the wind facility construction would depend on the size of the wind facility. A wind facility in which there are 40 WTGs situated on monopoles and an ESP would disturb an estimated 9,270 m^2 (99,500 ft^2 or 2.3 acres) of bottom area (Elcock 2006).

Impacts to geologic features and processes would be minimized through the careful siting of the WTGs and ESP on the basis of data collected to characterize the seafloor in the area of interest. Impacts to coastal sediment transport processes would likely be negligible since the facility would be located some distance offshore. However, impacts could potentially occur along the Pacific Coast in areas where the shelf is particularly narrow, requiring construction closer to shore. Impacts to coastal processes would need to be assessed on a project-specific basis, taking into account the size and location of the wind facility, and the wave energy and predominant wave direction in the area of interest.

Geohazards. The components of a wind facility most vulnerable to geohazards on the OCS are the tower foundation structures and the underwater cables between the WTGs and between the ESP and shore. Foundation structures are at greatest risk of adverse impacts associated with seafloor instability because they are embedded in or rest on top of the seabed. These structures would be most impacted by sediment characteristics affecting load-bearing capacity, displacement caused by earthquakes, and slope failure (slumping and mudslides). They are also vulnerable to the scouring action of ocean currents, which can undermine structures and cause failure.

Undersea transmission cables used to connect neighboring turbines to the ESP and to deliver power from the ESP to shore would be most vulnerable to displacement caused by earthquakes and slope failure.

5.2.1.4 Operation

Potential Impacts. Routine operations of an OCS wind facility generally would not require offshore personnel. Controlling and monitoring of devices and transformers would be done remotely by using fiber-optic cables or other communication devices. However, periodic maintenance and inspection would be required. Wind turbines would typically be inspected and serviced about twice a year (involving changing of oil, lubrication, and renovation of gearbox and generator); periodic repair of malfunctions would also be required. Together, such services may average about a week per year per turbine. Technicians would be transported by relatively small boats to the turbine (or transformer) sites, where they would either work directly on the turbine or remove components to the shore for repair and later return.

Project impacts to geologic features and processes during the operational phase of a wind facility are expected to be negligible since operations would not involve seafloor-disturbing activities. Adverse impacts to coastal sediment transport processes would also likely be negligible since the facility would be located some distance offshore. However, impacts could potentially occur along the Pacific Coast in areas where the shelf is particularly narrow, requiring construction closer to shore. While studies such as Cooper and Beiboer (2002) have found impacts to coastal processes related to the offshore wind facility to be negligible, impacts to coastal processes should be assessed on a project-specific basis, taking into account the size and location of the wind facility, and the wave energy and predominant wave direction in the area of interest.

Geohazards. Once a wind facility is operational, the risk of impacts due to seafloor instability is assumed to be minimal, because the site would have been chosen to avoid or minimize such hazards. Scouring action by ocean currents would be an ongoing hazard, especially in areas where ocean current energy is high.

5.2.1.5 Decommissioning

The typical design life of an offshore wind project is 20 to 25 years, after which time decommissioning would likely occur. Decommissioning would entail dismantling of the WTGs and the ESP and their foundations; removing scour protection structures; and transporting these materials to shore. The WTGs would be dismantled in the same manner that they were assembled, with similar equipment, only in reverse.

During the decommissioning phase, monopiles may be cut and removed to a depth of 4.6 m (15 ft) below the seabed, or they may be left in place to be converted to other uses. Gravity foundations may be removed and transported back to shore or left in place. During these activities, the facility would encounter the same project impacts (mainly due to seafloor disturbance) and risk of geological or meteorological events as would be present during the facility’s construction.

5.2.1.6 Mitigation Measures

Seafloor mapping conducted in the early phases of a project would help to ensure that the wind facility is sited appropriately to avoid or minimize potential impacts and the hazards associated with seafloor instability. Therefore, adverse impacts to geologic features and processes on the seafloor during technology testing, site characterization, operation, and decommissioning phases would likely be negligible.

Scouring action by ocean currents around tower foundations could be mitigated by using scour protection devices and employing periodic routine inspections to ensure structure integrity. Because hard scour-protection devices such as rip-rap can increase erosion over time, softer approaches, such as natural, softer materials or sediment nourishment, would also be considered as mitigating measures. Controlling scouring effects would also minimize changes to seafloor topography that could ultimately impact sediment transport processes along the coast. Hazards to underwater cables could be mitigated by building cable systems with sufficient slack to reduce the risk of breakage due to increased tension caused by irregular topography or seafloor displacement as a result of mass movement or faulting.

5.2.2 Air Quality

The nature and magnitude of potential impacts on ambient air quality associated with offshore wind energy development depend on many factors, such as location, scope and scale of project, type and capacity of equipment, and schedule of each project phase. No detailed information on these site- and project-specific factors is available at the programmatic level for this EIS. Thus, no emission estimates were made, and no air quality modeling was done. Most analysis evaluates potential impacts in a qualitative manner.

5.2.2.1 Technology Testing

OCS wind technologies have been demonstrated at several locations in Europe, and several offshore commercial wind facilities have been built and are now generating electricity. Therefore, there should be little need to prove the concept on the OCS except, possibly, in a few demonstration projects for new innovative foundation technologies farther offshore or in deeper waters. As a result, the level of new technology testing activities would be minimal.

These activities would occur in a shorter time period and on a much smaller scale than construction, operation, and decommissioning of full-scale projects that are addressed in Sections 5.2.2.3 to 5.2.2.5. Primary emission sources associated with testing activities would be from engine exhaust of vessel traffic (e.g., boat or barge) and heavy equipment (e.g., pile drivers, drill rigs). In general, most criteria pollutant emissions would be from internal combustion engines burning diesel fuel and would include primarily nitrogen oxides (NO_x) and carbon monoxide (CO), lesser amounts of volatile organic compounds (VOCs) and PM_{10} (mostly in the form of $PM_{2.5}$), and negligible amounts of sulfur oxides (SO_x). These emissions would be emitted from all phases of OCS projects in common; only the amounts would differ as a result of differences in levels of activities between phases.

Source emissions during the technology testing phase would be small in absolute terms but measurable, and intermittent and temporary in nature. Accordingly, potential impacts of technology testing activities on ambient air quality would be minor.

5.2.2.2 Site Characterization

After a technology has been tested, site-specific characterizations would need to be conducted to collect data on resource potential and characteristics, possible conflicting uses of the site, and ocean-bottom and wave and current characteristics (to support design decisions for foundations and the selection of appropriate methods for installing undersea power transmission and signaling/monitoring cables). For OCS wind development, a key component used for characterizing wind conditions is the meteorological tower. It takes an estimated 8 to 10 weeks to construct the tower after the piles have been driven into the sea bottom (which takes about 3 days). The tower is typically in operation for a year to 18 months and remains in place for fewer than 5 years, including construction, data collection, and decommissioning.[2] At the general area of the proposed development site, wave and current action data would be collected. In addition, sea-bottom characterization for anchoring and cable installation would be needed to map the seafloor and drilling of sediment cores during the site characterization period.

During the site characterization period, emission sources would be similar to those in the technology testing period. Moderate activity levels would last several weeks, such as during the construction or decommissioning of a meteorological tower, but potential air emissions would be negligible during the meteorological data collection period. Air emissions from construction and decommissioning of a meteorological tower during site characterization would be measurable and of short duration and intermittent in nature (several weeks at most), and accordingly, potential impacts on ambient air quality would be minor.

5.2.2.3 Construction

Within the scope of this programmatic EIS (5 to 7 years), the project would most likely use existing docks and piers and other onshore port infrastructure and thus activities to construct new port infrastructure would be minimal. However, onshore activities such as construction of substations, cable landings, and other onshore facilities to support the OCS facilities would nevertheless occur within this planning horizon. In general, onshore and offshore construction activities would generate the highest air emissions in the life of a wind energy project, and thus produce the greatest air impacts.

Onshore construction activities could include site preparation of staging areas, construction of remote control/monitoring buildings, assembly of components, and transport of materials to the location via truck. Other onshore construction activities might address transmission-related needs, such as installing new conduits, substations, and overhead transmission lines.

The largest air emission sources during onshore construction activities would likely be from fugitive dust from heavy equipment operation and vehicular traffic on bare soil surfaces

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2 The majority of commercial wind turbines are equipped with their own meteorological instrumentation, obviating the need to continue operation of a separate meteorological tower once the first few turbines become operational.

and paved/unpaved roads (e.g., bulldozer, truck), and from wind erosion.[3] Smaller emission sources would include diesel engine exhaust from heavy equipment and vehicular traffic (e.g., bulldozer, truck, boat, barge, crane, generator).[4]

In general, the highest emissions would be anticipated during the earliest phase of construction of related onshore facilities (e.g., cable landings, electrical substations) and would include clearing, excavation, backfilling, and grading for staging areas and transmission-related facilities. Still, these emission levels would be no higher than those for typical land-based construction activities (e.g., commercial building construction). Fugitive dust emissions could temporarily impact ambient air quality because of near-ground-level release and lack of buoyancy and thus could contribute to an exceedance of Federal or State ambient air quality standards at the nearest property line. These impacts could range from minor to moderate for short durations. However, potential air quality impacts from engine exhaust emissions would not be expected to contribute to exceedances of air quality standards and would be minor.

Offshore construction activities would involve vessel traffic (boat or barge) from port to the project site, and would include installation of anchoring devices, energy conversion devices, transformer/service platforms, and underwater cables with the use of the highly specialized equipment (e.g., cable-laying ship). Offshore assembly of individual devices might require less than a day for some WTGs. Construction time would depend on the number of WTGs; estimated times range from about 6 months to 2 years or more.

Air emission sources during offshore construction would include motive engines for construction, equipment, and crew vessels during their travels between onshore support facilities and the OCS facility. These vessels are all expected to utilize diesel engines burning ultra-low-sulfur fuel. However, larger construction vessels may use bunker fuel and consequently would

3 In a nonattainment area, the responsible agency must develop a State Implementation Plan (SIP) demonstrating how it will attain and maintain the NAAQS. The Regional USEPA office approves the SIP. Nonattainment areas where the air quality has improved to meet the NAAQS are redesignated maintenance areas and are subject to an air quality maintenance plan. Section 176(c) of the CAA prohibits federal departments, agencies, and instrumentalities from taking various actions in nonattainment or maintenance areas unless they first demonstrate that the action will conform to the SIP. Accordingly, construction and operation of MMS OCS projects that are located in nonattainment or maintenance areas and that emit pollutants or precursors of pollutants for which the area is designated nonattainment or maintenance will have to undergo a "general conformity" review. Projects may be exempt from a detailed analysis if their emissions are lower than *de minimis* levels. Nonexempt projects will need to perform a detailed conformity determination and may be required to obtain offsets or emission credits.

4 Uncontrolled SO_x emissions are almost entirely dependent on the sulfur content of the fuel. Currently, sulfur content for diesel fuel sold in United States ranges from 300 to 500 ppm, while that for bunker fuel ranges from 0.5–4% (5,000–40,000 ppm). Accordingly, SO_x emissions for bunker fuel are more than an order of magnitude greater than those for diesel fuel.

have much higher emissions of SO_x than vessels using diesel fuel.[5] Various internal combustion engines (ICEs) incorporated into construction equipment and mounted on construction barges (e.g., cranes, generators, air compressors) would constitute additional air emission sources during the period when these vessels are engaged in OCS facility construction. All such vessel-mounted equipment is also expected to use diesel ICEs and burn ultra-low-sulfur diesel fuel.

Air emissions from offshore construction activities (mostly from diesel engine exhaust from construction vessels [and possibly also exhaust from larger construction vessels powered by bunker fuel]) could be transported to onshore communities during daytime sea breeze. However, such emissions would be small compared with onshore emissions in coastal metropolitan areas and would be transported over some distance with relatively high winds (compared with nighttime land breeze) and with relatively high daytime mixing heights of typically 500 to 1,000 m (1,640 to 3,280 ft). Accordingly, potential impacts of these offshore activities on ambient air quality would be typically minor. However, greater impacts to air quality could be anticipated, depending on the number of individual vessels and pieces of equipment and the scheduling of construction activities that would allow all such equipment to be operating simultaneously.

Under certain conditions, it is possible for OCS emissions, although relatively minor, to contribute to or exacerbate an exceedance episode in areas plagued by high ozone levels. Notwithstanding such episodes, OCS contributions would probably produce undetectable impacts. As an example, the nighttime land breeze, combined with aged onshore polluted air masses and OCS sources, could concentrate ozone precursors (NO_x and VOCs) offshore during the night and early morning, and these polluted air masses could then be transported back onshore and contribute to mid-afternoon peak ozone episodes along with fresh emissions (SAI et al. 1995).

Emissions of SO_2, especially when construction barges or other vessels are using high-sulfur bunker fuel, could also make PSD requirements applicable, especially when the OCS facility is proximate to a Class I area.

5.2.2.4 Operation

Routine operations of OCS wind energy generation facilities would generally not require offshore personnel. Controlling and monitoring of devices and transformers would be done remotely with the use of fiber-optic cables or other communication devices. However, periodic maintenance and inspection would be required. Wind turbines are typically inspected and

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5 Uncontrolled SO_x emissions are almost entirely dependent on the sulfur content of the fuel. Currently, allowable sulfur content for nonroad diesel fuel sold in United States ranges from 300 to 500 ppm. Federal regulations require nonroad applications to switch to ultra-low diesel sulfur of 15 ppm in 2010. However, some refineries have already discontinued production of higher sulfur nonroad diesel fuel so that only ultra-low-sulfur diesel fuel is available for both on road and nonroad usage while bunker fuel continues to be available for ocean-going vessels. Sulfur content for bunker fuel is not affected by recent regulation and continues to range from 0.5–4% (5,000–40,000 ppm). Accordingly, SO_x emissions for bunker fuel are more than an order of magnitude greater than those for diesel fuel.

serviced about twice a year (involving the changing of oil, lubrication, and renovation of gearbox and generator); repair of malfunctions would also be required. Together, such services may average about a week per year per turbine. Technicians typically would be transported by boats to the turbine (or transformer) sites where they would either work directly on the turbine, or remove components to the shore for repair and later return to install repaired or replacement components.

Essentially, no air emissions associated with the actual operation of wind turbines would be expected. Minimal amounts of criteria pollutants may be emitted during preventive maintenance testing[6] and (if necessary) operation of the backup diesel generator on the offshore ESP. (The generator would provide power for aviation and boat navigation lights in the event of a grid power failure.) Other minor air emissions during operation would be from vessel traffic related to infrequent site inspection and maintenance/repair activities. Wind turbine operations would generate minor air emissions and, therefore, potential impacts on ambient air quality would be minor. However, there may be situations involving a major overhaul or replacement of a turbine unit, which could result in emissions comparable to those arising from construction/decommissioning activities, albeit of short duration.

5.2.2.5 Decommissioning

The typical design life of an offshore wind energy project is 20 to 25 years, after which decommissioning would likely occur. Decommissioning entails dismantling of the WTGs, ESP, and foundations; removal of associated scour protection structures; and subsequent transportation of these materials to shore for reuse or recycling. The WTGs would be dismantled in the same manner that they were assembled utilizing similar equipment, only in reverse.

Accordingly, types of activities for decommissioning would be similar to those for construction but of lower activity levels and shorter time frames. However, if explosives were used to dismantle turbine foundations, unique air emissions would result. While the majority of gaseous and particulate emissions that are created would be captured by the water, some could be expected to reach the surface and be discharged into the air. However, the overall impact to air quality from the use of explosives is expected to be minor. Also, some structures may be left in place to be converted to other uses. In all, potential air quality impacts from decommissioning activities would be less than those from construction and would be anticipated to be minor.

5.2.2.6 Mitigation Measures

As discussed above, adverse potential air quality impacts during technology testing, site characterization, and operation phases would be minor. The greatest potential impacts among the

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6 Typical preventive maintenance procedures for diesel generators require that the engine to be operated at least once each month for a period of 30 min to 1 h. Generators that provide more critical service may be tested more frequently. In addition to preventive maintenance runs, engines are run for about that same period of time after completion of every major repair of the engine or generator.

project activities would be from fugitive dust emissions from earthmoving activities (at onshore support facilities) and vehicle traffic during the construction and decommissioning phases. Generation of fugitive dust would be regulated both through the permitting process and the application of mitigation measures, where applicable.

Albeit of short duration and regulated, onshore site preparation activities could generate considerable amounts of fugitive dust emissions and impact neighboring communities and possibly cause Federal or State ambient air quality standards to be exceeded when added to existing sources. Accordingly, these activities would be conducted to minimize potential impacts on ambient air quality. For example, fugitive dust would be controlled by standard dust control practices for construction, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles or by suspending dust-generating activities during high-wind periods. On windy or dry days, more frequent application of water spraying would be exercised to maintain the effectiveness of dust suppression efforts.

Other general mitigative measures would include proper maintenance of heavy equipment (e.g., bulldozer, crane) and onshore vehicles (e.g., trucks) and offshore vessels (e.g., boat or barge) to minimize air emissions of diesel-powered engines.

The use of low-sulfur fuel (diesel or bunker fuel) especially for operations within 100 km (62 mi) of Class I areas would reduce potential SO_2 impacts to those areas. During the ozone season, NO_x control in ozone nonattainment areas (e.g., including low NO_x fuel, power management operations, retarding engine firing, catalytic converters, turbo-chargers/after-coolers), would reduce potential impacts from ozone. Timing source emissions to occur during nonpeak ozone periods would be an option. Use of offsets or emission credits in nonattainment and maintenance areas could reduce potential impacts from several pollutants.

5.2.3 Ocean Currents and Movements

5.2.3.1 Technology Testing

In the near term, existing offshore technologies, which have been used in Europe's shallow waters for more than a decade, may be applicable for shallow OCS waters as discussed in Section 3.2. With recent advances, the technologies can also be effectively used in deeper waters (i.e., waters deeper than about 50 m) of the OCS where wind velocities and wave action can be greater. Technology testing for these technologies could produce a very slight reduction in current energy produced by structural drag, a decrease in wave height in the vicinity of any support structures caused by wave interception, and a decrease in wave height downwind of the test facility caused by a decrease in wind energy. Because of the small scale of associated testing equipment, impacts would be negligible, temporary, and very difficult to measure outside of the immediate area of the test equipment.

5.2.3.2 Site Characterization

A wind energy facility could be constructed and operated anywhere in waters of the OCS where conditions are favorable. Favorable conditions include primarily high, sustained, and regular winds. As with technology testing, site characterization could produce a very slight reduction in current energy because of structural drag, a decrease in wave height in the vicinity of any support structures caused by wave interception, and a decrease in wave height downwind of the site characterization equipment caused by a decrease in wind energy. Because of the small scale of associated characterization equipment, impacts would be negligible, temporary, and very difficult to measure outside of the immediate area of the equipment.

5.2.3.3 Construction

Construction of a wind energy facility could occur in either shallow or deeper waters of the OCS. Towers or other forms of support would be anchored to the seafloor. Installation activities would not have any measurable impacts on ocean currents or waves, except in the immediate vicinity of the support. Potential impacts include a decrease in wave height as waves intercept the support and an exceedingly small decrease in current energy produced by support structure drag. Such impacts would be small, very local, temporary, and not measurable outside the area of the support.

5.2.3.4 Operation

Potential impacts of operating a wind energy facility on physical oceanographic resources include a reduction in current energy produced by structural drag, a decrease in wave height in the vicinity of the support structures caused by wave interception, and a decrease in wave height downwind of the facility caused by a decrease in wind energy. In all cases, these impacts would be small and limited to the immediate vicinity of the facility.

5.2.3.5 Decommissioning

Decommissioning and removing structures of a wind energy facility would increase wave height and current energy in the vicinity of the removed structures. For similar pre- and post-project conditions, decommissioning and removal of associated structures would return the system to its original condition.

5.2.3.6 Mitigation Measures

Because construction, operation, and decommissioning activities associated with wind energy generation would have no measurable impacts on ocean currents or waves outside of the immediate vicinity of associated structures, no mitigation measures would be required.

5.2.4 Water Quality

5.2.4.1 Technology Testing

Offshore wind energy has been tested and installed in other parts of the world, so there should be little need to prove the concept for the OCS. Consequently, the amount of new technology testing activity should be minimal. There may be some testing of new foundation structures that could disturb sediments. The nature of water quality impacts anticipated during the technology testing phase should be negligible because of the limited number of tests and their short duration.

5.2.4.2 Site Characterization

The process of selecting appropriate sites for offshore wind facilities would involve a variety of tests and samples to determine the local and regional depth contours and sediment types. This information is used in selecting the type of tower structure and the corresponding foundation, as well as identifying preferred routes for the underwater cables that carry electricity between towers and back to shore (Hiscock et al. 2002). Tests may also include ecological sampling to determine the species that are present at or near the site. Site characterization surveys are likely to involve sediment coring, geological and geophysical surveys, and possibly ecological sampling. The geophysical surveys would not likely influence water quality, but sediment coring and ecological monitoring would cause temporary disturbance of the seafloor and introduction of sediment into the water column. To the extent that sediment samples are collected by well drilling equipment that uses drilling fluids, the disposition of the used drilling fluids and the sediment core material itself could cause short-term water quality impacts.

Each proposed wind facility may install a meteorological tower to collect wind speed and direction data and other weather-related information. Construction of the tower may create temporary and minor sediment impacts as discussed in 5.2.4.3.

Site characterization would necessitate the use of work boats and ships. The process of operating vessels on the OCS can contribute small amounts of fuel or oil to the water column through bilge discharges or leaks, although this should be minimal. Vessels are expected to comply with U.S. Coast Guard (USCG) requirements relating to prevention and control of oil spills. The process of anchoring the vessels and anchor removal would cause intermittent disturbance of the seafloor, with movement of sediment into the water column.

The nature of water quality impacts anticipated during the site characterization phase should be negligible or minor because of the short duration, except in the event of a significant spill of oil or chemical from a work vessel.

5.2.4.3 Construction

The types of water quality impacts anticipated during the construction phase are similar to those described for the site characterization phase. Because the construction phase would involve more vessels for longer periods of time than the site characterization phase, there would be a potential for larger or more frequent releases of oil or other chemicals found on the vessels through bilge discharges, leaks, or oil spills. The vessels would most likely be anchored for longer periods of time or use more significant anchoring structures (e.g., pilings or jack-up rigs) to allow preparation and installation of the tower foundations, installation of the towers, and installation of the turbine and blade assemblies (Hiscock et al. 2002).

For the next 5 to 7 years, wind turbines in water depths of less than 15 m (50 ft) are likely to be mounted on towers supported by steel monopile foundations. The monopiles are hammered, drilled, or vibrated into the seabed. The installation process will temporarily disturb some sediment. If larger steel or concrete foundation structures are utilized, the excavations required for the foundation will occupy tens to hundreds of square meters of seafloor area and will be drilled tens of meters deep into the sediment (Elcock 2006). These types of foundations will disturb and displace more of the sediment than would monopile foundations. Depending on the total volume of sediment, and how it is managed, the impact could be negligible or minor. However, if the area being considered has sediments that are already contaminated, the construction activities will resuspend the sediments and cause some of the contaminants to enter the water column.

If the process of preparing the foundation involves rotary well drilling equipment that uses drilling fluids, the disposition of the used drilling fluids and the drilled material itself could cause water quality impacts. The volume of drilled material will be substantially greater than the sediment cores collected in the site characterization phase. Because the foundations will be shallow holes compared to oil and gas wells, drillers should be able to use environmentally friendly water-based drilling fluids that pose minimal water quality impacts or use drilling techniques that do not require drilling fluids.

During installation of the towers, the towers may be fastened into the foundation with cement. Excess cement could be released to the seafloor or water column, but should pose negligible impacts.

Installation of the nacelles, turbines, and blades could involve minor releases of lubricants, solvents, or other chemical products. Unless containers of materials are accidentally spilled, the quantities of these released through normal operation should be very small. Cables will be installed by jet plowing, which will create some disturbance along the cable corridor.

The nature of water quality impacts anticipated during the construction phase should be negligible or minor because of the short duration, except in the event of a significant spill of oil or chemical from a work vessel.

5.2.4.4 Operation

Once the wind turbines are in operation, they should pose little direct water quality impact. Routine wastewater or cooling water discharges are not anticipated, but if they do occur, they would be regulated under National Pollutant Discharge Elimination System (NPDES) permits.

The nacelles contain lubricating oil. The towers may contain internal equipment that may also use various oils or hydraulic fluids. If the wind facility utilizes a central ESP, that platform may house transformers that contain large reservoirs of oil. It is unlikely, but conceivable, that some of that oil could gradually leak out into the sea. An even less-likely scenario would involve catastrophic rupture of one or more of the large transformers on the ESP. However, if this type of event occurred, there is potential for thousands of liters of electrical insulating oil (mineral oil, not crude oil) to be released to the ocean. Depending on the distance of the platform from shore and the prevailing winds and currents, the spilled oil could create an oil slick that could reach shore and contaminate beaches and aquatic life. ASA (2006) performed a computer simulation of a hypothetical oil spill occurring at a location off the Massachusetts coast. The simulation assumed that nearly all the oil held on the ESP (in that case, 150,000 L [40,000 gal]) was released at the same time. This is an extremely conservative assumption, because the oil at that location would be held in several large transformers rather than in a single large tank or reservoir, and it is unlikely that all transformers would rupture at the same time. Under those assumed conditions, however, the simulation found that there was a greater than 90% probability that the spill would affect some shoreline. The simulation did not estimate quantities of oil reaching the shoreline, nor did it consider fate and effects or any reduction of oil volume attributable to oil spill response mitigation efforts.

The tower and turbine structure may need periodic painting or other maintenance. Through the maintenance activities, minor amounts of paint, solvent, lubricant, or other chemicals could enter the water column.

There is some possibility for water quality impacts that are not directly related to wind facility operation. Instead the impacts would be related to the presence of the structures in the sea. A wind facility containing tens to hundreds of towers presents greater opportunity for collisions by vessels that attempt to navigate between the towers (Hiscock et al. 2002). To reduce this potential impact, institutional controls may be applied to exclude commercial vessels from the area. If commercial vessels are allowed in the area and collisions occur, substantial releases of oil and other chemicals are possible.

The towers also can serve as attractants for marine life, which in turn attracts recreational fishermen to the area. Unless recreational vessels are excluded from the area, there is some potential for releases of oil, fuel, trash, and other material from the vessels.

Overall, except for a spill related to a vessel collision, the impacts related to the operation phase should be negligible to minor because the normal operations do not create discharges to water.

5.2.4.5 Decommissioning

Decommissioning is likely to involve complete removal of the structure to 4.6 m (15 ft) below the seafloor. In that case, water quality impacts would be related to vessel operations, material dislodged from the tower and turbine during removal, oil that leaks from the nacelle during removal, and sediment resuspension during the removal of the tower, foundation, and electrical cables. These are likely to be short-term events without any long-lasting impacts. The water quality impacts related to decommissioning should be negligible to minor because of the short duration.

5.2.4.6 Mitigation Measures

During the site characterization and construction phases, water quality impacts can be mitigated by choosing drilling and coring methods that either do not use drilling fluids or use environmentally friendly fluids. Water quality impacts associated with resuspended sediments will be minimized if the sediments in the area are clean rather than contaminated by prior activities.

During the operational phase, regular inspection and maintenance should help to detect components that are leaking oil or other chemicals. In particular, operators should have a comprehensive inspection and maintenance program in place for monitoring the transformers on the ESP. All facilities should operate under up-to-date spill prevention, control, and countermeasure plans. The plans should include protocols for spill response, including prestaging of response vessels and equipment.

During the decommissioning phase, all oil and other chemicals should be removed or otherwise controlled before the structure is moved.

Vessels should follow good maintenance and housekeeping procedures to minimize releases of oil and other chemicals to the sea. They should have up-to-date oil spill response plans. Vessel collisions within the wind facility area and the resulting spills of oil, fuel, and chemicals can be reduced by adherence to the guidelines in the USCG circular NVIC 07-02.

5.2.5 Acoustic Environment

5.2.5.1 Technology Testing

It is expected that technology testing for any of the alternative energy technologies under consideration would concentrate on evaluating the unique circumstances and uncertainties of the OCS location and adapting the technology to the challenges presented by those factors. In most instances, installation of only one energy capturing device would be all that is necessary during the technology testing phase. Also, it is assumed that the technology testing phase may involve evaluation of construction and installation techniques for undersea cables, but would not extend to constructing any onshore facilities.

Technology testing for wind energy technologies on the OCS would likely be directed at new foundation technologies in deep waters, as mainline technologies for the wind turbines themselves are already well established and can be expected to be introduced into any OCS area without significant modifications. With respect to noise impacts, such testing would involve ship and barge noise, above-water construction noise, and noise associated with the installation of various wind turbine foundations in various depths of water. The latter activities could involve geophysical surveys, pile driving, the use of vibratory hammers, drilling, or dredging. Explosives are not expected to be used in any technology testing activities.

The nature and potential impacts of these activities are discussed in greater detail in the subsequent sections. For the purposes of the current discussion, construction activities related to technology testing of wind technologies would be conducted at prospective locations for wind power projects, that is, some distance offshore. Noise from these activities would be intermittent and of short duration. The noise sources would originate from activities similar to those associated with full-scale projects, but conducted at a much smaller scale and over shorter durations.

Impacts from noise to human populations related to technology testing would be minimal, as these activities would be carried out some distance away from population centers, and would be of short duration and of similar character to background noise (e.g., ship noise). Operational noise from turbine rotors and machinery would be of low intensity and would have similarly minimal impacts.

5.2.5.2 Site Characterization

Site characterization activities that could produce noise impacts include the placement of pilings to support meteorological towers, the use of a variety of survey and sampling techniques to map the seafloor and subsurface environments, drilling of sediment cores, operation of submersible vehicles, and ship and barge operation.

Seafloor characterizations would be most intense for technologies requiring the strongest foundations and anchoring, such as wind turbine technologies. Wind technologies, similarly, would be the most likely to require meteorological towers, although meteorological data may also be required to characterize the conditions of any location for technology placement.

Noise impacts from site characterization activities would be intermittent and of short duration. However, some of the expected activities such as pile driving could produce high-intensity noise pulses that could impact marine life. Impacts from pile driving would be similar to those described for pile driving for wind turbine testing and could be of concern at close range. Such noise impacts could be mitigated by a number of means, including deterring fish and marine mammals from the work site, ramping up noise activities, and dampening pile-driving noise at the source by using such means as bubble curtains or insulated piles.

Finally, a site survey would be required as part of site characterization, irrespective of the alternative energy technology being pursued, to identify unique features of the affected area such as cultural resources and geologic hazards. In the case of wind facilities, such site surveys would be necessary to determine the nature of sediments and the materials comprising the ocean subfloor, both determinations essential for tower foundation engineering design and installation decisions. Seafloor characterizations would also be necessary to support decisions regarding design and emplacement of power and control cables that would connect to shore-based support facilities. A variety of geological and geophysical (G&G) technologies could be employed to perform this site characterization survey. In 2004, the Minerals` Management Service (MMS) published a final programmatic environmental assessment on the impacts resulting from the application of the most common G&G technologies (Continental Shelf Associates 2004). The technologies that were evaluated included seismic surveys, deep-tow side-scan sonar surveys, electromagnetic surveys, geological and geophysical sampling, and remote sensing surveys.[7] Noise impacts were among the potential impacts evaluated. None of the G&G technologies that were evaluated was expected to result in significant adverse impacts to any of the potentially affected resources when properly executed and mitigated. Nevertheless, judicious selection of site survey techniques should be encouraged as a means of minimizing impacts during this phase of facility development.

Traditionally, high-resolution seismic surveys employing the use of high-pressure (typically 2,000 pounds/square inch [psi]) air guns have been used to investigate the shallow subsurface for geohazards and to define soil conditions. While such surveys return substantial amounts of high-quality data, they also produce a high-intensity noise signal that could potentially impact marine life adversely. In most instances, only information on the uppermost portion of the seafloor (to depths below the seafloor of 100 ft or less) would be required. Consequently, high-resolution seismic surveys can be replaced with relatively low-intensity alternatives that can still produce sufficient quantities of data with which to complete the necessary surveys. It is, therefore, not expected that seismic survey techniques will be employed in initial site characterizations, but instead, characterizations would be accomplished through the use of less intrusive technologies such as deep-tow side-scan sonar surveys and electromagnetic surveys, neither of which employs a high-energy sound source. Alternatively, a variety of remote sensing survey techniques such as radar imaging, aeromagnetic surveys, gravity surveys, and marine magnetic surveys could be utilized, none of which involves a high-intensity sound source. Where foundations are anticipated, geologic sampling (shallow coring) may also be necessary to support foundation design decisions. Some negligible amount of low-intensity noise, lasting over a relatively short duration, would result from such drilling and coring operations. Finally, most of the survey and sampling technologies described above would be ship-based, thus introducing ship-related noise signals during data collection or sampling.

5.2.5.3 Construction

The construction of offshore wind projects would involve a number of activities that can be discussed generically with respect to impacts from noise. Underwater noise sources could

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7 An expanded discussion on each of these survey technologies is provided in Chapter 3.

include ship and barge noise, pile driving, drilling, and geophysical surveys. Above-water noise sources could include ship and barge noise, aircraft noise, and construction noise. A portion of above-water noise can also be projected underwater directly under noise sources. Sound waves at shallow incident angles tend to be reflected off the surface of water bodies and do not penetrate below the surface. Tables 5.2.5-1 and 5.2.5-2 present descriptions of the character and intensity of various above-water and below-water noise sources related to construction.

5.2.5.3.1 Ship and Barge Noise. Ship and barge noise is associated with ferrying workers and materials to offshore construction sites, laying underwater electrical and signal cables, performing geological and geophysical surveys, and providing work platforms for construction. Underwater ship and barge noise is generated from three main sources; directly from turning propellers, indirectly from engine and other ship noises being projected though ships hulls, and directly from the interactions of waves with the ship's hull. Propeller noise will be generated whenever the vessel is underway. Mechanical noise from machinery other than the vessel's propulsion system and noise from the interaction of waves with the ship's hull will be generated whenever the vessel is underway (i.e., to and from the installation location) as well as when the vessel is anchored at the construction site. Thus, some vessel related noise can be expected to be relatively constant throughout the course of the construction day, while noise from vessel movements will occur primarily at the beginning or end of each construction day, as well as whenever vessels move to or from the construction site bringing crews or equipment throughout the course of the workday.

TABLE 5.2.5-1 Above-Water Noise Sources

Noise Source	Duration	Frequency Range	Frequency of Peak Level (Hz)	Peak Sound Level (dB re-20 μPa)	Reference Distance (m)
Ship/barge/boat[a,b,c]	Intermittent to continuous, up to several h/d	Broadband, 20–50,000 Hz	250–2,000	68–98	Near source
Helicopter	Intermittent, short duration	Broadband with tones	10–1,000	88	Near source
Pile driving[a,c]	50- to 100-ms pulses/beat, 30–60 beats/min, 1–2 h/pile	Broadband	200	110	15
Construction[c]	Intermittent to continuous	Broadband	Broadband	68–99	15

[a] Thomsen et al. (2006).

[b] LGL (1991).

[c] Washington DOT (2005).

TABLE 5.2.5-2 Below-Water Noise Sources

Noise Source	Duration	Frequency Range	Frequency of Peak Level (Hz)	Peak Sound Level (dB re-1 μPa)	Reference Distance (m)
Ship/barge/boat[a,b,c]	Intermittent to continuous, up to several h/d	Broadband, 20–50,000 Hz	250–2,000	150–180	1
Pile driving[a,d]	50- to 100-ms pulses/beat, 30–60 beats/min, 1–2 h/pile	Broadband	200	Up to 205	30
Seismic air-gun array[b]	300- to 500-ms pulses, repeated at 10- to 15-s intervals	Mainly low frequency, but some 500–1,000 Hz	40–125	Up to 252 downward, up to 210 horizontally	1
Seismic explosions[e]	6- to 10-s intervals	Broadband	Broadband	205–215	1
Dredging[c]	Continuous	Broadband, 20–1,000 Hz	250	150–162	1
Drilling[b,c]	Continuous	Broadband	10–500	154	1

[a] Thomsen et al. (2006).

[b] LGL (1991).

[c] Richardson et al. (1995).

[d] Washington DOT (2005).

[e] Ross (1976).

Noise levels from ships are generally proportional to ship size and speed. High speeds and the use of thrusters increase noise levels significantly (Richardson et al. 1995). Underwater noise from propeller cavitation is the strongest noise from ships. As shown in Table 5.2.5-2, this broadband noise can range from subsonic to ultrasonic frequencies and can reach 160 dB (re-1 μPa at 1 m) (Thomsen et al. 2006). Mechanical noise from engines and mechanical systems on ships transmitted under water have lower frequencies (<5 kHz) and lower levels than propeller noise (Gales 1982). Ship sonar typically operates in the range of 15–200 kHz, with a sound level range of 150–215 dB (Washington DOT 2005).

Impacts to human populations for ship noise generated during construction of offshore wind energy projects would be minor. Noise levels transmitted above water to human receptors would be low, and would be similar to, and masked by, background noise, while receptors would be at distances of several miles or more from most ship activity.

Impacts to fish and marine mammals are also expected to be minor, while sound levels experienced by these populations would be greater than those above water. Sound levels might be audible to fish and cause some behavioral changes, such as avoidance of the area, but sound levels from propellers, for example, would not cause physical harm to fish. Similarly, sound levels from ships, including ship sonar, may affect behavior and disturb communication of marine mammals (Thomsen et al. 2006), but not cause physical harm. In areas of existing shipping, these effects could be reduced due to habituation by the animals. Habituation of marine mammals to ship noise has not been widely studied, but might be expected to occur based on observations of the presence of harbor porpoises and harbor seals close to shipping routes (Koschinski et al. 2003). In previously undisturbed areas, fish and mammals might avoid the work area or experience some other temporary behavior changes. Such changes would not be expected to affect the survival of these species in the vicinity of projects.

5.2.5.3.2 Pile-Driving Noise. Pile driving typically involves various means of dropping a weight, or hammer, on the top of a pile, often a hollow steel tube, to drive the pile into seafloor sediments where it provides a foundation for construction of above-water or below-water structures. Pile driving produces intense sound pulses in water that are generally the primary concern with respect to noise impacts from offshore construction projects.

Pile driving typically is carried out at 30–60 beats/min, requiring 1–2 h/pile. Each beat produces an intense pulse 50–100 ms in duration of broadband noise (20 Hz–20 kHz) with maximum noise levels occurring at around 200 Hz. Peak sound pressure levels of 205 dB (re-1 μPa) at a distance of 30 m (98 ft) from the piling can be reached. In water, sound pressure diminishes with distance at a rate of about 4.5 dB per doubling of distance (Thomsen et al. 2006). Peak sound levels for vibratory pile drivers, which only drive piles to non-load-bearing depths, are 10–20 dB lower than for impact hammers, which may be used to finish the pile (Washington DOT 2005).

Assuming an ambient noise level in open ocean of 130 dB and a transmission loss of 4.5 dB per doubling of distance for a 205-dB source at 30 m (98 ft), a simple transmission model would estimate that pile-driving noise would be distinguishable for up to 2,000 km (1,240 mi) (i.e., 16 doublings of 30 m). However, common experience suggests that pile-driving noise would be absorbed more rapidly than this rate. Using an empirical rate of 0.15 dB/m (0.05 dB/ft) for marine systems like Puget Sound (Washington DOT 2005) would predict that levels would be at ambient levels at a distance of 500 m (1,640 ft) in similar confined systems.[8] Pile-driving noise could be perceptible to harbor seals and harbor porpoises for tens to hundreds of kilometers from construction sites. Such noise could exclude these and other marine mammals from critical habitat, especially when multiple noise sources are present. The availability of alternate habitat should be confirmed in such cases (Koschinski et al. 2003).

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8 This empirical rate of absorption of pile-driving noise is offered for example only. It is important to emphasize that sound pressure level reductions with distance are affected by various factors, the two most important of which are the composition of sediments and seafloor topographies, both of which could either attenuate or enhance sound propagation.

Offshore pile driving would likely be audible to shoreline populations. Impacts to such populations would typically be experienced as annoyance. The degree of impact would depend on the amount and character of background noise. Impacts would be intermittent and short term, and generally proportional to the number of pilings required for a project.

5.2.5.3.3 Other Construction Noise. Construction of wind energy projects would also involve above-water or in-water construction that could have noise impacts to both human and marine receptors. In addition to ship noise, discussed above, such construction could involve helicopter noise, general construction noise from use of hand tools and machinery, such as air compressors, and noise from work boats and small craft used for construction. Construction noise associated with the erection of turbines would occur at each turbine location. However, construction noise associated with other offshore components such as power-gathering platforms could occur at onshore locations where such components could be assembled before being towed out to their final operating location.

As seen in Table 5.2.5-1, construction noise sources above water for a number of activities range from 68 to 99 dB (re-20 μPa), the latter for jackhammers (Washington DOT 2005). As these are point sources in air, they will attenuate at a rate of at least 6 dB for a doubling of distance. In the presence of linear noise sources, such as traffic noise, which attenuate at about 3 dB per doubling, construction noise reduces to background levels within a short distance. For example, construction noise of 91 dB at 15 m (50 ft) will reduce to background (i.e., preconstruction) levels (existing traffic noise) of 86 dB at 15 m (50 ft) within about 60 m (200 ft). Thus, general construction noise would be of short range and low impact in typical urban or suburban locations near offshore projects or near locations of onshore construction or assembly of project components where linear noise sources are present.

Helicopters may be used to ferry workers or materials to offshore work sites. Noise from helicopters is characterized by 10 to 1,000 Hz broadband noise with primary tones for rotor noise around 10 Hz with harmonics at higher frequencies. Helicopter noise can penetrate below the water surface, but mainly only directly below the craft. Thus, helicopter noise is experienced at underwater locations for durations of generally less than 30 s for a single pass. In one study, underwater noise levels at a depth of 9 m (30 ft) were on the order of 110 dB re-1 μPa for a two-rotor helicopter flying at about 300 m (980 ft) above the water surface (LGL 1991). Such noise levels would have little if any effect on marine life.

Helicopter noise is more likely to affect human populations in near shore areas. Here, helicopter noise would be louder and would be audible for longer periods than underwater. Estimated source levels for a typical helicopter are 150 dB re-1 μPa, or about 88 dB after subtracting 62 dB for converting sound pressure levels in water to those in air (re-20 μPa) (Washington DOT 2005). Noise levels on the ground would be somewhat lower. Such levels could produce annoyance in affected areas, but only for relatively short durations.

Small boats with outboard motors as well as larger crew boats and small tugs would be another noise source during construction of wind energy projects. Underwater noise levels for boats with outboard motors from 18 to 90 horsepower (hp) have been estimated at 88–142 dB re-1 μPa at a distance of 50 m (164 ft). The motors produce broadband noise from 100 to 10,000 Hz. Small vessels, including small tugs and crew boats, typically with inboard diesel engines, produce a narrower range of noise levels at around 130 dB re-1 μPa at 50 m (164 ft) (LGL 1991) and at lower frequencies than small boats with outboard motors.

Subtracting 62 dB from underwater noise levels for small vessels produces estimates of above-water noise of 68–99 dB (re-20 μPa) near the source (Table 5.2.5-1). This noise range is very similar to that for general construction noise. Impacts to human populations would also be similar to that for construction noise (typically annoyance).

Construction noise is also associated with the installation of cables that interconnect various energy generating devices (e.g., each of the turbines in a wind facility to a centrally located, offshore power management facility) and interconnect the alternative energy facility with a shore-based facility. Other uses of an area will dictate installation requirements for seabed cables to avoid potential adverse impacts or conflicts. The nature of the seabed will dictate the construction/installation techniques that will be employed (and thus the noise profiles that will result), from simple air guns to create a trench in loosely consolidated materials to rock cutters or even shaped charges in areas with exposed bedrock. Although the noise from some techniques will be intense, noise related to cable installation will occur over a very short period of time, regardless of the installation techniques employed.

Finally, noise will be associated with onshore staying, pre-assembly, hauling, and loading of wind turbine components and with the construction of onshore facilities that receive power from the offshore wind energy facility and modify and synchronize it for connection to the electric grid or to nearby distributed energy systems. Such onshore facilities will act essentially as electric substations. Construction-related noise will come from the various activities that constitute construction of such a facility. Table 5.2.5-3 shows the noise resulting from construction vehicles and equipment that would likely be used. Depending on the size and complexity of the substation, construction may take as long as six months but would typically take less.

In summary, noise impacts from construction are possible from several sources, including from ship and barge operations, pile driving, general construction, and helicopter and crew boat traffic. Of these sources, pile driving would produce the largest noise impacts. Ship and barge noise impacts would be less and similar to those of general ship traffic. General construction noise would also be less, most likely impacting onshore areas where pre-assembly of energy technologies takes place. Helicopter and crew ship noise might cause temporary annoyance to nearshore communities.

5.2.5.4 Operation

Among the alternative energy technologies being considered for offshore development, operational noise characteristics are by far best known for wind turbines. However, all such technologies will have certain features in common with respect to noise emissions. All or most will generate mechanical noise from electrical generators and associated drive systems. All will

TABLE 5.2.5-3 Typical Noise Levels of Construction Equipment

Equipment	Range of Noise Level (dBA) at 15 yd
Earthmovers	
Front loaders/excavators	72–84
Backhoes	72–93
Tractors/dozers	76–96
Scrapers/graders	80–93
Pavers	86–88
Trucks	82–94
Materials handling	
Concrete mixers/millers	75–88
Concrete pumps/spreaders	81–83
Cranes (moveable)	75–86
Cranes (derrick)	86–88
Stationary equipment	
Pumps	69–71
Generators	71–82
Compressors	74–86
Drill rigs	70–85

Source: CPUC (2003).

generate noise from service boats and maintenance work. Finally, all will generate both above- and below-water noise to some extent. Overall, however, operational noise for all proposed technologies is expected to be generally low as a consequence of the low-intensity energy conversion mechanisms that drive the technologies.

Offshore wind turbine noise has been fairly well characterized from experience developed in Europe. Wind turbine generators produce noise of primarily two types, aerodynamic turbine blade noise and mechanical noise. Mechanical noise may be transmitted underwater through the turbine towers and foundations (pilings). Underwater noise from a 1.5-MW turbine in Sweden was measured at 90–115 dB re-1 μPa at a distance of 110 m in moderate winds. This noise covered a frequency range of 20–1,200 Hz, with peak levels at 50, 160, and 200 Hz (Thomsen et al. 2006). At these levels, impacts to marine mammals would be limited to audibility and perhaps some degree of responsiveness, such as avoidance. Fish could be similarly impacted, but only at close range, within 100 m (328 ft) (Thomsen et al. 2006).

Another focused study of underwater noise from wind turbines was undertaken at the Utgrunden offshore wind facility in Sweden (Lindell 2003). Three hydrophones were positioned 1 m above the seafloor in the vicinity of the center 1.5-MW GE Wind Energy turbine in the seven-turbine wind facility to collect sound data over the period of November 2002 to

February 2003. The salient findings of the study are generally consistent with the Thomsen 2006 study and include the following:

- Underwater sound from wind turbines is mainly generated by vibrations in the tower.
- The large contact area of a tower with the water provides an effective path for sound transmission to the water.
- Tower vibrations transmitted to the seafloor have negligible impact on underwater sound levels.
- Airborne sound such as aerodynamic noise from a rotating blade is effectively reflected at the water's surface and does not contribute significantly to underwater sound levels.
- Tower vibrations are mainly the result of the movement of mechanical components in the gearbox and generator of the turbine.
- The majority of underwater sound from wind turbines is below 1,000 Hz; dominating frequencies vary with wind speed, with higher frequencies predominating as wind speed increases; sound intensity levels increase with wind speed across the entire frequency range of emitted sound.
- Underwater sound attenuation was calculated at approximately 4 dB per doubling of distance, which is a relatively good correlation with the theoretical value of 4.5 dB per distance doubling.

Above-water operational noise of wind turbines has also been characterized in Sweden (Pedersen and Halmstad 2003). Aerodynamic noise from rotating turbine blades increases with blade tip speed (the speed at which the outermost tip of the blade travels around the circumference of the rotor), so noise increases with rotor size or rotor rotational speed. Mechanical noise, which has main bands below 1,000 Hz, is generally of lower intensity than rotor noise and does not increase with turbine size. Since this noise is also easily insulated, it can be disregarded in terms of impacts.

Aerodynamic noise from air flow around turbine blades is characterized as broadband with perceptible beats related to rotor blade speed in some instances (Pedersen and Halmstad 2003). Beats are amplitude modulations in noise level at regular intervals. A three-blade 600-kW turbine rotating at 26 rpm has a beat frequency of 1.3 Hz, or about 1 beat/s. At a given noise level, beats make noise more noticeable against background noise and may produce increased annoyance over noise that is not modulated (Pedersen and Halmstad 2003). This feature of turbine blade noise may not be reducible since it is related to the blade's essential mode of operation. At low-to-moderate wind speeds, noise from a fixed-speed wind turbine increases at a rate of 0.5 to 1.5 dBA/m/s (ETSU 1996).

Surveys of residents in Europe living near wind projects reported by Pedersen and Halmstad (2003) found low levels of annoyance from wind turbine noise for only about 7% of respondents. Most complaints were related to turbine blade noise, and complaints were highest in the time period of 8:00 pm to midnight. Annoyance levels were weakly correlated to actual sound pressure levels in some European studies, and were often affected by such things as visual impacts, respondent's opinion of wind power, and the length of time turbines had been in operation. A Danish study found that low reports of annoyance corresponded to distances to turbines of at least 300 m (984 ft) and turbine heights below 3.5 degrees to the horizon for small turbines. In a Swedish study where residents were exposed to wind turbine noise of 25–40 dBA, annoyance rates became strongly correlated with turbine noise above 37.5 dBA. Above 40 dBA outdoors, 36% of respondents reported being very annoyed. Wind turbine noise guidelines and limits outside of dwellings in Europe range from 35 to 45 dBA, depending on time of day and sensitivity of the affected area (Pedersen and Halmstad 2003).

Species potentially affected by above-water operational noise from wind turbines include birds and bats. Any impacts from construction noise on these species would be short-term and temporary. Large data gaps remain in general regarding the presence, movements, flight behavior, and foraging behavior of seabirds in the offshore areas most likely to be used for wind energy development (Michel et al. 2007). Even less is known about the potential effects of operational noise on these species. Effects could include avoidance or attraction responses to structures because of noise, but such effects would be difficult to distinguish from similar effects from aviation lighting or the visual presence of the structures. Observed migration deflections near European wind facilities may be partially attributable to noise, but studies are inconclusive. Bats may be attracted to the low-frequency emissions of some turbine blades, however (Michel et al. 2007). The overwhelming concern about impacts of wind turbines on birds and bats pertains to collisions with turbine blades as well as with stationary structures (i.e., bird strikes). Such effects would be expected to dominate any possible effects from noise. However, avoidance or attraction responses to noise might slightly reduce or increase, respectively, such strikes.

Offshore wind energy facilities would require regular maintenance and some would require daily commutes by operators. These activities would produce noise from the crew boats or small tugs used. This noise would be indistinguishable from other ship and boat noise in near shore areas. If helicopters were used to ferry crews, however, noise impacts could be higher. Noise impacts from crew boats and helicopters are discussed above.

Finally, transformers and shunt reactors[9] in shore-based electric substations would produce noise during the operating period. Transformer noise sources are: (1) core noise, a humming noise due to core vibration at roughly twice the frequency of the alternating current; (2) coil noise, which is principally caused by the electromagnetic forces associated with the

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9 Transformers are used to convert electrical power at high voltage and low current (the nature of the electric power normally present in long-distance transmission systems) to electric power at low voltage and high current (as is typically found in most industry and residential applications). Shunt reactors are high-voltage, high-power electrical inductance devices that are used in electrical energy distribution systems to improve the overall efficiency of power transmission.

alternating current flowing in the windings; and (3) fan noise caused by the cooling system for the transformers (a broadband noise typical of low-speed fans) (Moreland and Girgis 1991). All three sources in combination produce noise between roughly 30 and 8,000 Hz at sound pressure levels between 30 and 78 dBA, primarily as discrete tones at even harmonics of the line frequency.[10] Core noise is the dominant noise source in a typical transformer. Coil noise is generally a minor contribution to overall noise compared to core noise. Fan noise becomes a significant contributor to overall transformer noise for smaller rated transformers and for low induction transformers. Shunt reactors consist of a core and a coil for each phase of the electrical power source they manage and produce noise via mechanisms similar to those in transformers, including cooling fan noise and noise resulting from the vibrations of the core and the coil. However, an additional factor is that because shunt reactors operate at high voltages, electromagnetic forces present around the coils are sufficiently strong to produce a substantial amount of vibration in the tank or outer shell of the shunt reactor. This tank vibration becomes the predominant noise source in a shunt reactor. Consequently, whereas outer shell vibration is negligible in transformers, the total amount of noise produced by shunt reactors is typically greater than the noise from transformers of comparable size and electric power rating.

The American National Standards Institute (ANSI) and the International Electrotechnical Commission (IEC) have established a methodology for measuring noise from transformers and other electrical devices. The methodology involves A-weighted sound measurements using microphones positioned 0.3 m (1 ft) from a tautly drawn string that encircles the device at a height that is one-half the overall height of the device. The device's noise signal is the average of all measurements taken around the perimeter of the device, allowing for unique noise sources such as cooling fans to contribute to the overall rating without having disproportional influence on that sound rating. The National Electrical Manufacturers Association (NEMA) published NEMA Standards TR1-1993 (R2000), which establish the maximum noise level allowed for transformers, voltage regulators, and shunt reactors based on the equipment's method of cooling its dielectric fluid (air-cooled vs. oil-cooled) and the electric power rating.[11] It is reasonable to expect that any transformer or shunt reactor installed as part of any OCS alternative energy system will conform to all relevant NEMA standards.[12]

5.2.5.5 Decommissioning

Noise from facility decommissioning of offshore wind energy facilities would be similar to that from construction of the facilities. Dismantlement of facilities would involve, for example, removal of above-water equipment and machinery, such as turbine rotors, generators,

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10 Thus, for alternating current at 60 Hz, the harmonics will be 120, 240, 360 (etc.) Hz.

11 As with other NEMA standards, the noise standard is an industry-developed, national consensus standard to which most electrical equipment manufacturers voluntarily conform. Most NEMA standards incorporate relevant national consensus standards developed by ANSI and other industry standard-setting bodies.

12 NEMA standards are available for purchase or electronic download from the NEMA website: http://www.nema.org/stds/list-Title.cfm.

and transformers, dismantlement of support structures, such as towers, removal of underwater cables, and finally removal of pilings to below seafloor level.

These activities would produce noise from the use of construction equipment, hand tools, cranes, and compressors. Noise from work boats, barges, and associated equipment, such as power shovels, would be expected for large projects like wind facilities. Noise impacts from these activities are discussed above under construction noise, and noise levels are presented in Tables 5.2.5-1 and 5.2.5-2.

The greatest noise impacts from decommissioning could be from the use of explosives for removing pilings if such practices were used. Underwater noise from explosions could easily exceed 200 dB re-1 μPa (Table 5.2.5-2) and cause possible impacts to marine mammals and fish close to work sites. The nature of these impacts would be similar to those from pile driving, discussed above, but only a single blast would be required per piling. Impacts could be mitigated to a great degree by using some of the same means described for pile driving.

Pilings could also be removed by simple cutting, which would have reduced noise impacts. Even large pilings could be removed by cutting in noise sensitive areas. Rocks and boulders used to protect pilings would be removed by using cranes and shovels. Noise impacts would be similar to those for construction.

5.2.5.6 Mitigation Measures

Impacts from pile-driving noise may be mitigated by a number of means involving either removing potential receptors from the work area or reducing sound emissions into water. Mitigation can also be accomplished by changing the behavior of sensitive marine species. Details are provided in sections addressing impacts to such species. Mitigation of pile driving noise at the source is possible by various means, including the use of bubble curtains or insulated piles, limiting nighttime pile-driving activities, working inside of caissons or coffer dams, or working during periods of slack tide (Lewis 2005). Finally, monitors who have a clear view of the surrounding area can be stationed to alert operators of the presence of sensitive marine life so that pile driving can be temporarily halted until the area is clear. Work would be postponed until it could be confirmed that sensitive species were no longer present within a radius of concern.

In addition to the above measures, the use of passive acoustic monitors (PAMs) should be considered in sensitive locations where vocalizing marine mammals are present, to assist visual monitoring. PAMs can be used to determine the noise characteristics of a project site and to monitor vocally active marine life and to aid the avoidance of ship and whale collisions. In conjunction with monitoring, an assessment should be made of the availability of alternate temporary habitat for sensitive species that would be excluded from work areas.

Removal of species might be impractical in instances where animals do not respond to the available deterrents or may not be readily detected near the work area. Similarly, deterrents might work on some species but not on others. For example, horn blasts might deter mammals such as seals from above-water shoreline areas, but have little effect on others, such as whales, that remain under water. In cases where sensitive species that are not easily deterred could be present, NOAA and other involved agencies should be consulted before work is begun.

Other potential sources of noise impacts, namely, seismic surveys and the use of explosives, can be avoided entirely by using alternate means. Air-gun seismic surveys are not expected to be necessary for site characterization and can be avoided in this context, while sufficient characterization of the sea bottom for constructing alternative energy projects can likely be achieved by using geophysical means to obtain measurements that have far lower noise impacts as outlined in Section 5.2.5.2. Similarly, the use of explosives to remove foundation pilings during decommissioning can be avoided in many cases by cutting pilings instead. In any case, nighttime hours should be avoided for activities involving high noise levels.

General construction noise can be mitigated by using a number of well-established means and work practices. Among these practices are closing engine doors on diesel-powered equipment, using sound blankets over noisy equipment, and using electric-powered (rather than diesel-powered) equipment when possible, for example, in air compressors. Lastly, temporary sound barriers can be set up, if appropriate, in sensitive areas.

Transformers are typically installed in fenced areas that prevent close access by all but authorized personnel or are placed in vaults. In locations where even minor amounts of transformer noise cannot be tolerated, transformers with specially designed noise-mitigating cases are also available. It is reasonable to anticipate that safe stand-off distances incorporated into substation design, vaulting, and/or transformer design will reduce transformer noise impacts to negligible levels. Further noise reduction can be accomplished by surrounding substations with noise-reducing fencing, shrubs or trees, or other noise barriers.

5.2.6 Hazardous Materials and Waste Management

Each offshore wind energy project would require deliveries and pick-ups of personnel, supplies, and materials to and from its offshore site. Vessels used for this purpose may generate wastes, including bilge and ballast waters, garbage (trash and debris), domestic wastes, and sanitary wastes. The need for vessels to support offshore wind energy projects during all project stages is not expected to result in an overall increase in the total number of vessels of this type operating in any of the OCS regions. Also, management of wastes from these vessels is regulated by the USCG (33 CFR 151). Accordingly, the impacts of waste generated by support vessels servicing offshore wind energy projects during all project stages would be negligible in all regions.

As identified in Sections 4.2.6.2, 4.3.6.2, and 4.4.6.2, there is a potential for disposal areas containing chemical weapons to occur in marine waters of the three OCS regions considered for potential development of alternative energy facilities. The exact locations of most of these disposal areas are not readily available to the public, with records typically supplying only references to the general offshore locations, because of the hazardous and sensitive nature of the materials disposed of. Notwithstanding, applicants developing alternative energy facilities in offshore waters should be able to avoid such areas by consulting with the appropriate military agencies during case-specific siting processes. Hence, chemical weapons disposal areas are not expected to contribute impacts during development of offshore wind energy projects.

5.2.6.1 Technology Testing

As Section 3.2 indicates, testing of wind technologies with demonstration facilities is not expected to be necessary. However, if a demonstration facility were to be constructed, impacts from hazardous materials and waste management during site characterization would be essentially the same as for a commercial facility because the monitoring and testing requirements would be similar to those for a commercial facility (Elcock 2006). These impacts are described in Section 5.2.6.2.

The types of impacts from construction and operation of a demonstration wind energy facility would be the same as for a commercial facility, but their magnitude would be scaled down. Sections 5.2.6.3 and 5.2.6.4 discuss the impacts from construction and operation of a commercial wind energy facility.

A demonstration wind energy facility would be decommissioned in the same manner as a commercial facility. Hence, the types of impacts from decommissioning would be the same as for a commercial facility, but the magnitude of the impacts would be scaled down. Section 5.2.6.5 discusses the impacts from decommissioning of a commercial wind energy facility.

5.2.6.2 Site Characterization

No hazardous materials are expected to be transported to, used on, or stored on the OCS during site characterization for wind projects (Elcock 2006). Activities necessary for geological and geophysical characterization, identification of sensitive biological resources, archaeological characterization, etc., would involve the use of vessels for a short duration and would not require the transport, use, or storage of hazardous materials. Similarly, hazardous wastes would not be transported, generated, or otherwise managed either on the OCS or onshore from site characterization activities (Elcock 2006). Thus, impacts from hazardous waste management and the use or storage of hazardous materials during the site characterization stage for wind energy projects would be negligible.

The discharge of garbage (domestic waste) from a fixed or floating platform on the OCS is regulated by the USCG and is prohibited, unless the garbage consists only of food waste that has been passed through a pulverizer to reduce particle size (33 CFR 151.73). Considering that a small number of people would be present at any particular wind energy site during site characterization activities and that only short visits would occur during most of the site characterization period (less than one full-time equivalent [FTE] total) (Elcock 2006), garbage would be generated only in very small quantities during this stage. Also, it is assumed that sanitary waste would be contained on support vessels. The small amounts of garbage would be segregated, with food waste being pulverized and discharged under USCG regulations and nonfood wastes being returned to shore for disposal in appropriate, permitted disposal facilities, or all of the garbage may be returned to shore. Only minimal quantities, if any, of construction and demolition debris would be generated during this project stage because the meteorological monitoring tower and equipment would be fabricated onshore and carried to the site by support vessel (Elcock 2006). In addition, it is assumed that, at the end of their useful lives, monitoring towers either would be partially dismantled, with the foundation left in place to form an artificial reef and the remainder removed to shore, or would be completely removed to shore for reuse, recycling, or disposal in appropriate, permitted disposal facilities. As Chapter 4 indicates, disposal facilities for garbage and industrial debris are available onshore in all three OCS regions. Hence, impacts that result from managing garbage and debris wastes during site characterization would be negligible on the OCS, and onshore impacts would be minor.

5.2.6.3 Construction

Section 3.2 describes the components of a wind energy project, which include the support structures for the WTGs, the WTGs themselves, electricity transmission cables, and voltage transformers. These components would be staged at onshore port facilities before the start of construction along with certain hazardous materials necessary to support their proper installation, startup, and maintenance. Onshore transportation of these materials to a port would be governed by the U.S. Department of Transportation (USDOT) Hazardous Materials Regulations (HMR) (49 CFR Parts 170–179). Storage of these materials in onshore port facilities prior to construction is regulated by the USCG. The USCG considers hazardous materials subject to the DOT HMR to be “dangerous cargo” in a U.S. port. Dangerous cargo must be loaded, handled, discharged, or stowed only at a “designated waterfront facility” (33 CFR 126.13), which must comply with directives regarding packaging, marking, labeling, and arranging of such dangerous cargo. Table 4.2.6-1 lists the expected types of hazardous materials associated with a wind energy project. The amounts of such materials that would be present in equipment or in storage at an operating wind energy project site are also provided in Table 4.2.6-1. These amounts are small relative to the total amounts of dangerous cargo likely to be present at a designated waterfront facility. Accordingly, impacts onshore from staging of hazardous materials prior to construction of wind energy projects would be minor.

During construction of a wind energy project, the staged components and other materials would be loaded onto vessels for transport through both coastal and OCS waters to the offshore site. Also, onshore horizontal directional drilling would occur during hookup of the transmission cable to an existing onshore substation. Wastes would be transported back to shore from the offshore site. As Table 4.2.6-1 and Sections 4.2.6, 4.3.6, and 4.4.6 indicate, the total quantity of hazardous materials, including petroleum products and chemical products, shipped to a wind energy project on the OCS is minuscule relative to the quantity of likely hazardous materials shipped on the ocean during 2004 in any of the three OCS regions. Impacts from transporting wastes and hazardous materials to and from wind energy construction sites are discussed in Section 5.2.17.

During construction of wind energy projects, impacts from hazardous materials may occur because of accidental spills. As was discussed in Section 4.2.6, such spills must be reported to the National Response Center if they exceed reportable quantities set forth in 40 CFR Part 302, and if a spill exceeds 50 barrels (bbl) (2,100 gal or 7,949 L) on a Federal lease in the Atlantic or GOM regions, its cause would be investigated by the MMS. In the Pacific region, the MMS would investigate the cause of any hazardous material spill, regardless of size. Considering the quantities of hazardous materials that would be present at a wind energy project site, as reported in Table 4.2.6-1, it is unlikely that any single spill would exceed 50 bbl, if appropriate precautions are taken. Even so, during construction, significant quantities of dielectric fluids, fuels, and lubricants would be delivered for later use during operations or storage at a centrally located ESP. For example, as many as four transformers, each containing up to 37,500 L (10,000 gal) of a dielectric fluid, such as mineral oil, could be delivered to the ESP during construction. In the unlikely event that a catastrophic rupture of one or more of the transformers occurred during construction, some impacts could result along the shore (see Section 5.2.4.4). If smaller spills of hazardous materials occurred, those spills could cause localized impacts. The nature of the impacts would depend on factors such as, but not limited to, prevailing winds and currents, quantity spilled, and proximity of the spill to receptors. Regardless of the projected size or likelihood of a hazardous materials spill at wind facilities on the OCS, implementation of appropriate precautions to prevent spills and implementation of proper mitigation measures when a spill occurs would reduce impacts substantially. Accordingly, impacts from hazardous materials spills during construction of a wind facility would be minor to moderate.

Nonhazardous wastes, hazardous wastes, and recyclable materials that may be generated during construction of wind energy projects are among those indicated in Table 4.2.6-2. The generation of nonrecyclable hazardous wastes is not expected during construction of wind energy projects.

Recyclable and reusable materials would be generated in varying amounts. These would be collected and returned to shore for appropriate management. Recyclable or reusable materials that are hazardous as defined under the Resource Conservation and Recovery Act (RCRA) must be managed during collection and transport in compliance with applicable regulations in 40 CFR 261 and 40 CFR 266. Alternatively, they could be collected and returned to shore for appropriate treatment and disposal at permitted hazardous waste treatment and disposal facilities. As Chapter 4 indicates, disposal facilities for hazardous wastes are available onshore in all three OCS regions. Hence, impacts that would result from managing recyclable or reusable materials as hazardous wastes during construction of wind energy projects would be negligible on the OCS, and onshore impacts would be minor.

Nonhazardous wastes would be generated in small quantities, collected, and returned to shore for appropriate treatment and disposal in a permitted disposal facility, except possibly sanitary waste. If bentonite drilling fluid were to be inadvertently released during drilling for the transmission cable hookup, it would be collected as much as practicable and removed to shore for disposal in an appropriate nonhazardous waste facility. As Chapter 4 indicates, disposal facilities for nonhazardous solid and industrial wastes are available onshore in all three OCS regions. Hence, impacts that result from managing nonhazardous wastes during construction of wind energy projects would be negligible on the OCS, and onshore impacts would be minor.

5.2.6.4 Operation

Section 3.2 describes the components of a wind energy project, which include the support structures for the WTGs, the WTGs themselves, electricity transmission cables, and voltage transformers. Table 4.2.6-1 lists the expected types of hazardous materials associated with these components and presents the amounts of such materials that would be present in equipment or in storage during operation of a wind energy project. Sections 4.2.6, 4.3.6, and 4.4.6 discuss the total quantity of hazardous materials, including petroleum products and chemical products, shipped on the ocean during 2004 in the three OCS regions. Based on the information in Table 4.2.6-1 and Sections 4.2.6, 4.3.6, and 4.4.6, the total amounts of hazardous materials being used or stored at wind energy sites on the OCS would be minuscule compared to the total amount of hazardous materials transported by ocean vessels on the OCS.

Impacts from transporting wastes and materials to and from wind energy sites during their operating periods are discussed in Section 5.2.17. As during construction, impacts from using and storing hazardous materials at wind energy sites for maintenance during operation may occur due to accidental spills. Such spills would be like those that might occur during construction, which are discussed in Section 5.2.6.3. Implementation of appropriate precautions to prevent spills and implementation of proper mitigation measures when a spill occurs would reduce impacts substantially. Accordingly, impacts from hazardous materials spills during operation of a wind facility would be minor to moderate.

The generation and management of nonhazardous wastes, hazardous wastes, and recyclable materials would be the same during operation of wind energy projects as described in Section 5.2.6.3 for construction. Therefore, the impacts of these activities would also be like the impacts during construction. Specifically, the generation of nonrecyclable hazardous wastes is not expected during operation, and impacts that would result from managing recyclable or reusable materials and from managing nonhazardous wastes would be negligible on the OCS. Onshore impacts would be minor.

5.2.6.5 Decommissioning

This section addresses impacts that may result from hazardous materials and waste management during decommissioning of wind energy projects.

As was explained in Section 5.2.6.4, the total amounts of hazardous materials being used or stored at wind energy sites on the OCS would be minuscule compared to the total amount of hazardous materials transported by ocean vessels on the OCS. It is assumed that any hazardous materials stored at a wind energy site or contained in equipment would be removed from the site early in decommissioning. Impacts from transporting these wastes and materials to shore are discussed in Section 5.2.17. Impacts from using and removing hazardous materials at wind energy sites during decommissioning may occur as a result of accidental spills. Such spills would be like those that might occur during construction, which were discussed in Section 5.2.6.3. Implementation of appropriate precautions to prevent spills and implementation of proper mitigation measures when a spill occurs would reduce impacts substantially. Accordingly, impacts from hazardous materials spills during decommissioning of a wind facility would be minor to moderate.

The generation and management of nonhazardous wastes, hazardous wastes, and recyclable materials would be the same during decommissioning of wind energy projects as described in Sections 5.2.6.3 and 5.2.6.4 for construction and operation. Therefore, the impacts of these activities would also be like the impacts during construction and operation. Specifically, the generation of nonrecyclable hazardous wastes is not expected during decommissioning, and impacts that would result from managing recyclable or reusable materials and from managing nonhazardous wastes would be negligible on the OCS. Onshore impacts would be minor.

5.2.6.6 Mitigation Measures

Impacts from hazardous materials and waste management activities associated with wind energy projects would be reduced further by the management practices and mitigation measures listed below.

- Develop a hazardous materials management plan addressing storage, use, transportation, and disposal of each hazardous material anticipated to be used at the site. Emergency response procedures, including notification requirements, should also be incorporated.

- Develop a waste management plan that includes waste minimization procedures and pollution prevention goals.

- Develop a spill prevention and response plan that includes training and notification requirements.

- Provide secondary containment for all hazardous materials containers, including liquid fuel tanks and transformers.

- Store both recyclable and nonrecyclable hazardous wastes in closed containers with appropriate labels, and remove the containers in accordance with the site's written waste management plan.

- Applicants developing alternative energy facilities in offshore waters, including the installation of subsea transmission cables, should consult with the appropriate military agencies during case-specific siting processes to ensure avoidance of disposal areas possibly containing chemical weapons.

- Applicants should substitute environmentally preferable or "green" materials for less environmentally friendly fluids such as dielectric fluid alternatives (e.g., natural esters rather than mineral oil) whenever possible. These materials are derived from renewable, domestically produced seed oils, are not listed as suspected carcinogenic agents, and meet stringent performance requirements.

- Report any oil spilled in State waters, or having the potential to reach State waters, to the appropriate local, State, and Federal authorities.

5.2.7 Electromagnetic Fields

The electromagnetic field (EMF) analysis in this section includes an assessment of anticipated EMF impacts from ocean-based electrical transmission lines.

5.2.7.1 Technology Testing

During technology testing, EMF impacts may arise if a submarine cable is laid to shore from the study area or among generation units. Such impacts are discussed in Section 5.2.7.4.

5.2.7.2 Site Characterization

No EMF impacts are expected during site characterization activities because power cables between units and/or onshore locations will not yet be in operation.

5.2.7.3 Construction

No EMF impacts are expected during facility construction activities because power cables between units and/or onshore locations would not yet be in operation.

5.2.7.4 Operation

The proposed cable system would be shielded to effectively block the electric field produced by the conductors. Therefore, no electric field impacts are expected from the submarine cables.

With regard to potential magnetic field impacts from submarine cables, the following summary considerations support an absence of impacts on living organisms (ICNIRP 2000; NAS 1993; VNTSC 1994):

- 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), but such a receptor would not be affected by power lines, 60-Hz magnetic fields, which alternate in direction, and average to zero over 1/60th of a second.

- The actual magnitude of typical 60-Hz magnetic fields in the vicinity of the submarine cables is, in most locations, manyfold below that of the steady geomagnetic field (~500 milliGauss [mG]).

- The very low energy content of 60-Hz EMF means that the amount of radiative thermal energy absorbed by nearby sea creatures would be extremely small.

Investigations of the potential effects of the electromagnetic field associated with the cable lines for the Nysted offshore wind facility in Denmark indicated that the migration behavior of some fish species (Baltic herring, common eel, Atlantic cod, and flounder) was altered, but not completely blocked, in the vicinity of the cables (Dong Energy et al. 2006). As long as sufficient numbers of individuals pass over cables to maintain genetic diversity, population-level effects on aquatic organisms would be unlikely to occur. Thus, while it is expected that the impacts of EMF on populations of aquatic species would be negligible to minor, uncertainties remain and additional studies are needed on the potential effects on species that inhabit the U.S. coasts in the vicinity of proposed projects. Additional discussion on EMF impacts to aquatic species can be found in Sections 5.2.11.4 and 5.2.14.4.

5.2.7.5 Decommissioning

No EMF impacts are expected during decommissioning activities because power cables between units and/or onshore locations would not be in operation.

5.2.7.6 Mitigation Measures

Mitigation measures that may be undertaken include use of a submarine cable that has the proper electrical shielding and burial of the cable in the ocean floor.

5.2.8 Marine Mammals

Because of differences in distribution and ecology, not all species of marine mammals that occur off the Atlantic, Gulf of Mexico, or Pacific Coasts would be expected to be equally exposed to or affected by activities associated with development of wind energy in OCS waters. A number of these species, such as the fin and blue whales, are extremely rare or considered extralimital in some OCS waters but are often seen in other OCS waters. Many of the other species are relatively uncommon or very limited in their distributions and thus are unlikely to be exposed to wind energy development at any given location within OCS waters.

In contrast, other species such as many of the odontocetes (toothed whales) are considered relatively common in some of the OCS waters. Thus, there is a greater potential that some of these species may occur in areas where they could be affected by wind energy-related activities.

Potential impacts to threatened or endangered species of marine mammals from wind energy technology testing, site characterization, construction, operation, and decommissioning would be similar in nature to the impacts identified for nonlisted species and could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA and MMPA regulations and coordination with the NMFS and USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.2.8.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would likely skip the demonstration phase and move directly toward commercial operation. As a consequence, there would be no anticipated impacts to marine mammals from technology testing activities. In the event that a demonstration wind project were undertaken, the impacts to marine mammals would be similar to those described for site characterization and facility construction (see Sections 5.2.8.2 and 5.2.8.3), but the level of impacts would be greatly reduced and, with the possible exception of threatened and endangered species, impacts to marine mammals during technology testing are expected to be negligible.

5.2.8.2 Site Characterization

Activities associated with site characterization that may affect marine mammals include (1) geological and geophysical surveys, (2) construction of one or more meteorological towers, (3) construction vessel traffic, (4) discharges of waste materials and accidental fuel releases, and (5) meteorological tower decommissioning.

5.2.8.2.1 Geological and Geophysical Surveys. Geological and geophysical surveys may be employed to characterize ocean-bottom topography and subsurface geology. Noise generated by such surveys may have physical and/or behavioral effects on marine mammals, such as (1) hearing loss, discomfort, and injury; (2) masking of important sound signals; and (3) behavioral responses such as fright, avoidance, and changes in physical or vocal behavior (Richardson et al. 1995; Davis et al. 1998; Gordon et al. 1998). There have been no documented instances of deaths of or direct physical injuries to marine mammals from geological and geophysical surveys (Continental Shelf Associates 2004). However, it is important to note that these types of effects have not been directly tested for and are likely difficult to detect (i.e., nonimmediate mortality, sinking of carcasses). Because of its restriction to nearshore coastal marine and freshwater habitats, the endangered West Indian manatee would be unlikely to come in contact with offshore geological and geophysical surveys. The marine mammals most likely to be exposed to and affected by such routine surveys are the cetaceans and pinnipeds.

Physical impacts of geological and geophysical survey noise on marine mammals may range from temporary hearing impairment to gross physical injury (Richardson et al. 1995) depending on the survey technique employed (air-gun arrays, side-scan sonar). Hearing impairment and gross physical injury could occur with the use of high-energy air-gun arrays. Because geological and geophysical characterization for siting wind energy towers would most likely employ low-energy and high-frequency techniques, such as side-scan sonar rather than air-gun arrays (see Section 3.5.2 for descriptions of geological and geophysical survey methods that may be used during site characterization), physical impacts to marine mammals from geological and geophysical characterization surveys may be less likely to occur. Side-scan sonar is a low-energy system that generates noise levels that may be less likely to cause hearing impairment or physical injury. For example, the NMFS (2002), in issuing an incidental harassment authorization for seismic data collection off of southern California, concluded that the short-term impact of collecting marine seismic reflection data with multiple instrument systems including side-scan sonar would result, at worst, in a temporary modification in the behavior of certain species of marine mammals and possibly some individuals. It was further concluded that while behavioral modifications may occur in some species of marine mammals to avoid the noise generated by the air gun arrays, the behavioral changes are expected to affect only small numbers of each of several species of marine mammals that may be present in the survey area and would have no more than a negligible impact on the affected species of marine mammals. Marine mammals in the vicinity of the geological and geophysical surveys may be expected to be similarly affected, although the nature and magnitude of potential effects would depend on the location of a proposed project, the species affected, the number of individuals affected, the time of year, and the survey instrumentation used at that location.

A number of studies have documented behavioral reactions of cetaceans to noise generated by geological and geophysical surveys (Richardson et al. 1995). Behavioral reactions may include avoidance of or flight from the sound source and its immediate surroundings, disruption of feeding behavior, interruption of vocal activity, and modification of vocal patterns (Watkins and Scheville 1975; Malme et al. 1984; Bowles et al. 1994). The biological importance of such responses (e.g., effects on energetics, survival, reproduction, population status) is unknown, and there is little information regarding short-term or long-term effects of behavioral reactions on marine mammal populations.

In general, seals have been reported to move away from seismic vessels, although some have been observed swimming in the vicinity of large geological and geophysical arrays (NMFS, 67 CFR 35793; Thomson and Davis 2001; USDOI/MMS 2003b). Small groups or individual pinnipeds may be locally displaced during geological and geophysical activities. Because geological and geophysical surveys would occur away from coastal habitats, routine surveys are not expected to disturb pinnipeds (including the endangered Steller sea lion) or the sea otter in coastal habitats such as rookeries, haulouts, and nearshore foraging areas. However, seals present in waters over the continental slope may be disturbed by geological and geophysical surveys.

While a geological and geophysical survey may disturb more than one individual, routine surveys are not expected to result in population-level effects. Individuals disturbed by a survey would likely return to normal behavioral patterns after the survey has ceased (or after the animal has left the survey area). Because cetaceans and pinnipeds are highly mobile, they may be expected to quickly leave an area when a geological and geophysical survey is initiated. Little information is available regarding the subsequent health and condition of such displaced individuals.

Because of the limited duration of geological and geophysical surveys, as well as the likelihood that marine mammals would leave the immediate vicinity of the surveys, impacts of such surveys to marine mammals in general would be negligible. However, behavioral changes (including alteration of migration paths) may result in minor impacts to threatened and endangered mysticetes.

5.2.8.2.2 Construction-related Noise. During meteorological tower construction, marine mammals in the vicinity of the construction site may be disturbed by noise generated during pile driving. Pile driving would generate sound levels up to 180 dB and have a relatively broad band of 20 Hz to >20 kHz (Madsen et al. 2006; Thomsen et al. 2006). Such noise could disturb normal behaviors (e.g., feeding, social interactions), mask calls from conspecifics, disrupt echolocation capabilities, and mask sounds generated by predators. Behavioral effects may be incurred at ranges of many miles, and hearing impairment may occur at close range (Madsen et al. 2006). Behavioral reactions may include avoidance of, or flight from, the sound source and its immediate surroundings, disruption of feeding behavior, interruption of vocal activity, and modification of vocal patterns (Watkins and Scheville 1975; Malme et al. 1984; Bowles et al. 1994; Mate et al. 1994). Depending on the frequency of the noise generated during construction of the meteorological towers, impacts to marine mammals may also include temporary hearing loss or auditory masking (Madsen et al. 2006). The biological importance of hearing loss or behavioral responses to construction noise (e.g., effects on energetics, survival, reproduction, population status) is unknown, and there is little information regarding short-term or long-term effects of behavioral reactions on marine mammal populations.

While noise generated during construction of a meteorological tower may affect more than one individual, population-level effects are not anticipated. Some species may be expected to quickly leave the area with the arrival of construction vessels, before pile-driving activities are begun, while individuals remaining in the area may flee with the initiation of construction, thereby greatly reducing their exposure to maximal sound levels and, to a lesser extent, masking frequencies. Individuals disturbed by or experiencing masking due to construction noise would likely return to normal behavioral patterns after the construction had ceased (pile driving is anticipated to be completed within a 3-day period), or after the animal has left the survey area. Little information is available regarding the subsequent health and condition of such displaced individuals.

Construction of a meteorological tower would be of relatively short duration and limited to one or two locations. Because marine mammals would be expected to leave the immediate vicinity of the tower during its construction, impacts to marine mammals in general would be minor. Hearing damage, auditory masking, or behavioral changes (including alteration of migratory paths) may, however, result in minor impacts to most marine mammals and in moderate impacts to threatened or endangered species.

5.2.8.2.3 Vessel and Helicopter Traffic. Vessel traffic bringing equipment and personnel to meteorological tower construction sites may affect marine mammals either by direct collisions with vessels or by disturbances from either vessels or helicopters. At least 11 species of cetaceans have been documented to have been hit by ships in the world's oceans, and in most cases the whales were not seen beforehand or were seen too late to avoid collision (Laist et al. 2001; Jensen and Silber 2004). Whale strikes have been reported at vessel speeds ranging from 2–51 knots (2–59 mph), with most lethal or severe injuries occurring at ship speeds of 14 knots (16 mph) or more (Laist et al. 2001; Jensen and Silber 2004). Whale strikes have occurred with a wide variety of vessel types, including Navy vessels, container and cargo ships, freighters, cruise ships, and ferries (Jensen and Silber 2004), and collisions with vessels greater than 80 m (260 ft) in length are usually either lethal or result in severe injuries (Laist et al. 2001).

Ship strikes have been recorded in U.S. waters in almost every coastal State. Collisions between whales and vessels have been most commonly reported along the Atlantic Coast, followed by the Pacific Coast (including Alaska and Hawaii); ship-whale collisions have been least common in the Gulf of Mexico (Jensen and Silber 2004). In addition, most ship strikes seem to occur over or near the continental shelf (Laist et al. 2001).

The most frequently struck species has been the fin whale, followed by humpback, North Atlantic right, gray, minke, southern right, and sperm whales (Jensen and Silber 2004). Among these species, the sperm whale is a common resident of the northern Gulf as well as the Atlantic seaboard, the North Atlantic right whale has six major congregation areas from Florida to Maine, the humpback and fin whale congregate at feeding grounds in the North Atlantic, and the North Pacific gray whale is relatively common along the Pacific Coast during spring and fall migrations. Thus, among these species, the sperm whale in Gulf of Mexico and Atlantic waters, the North Atlantic right whale along the Atlantic Coast, the humpback and fin whales in the North Atlantic, and North Pacific gray whale along the Pacific Coast may be considered most likely to encounter vessels supporting the construction of meteorological towers on OCS waters. Because of the very low estimated population size for the western stock of the Atlantic right whale (fewer than 400 individuals), this species may be especially susceptible to incurring population-level impacts from a vessel strike involving a single female animal.

Among the nonlisted and smaller cetaceans and pinnipeds, many are relatively abundant and thus may be more likely to encounter OCS-related vessels that are in transit to and from meteorological tower construction sites. At times, many of these species, such as the dolphins and seals, are attracted to moving vessels and spend periods of time following moving vessels or swimming within the bow waves of ships, even those traveling at high speeds. Because these species are agile, powerful swimmers, they are usually capable of avoiding collisions with oncoming vessels. Nevertheless, some may be injured by vessels (e.g., contacting propellers). Such injuries may or may not be lethal, and they may be expected to be relatively uncommon and not result in population-level effects. Vessel strikes in inland waterways are a major cause of death in the manatee population (USFWS 2002). This species occurs primarily along the Florida coast and could encounter OCS-related vessels traveling between construction sites and inland harbors and marinas. However, because this species is rare in the Eastern Gulf of Mexico, Straits of Florida, and South Atlantic waters, encounters with the very limited number of meteorological tower construction vessels expected in these areas would be unlikely. Impacts from vessel strikes may be expected to be minor for most species, but could be moderate to major for species that are threatened or endangered, such as the mysticetes.

In addition to vessel collisions, marine mammals may also be affected by the noise generated by surface vessels traveling to and from construction sites. Exposure of marine mammals to individual construction vessels would be transient, and the noise intensity would vary depending upon the source and specific location. Reactions of marine mammals may include apparent indifference, cessation of vocalizations or feeding activity, and evasive behavior (e.g., turns, diving) to avoid approaching vessels (Richardson et al. 1995; Nowacek and Wells 2001). Behavior would likely return to normal following passage of the vessel or helicopter, and it is unlikely that such short-term effects would result in long-term population-level impacts for most species of marine mammals. Thus, impacts from vessel noise would be short-term and negligible.

Marine mammals may also be disturbed as a result of overflights of helicopters supporting offshore construction activities. Individuals beneath or near the flight paths may be startled by the presence of noise of the passing helicopter, ceasing normal behaviors and diving or fleeing the immediate area to avoid the oncoming helicopter (see Richardson et al. 1995 and Withrow et al. 1985), but may be expected to return after the helicopter has left the area. Helicopter overflights have a greater potential to adversely affect pinniped rookery sites, where disturbed adults may temporarily cease normal behaviors (such as feeding of young), leave the rookery site thereby increasing predation risks of unattended pups, or trample young while fleeing. While temporary disturbance of pinnipeds in coastal and offshore waters is expected to have negligible population-level effects, cub or pup survival may be reduced if adults temporarily abandon their young or trample young during flight, and thus result in minor to moderate population-level impacts.

Large groups of humpbacks have been observed to show little to no response to small aircraft, while groups containing only adults showed some avoidance (Richardson et al. 1995). Fin whales have been observed to react slightly to small aircraft circling at altitudes of about 160 to 980 ft (50–300 m) above the surface. Helicopter traffic is probably more disruptive, but few data are available on the effects of helicopter overflights on these or other species. Cetaceans disturbed by helicopter overflights may be expected to cease their normal behaviors. Because of the short duration and transient nature of a helicopter overflight, affected individuals may be expected to resume normal behaviors following passage of the helicopter and incur negligible to minor impacts.

5.2.8.2.4 Discharge of Waste Materials and Accidental Fuel Leaks. Marine mammals could be exposed to operational discharges or accidental fuel releases from construction sites and construction vessels and to accidentally released solid debris. Operational discharges from construction vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal. Sanitary and domestic wastes would be processed through on-site waste treatment facilities before being discharged overboard. Deck drainage would also be processed prior to discharge. Thus, waste discharges from construction vessels would not be expected to directly affect marine mammals.

Ingestion of, or entanglement with, solid debris can adversely impact marine mammals. Mammals that have ingested debris, such as plastic, may experience intestinal blockage, which in turn may lead to starvation, while toxic substances present in the ingested materials (especially in plastics) could lead to a variety of lethal and sublethal toxic effects. Entanglement in plastic debris can result in reduced mobility, starvation, exhaustion, drowning, and constriction of, and subsequent damage to, limbs caused by tightening of the entangling material. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]). Thus, entanglement in or ingestion of OCS-related trash and debris by marine mammals would not be expected during normal operations.

Because of the very limited amount of vessel traffic and construction activity that might occur with construction and operation of a meteorological tower, the release of liquid wastes would occur infrequently and cease following completion of tower construction. The likelihood of an accidental fuel release would also be limited to the active construction and decommissioning periods of the site characterization. Impacts to marine mammals from the discharge of waste materials or the accidental release of fuels are expected to be negligible.

5.2.8.2.5 Meteorological Tower Decommissioning. Upon completion of site characterization, the meteorological tower would be removed and transported by barge to shore. During this activity, marine mammals may be affected by noise and operational discharges as described for meteorological tower construction. Removal of the piles would be accomplished by cutting the piles (using explosives, acetylene torches, mechanical cutting, or high-pressure water jet) at a depth of 4.6 m (15 ft) below the seabed. Marine mammals could be affected by noise during pile cutting. If employed, explosive removal could affect marine mammals from pressure- and noise-related effects. Underwater explosions associated with the removal of offshore meteorological towers may generate broadband noise, with sound levels of 267 dB re µPa-m or more (Section 3.1.1.5). Exposure criteria developed by the U.S. Navy (as cited in Frankel and Ellison 2005) to evaluate potential impacts of impulsive sounds (i.e., underwater detonations) on marine biota include a sound level of 182 dB re µPa-m, at which marine mammals could be affected during explosive tower removal. The nature and magnitude of effects would depend on the size of the charges used for an explosive detonation, the surrounding water depth, the distance to the nearest marine mammal, the number of marine mammals exposed to sound levels greater than 182 dB re µPa-m, and the species affected. Only animals in the immediate vicinity of the characterization site (those that had not moved away from the area upon arrival of decommissioning vessels) would be expected to be affected during tower removal and transport, and pile cutting. Disturbance of marine mammals during decommissioning is expected to be minor.

5.2.8.3 Construction

Construction activities associated with a wind facility development could affect marine mammals in a variety of ways. Construction-related impacting factors include: (1) geological and geophysical surveys, (2) construction noise, (3) vessel traffic, and (4) waste discharge and accidental fuel releases. These impacting factors would be associated with construction of the turbine platforms and offshore transformers or substations, placement of cables from the turbine towers to the offshore transformer or substation, and placement of cables from offshore facilities to onshore facilities.

5.2.8.3.1 Geological and Geophysical Surveys. Geological and geophysical surveys conducted to more fully characterize bottom topography and subsurface geology at individual turbine platform locations could affect marine mammals in the same manner as described for site characterization (Section 5.2.8.2). Marine mammals exposed to geological and geophysical surveys could exhibit behavioral changes. Impacts to marine mammals are expected to be negligible for most species, and minor for species that are threatened or endangered.

5.2.8.3.2 Construction Noise. Noise generated during construction of platforms and associated infrastructure such as the ESP could disturb marine mammals that may be present in the vicinity of the construction area. Most noise would be generated during pile-driving for the turbine platforms, which could generate sound levels up to 180 dB for 4 to 6 h for each pile. These sounds would also have a relatively broad band of 20 Hz to >20 kHz (Madsen et al. 2006; Thomsen et al. 2006). Noise generated during construction could disturb normal behaviors (e.g., feeding, social interactions), mask calls from conspecifics, disrupt echolocation capabilities, mask sounds generated by predators, or cause animals to avoid preferred habitat during construction or even permanently relocate to other habitats. Behavioral effects may be incurred at ranges of many miles, and hearing impairment may occur at close range (Madsen et al. 2006).

For individual wind platforms, such effects would likely be limited to individuals or small groups that are present in the vicinity of the tower platform and not entire populations. In most cases, affected individuals or groups would be expected to leave the construction area upon arrival of construction equipment and initiation of pile-driving activities, thereby reducing the likelihood of exposure to noise levels that could impact hearing.

As discussed in Section 5.2.8.2, odontocetes may be less prone to hearing loss from construction noise, while mysticetes may be more likely to be affected by construction noise. In general, however, noise impacts to most marine mammals would be minor. However, disturbance of normal behaviors, masking, or hearing damage of individuals during migrations between winter calving areas and summer feeding grounds or in feeding areas could result in moderate impacts to some species. Impacts to species that are threatened or endangered may be minor or moderate, depending on the nature of the effect. Greater impacts may be incurred if individuals avoid or are permanently displaced from preferred habitats.

5.2.8.3.3 Vessel Traffic. Marine mammals may be injured or killed as a result of collisions with vessels supporting construction activities. As discussed in Section 5.2.8.2, at least 11 species of cetaceans have been documented to be hit by ships in the world's oceans, and in most cases the whales are not seen beforehand or are seen too late to avoid collision (Laist et al. 2001; Jensen and Silber 2004).

Collisions between whales and vessels have been most commonly reported along the Atlantic Coast, followed by the Pacific Coast (including Alaska and Hawaii); ship-whale collisions have been least common in the Gulf of Mexico (Jensen and Silber 2004). In addition, most ship strikes seem to occur over or near the continental shelf (Laist et al. 2001). The most frequently struck species has been the fin whale, followed by humpback, North Atlantic right, gray, minke, southern right, and sperm whales (Jensen and Silber 2004). Among these species, the sperm whale is a common resident of the northern Gulf as well as the Atlantic seaboard, the North Atlantic right whale has six major congregation areas from Florida to Maine, the humpback and fin whale congregate at feeding grounds in the North Atlantic, and the North Pacific gray whale is relatively common along the Pacific Coast during spring and fall migrations. Thus, among these species, the sperm whale in Gulf of Mexico and Atlantic waters, the North Atlantic right whale along the Atlantic coast, the humpback and fin whales in North Atlantic, and North Pacific gray whale along the Pacific Coast may be considered most likely to encounter vessels supporting the construction of wind platforms on OCS waters.

Marine mammals in coastal habitats may encounter vessels traveling between offshore construction sites and onshore facilities, and also vessels placing cables between the offshore turbines and onshore electric distribution facilities. Species such as the endangered West Indian manatee in the southern Atlantic OCS waters and the California sea otter and Guadalupe fur seal in the southern California waters could be injured or killed by collisions with these vessels.

Because of the low level of vessel traffic that could occur during construction, potential impacts to marine mammals from this traffic would likely be limited to a few individuals, be largely short-term, and for many of the species not result in population-level effects. Thus, impacts to marine mammals from ship collisions are expected to be minor for most species. Collisions of the threatened and endangered species of marine mammals could result in long-term population-level effects, depending on the number of individuals affected and the particular species involved. Injuries to threatened or endangered species, however, could result in moderate to major impacts to these species.

5.2.8.3.4 Waste Discharge and Accidental Fuel Releases. Operational discharges from OCS service and construction vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal (Section 5.2.6.3). Permitted operational discharges at a construction site would be quickly diluted and dispersed by local currents, and thus are expected to have a negligible impact on marine mammals. Because of the small amount of fuels or other potentially hazardous materials that may be present at any given time during construction (see Section 5.2.6.3), accidental spills, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents, and thus are not expected to pose a threat to marine biota. Thus, potential impacts to marine mammals from accidental spills of hazardous materials are expected to be negligible.

Ingestion of, or entanglement with, solid debris can adversely impact marine mammals (Marine Mammal Commission 2003). Mammals that have ingested debris, such as plastic, may experience intestinal blockage, which in turn may lead to starvation, while toxic substances present in the ingested materials (especially in plastics) could lead to a variety of lethal and sublethal toxic effects. Entanglement in plastic debris can result in reduced mobility, starvation, exhaustion, drowning, and constriction of, and subsequent damage to, limbs caused by tightening of the entangling material. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Thus, entanglement in or ingestion of OCS-related trash and debris by marine mammals would not be expected during construction.

5.2.8.4 Operation

During operation of an offshore wind facility, marine mammals may be affected by (1) turbine noise, (2) service vessel traffic, (3) accidental releases of hazardous materials or fuels, and (4) entanglement with buried transmission cables. Marine mammals may also be affected by the presence of underwater pilings and other project infrastructure that could occupy 10 to 26 km^2 (4 to 10 mi^2) of ocean habitat.

5.2.8.4.1 Turbine Noise. During normal operations, mechanical noise from turbines may be transmitted underwater through the turbine towers and foundations (pilings) (Section 5.2.4.4). Underwater noise from a turbine may reach levels of 90 to 115 dB at a distance of 110 m (360 ft) in moderate winds, and cover a frequency range of 20 to 1,200 Hz, with peak levels at 50, 160, and 200 Hz (Thomsen et al. 2006). At these levels, impacts to marine mammals could be affected in a manner similar to that identified for wind turbine generator construction although noise levels generated during construction may be expected to be much greater than levels generated during normal operations. Affected animals may exhibit behavioral modifications such as changes in foraging, socialization, or movement. Affected animals may also experience auditory masking, which in turn could affect foraging and predator avoidance.

In contrast to the relatively short period during which construction noise could affect marine mammals, and the limited number of locations where construction noise would be generated at any particular time, noise generated during normal operations may affect many more species and individuals, and for a much longer time period. Under normal operations, there would be continuous or near continuous generation of 90 to 115 dB noise levels at frequencies detectable by marine mammals. These noise levels would be generated over the entire wind facility (over 10 to 26 km^2 [4 to 10 mi^2]). Such noise generation could result in the long-term avoidance of the wind facility area and surrounding vicinity. (Depending on the distance, operational noises are transmitted underwater to levels actively avoided by, or affecting, marine mammals.) This could lead to abandonment of feeding or mating grounds (such as those of the North Atlantic right whale off the New England coast) and disruption of migratory routes (such as those followed by the humpback whale along the Pacific Coast), which could result in long-term population level effects. Thus, normal operational noise may result in moderate impacts to marine mammals, especially those that may have important feeding or mating areas or migratory routes intersected by a major wind facility.

5.2.8.4.2 Service Vessel Traffic. During normal operations, there would be at least one vessel trip to and from the wind facility each day to perform maintenance duties. Marine mammals may be affected by this traffic either by direct collisions with, or disturbance by, these vessels. Animals may be injured or killed as a result of ship collisions, while ships traveling to and from wind facilities may disturb animals in the vicinity of their path. Disturbed individuals may be expected to leave the vicinity of the ship and return to normal behavior following passage of the ship. Because of the low level of vessel traffic that could occur during normal operations, potential impacts to marine mammals from this traffic would likely be limited to a few individuals, be largely short-term, and not result in population-level effects. Thus, impacts to marine mammals from ship collisions are expected to be minor. Injuries to threatened or endangered species (especially the North Atlantic right whale), however, could result in moderate to major impacts to the affected species.

In addition to vessel collisions, marine mammals may be affected by the noise generated by ships traveling to and from the wind facilities. While there is a certain background level of ship noise in each of the Atlantic, Pacific, and Gulf of Mexico OCS waters, exposure of marine mammals to individual wind facility maintenance vessels would be transient, and the noise intensity would vary depending upon the source and specific location. Reactions of marine mammals may include apparent indifference, cessation of vocalizations or feeding activity, and evasive behavior (e.g., turns, diving) to avoid approaching vessels (Richardson et al. 1995; Nowacek and Wells 2001). Behavior would likely return to normal following passage of the vessel, and it is unlikely that such short-term effects would result long-term population-level impacts. Thus, disturbance of marine mammals by maintenance vessels is expected to be negligible.

5.2.8.4.3 Accidental Releases of Hazardous Materials or Fuels. Discharges from service vessels, or accidental or gradual releases of electrical insulating oil, diesel fuel, or lubricating oil from a central ESP, would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal (Section 5.2.6.3). Operational discharges would be quickly diluted and dispersed by local currents, and thus are expected to have a negligible impact on marine mammals. Because of the small amount of fuels or other potentially hazardous materials that may be present or used at any given time during normal operations (see Section 5.2.6.4), accidental releases or spills, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents and thus would not be expected to pose a threat to marine biota. Thus, potential impacts to marine mammals from small or gradual accidental spills of hazardous materials are expected to be negligible.

Wind facilities utilizing a central ESP may have transformers that contain large reservoirs (150,000 L [40,000 gal]) of electrical insulating oil (such as mineral oil), as well as smaller amounts (7,600 L [2,000 gal]) of additional fluids such as diesel fuel and lubricating oil. In the event of a catastrophic release of all these materials (see Section 5.2.4.4), marine mammals may be exposed to the spilled fluids by 1) direct contact, 2) inhalation, and 3) ingestion (directly, or indirectly through the consumption of prey species affected by oil). Fouling of fur of some species (e.g., sea otter and seals) could affect thermoregulation and reduce survival. Spill cleanup operations may also result in short-term disturbance of marine mammals in the vicinity of the cleanup site, while a collision with a cleanup vessel could injure or kill the affected individual.

The magnitude of effects from accidental spills would depend on the location, timing, and volume of the spills; the environmental settings of the spills (e.g., restricted coastal waterway, deeper-water pelagic location), the toxicity of the materials released, the species (and its ecology) exposed to the spills, and the nature and magnitude of exposure. For example, spills that occur in or reach coastal areas and islands, and especially sheltered coastal habitats such as bays and estuaries, would be more likely to affect coastal delphinids, pinnipeds, the sea otter, and the West Indian manatee than more open- and deep-water-inhabiting marine mammals. A large spill contacting an active pinniped rookery or haulout site could result in population-level effects for the affected species.

Thus, potential impacts to marine mammals may range from negligible to major, depending on the size of the spill (50 gal vs. 40,000 gal), the materials released (type of electrical insulating fluid), the species (common, endangered) exposed to the accidental spill, the type of exposure (direct contact, ingestion), and the nature and effectiveness of spill containment and cleanup activities.

The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Thus, entanglement in or ingestion of OCS-related trash and debris by marine mammals would not be expected during normal operations.

5.2.8.4.4 Entanglement. The gray whale, which feeds on bottom-dwelling invertebrates, could encounter buried transmission cables connecting offshore wind facilities with onshore infrastructure and become entangled or injured. Depending on the number of individuals affected, contact with buried transmission cables may result in minor to moderate impacts to the gray whale.

5.2.8.5 Decommissioning

Decommissioning of a wind facility would involve the dismantling and removal of infrastructure from each wind turbine platform, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Platforms would be removed by cutting the monopiles (using explosives, acetylene torches, mechanical cutting, or high-pressure water jet) at a depth of at least 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, marine mammals may be affected by (1) noise generated by equipment dismantling the towers, (2) decommissioning vessels, and (3) accidental releases of hazardous materials and fuel.

Decommissioning activities would be similar to construction activities, although largely in reverse and at lower levels. Thus, the types of impacts that could be incurred by marine mammals during decommissioning would be similar in nature to but likely lower in magnitude than impacts associated with facility construction. While the major impacting factor associated with construction, namely pile driving (see Section 5.2.8.3.2), would not occur during decommissioning, explosives may be used for the removal of some platforms. During such platform removal, marine mammals in close proximity of the detonations could be injured from pressure- and noise-related effects. In contrast to noise generated during pile driving, which would be continuous at each platform location for a short time period, noise resulting from the use of explosives would be a one-time event at each platform location, thus limiting the likelihood and duration of exposure by marine mammals.

With the possible exception of explosive platform removal, impacts to marine mammals from decommissioning are expected to be negligible to minor. The potential for adversely affecting marine mammals may be further reduced if marine mammals have been avoiding the vicinity of the wind facility during normal operations because of operational noise, although it is not known to what extent marine mammals may habituate to operational noise.

5.2.8.6 Mitigation Measures

The principal factors that could affect marine mammals are noise, vessel strikes, and displacement. The measures identified in Section 5.2.5 to mitigate noise generated during site characterization and the construction, operation, and decommissioning of a wind facility would also provide mitigation of noise impacts to marine mammals. Other, general measures that may reduce the likelihood of adverse effects on marine mammals may include the following:

- During site characterization, conduct surveys and coordinate project siting with appropriate resource management agencies (NMFS and USFWS) in order to:
  - Avoid locating facilities near known important cetacean congregation, mating, or feeding areas, such as the six major sites of the endangered northern right whale along the Atlantic Coast.
  - Avoid locating facilities and helicopter flight paths near known coastal rookeries and haulouts of pinnipeds such as the threatened Steller sea lion and Guadalupe fur seal along the Pacific Coast.
  - Avoid locating facilities at known high use areas along migratory routes or at known migratory route bottlenecks.
- Vessels related to project planning, construction, and operation shall travel at reduced speeds when assemblages of cetaceans are observed and maintain a reasonable distance from whales and small cetaceans.
- Coordinate with NMFS and USFWS to determine if MMPA authorization is warranted.

- At least one qualified marine mammal observer should be posted during construction activities. Additional observers may be required by NMFS under any issued MMPA authorization.

- Project-related vessels will follow NMFS Regional Viewing Guidelines while in transit. Operators will be required to undergo training on applicable vessel guidelines.

- Time major noise generating activities, such as geophysical surveys, pile driving, and explosive platform removal (if employed), to avoid periods when marine mammals may be more common in the project area. For example, the endangered fin whale is believed to calve in the Mid-Atlantic OCS waters from October to January.

- Cutting, rather than the use of explosives, should be preferred for platform removal. If explosives are used, platform removal should be conducted in a manner similar to that identified in the guidelines established by the MMS for explosive removal of oil and gas platforms on the Gulf of Mexico (NTL No. 2004-G06). These guidelines include visual surveys to detect marine mammals within the blast zone and the immediate delay of structure removal until the animals have left the area. Such measures would greatly reduce the likelihood of marine mammals being affected by explosive removal of wind platforms during facility decommissioning.

5.2.9 Marine and Coastal Birds

The nature and magnitude of effects of offshore wind energy development on marine and coastal birds would depend on the specific location of the offshore wind facility and its associated infrastructure (e.g., between coastal roost sites and offshore feeding areas), the timing of project-related activities (e.g., platform construction, cable trenching), and the nature and magnitude of the project-related activities (e.g., several miles of trenching through nearshore coastal habitats).

Potential impacts to threatened or endangered species of marine and coastal birds from wind energy technology testing, site characterization, construction, operation, and decommissioning would be similar in nature to the impacts identified for nonlisted species and could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA regulations and coordination with the USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.2.9.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would likely skip the demonstration phase and move directly toward commercial operation. As a consequence, there would be no anticipated impacts to marine and coastal birds from technology testing activities. In the event that a demonstration wind project were undertaken, the impacts to marine and coastal birds would be similar to those described for site characterization and facility construction (see Sections 5.2.9.2 and 5.2.9.3), but the level of impacts would be greatly reduced and, with the possible exception of threatened and endangered species, impacts to marine and coastal birds during technology testing are expected to be negligible.

5.2.9.2 Site Characterization

Site characterization would involve geological and geophysical surveys, the construction of one or more meteorological towers, and meteorological tower decommissioning. During site characterization, birds may be affected by (1) the discharge of liquid wastes, hazardous materials, solid debris, or fuel from survey and construction vessels, (2) collisions with the meteorological tower, and (3) explosive removal of the meteorological tower.

5.2.9.2.1 Discharge of Liquid Wastes, Hazardous Materials, Solid Wastes, or Fuel. Marine and coastal birds could be exposed to operational discharges or accidental fuel releases from construction sites and construction vessels and to accidentally released solid debris. Many species of marine birds (such as gulls) often follow ships and forage in their wake on fish and other prey injured or disoriented by the passing vessel. In doing so, these birds may be affected by discharges of waste fluids (such as bilge water) generated by the vessels. Operational discharges from construction vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal. Sanitary and domestic wastes would be processed through on-site waste treatment facilities before being discharged overboard. Deck drainage would also be processed prior to discharge. Thus, impacts to marine and coastal birds from waste discharges from construction vessels are expected to be negligible.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris (Heneman and the Center for Environmental Education 1988; Ryan 1987, 1990). Entanglement may result in strangulation, the injury or loss of limbs, entrapment, or the prevention or hindrance of the ability to fly or swim, and all of these effects may be considered lethal. Ingestion of debris may irritate, block, or perforate the digestive tract, suppress appetite, impair digestion of food, reduce growth, or release toxic chemicals (Dickerman and Goelet 1987; Ryan 1988; Derraik 2002).

The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]). Thus, entanglement in or ingestion of OCS-related trash and debris by marine and coastal birds is not expected, and impacts to marine and coastal birds would be negligible.

Because of the very limited amount of vessel traffic and construction activity that might occur with construction and operation of a meteorological tower, the release of wastes, debris, hazardous materials, or fuels would occur infrequently and cease following completion of the geological and geophysical surveys, meteorological tower construction, and meteorological tower decommissioning. The likelihood of an accidental fuel release would also be limited to the active construction and decommissioning periods of the site characterization. Impacts to marine and coastal birds from the discharge of waste materials or the accidental release of fuels are expected to be negligible.

5.2.9.2.2 Collisions with Meteorological Towers. It has been estimated that hundreds of millions of birds are killed each year in collisions with communication towers, windows, electric transmission lines, and other structures (see Klem 1989, 1990; Dunn 1993; Shire et al. 2000). It is possible that some birds may collide with the meteorological towers and be injured or killed. Because of the small number of meteorological towers that would be used during site characterization, potential impacts to marine and coastal birds from collisions would be negligible.

5.2.9.2.3 Meteorological Tower Decommissioning. Seabirds, such as the endangered eastern brown pelican, commonly use offshore oil and gas production platforms as rest areas or as temporary shelters during inclement weather (Russell 2005), and they may use meteorological towers for the same purposes. Thus, there is a potential for some birds to be affected during meteorological tower removal. Birds using the meteorological tower would likely leave the platform during dismantling activities. If explosives were used to collapse the tower, any remaining birds would be startled by the underwater detonations and quickly leave the collapsing structure. The MMS conducts detailed technical and environmental reviews of proposed removal projects to ensure that listed species would not be impacted; these reviews include consultation with the NMFS and USFWS. Thus, no impacts to birds would be expected from decommissioning activities.

5.2.9.3 Construction

Marine and coastal birds may be affected by construction related to cable trenching and through the release of liquid wastes, solid debris, hazardous materials, or fuel. These impacting factors would be associated with construction and geological and geophysical survey vessels, placement of cables from the turbine towers to onshore facilities, and onshore construction of cable landfalls, substations, and other infrastructure. Birds may also be displaced from offshore feeding areas and offshore migratory staging and resting areas during construction.

5.2.9.3.1 Cable Trenching. The construction of new offshore structures is not expected to adversely affect marine or coastal birds. Cable trenching may affect birds in nearshore coastal areas if trenching occurs in or near foraging, nesting, staging, or resting areas. For many species, the effects would be primarily behavioral in nature, namely, the short-term avoidance or abandonment of habitats in the immediate area of trenching. Cable trenching near nesting colonies (such as heron rookeries) may disturb adults that are incubating eggs or feeding young, potentially affecting nesting success. Similarly, trenching in or near migratory staging and resting areas may disturb birds from these areas, with unknown consequences. Because trenching could result in some long-term loss of coastal habitat, habitat loss for some coastal birds may also occur. However, the amount of habitat disturbed during cable trenching would be relatively small. Trenching in some coastal habitats may temporarily expose or mobilize food items and attract birds to the trenching locations. Overall, impacts to marine and coastal birds from cable trenching are expected to be negligible to moderate.

5.2.9.3.2 Waste Discharge and Accidental Fuel Releases. Discharges from construction and geological and geophysical survey vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal (Section 5.2.6.3). Operational discharges at a construction site would be quickly diluted and dispersed by local currents, and thus are expected to have a negligible impact on marine or coastal birds. Because of the small amount of fuels or other potentially hazardous materials that may be present at any given time during construction (see Section 5.2.6.3), accidental spills, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents and thus are not expected to pose a threat to marine biota. In addition, spill containment and cleanup would act to reduce and limit the size and extent of accidental spills. Thus, potential impacts to marine or coastal birds from accidental spills of hazardous materials or fuel are expected to be negligible.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris from construction or geophysical/geological survey vessels. Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]), entanglement in or ingestion of trash and solid debris by marine and coastal birds would not be expected during construction and thus have negligible impacts on marine and coastal birds.

5.2.9.3.3 Onshore Construction. Loss or alteration of preferred coastal habitat due to cable landfalls and construction of onshore electrical substations could result in the displacement of individual or groups of birds from important foraging, roosting, migratory staging and resting, and overwintering areas, or from nesting habitats. Disturbance of birds from these locations may affect condition or overwintering survival, and disrupt nesting activities and reduce nesting success of affected birds. Coastal construction may also directly disturb coastal habitats. While the disturbance of birds would be expected to be short-term (lasting only until construction was completed), disturbance of some habitats may be long-term pending natural or engineered recovery, and local population-level effects may be incurred by some species. Thus, impacts to marine and coastal birds are expected to by minor to moderate.

5.2.9.3.4 Offshore Construction. Marine and coastal birds may be displaced during construction from offshore feeding habitats and staging and resting areas if the wind facility is located in such habitats. Birds could be disturbed by construction vessel traffic as well as noise associated with pile driving and construction of above-water portions of the towers and the ESP. Affected birds would be expected to leave the area during the construction period, and some may permanently abandon the area due to the subsequent presence and operation of the completed wind facility. While it is not possible to identify how birds would be affected, individual birds may experience reduced condition due to increased energetics costs associated with traveling to other (and possibly lower quality) feeding habitats.

Population-level effects may result if the affected birds are using the project area to collect food for young birds located at coastal nest sites or rookeries. Displacement of parents to other foraging habitats may increase the time of adults away from the nests, increase risk of nest predation, and possibly decrease feeding intensity, affecting growth and condition of young birds. Alternate foraging habitat may not provide food of similar quality and quantity, potentially affecting both adult birds and young birds in coastal rookeries or nest sites.

Impacts to marine and coastal birds may be negligible to moderate, depending on the habitats and birds affected by the location of the wind facility.

5.2.9.4 Operation

During operation of an offshore wind facility, marine and coastal birds may be affected by collisions with turbine structures and by exposure to accidental releases of hazardous materials or fuels from turbine platforms and service vessels. Marine and coastal birds may also be displaced from feeding, staging, and resting areas by the presence of offshore wind facilities.

5.2.9.4.1 Turbine Collisions and Site Avoidance. As previously discussed (Section 5.2.9.2), it has been estimated that hundreds of millions of birds are killed each year in collisions with communication towers, windows, electric transmission lines, and other structures (Klem 1989, 1990; Dunn 1993; Shire et al. 2000). Annual bird mortality from collisions with oil and gas platforms in the northern Gulf of Mexico has been estimated at 200,000 (Russell 2005). In addition, while bird strike mortality has been reported from all inland wind facilities, frequent collisions have been reported from only a few exposed sites with high migration densities or large numbers of soaring birds (see Thelander et al. 2003; Barrios and Rodriguez 2004). On the basis of reported bird collisions at offshore platforms and onshore wind facilities, marine and coastal birds may collide with offshore wind tower platforms.

In contrast to onshore wind facilities, weather conditions and the tendency for many marine and coastal birds to exhibit flocking behavior and/or daily onshore-offshore movements may increase the potential for bird strikes at offshore wind facilities. In some areas, marine and coastal birds form large congregations which undertake large morning movements from coastal roosting sites to offshore feeding areas (Dirksen et al. 1999). In addition to such daily movements, many marine and coastal birds undergo seasonal migrations along the Pacific and Atlantic Coasts. Birds undergoing such daily or seasonal movements in the vicinity of wind facilities may have a greater potential for encountering offshore wind facilities. Weather may affect offshore collision rates because of its effect on flight behavior (Dirksen et al. 1999; Kingsley and Whittam 2001; Percival 2001; Curry and Kerlinger 2002; Keil 2005). Mist and fog have been shown to reduce the intensity of these morning flights and thus may reduce the potential for collisions. However, foggy conditions act to obscure the view of rotors and towers and may increase the likelihood of collisions (Kingsley and Whittam 2001). Darkness may similarly obscure rotors and towers and thus also increase the potential for bird collisions (Keil 2005).

It is not possible to estimate the collision rate for offshore turbines, as this would depend on the specific location of the facilities and the marine and coastal birds that occur in or migrate through the surrounding areas. Many of the threatened and endangered birds found in coastal habitats (spotted owl, marbled murrelet, least Bell’s vireo) would not be expected to fly to relatively distant, open-water areas where offshore wind facilities would be located and thus would not be expected to be affected at the offshore facilities. In contrast, other marine and coastal birds, as well as migrating inland birds (especially those crossing the Gulf of Mexico), may readily encounter offshore wind facilities and thus have the greatest potential for colliding with rotors and towers. Impacts to these species may be minor to major, depending on the species involved and the number of individuals affected.

Recent studies of the behavior of water birds (birds that can settle on the water surface for foraging and resting) at two offshore Danish wind facilities (Peterson et al. 2006) found migrating flocks of water birds to generally avoid entering the wind facilities, although the responses were highly species-specific. Some species, such as cormorants and gulls, exhibited little avoidance of the wind facilities. Overall, more than 50% of birds heading toward the wind facilities avoided entering the facilities. Studies at these wind facilities also reported some species such as the long-tailed duck to exhibit statistically significant displacements from formerly favored feeding areas after construction of the wind facilities, although the studies concluded that the number of birds displaced would not be expected to result in population-level effects to the affected species.

While similar avoidance and displacement behaviors may be exhibited by water birds along the Atlantic, Pacific, and Gulf coasts, it is unknown how individual species may respond to wind facilities in OCS waters. In addition, the results of the Danish studies should not be extrapolated to migrating birds of species that cannot rest on the water surface, such as neotropical passerines, wading shorebirds, and hummingbirds. These species experience high energetic costs when crossing large expanses of open water (such as the Gulf of Mexico), and deviations in flight paths may adversely affect their condition and ability to successfully reach land.

5.2.9.4.2 Service Vessel Traffic. During normal operations, there would be at least one vessel trip to and from the wind facility each day to perform maintenance duties. Marine and coastal birds disturbed by the presence of these service vessels may flee an area. Displaced birds would move to other habitats and may or may not return. Because of the low level of vessel traffic that could occur during operations, potential impacts to marine and coastal birds would likely be short-term and have negligible effects.

5.2.9.4.3 Accidental Releases of Hazardous Materials or Fuels. Small operational discharges from service vessels or gradual accidental releases of electrical insulating oil, diesel fuel, or lubricating oil from a central ESP would be released into the open ocean or collected and taken to shore for treatment and disposal (Section 5.2.6.3). Operational discharges at a platform site would be quickly diluted and dispersed by local currents and thus are expected to have a negligible impact on marine or coastal birds. Because of the small amount of fuels or other potentially hazardous materials (hydraulic fluid, lubricating oil) that may be present at any given time during maintenance activities, accidental spills of any of these materials, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents and not be expected to pose a threat to marine biota. Thus, potential impacts to marine or coastal birds from small or gradual accidental spills of hazardous materials or fuel are expected to be negligible.

Wind facilities utilizing a central ESP may have transformers that contain large reservoirs of electrical insulating oil as well as smaller amounts of additional fluids such as diesel fuel and lubricating oil (Section 3.2). In the event of a catastrophic release of all these materials (see Section 5.2.4.4), marine and coastal birds may be adversely affected through direct contact with the spilled fluids, by the fouling of their habitats and contamination of their food by the fluids, or by spill response activities. Adult and young birds may come in direct contact with oil on the water's surface or on oiled beaches, mudflats, and other shore features. Oil may also be physically transferred by nesting adults to eggs or young. Direct contact with oil by young and adult birds may result in the fouling or matting of feathers, which would impact flight and/or diving capabilities, affecting such activities as foraging and fleeing predators.

Certain species of marine and coastal birds may be more susceptible to contact with spilled oil than others, based on their life histories. For example, diving birds and underwater swimmers such as loons, cormorants, and diving ducks may be the most susceptible to spilled oil because of their relatively long exposure time within the water and at the sea surface. Shorebirds and wetland birds may also be susceptible to direct oiling if a spill were to reach the beach intertidal zone or inshore wetland habitats, respectively, where these species forage and raise young. The magnitude of the impact would depend on the size of the spill, the species and life stage when exposed, and the size of the local bird population.

Depending on the type of fluid released and its toxicity, the exposure of eggs, young, and adult birds may result in a variety of lethal and sublethal effects. Fouling of habitats can reduce habitat quality and contaminate foods. Cleanup activities in coastal habitats may also affect local populations of coastal birds, resulting in their temporary displacement from these areas. If the abandoned area is an important nesting habitat (especially during the breeding season), local population-level impacts may be incurred.

The magnitude of effects from accidental spills would depend on the location, timing, and volume of the spills; the environmental settings of the spills (e.g., restricted coastal waterway, deeper-water pelagic location), the toxicity of the materials released, the species (and its ecology) exposed to the spills, and the nature and magnitude of exposure. Potential impacts to marine and coastal birds may range from negligible to major, depending on the size of the spill (50 gal vs. 40,000 gal), the materials released (type of electrical insulating fluid), the species (common, endangered) exposed to the spill, the type of exposure (direct contact, ingestion), and the effectiveness and type of spill containment and cleanup activities.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris from service vessels or platforms undergoing maintenance activities. Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]), entanglement in or ingestion of trash and solid debris by marine and coastal birds would not be expected during normal operations and thus have negligible impacts on marine and coastal birds.

5.2.9.5 Decommissioning

Decommissioning of a wind facility would involve the dismantling and removal of infrastructure from each wind turbine platform, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Platforms would be removed by cutting the monopiles (using explosives, acetylene torches, mechanical cutting, or high-pressure water jets) at a depth of at least 4.6 m (15 ft) below the surface of the surrounding sediment.

Because many marine birds as well as migratory birds are attracted to platforms, there is a potential for some individuals to be affected during decommissioning. Birds using a platform undergoing decommissioning would likely leave the platform during dismantling activities. Any remaining birds would be startled by the underwater detonations and quickly leave the collapsing structure. Thus, impacts to birds from decommissioning activities are expected to be negligible.

The MMS has established guidelines for explosive platform removals (30 CFR 250). These guidelines require structure removal-specific plans to protect marine life and the environment and specify procedures and mitigation measures to be taken to minimize potential impacts. The MMS conducts detailed technical and environmental reviews of proposed removal projects to ensure that listed species would not be impacted; these reviews include consultation with the NMFS and USFWS. Thus, compliance with the MMS guidelines should reduce the likelihood that decommissioning activities would impact listed birds.

5.2.9.6 Mitigation Measures

The principal impacting factors that could affect marine and coastal birds and inland birds migrating over OCS waters are collisions with rotors and platforms, displacement of birds from offshore habitats during facility construction and operation, disturbance of birds and habitats during cable trenching and onshore construction, and disturbance of birds by survey, construction, and maintenance vessels. Mitigation measures that may reduce the likelihood of adverse effects on marine and coastal birds include the following:

- Conduct surveys of coastal and offshore areas to identify important feeding, nesting, staging, and wintering areas, and avoid siting facilities and cable paths in or near these areas.

- Coordinate surveys, project design, siting and construction, and development of location- and project-specific mitigation measures with the USFWS and State natural resource agencies as appropriate.

- Avoid locating facilities in or near areas of known important or high bird use (e.g., foraging and overwintering areas, rookery sites, migratory staging or resting areas).

- Time major construction and noise-generating activities, such as pile driving and cable trenching, to avoid periods when marine and coastal birds are nesting near construction zones.

- Reduce or stop operation of turbines that are located directly in migration paths during peak migration periods.

- Avoid use of bright lights to reduce the attractiveness of towers to birds. Use low-intensity strobe lights instead of more commonly used medium-intensity red incandescent blinking lights when complying with Federal Aviation Administration (FAA) lighting guidelines. Low-intensity strobe lights may be less attractive to night migrants (Curry and Kerlinger 2002).

- To reduce attraction of birds to construction and service vessels and thus further reduce potential for ingestion of or entanglement with accidental releases of solid debris from these ships, limit use of steady-burning, bright lighting.

- Because many marine birds fly close to the water surface, turbine blades should not come within 30 m (98 ft) of the ocean surface.

- To increase visibility of moving rotors, paint the distal portion of each blade to sharply contrast with the remaining portions of the rotor.

- Use antiperching devices to reduce the attractiveness of towers to birds.

- Employ blade feathering during periods of high migratory bird occurrence.

- Cutting, rather than the use of explosives, should be preferred for platform removal.

5.2.10 Terrestrial Biota

Development of offshore wind energy facilities is expected to have largely negligible to moderate impacts on terrestrial biota depending on the species affected. With the exception of construction and operations of cable landfalls and onshore infrastructure (such as electrical substations), most wind energy activities would occur in offshore waters. Migratory birds crossing OCS waters where wind energy facilities are located may be affected as a result of collisions with these facilities.

Potential impacts to threatened or endangered species of terrestrial biota from wind energy technology testing, site characterization, construction, operation, and decommissioning would be similar in nature to the impacts identified for nonlisted species and could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA regulations and coordination with the USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.2.10.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would likely skip the demonstration phase and move directly toward commercial operation. However, if technology testing were considered necessary, no construction or other surface-disturbing would be expected on coastal or inland areas. As a consequence, there would be no impacts to terrestrial biota during technology testing.

5.2.10.2 Site Characterization

No impacts to terrestrial biota would be expected during site characterization. Characterization activities would include geological and geophysical surveys and the construction and operation of a meteorological tower. These activities would be restricted to offshore waters and thus not be expected to affect terrestrial biota. Although terrestrial birds migrating over open waters may be injured or killed by colliding with a meteorological tower, the likelihood of such collisions is expected to be very small due to the small number and size of meteorological towers that would likely be used at any particular site. With the exception of impacts to migrating terrestrial birds, impacts to terrestrial biota from site characterization activities are expected to be negligible, while impacts to migrating birds are expected to be negligible to minor.

5.2.10.3 Construction

Construction of offshore wind energy projects may include construction of onshore cable landfalls and electrical substations. These surface-disturbing activities would result in the temporary disturbance or permanent loss of terrestrial habitats and could disturb wildlife in the vicinity of the onshore construction activities. Vegetation and wildlife with limited mobility would be killed within the construction footprint. More mobile wildlife would be expected to leave the area for surrounding habitats. However, survival of the displaced biota would be uncertain, depending on the quality of the surrounding habitats and the capacity of those habitats to support additional biota.

Construction of the onshore facilities (electrical substations) may also temporarily disturb terrestrial biota in the vicinity of the construction sites, with affected individuals largely moving to other habitats. Displacement from preferred to less-optimal habitats could affect overall condition and subsequent survival or reproductive success. Disturbance of terrestrial biota in surrounding habitats during construction would be temporary, affect a relatively small number of individuals, be localized to the immediate vicinity of the construction activity, and would not be expected to result in long-term impacts to terrestrial wildlife populations. Thus, impacts to terrestrial biota are expected to be negligible to minor.

Potential impacts to threatened or endangered species of terrestrial biota would be similar to those of nonlisted biota. However, compliance with the ESA would require that any new cable landfalls and onshore infrastructure be sited and constructed in a manner that would avoid impacting these species or their habitats. For example, the USFWS and U.S. Army Corps of Engineers (USACE) review proposed dredge-and-fill activities and construction projects in waters of the United States where projects may affect the Florida salt marsh vole or its habitats. In addition, the occurrence of many of the threatened and endangered species within protected areas (such as National Wildlife Refuges and State parks) further precludes these species or their habitats from incurring adverse impacts from the construction of onshore infrastructure.

5.2.10.4 Operation

Potential impacts to terrestrial biota during operation of an offshore wind energy facility may include the disturbance of terrestrial wildlife from operational noise and human activity, exposure to accidental releases of hazardous materials or fuels, and the collision of migrating birds with turbine rotors and support structures. Operation of completed onshore facilities could result in the long-term avoidance of adjacent habitats by species sensitive to noise and human activity. Some species may become habituated to human activities and facilities and be largely unaffected by onshore operations, while other species are sensitive and may permanently leave habitats near the onshore facilities (e.g., Klein et al. 1995; Taylor and Knight 2003; Rodgers and Smith 1995; Lafferty 2004). Thus, depending on the species present in habitats near onshore facilities, impacts to terrestrial wildlife from operational noise and human activity may be negligible to moderate.

Wind facilities utilizing a central ESP may have transformers that contain large reservoirs of electrical insulating oil as well as smaller amounts of additional fluids such as diesel fuel and lubricating oil (Section 3.2). A catastrophic release of these materials (see Section 5.2.4.4) that reaches coastal habitats may affect terrestrial biota using those habitats. Biota may come in direct contact with the spilled fluids washing up on beaches, mudflats, and other coastal habitats, and by subsequent spill cleanup activities. Individuals coming in direct contact with spilled fluids may experience skin, eyes, and mucous membranes irritations as well as the oiling of fur. Spilled fluids may also be ingested during cleaning of oiled fur or eating contaminated foods.

An accidental fluid spill may also affect the habitats of these small mammals. Spills contacting their habitats could result in reduced food quality or supply, reduced physical habitat quality, and fouling of nests and burrows. The fouling of nests and burrows may also lead to a temporary displacement from or permanent abandonment of these habitats. Depending on the persistence of the spilled fluids in these habitats and the effectiveness of spill cleanup, long-term reductions in overall habitat quality and quantity may be possible.

The magnitude of effects on terrestrial biota from accidental spills would depend on the location, timing, and volume of the spills; the environmental settings of the spills (e.g., coastal dunes, coastal wetlands), the toxicity of the materials released, the species (and its ecology) exposed to the spills, and the nature and magnitude of exposure. Potential impacts to terrestrial biota may range from negligible to moderate, depending on the nature of the release (electrical insulating fluid, diesel fuel), the size of the spill (50 gal vs. 40,000 gal) reaching coastal habitats, the habitat and species exposed to the release (nesting habitat, endangered species), the type of exposure (direct contact, ingestion) experienced by affected biota, and the type and effectiveness of spill containment and cleanup activities.

Bats are often observed foraging over surface waters such as ponds, lakes, wetlands, streams, and rivers, where they feed on adult aquatic insects such as mosquitoes, gnats, mayflies, and damselflies. Because of potential wind facilities' great distance from shore and the likely very limited abundance of flying insects at such locations, bats would not be expected to forage in OCS waters. The land-based roosting, breeding, and foraging behavior of bats, as well as their limited home ranges and echolocation sensory systems, suggest that the risk of collision with offshore wind turbines in OCS waters is low.

Although the migration patterns of bats are not well-documented, many bats species make extensive use of linear features in the landscape, such as ridges of rivers while commuting and migrating, which may indicate a preference for overland migration routes. Thus, bats are not expected to exhibit migratory flights over OCS waters, but such flights would be more closely associated with the shoreline, well away from any turbine facilities. Thus, potential impacts to bats are considered to be negligible. However, migrating bats may on occasion be driven to offshore OCS waters by prevailing winds. Bats affected in this manner could encounter offshore wind turbines and thus be susceptible to collisions with the turbines. While the frequency of bat displacement to OCS waters is unknown, this displacement is probably uncommon.

Inland birds migrating across OCS waters may encounter offshore wind turbine platforms. It is not possible to estimate the collision rate of these migrating birds for offshore turbines, as this would depend on the specific location of the wind energy facility, the individual species that would be migrating through the area, and the number of birds encountering the facility. These migrating birds have the greatest potential for colliding with rotors and towers, and impacts from such collisions may be minor to moderate, depending on the species involved and the number of individuals affected.

5.2.10.5 Decommissioning

Terrestrial biota are not expected to be affected by decommissioning of a wind energy facility, although wildlife could be disturbed by noise generated during any nearshore cable removal activities. Affected wildlife could leave the area, but may return following completion of cable removal activities. Thus, impacts to terrestrial biota from the decommissioning of onshore infrastructure are expected to be negligible.

5.2.10.6 Mitigation Measures

A number of mitigation measures may be employed to reduce or eliminate the potential for impacting terrestrial biota during the development, operation, and decommissioning of onshore components of an offshore wind energy development. These measures include the following:

- Avoid siting onshore facilities in areas of known important or high habitat quality or wildlife use, such as migratory bird staging and resting areas.

- Coordinate siting and onshore construction activities with USFWS and appropriate State natural resources staff to identify and avoid Federal and State-listed plants and wildlife and important habitats.

- Time construction activities to avoid important life history activities such as nesting.

- Employ blade feathering during periods of high migratory bird occurrence.

- To reduce the attractiveness of wind turbine towers to migrating birds, the use of bright lights should be avoided.

- Avoid locating offshore facilities in areas of known high migratory bird use.

The use of bright lights will reduce the attractiveness of towers to migrating birds and bats. The use of low-intensity strobe lights may be less attractive to night migrants (Curry and Kerlinger 2002) than the more commonly used medium-intensity red incandescent blinking light.

5.2.11 Fish Resources and Essential Fish Habitat

This section evaluates potential impacts to fish resources and Essential Fish Habitat (EFH) that could occur during the testing, site characterization, construction, operation, and decommissioning phases of OCS wind energy developments. While the following sections identify the activities that would occur during each phase of development and types of direct and indirect impacts that could occur to fish resources from those activities, the potential for impacts can be influenced by site-specific conditions, including physical conditions (e.g., water depth, currents, and topography) and the types, distribution, and abundance of habitats and species present in the vicinity of a particular project. As a consequence, more detailed analyses of potential impacts to fish resources and EFH would be conducted as part of site-specific evaluations for proposed projects.

If threatened or endangered species occur in the vicinity of individual projects, potential impacts could be greater than those described below for non-listed fish species, since the populations or distributions of listed species are already greatly reduced. During site-specific planning, consultations with the USFWS and the NMFS would be conducted, as directed by the ESA, to identify and address the potential for impacts on listed fish species from individual projects. During those consultations, appropriate measures to eliminate or reduce the potential for impacts to listed species would be identified.

5.2.11.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would likely skip the demonstration phase and move directly toward commercial operation. As a consequence, there would be no impacts to fish resources or EFH from technology testing activities.

If testing was conducted, it would likely include the placement of a structure offshore, requiring the transportation of components by barge or other vessel. Although noise generated by vessel traffic could potentially affect behavior of some fish resources, impacts from the small number of vessel trips required for technology testing would be expected to be negligible. Impacts due to noise from resulting construction activity for installation of structures would be similar to the impacts described in Section 5.2.11.2.

Fuel spills could also occur as a result of vessel accidents or leaks. Spilled fuels that affect areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some aquatic organisms. Contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of fishes or their prey. Overall, the risk of such spills is relatively low because of the small number of trips that would be required during the technology testing phase. If spills occurred, the volume of fuel that could be spilled by vessels associated with technology testing activities would be small, and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Because spills from technology testing activities would be unlikely to measurably affect fish populations, impacts to fish resources or EFH would be negligible to minor.

5.2.11.2 Site Characterization

Activities that could affect fish resources during site characterization include the presence of survey vessels, the performance of surveys to identify the presence of sensitive species and habitats, geological and geophysical surveys, and drilling and core sampling to evaluate the underlying geological conditions. In addition, one or more meteorological towers would be installed in the area of the proposed facility to measure wind speeds and collect other relevant data to determine whether a site qualifies for a wind turbine facility.

Most fish within the three regions being considered for OCS alternative energy development are presumed to be able to detect, with varying degrees of sensitivity, the frequency range of sounds that would be produced by site characterization activities. Sounds have a potential to mask the sounds normally used by some fishes for communication or foraging. Continuous, long-term exposure to high-pressure sound waves from air guns has been shown to cause damage to the hair cells of the ears of some fishes when the fish were prevented from escaping the immediate vicinity of the air-gun discharges (Popper 2003). Although the indirect impacts of noise exposure on the fecundity and survival of fishes is not certain, fishes with impaired hearing may have reduced survival if the ability to locate prey, avoid predators, or communicate with other fishes is affected (Popper 2003). Due to attenuation of the associated pressure waves, the probability of hearing impairment decreases as the distance between a fish and the noise source increases (Thomson and Davis 2001) and movements to avoid areas with intense sound sources could allow fish to avoid damage to hearing structures under natural conditions (Popper 2003). Loud sounds could cause fishes near a sound source to change their behavior (Pearson et al. 1992), and resulting movements by some species to avoid areas with excessive levels of noise could temporarily alter the distribution of fish within the area.

It is assumed that a project-specific geological and geophysical survey would cover the area being considered for an offshore wind facility to identify potential placement locations based on topographic features and to determine the appropriate types of foundations for the conditions that are present. The size of the surveyed area would be project specific; previously constructed offshore wind facility projects have covered areas of approximately 10 to 26 km^2 (4 to 10 mi^2). Based on experience from the surveys conducted for OCS oil and gas projects, the surveys for a large wind generation project could take approximately a month to complete. Further, it is assumed that there would be no need to conduct multiple surveys within the project area.

Although it is possible that sounds from low-energy geological and geophysical devices such as echosounders or side-scan sonar devices could temporarily affect fish behavior, it is believed that there would be no detrimental effects on fishes or invertebrates; in fact, such devices are commonly used to map fish habitats and detect aggregations of some fish species.

In addition to noise from geological and geophysical surveys, there would also be noise generated by other activities during the site characterization phase. Sound sources could include drilling noises associated with geological characterization (e.g., core sampling), noises from vessels associated with surveys or movement of materials and personnel, and noises from construction and placement of meteorological towers. Noises associated with core sampling would likely be short-lived and localized but could temporarily disturb or displace individual fish. For each project, one vessel would be required each day to transport personnel needed to construct meteorological towers, and construction could take up to 10 weeks depending on the number of towers needed to adequately characterize an area. Movement of construction materials for the meteorological tower could require several round-trips of a barge to the project area. Geological and geophysical surveys could require a single vessel within the project area daily for up to one month. Overall, noise associated with these activities would have no detectable or persistent effects on fish resources.

Pile drivers would likely be used to install pilings for meteorological towers. For the Cape Wind meteorological tower, the noise from pile driving ranged from 145 to 167 dB at a distance of approximately 500 m (1,640 ft). Thomsen et al. (2006) reported that it typically takes at least 1 to 2 h to drive one piling into the bottom. Therefore, it can be assumed that the total time for pile-driving noises for each meteorological tower would require between 6 and 8 h, occurring intermittently over an estimated 3-day period. Based on analysis of construction noise for offshore wind generation, noise from pile-driving activities could be detected by fish for many kilometers from the source (Thomsen et al. 2006). Fish may temporarily move away from noise sources until work has been completed, although some individual fish could be harmed or killed by noise from pile-driving activities (Feist et al. 1992; Hastings and Popper 2005). Immediate or delayed mortality of fish from pile-driving activities has reportedly been observed at 10 to 30 m (33 to 98 ft) from the source (depending upon the size of the hammer used), and it is estimated that delayed mortality could occur 150 to 1,000 m (492 to 3,280 ft) from the source, although this remains somewhat speculative (Thomsen et al. 2006). The potential for impacts to fish populations from such losses is unclear, although it is unlikely that detectable proportions of most fish populations would be affected. Recovery would likely occur shortly following installation of pilings.

The entire structure for a meteorological tower can cover an area of ocean floor of approximately 85 m^2 (900 ft^2). Assuming that especially uncommon or sensitive benthic habitats are avoided, impacts to food resources or habitats for demersal fish would be minor. Such towers are typically in operation for 1 year to 18 months and would remain in place for less than 5 years. During removal, the piles would likely be cut and removed at a depth of at least 4.6 m (15 ft) below the seabed. Disturbance of the seabed during such operations would represent negligible impacts considering the expanse of similar seafloor habitats likely to be present in the vicinity.

Mortality of fish resources associated with meteorological towers could result if explosives were used for removing the towers. Studies conducted at platform removal sites in the central and western Gulf of Mexico by the NMFS (Gitschlag 2000) estimated that between 2,000 and 6,000 fishes were killed during explosive removals in water depths ranging from 14 to 32 m (46 to 105 ft). Sheepshead, spadefish, red snapper, and blue runner accounted for 89% of the mortality estimated by those studies, and the estimates indicated that the overall mortality of red snapper caused by explosive platform removal, even if doubled, would not add significantly to the mortality estimates already determined for the fished population (Gitschlag et al. 2000). Fish species associated with similar structures would likely differ in other OCS regions, and, depending upon the population status of the species present, impacts could be greater. For example, in the Pacific region various rockfish species are likely to become associated with structures placed in OCS areas. Since many rockfish populations are considered depleted due to overfishing, additional mortality of adults could be considered a major impact (Schroeder and Love 2004). However, given the small number of meteorological towers that would require removal from a project area together with a mitigation measure that calls for avoiding the use of explosives for removing pilings (Section 5.2.11.6), impacts on fish populations would likely be negligible.

Geological and geophysical surveys and placement and servicing of meteorological towers in offshore areas would require the transportation of components and personnel by barge or other vessels. Although noise generated by vessel traffic could potentially affect behavior of some fish resources, impacts from the small number of vessel trips required for site characterization would be expected to be negligible.

The presence of the meteorological towers would not result in hazardous emissions to water and would not result in the release of sanitary or hazardous wastes. However, fuel spills could occur during site characterization as a result of vessel accidents or leaks. Spilled fuels affecting areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some fish resources by causing injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required. If spills occurred, the volume of fuel that could be spilled by vessels associated with site characterization activities would be small, and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Because such spills would be unlikely to measurably affect fish populations and because recovery would likely occur within one or two seasons, impacts to fish resources or EFH would be negligible to minor.

5.2.11.3 Construction

Construction of platforms to support wind structures, construction of ESPs, and placement of transmission lines on the seafloor to transport electricity to shore could affect fish resources or EFH through sediment disturbance and settling, crushing of benthic organisms, increased turbidity due to suspension of sediments, and changes in the fish communities associated with alteration of habitats from monopiles and associated antiscour devices placed around the base. Turbidity caused by activities could result in temporary localized decreases in photosynthesis by phytoplankton; because of the short-term and localized nature of such effects, impacts on primary productivity and the availability of other planktonic organisms that serve as a base of the food chain for fish resources would be negligible. Individual fish may temporarily move from affected areas but might return after construction is completed and after the suspended sediments had settled. Construction time would depend on the number of wind turbine generators in an individual project; estimated times range from about 6 months to 2 years or more.

Although some benthic organisms could be smothered and killed by sediment deposition, most individual fish would move before smothering could occur. Impacts to benthic invertebrate communities could indirectly affect demersal fishes and shellfishes that utilize benthic organisms for food. Some demersal organisms would likely relocate to nearby areas until food resources within an affected area recovered, although less-mobile species within deposition areas could be killed. While sediment deposition could locally affect benthic organisms for a few years in the project area, wind structures for a particular project would be somewhat dispersed over the project area, and the total area affected by seafloor disturbance would usually be relatively small compared with the availability of similar seafloor habitat in surrounding areas.

Vessels used during construction activities could disturb fish resources within project areas. For each project, one vessel would be required each day to transport personnel needed to construct platforms and to install turbines and transmission lines. Movement of construction materials could require several round-trips of a barge to the project area. Although the distribution of some fish resources could be temporarily affected, the noise associated with construction vessels would have no detectable or persistent effects on fish resources.

Pile drivers would be used to install pilings for platforms. As identified in Section 5.2.11.2, the noise from pile driving could affect fishes for some distance surrounding each work location. Although data on fish behavior in relation to anthropogenic noise are scarce, fish may move away from noise sources until work has been completed, although some fish could be harmed or killed by noise from pile-driving activities. Fish with swim bladders or species with especially sensitive hearing may experience greater harm than other species. Distribution of fishes within the project area could be temporarily altered by noise from construction activities, although studies have shown that fish return to and colonize wind facility areas following construction (Hvidt et al. 2006). It is estimated that it would take 4 to 6 h of pile driving to install each piling—the overall amount of time that noise disturbance would occur would be a function of the number of pilings required for a specific project.

Construction of the platforms would not result in hazardous emissions to water and would not result in the release of sanitary or hazardous wastes. However, fuel spills could occur during site construction as a result of vessel accidents or leaks. Spilled fuels that affect areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some fish resources by causing injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required. If spills occurred, the volume of fuel that could be spilled by vessels associated with site characterization activities would be small, and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Such spills would be unlikely to measurably affect fish populations, and recovery would likely occur within one or two seasons. Overall, impacts to fish resources or EFH from construction activities would be negligible to minor.

5.2.11.4 Operation

Once construction of an offshore wind facility was completed and operation of the constructed facilities commenced, fish resources (including invertebrate prey for fish) could be affected by the presence of the structures themselves, traffic and noise from vessels used to maintain the structures, and noise associated with turbine operation. In addition, the presence of electromagnetic fields associated with transmission cables could affect some fish species.

Construction of platforms would kill sedentary benthic organisms within the immediate footprint of the pilings for individual towers, and recolonization of the underlying sediments would be precluded by the presence of the pilings throughout the life of the project. However, in many cases construction of platforms on the OCS would occur in areas with soft sediments and would introduce an artificial hard substrate that opportunistic benthic species that prefer such substrate could colonize. In addition, minor changes in species associated with softer sediments could occur due to scouring around the pilings (Hiscock et al. 2002). Fishes, including pelagic species, would likely be attracted to the newly formed habitat complex, and fish population numbers in the immediate vicinity of the platforms are likely to be higher than in surrounding waters away from the structures. The presence of fish could, in turn, attract species of fish-eating seabirds. The overall change in habitat could result in changes in local community assemblage and diversity. Although construction of an individual platform would represent a relatively small amount of hard-substrate habitat that would likely have little effect on overall fish populations, there is a possibility that major projects that cover areas of 10 to 26 km^2 (4 to 10 mi^2) with multiple platforms dispersed within the project area could result in substantial changes in the abundance and diversity of fish within the area. Some rare or overfished fish species attracted to such structures could be negatively affected if increased harvest were to result due to a concentration of fishing effort. There is also a potential that invasive species could colonize such structures. Effects on diversity and fish abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats and fish species within surrounding areas.

Depending on the design of specific structures, lighting could be incorporated to provide navigational aids or to provide lighting if work crews needed to perform repairs or maintenance at night. Because no personnel would be permanently stationed at offshore wind facilities, it is anticipated that there would be little need for the continual use of work lights. Some fish species are nocturnal feeders and may be disturbed by lights shining on the surface, while other species could be attracted. However, there is little information available about the potential effects of such lighting on offshore fish populations. The potential magnitude of impacts to fish from navigational lights is unknown.

Vessels used to perform maintenance during the operational life of a project could disturb fish resources within project areas. For each project, one vessel would be required daily to conduct maintenance. Although the distribution of some fish resources could be temporarily affected by noises from these vessels, the noise associated with construction vessels would have no detectable or persistent effects on fish resources.

Noise and vibrations associated with the operation of the turbines would be transmitted into the water column and through the sediment. Depending on the intensity, such noises could potentially disturb or displace some fish within surrounding areas or could mask sounds used by fish for communicating and detecting prey. Thomsen et al. (2006) calculated that dab and salmon may be able to detect operational noise from a wind turbine up to 1 km (0.6 mi) from the source, and that cod and herring could potentially detect such sounds up to 5 km (3 mi) from the source. Westerberg (1994, 2000; as reported in Thomsen et al. 2006) found that catches of some fish species were two times lower within 100 m (328 ft) of operating wind turbine platforms than areas farther away, whereas catches near wind turbine platforms were higher than areas farther away when the turbines were stopped. However, Wahlberg and Westerberg (2005) estimated that fish would be scared away from operating turbines only up to 4 m (13 ft) from the structure. Habituation of fish to the sounds associated with such structures could also occur (Thomsen et al. 2006).

Electrical cabling to interconnect all of the wind turbines, plus the high voltage (115 kV or greater) cable that delivers the electricity to the existing transmission system on land, would likely be trenched into the seabed. The cables would generally be buried 1 to 3 m (3 to 10 ft) into the seafloor. A potential concern associated with underwater electric transmission cables is the generation of electromagnetic fields that could affect some fish species. Weak electric fields can be detected by certain fish (e.g., rays and sharks) and are used in orientation and prey location. There is some evidence that electric fields from submarine cables are detectable by some fish species and that this detection may result in attraction or avoidance (Gill et al. 2005). However, the cable system likely to be used by OCS wind facility projects would be shielded to effectively block the electric field produced by the conductors. Therefore, no electric field impacts are expected for the submarine cables. In addition, some fish and invertebrates are sensitive to magnetic fields that could be generated by electricity passing through underwater cables (Gill et al. 2005). Although individual organisms could be attracted to or avoid cables, the potential for population-level effects on fishes or invertebrates from such electromagnetic fields is largely unknown.

Investigations of the potential effects of the electromagnetic field associated with the cable lines for the Nysted offshore wind facility in Denmark indicated that the migration behavior of some fish species (Baltic herring, common eel, Atlantic cod, and flounder) was altered, but not completely blocked, in the vicinity of the cables (Dong Energy et al. 2006). As long as sufficient numbers of individuals pass over cables to maintain genetic diversity, population-level effects on aquatic organisms would be unlikely to occur. Thus, while it is expected that the impacts of EMF on populations of aquatic species would be negligible to minor, uncertainties remain and additional studies are needed on the potential effects on species that inhabit the U.S. coasts in the vicinity of proposed projects.

During facility operation, it is unlikely that sanitary or hazardous wastes would be released to the water. Fuel spills could occur during site maintenance as a result of vessel accidents or leaks. Spilled fuels that affect areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some fish resources by causing injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required. If spills occurred, the volume of fuel that could be spilled by vessels associated with site characterization activities would be small, and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Because such spills would be unlikely to measurably affect fish populations and because recovery would likely occur within one or two seasons, it is anticipated that impacts to fish resources or EFH would be negligible to minor.

Wind facilities utilizing a central ESP may have transformers that contain large reservoirs (150,000 L [40,000 gal]) of electrical insulating oil (such as mineral oil), as well as smaller amounts (7,600 L [2,000 gal]) of additional fluids such as diesel fuel and lubricating oil. In the event of a catastrophic release of all these materials (see Section 5.2.4.4), there would be an increased potential for negative effects on fishery resources.

The magnitude of effects from accidental spills would depend on the location, timing, and volume of the spills, the toxicity of the materials released, and the species (and its ecology) exposed to the spills. For example, spills that reach coastal areas and islands, and especially sheltered coastal habitats such as bays and estuaries, would be more likely to affect nearshore fish communities than communities in deeper waters. A large spill that reaches sensitive fishery habitats that are in limited supply, such as areas near salmon-spawning streams or coastal nursery areas for specific fishery resources, could result in substantial population-level effects to some species and could adversely impact EFH. Recovery from such impacts could be slow.

Thus, the potential impacts to fishery resources or EFH from a catastrophic spill could range from negligible to major, depending on the size of the spill, the materials released, the species (common, endangered) exposed to the accidental spill, and the effectiveness of spill containment and cleanup activities. As described in Section 5.2.4.4, the likelihood of a large release of hazardous materials from these facilities is considered to be low.

Except for the potential for catastrophic spills of materials stored at an ESP, and assuming that potentially sensitive habitats are appropriate characterized and avoided (Section 5.2.11.6), it is anticipated that the overall impacts to fish resources or EFH from operation of an offshore wind facility (with implementation of the mitigation measures identified in Section 5.2.11.6) would be negligible to minor.

5.2.11.5 Decommissioning

Decommissioning of a wind facility would involve the dismantling and removal of infrastructure from each wind turbine platform, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5).

Platforms would be removed by cutting pilings at a depth of at least 4.6 m (15 ft) below the surface of the surrounding sediment or by using explosives to sever the piling. During decommissioning, fish resources or EFH could be affected by noise generated during dismantling, the alteration and loss of habitat provided by the existing structures, and accidental releases of hazardous materials and fuel. Overall, decommissioning activities would be similar to construction activities, although largely in reverse and at lower levels. While the major impacting factor associated with construction, namely pile driving, would not occur during decommissioning, explosives could be used for the removal of some platforms. In such cases, fishes close to detonation areas could be injured from pressure- and noise-related effects as discussed in Section 5.2.11.2.

The construction of towers would result in the creation of new hard substrate that would essentially perform as an artificial reef, supplying habitat and food for fish resources (Section 5.2.11.4). Removal of platforms from the project area would remove this artificial habitat. The overall result would be to return the project area to conditions, both physically and biologically, similar to those that existed before construction of wind facilities. Uses of wind facility areas by fishermen and recreational divers that develop as a consequence of the newly developed biological communities would also cease after decommissioning.

During decommissioning activities, it is unlikely that sanitary or hazardous wastes would be released to the water. Fuel spills could occur during site maintenance as a result of vessel accidents or leaks with potential effects on fish resources similar to those described in Section 5.2.11.4.

Notwithstanding the reversion of the biological conditions to those that existed prior to wind facility construction, impacts to fish resources and EFH from decommissioning are expected to be short-term and negligible to minor.

5.2.11.6 Mitigation Measures

The principal impacting factors that could affect fish populations from offshore wind facility development and construction include the introduction of noise, habitat alterations, and the potential for spills of fuel or other hazardous materials. The measures identified in Section 5.2.5 to mitigate noise generated during site characterization and the construction, operation, and decommissioning of a wind facility would also provide mitigation of noise impacts to fish resources. Other general measures that could reduce the likelihood of adverse effects on fish resources include the following:

- Conduct surveys during siting studies to identify and characterize potentially sensitive habitats.

- Minimize construction activities in areas containing anadromous fish during migration periods.

- Avoid locating facilities near known sensitive fish habitats, such as marine protected areas.

- Minimize seafloor disturbance during construction of towers and installation of underwater cables.

- Utilize practices and follow operating procedures that reduce the likelihood of vessel accidents and fuel spills.

- Utilize appropriate shielding for underwater cables to control the intensity of electromagnetic fields, especially in areas where more sensitive shark or ray species are likely to be present.

- Avoid the use of explosives for removing pilings when feasible. Cutting is the preferred method for removing pilings.

5.2.12 Sea Turtles

Sea turtles may be affected by all phases of offshore wind energy development. While adults may be found in all the Pacific, Atlantic, and Gulf of Mexico regions, they are generally more numerous in warmer waters. Thus, sea turtles may be more likely to encounter, and thus be affected by, wind energy-related activities in the South Atlantic and Straits of Florida, in the northern Gulf of Mexico, and Central and Southern California Pacific waters. One or more sea turtle life stages could be affected by (1) offshore structure placement and cable trenching, (2) noise, (3) collisions with OCS vessels, (4) operational discharges and wastes, (5) construction and operation of onshore infrastructure, and (6) removal of offshore structures during decommissioning.

Potential impacts to threatened or endangered sea turtle species from wind energy technology testing, site characterization, construction, operation, and decommissioning could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA regulations and coordination with NOAA and USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.2.12.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would likely skip the demonstration phase and move directly to commercial operation. As a consequence, there would be no anticipated impacts to sea turtles from technology testing activities. However, in the unlikely event that a demonstration wind project was undertaken, potential impacts to sea turtles would be similar to those described for site characterization and facility construction (see Sections 5.2.12.2 and 5.2.12.3), but the magnitude of potential impacts would be greatly reduced. All species of sea turtles that might be present in the Pacific, Atlantic, and Gulf of Mexico waters are either threatened or endangered under the Endangered Species Act. Any population-level impacts incurred by sea turtles during technology testing would be considered minor rather than negligible.

5.2.12.2 Site Characterization

Activities associated with site characterization that may affect sea turtles include: (1) geological and geophysical surveys, (2) construction of one or more meteorological towers, (3) construction vessel traffic, (4) discharges of waste materials and accidental fuel releases, and (5) meteorological tower decommissioning.

5.2.12.2.1 Geological and Geophysical Surveys. Few studies are available on sea turtle hearing sensitivity or noise-induced stress (Ridgway et al. 1969; Bartol et al. 1999); thus, it is largely unknown how sea turtles might respond to and be affected by geological and geophysical surveys. Surveys using air-gun arrays may generate low-frequency noise at levels up to

250 dB re 1 μPa-m, and these may be detected by sea turtles within the survey area (Geraci and St. Aubin 1987). In contrast, side-scan sonar generates noise at much lower intensity and higher frequencies, which may not be as readily detected. Potential responses to survey noises may be expected to be behavioral, and include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as feeding. If an air gun is used, sea turtles immediately below an air gun may experience sound pressure levels that could cause hearing damage.

Because site characterization would use low-energy side-scan sonar rather than high-energy air guns, sea turtles are not expected to be exposed to sound pressure levels that could cause hearing damage. Side-scan sonar, which uses a low-energy, high-frequency signal, is not expected to affect sea turtles. Side-scan sonar has been used extensively to investigate a wide variety of aquatic biota, from benthic organisms to whales, with little evidence of adverse effects (see USGS undated, and Kirk and Nelson 1984). Because of the limited location and duration of geological and geophysical surveys that may be conducted during site characterization, few individuals may be expected in most cases to be present within the survey areas. Thus, potential population-level impacts on sea turtles from geological and geophysical surveys are expected to be negligible. However, should such surveys be conducted at a time and location where hatchling turtles have passively aggregated or where females are gathering in preparation for nesting, larger numbers of individuals may be affected and impacts may be moderate to major.

5.2.12.2.2 Meteorological Tower Construction. During meteorological tower construction, sea turtles in the vicinity of the construction site may be disturbed by noise generated during pile driving. Most noise generated during pile driving would exhibit sound levels up to 180 dB and have a relatively broad band of 20 Hz to >20 kHz (Madsen et al. 2006; Thomsen et al. 2006). Such noise could disturb normal behaviors (e.g., feeding) and cause affected individuals to move away from the construction area. The biological importance of behavioral responses to construction noise (e.g., effects on energetics, survival, reproduction, population status) is unknown, and there is little information regarding short-term or long-term effects of behavioral reactions on sea turtle populations. While noise generated during construction of a meteorological tower may affect more than one individual, population-level effects are not anticipated. Because very few individuals would likely be exposed to construction-generated noise, potential population-level impacts to sea turtles from meteorological tower construction are expected to be minor.

5.2.12.2.3 Vessel Traffic. Sea turtles may be killed or injured by collisions with construction vessels traveling between the meteorological tower site and onshore facilities. Because of their limited swimming abilities, hatchlings may be more susceptible than juveniles or adults to vessel collisions, especially if they are aggregated in areas of current convergence or in mats of floating *Sargassum*.

The likelihood of collision would vary depending upon species and life stage, the location of the vessel, and its speed and visibility. Hatchling turtles, including those aggregated in convergence zones or patches of *Sargassum*, would be difficult to spot from a moving vessel because of their small size and generally cryptic coloration patterns, which blend in with the color and patterns of the *Sargassum*. While adult and juvenile turtles are generally difficult to observe at the surface during periods of daylight and clear visibility, they are very difficult to spot from a moving vessel when they are resting below the water surface, and during night and periods of inclement weather.

Because of the small amount and short duration of vessel traffic that would be associated with meteorological tower construction, population-level impacts to sea turtles from vessel collisions are expected to be minor.

5.2.12.2.4 Waste Discharge and Accidental Fuel Releases. During meteorological tower construction, a variety of sanitary and other waste fluids, and miscellaneous trash and debris, may be generated. Hatchling, juvenile, and adult sea turtles may be exposed to these wastes by discharges from the construction vessels. Operational discharges from construction vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal. Sanitary and domestic wastes would be processed through shipboard waste treatment facilities before being discharged overboard. Deck drainage would also be processed prior to discharge. Thus, discharges from construction vessels would be expected to have negligible population-level impacts to sea turtles.

Ingestion of, or entanglement with, accidentally discarded solid debris can adversely impact sea turtles. Ingestion of plastic and other nonbiodegradable debris has been reported for almost all sea turtle species and life stages (NOAA 2003). Ingestion of waste debris can result in gut strangulation, reduced nutrient uptake, and increased absorbance of various chemicals in plastics and other debris (NOAA 2003). Sublethal quantities of ingested plastic debris can result in various effects including positive buoyancy, making sea turtles more susceptible to collisions with vessels, increasing predation risk or reducing feeding efficiency (Lutcavage et al. 1997). Some species of adult sea turtles, such as loggerheads, appear to readily ingest plastic debris that is appropriately sized. In oceanic waters, floating or subsurface translucent plastic material and sheeting may be mistaken for gelatinous prey items such as jellyfish. Entanglement in debris (such as rope) can result in reduced mobility, drowning, and constriction of and subsequent damage to limbs (Lutcavage et al. 1997).

The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]). Assuming compliance with these regulations and laws and only accidental releases, very little exposure of sea turtles to solid debris generated during meteorological tower construction would be anticipated. Thus, entanglement in or ingestion of OCS-related trash and debris by sea turtles would not be expected during meteorological tower construction.

5.2.12.2.5 Meteorological Tower Decommissioning. Upon completion of site characterization, the meteorological tower would be removed and transported by barge to shore. During this activity, sea turtles may be affected in the same manner as described for meteorological tower construction. Removal of the mooring piles would be accomplished by cutting the piles (using explosives, acetylene torches, mechanical cutting, or high-pressure water jet) at a depth of 4.6 m (15 ft) below the seabed, and sea turtles in the immediate vicinity could be disturbed by noise during the cutting of the pilings. Affected animals may be expected to move away from the immediate vicinity of the site.

Underwater explosions associated with the explosive removal of offshore facilities may generate broadband noise, with sound levels of 267 dB re 1 μPa-m or more (Section 3.1.1.5). Exposure criteria developed by the U.S. Navy (as cited in Frankel and Ellison 2005) to evaluate the potential for impacts of impulsive sounds (i.e., underwater detonations) on marine biota include a sound level of 182 dB re 1 μPa-m. By this criterion, a sea turtle may be affected if exposed to a sound level that exceeds 182 dB re 1 μPa-m. Depending on the size of the charges used in an explosive detonation, the surrounding water depth, and the distance to the nearest sea turtles, individual turtles in the vicinity of the facility undergoing explosive removal may experience a sound level exceeding this criterion.

It is uncertain how sea turtles may be affected by sounds generated during meteorological tower removal. For example, experiments using air guns to try to repel turtles to avoid hopper dredges have been inconclusive (O'Hara and Wilcox 1990; Moein et al. 1995), while sea turtles exposed to an operating seismic source of 166 dB re-1 μPa-m have been observed to increase their swimming speed in response to the sound (McCauley et al. 2000).

Because of the relatively short duration of decommissioning activities, as well as the very limited location of decommissioning activities, potential impacts to sea turtles are expected to be negligible to minor.

5.2.12.3 Construction

During wind facility construction, sea turtles might be affected by (1) geological and geophysical surveys, (2) construction noise, (3) offshore construction and cable trenching, (4) vessel traffic, (5) discharge of liquid wastes and solid debris and accidental fuel releases, and (6) onshore construction. These impacting factors would be associated with construction of the turbine platforms and offshore transformers or substations, placement of cables from the turbine towers to the offshore transformer or substation, and placement of cables from offshore facilities to onshore facilities.

5.2.12.3.1 Geological and Geophysical Survey. Geological and geophysical surveys conducted to more fully characterize bottom topography and subsurface geology at individual turbine platform locations could affect sea turtles in the same manner as described for site characterization (Section 5.2.12.2). Sea turtles exposed to such surveys could exhibit behavioral changes. Very few sea turtles are expected to be present in the immediate vicinity of a construction site, and sound levels from expected survey approaches (side-scan sonar) are expected to be below levels that can result in hearing damage. Thus, impacts would be limited to no more than a few individuals at any one site and are expected to be negligible. However, because of the threatened or endangered status of all the sea turtle species, population-level impacts could be minor (rather than negligible) for these species. However, should such surveys be conducted at a time and location where females are gathering in preparation for nesting or where hatchlings have been passively aggregated, larger numbers of individuals may be affected, resulting in potentially moderate to major population-level impacts to the affected species.

5.2.12.3.2 Construction Noise. As discussed with regard to construction of meteorological towers, noise generated during construction of the wind turbine platforms and other infrastructure (such as the ESP) might affect sea turtles in a similar manner and impacts are expected to be minor. In addition, sea turtles might also be disturbed by noise during placement of cables from the wind facility to an onshore substation.

5.2.12.3.3 Offshore Construction and Cable Trenching. The placement of offshore structures and pipeline trenching might affect hatchling, juvenile, and adult sea turtles. Individuals coming in contact with construction or trenching equipment might be injured or killed; construction and trenching activities might temporarily affect habitat use; and habitats might experience short-term and long-term changes in abundance and quality.

In Atlantic and Gulf waters, once hatchlings enter offshore waters they are transported passively by ocean currents into areas of current convergence or to mats of floating *Sargassum* algae. Hatchlings originating from nest sites adjacent to OCS waters as well as from other locations (such as the Yucatan peninsula) might be carried into the open water environment where offshore construction activities may be taking place. Because hatchlings are not strong swimmers and undergo passive transport by currents, it is unlikely that they would be able to avoid or leave areas where cable trenching or wind platform placement was occurring. If the hatchlings were present during construction or trenching, they could be injured or killed.

In contrast, juvenile and adult sea turtles may avoid areas where construction or trenching is occurring. Sea turtles have been known to be killed or injured during dredging operations (Dickerson 1990; Dickerson et al. 1992); thus, they might also be affected during trenching activities. Juveniles or adults may also be affected if the placement of new structures occurs in foraging or developmental habitats or offshore of nesting beaches (see Section 4.2.12 for a discussion of these habitats and areas). Following several years out in open water as growing hatchlings, juvenile sea turtles move into nearshore habitats for further growth and maturation. Adults also utilize nearshore habitats for feeding and may mate in nearshore habitats directly off of nesting beaches. In addition, females may become residents in the vicinity of nesting beaches. Offshore construction and trenching may reduce the quality or availability of foraging habitat for juveniles and adults and may affect adult nesting behavior or access to nest sites. It is assumed that habitats such as seagrass beds and live-bottom areas commonly used by turtles for feeding or resting would be avoided during facility siting and cable routing, and that some soft-bottom areas affected by construction or trenching would recover.

At any single wind platform location, construction and trenching activities would be of relatively short duration. Thus, any impacts incurred from structure placement or trenching would be short term and localized to the construction area and immediate surroundings, and therefore, likely affect relatively few juveniles or adults. Because they are passively aggregated by currents, a greater number of hatchlings may be affected if present in a construction or trenching area. Thus, potential population-level impacts to sea turtles from the construction of offshore wind energy platforms and placement of undersea cables could be minor to moderate.

5.2.12.3.4 Vessel Traffic. Sea turtles might be killed or injured by collisions with construction vessels traveling between the wind energy development site and onshore support facilities. Because of their limited swimming abilities, hatchlings might be more susceptible to vessel collisions than juvenile or adult sea turtles, especially if aggregated in areas of current convergence or in mats of floating *Sargassum.*

The likelihood of such collisions would vary depending upon species and life stage, the location of the vessel and its speed, and visibility. Hatchling turtles, including those aggregated in convergence zones or patches of *Sargassum*, would be difficult to spot from a moving vessel because of their small size and generally cryptic coloration patterns, which blend with the color and patterns of the *Sargassum*. While adult and juvenile turtles are generally difficult to observe at the surface during periods of daylight and clear visibility, they are very difficult to spot from a moving vessel when they are resting below the water surface, and during nighttime and periods of inclement weather.

The potential for collisions with construction vessels would be temporary (limited to the construction period). In addition, only one or two platform sites would be under construction at any one time, and construction vessel traffic is estimated at only one vessel trip per day. Therefore, construction vessels may affect relatively few juveniles or adults. Because they are passively aggregated by currents, a greater number of hatchlings may be affected if present in a construction or trenching area. Because of their threatened or endangered status, potential population-level impacts to sea turtles from collisions with construction vessels may be minor rather than negligible for juveniles and adults, and moderate for hatchlings.

5.2.12.3.5 Waste Discharge and Accidental Fuel Releases. As previously discussed with regard to site characterization (Section 5.2.12.2), sea turtles in the vicinity of the construction site or construction-related vessels may be exposed to, and affected by, liquid wastes, solid debris, and accidental discharges of fuel. The potential for exposure and effects would be similar to that identified for meteorological tower construction, but would occur over a much greater area and for a longer duration. Liquid wastes or fuels may be expected to be quickly diluted and dispersed. The discharge or disposal of solid debris from OCS structures and vessels is prohibited by the MMS and the USCG. Assuming compliance with these regulations and laws and only accidental releases, very little exposure of sea turtles to solid debris generated on offshore facilities and OCS vessels may be expected. Thus, population-level impacts to sea turtles from the accidental release of liquid wastes, solid debris, or fuels during construction may be expected to be negligible or minor.

5.2.12.3.6 Onshore Construction. Along the Gulf and southern Atlantic coastlines, nests and emerging hatchlings may be affected by the construction of new onshore infrastructure such as cable landfalls. Because no nesting occurs along the Pacific Coast of the United States, onshore construction would not be expected to affect sea turtle nests or hatchlings. If present in a construction area, nests containing eggs or emerging hatchlings could be destroyed by clearing, grading, and other construction activities. Lighting from nearby construction areas or completed infrastructure may also affect hatchlings emerging from nearby nests. Disorientation by nearby lights could increase exposure to predators, cause entanglement in vegetation, or lead hatchlings away from the surf (National Research Council 1990). Onshore lighting may also draw hatchlings back out of the surf. However, given the small amount of onshore construction that could occur with the development of an offshore wind energy facility, it is unlikely that onshore construction would impact more than a few nests. Thus, population-level impacts to sea turtles could be negligible to moderate, depending on the presence of nesting beaches in the vicinity of the onshore facilities.

5.2.12.4 Operation

During operation of an offshore wind facility, sea turtles might be affected by (1) turbine noise; (2) vessel traffic; and (3) accidental releases of hazardous materials or fuels. Sea turtles might also be affected by operations at cable landfalls and onshore substations associated with the offshore wind facility.

5.2.12.4.1 Turbine Noise. Underwater noise from a turbine may reach levels of 90 to 115 dB at a distance of 110 m (361 ft) in moderate winds, and cover a frequency range of 20 to 1,200 Hz, with peak levels at 50, 160, and 200 Hz (Thomsen et al. 2006). Sea turtles may be affected by turbine noises at these levels. Potential responses to turbine noises generated during normal operations may be expected to be behavioral and include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as feeding.

In contrast to the relatively short time period during which construction noise could affect sea turtles, and the limited number of locations where construction noise would be generated at any particular time, noise generated during normal operations might affect many individuals, and for a much longer time period. Under normal operations, there could be continuous or near-continuous generation of 90 to 115 dB noise levels over the entire wind facility (up to 26 km^2 [10 mi^2]). Such noise generation could result in the long-term avoidance of the wind facility area and surrounding vicinity. While juveniles and adults may be able to leave the area, hatchlings passively transported to the vicinity of a wind energy development would not be able to actively leave the area and thus could experience long-term exposure to turbine noise.

Few studies are available on sea turtle hearing sensitivity or noise-induced stress (Geraci and St. Aubin 1987; Ridgway et al. 1969; Bartol et al. 1999). Thus, it is largely unknown how sea turtles may respond to, or be affected by, turbine noise, and the level of potential impacts to sea turtles is unknown. Because some sea turtles, such as the loggerhead, may be attracted to OCS structures, these species may be more likely to be exposed to sounds produced during routine operations.

5.2.12.4.2 Vessel Traffic. During normal operations, there would be at least one vessel trip to and from the wind facility each day to perform maintenance duties. Sea turtles may be injured or killed as a result of ship collisions. Because of the low level of vessel traffic that could occur during normal operations, potential impacts to sea turtles from this traffic would likely be limited to no more than a few juveniles or adults. However, a greater number of turtles may be affected by ships traveling through waters where hatchling sea turtles may have passively aggregated. Collisions with any of the threatened or endangered species of sea turtles may result in minor to moderate population-level impacts.

5.2.12.4.3 Accidental Releases of Hazardous Materials or Fuels. Small operational discharges from service vessels or accidental gradual releases of electrical insulating oil, diesel fuel, or lubricating oil from a central ESP would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal, and thus would have a negligible impact on adult or juvenile sea turtles. In addition, juvenile and adult turtles may be able to leave the immediate vicinity of an accidental spill and thus limit their level of exposure. Because hatchlings are passively aggregated and may be considered incapable of actively leaving the immediate area of an accidental spill, they may incur greater exposure to an accidental release. While there is limited information regarding the levels of some contaminants in sea turtle tissues, little is known about what concentrations are within normal ranges for a particular species or what tissue levels may result in acute or chronic effects (Pugh and Becker 2001; NOAA 2003).

Wind facilities utilizing a central ESP may have more than 150,000 L (40,000 gal) of electrical insulating oil as well as smaller amounts of additional fluids such as diesel fuel and lubricating oil (Section 3.2). A catastrophic release of these materials (see Section 5.2.4.4) could affect multiple sea turtle life stages. A catastrophic release reaching a coastline may foul nest sites and buried eggs, while hatchlings may be exposed as they emerge through the overlying fouled sands or as they make their way over the fouled sands to the surf. Hatchlings, juveniles, and adults may be exposed while swimming through released fluids on the water surface, through inhalation of vapors, and through ingestion of contaminated foods and floating tar. Nesting adults (females) may also be exposed while coming ashore on fouled beaches. In addition to direct adverse effects from such exposures, adults and juveniles may also be indirectly affected if an accidental spill reduces the quality or quantity of foraging or nesting habitat. Impacts to nesting habitats could result in major population level effects.

Oil-spill response activities that may adversely affect sea turtles include artificial lighting at night, machine and human activity, and sand removal and cleaning. Lights used to support night-time cleanup activities may attract sea turtles to the spill location or disorient hatchlings emerging from nearby nests. Machine and human activity may cause the temporary avoidance of nearby habitats (including nest sites) by sea turtles, and also increase the potential for sea turtle collisions with vessels and onshore vehicles. Onshore activities may also crush existing nests and result in beach compaction, reducing the suitability of existing nest sites for future use. Sand removal may also directly impact nest site habitat quality.

The magnitude of effects from an accidental release will depend on the location, timing, and volume (50 gal vs. 40,000 gal) of the release; the environmental settings of the spills (e.g., nesting beach, open water current convergence zone), the toxicity of the materials released, the species and life stage (egg, hatchling, juvenile, or adult) exposed to the release, the number of individuals exposed, the type of exposure (direct contact, nest fouling), and the effectiveness and type of spill containment and cleanup activities. Thus, potential impacts to marine mammals from an accidental release of hazardous materials or fuels may range from negligible to major.

The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]). Thus, entanglement in or ingestion of OCS-related trash and debris by sea turtles would not be expected during normal operations.

5.2.12.4.4 Onshore Operations. Lighting from onshore infrastructure such as electrical substations may affect hatchlings emerging from nearby nests. Disorientation by nearby lights could increase exposure to predators, cause entanglement in vegetation, or lead hatchlings away from the surf (National Research Council 1990). Onshore lighting may also draw hatchlings back out of the surf. Affected turtles may experience increased mortality, which could result in population-level effects, especially when heavily used nesting beaches are affected. In the absence of mitigation measures to control facility lighting, potential population-level impacts to sea turtles may be moderate to major.

5.2.12.5 Decommissioning

Decommissioning of a wind facility would involve the dismantling and removal of infrastructure from each wind turbine platform; the removal of offshore transformers; and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Platforms would be removed (by cutting or using explosives) at a depth of at least 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, sea turtles might be affected by (1) explosive platform removal, (2) noise generated by equipment dismantling the towers, (3) collisions with decommissioning vessels, and (4) exposure to accidental releases of hazardous materials and fuel.

Decommissioning activities would be similar to construction activities, although largely in reverse order. Devices and equipment would be dismantled in the same manner as they were assembled, only in reverse. Thus, impacts to sea turtles from decommissioning noise, vessel traffic, and accidental releases of wastes, solids, and fuels, would be similar, but of likely lower magnitude, than the potential impacts from these same factors during construction (see Section 5.2.12.3).

The major impacting factor associated with construction, namely pile driving, would not occur during decommissioning. If explosives are used rather than cutting for the removal of platforms, sea turtles close to the detonations could be injured from pressure- and noise-related effects. Sea turtles are known to be attracted to offshore platforms, and thus may be killed or injured during explosive platform removal (Klima et al. 1988; Gitschlag and Herczeg 1994). There would be no detonation-related impacts if platforms were removed using acetylene torches, mechanical cutting, or high-pressure water jets rather than explosives.

In contrast to noise generated during pile driving, which would be continuous at each platform location for a short period, noise resulting from the use of explosives would be a one-time event at each platform location, thus limiting the likelihood and duration of exposure by sea turtles. Underwater explosions associated with the explosive removal of offshore facilities may generate sound levels in excess of 267 dB re 1 μPa-m. Exposure criteria developed by the U.S. Navy (as cited in Frankel and Ellison 2005) to evaluate the potential for impacts of impulsive sounds (i.e., underwater detonations) on marine biota include a sound level of 182 dB re 1 μPa-m. Using this criterion, a sea turtle may be affected if exposed to a sound level that exceeds 182 dB re 1 μPa-m. Depending on the size of the charges used in an explosive detonation, the surrounding water depth, and the distance to the nearest sea turtles, individual turtles in the vicinity of the facility undergoing explosive removal may experience a sound level exceeding this exposure criterion.

The relative importance of offshore oil-platform removal to overall sea turtle mortality (from human activities) is considered to be low (National Research Council 1990; NOAA 2003; NOAA 2006g). With the possible exception of explosive platform removal, population-level impacts to sea turtles from decommissioning are expected to be negligible to minor.

5.2.12.6 Mitigation Measures

The principal impacting factors that could affect sea turtles are noise from geological and geophysical surveys, explosive platform demolition, vessel strikes, and onshore lighting and facilities near nesting beaches. Because all sea turtle species are either endangered or threatened, mitigation measures would be developed during site-specific consultations with NMFS and USFWS. General measures that might reduce the likelihood and/or magnitude of the potential impacts of these impacting factors on sea turtles include:

- Avoid locating facilities in areas where hatchlings are known to be passively aggregated by currents.

- Avoid locating facilities offshore of known, important nesting beaches, or in known and important coastal foraging areas and developmental habitats.

- Avoid locating cable landfalls and onshore facilities near known, important nesting beaches.

- Platform removal should employ cutting rather than the use of explosives. If explosives are used, platform removal should be conducted in a manner similar to that identified in the MMS guidelines for the explosive removal of oil and gas platforms in the Gulf (NTL No. 2004-G06) and to the conservation recommendations identified in the NMFS biological opinion on the removal of offshore structures in the Gulf of Mexico OCS (NOAA 2006g). In particular, visual surveys and physical removal of sea turtles from the blast zone should be conducted, and structure removal should be immediately delayed until the observed turtle leaves the area or is captured and moved.

- The potential for affecting sea turtle nests and emerging hatchlings by onshore construction would be greatly reduced through compliance with applicable statutes, regulations, and stipulations (such as those governing onshore lighting). The implementation of all mitigation measures required by Federal and State statutes and regulations would greatly limit the potential for impacts to nests and emerging hatchlings.

- In areas of known high use by or occurrence of sea turtles, time major characterization and construction activities, such as geophysical surveys and pile driving, to avoid periods when sea turtles may be more abundant in the project area.

- Conduct onshore preconstruction surveys for nest sites and delay construction activities until hatchlings have emerged and moved into open water.

- To minimize potential vessel impacts to sea turtles, project-related vessels should follow NMFS Regional Viewing Guidelines while in transit, and vessel operators should undergo training on applicable vessel guidelines.

- Use appropriate procedures for pile-driving to minimize potential impacts to sea turtles associated with underwater sound levels created by pile-driving activities.

5.2.13 Coastal Habitats

Although many of the activities associated with wind energy facilities would occur in offshore waters, coastal habitats could be directly or indirectly impacted by a number of factors associated with wind energy development. These factors include vessel traffic, construction and operation of onshore facilities, installation and operation of electric transmission cables, expansion of ports and docks, and operation of offshore wind energy components. The potential for impacts would be largely influenced by site-specific factors, such as the habitat types and distribution in the vicinity of a wind energy project.

5.2.13.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would likely forego the demonstration phase and move directly toward commercial operation. However, if technology testing was considered necessary, construction or other surface-disturbing activities would not be expected on nearshore land areas. Therefore, direct impacts to coastal habitats would not be expected to result from associated activities.

If testing was conducted, it would likely include the placement of a structure offshore, requiring the transportation of components by barge or other vessel. Although waves generated by vessel traffic can affect some habitats, such as barrier beaches, impacts to coastal habitats from the small number of vessel trips would be expected to be negligible.

Fuel spills could occur as a result of vessel collisions or leaks. Spilled fuels that reach barrier beaches or coastal wetlands could result in impacts to associated organisms (Hayes et al. 1992; Dahlin et al. 1994; Petrae 1995; Hoff 1995; NOAA 1998, 2000; Hensel et al. 2002; Mendelssohn and Lin 2003; Proffitt 1998). Contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of wetland vegetation or wildlife, or biota associated with sand or gravel beaches or rocky shores. Loss of tidal marsh vegetation could result in erosion of marsh substrates, with subsequent conversion of marsh habitat to open water. Spilled fuels could penetrate beach substrates or could persist in protected areas such as lagoons. Cleanup operations may also result in long-term impacts to barrier beaches or wetlands, such as from trampling of vegetation, incorporation of petroleum deeper into substrates, increased erosion, or removal of substrates. Leaks from vessels should be minimized by compliance with U.S. Coast Guard requirements for spill prevention and control. Fuel spills would likely be relatively small, and spill response would likely minimize impacts, allowing for habitat recovery. Therefore, impacts to coastal habitats from fuel spills could range from negligible to moderate. The degree of impact from fuel spills and length of recovery would depend on the amount and type spilled, degree of weathering prior to contact with coastal habitats, time of year, the site-specific characteristics of the affected habitat, and the clean-up response.

5.2.13.2 Site Characterization

As with technology testing, direct impacts to coastal habitats would not be expected during site characterization. The shipment of components and workers during construction of a meteorological tower would likely include one round-trip per day for up to 10 weeks for workers and three vessel trips in total during the construction period for transportation of components. In areas that currently experience barrier beach losses from ongoing shoreline degradation, such as in the Gulf of Mexico, particularly the coastal areas of Louisiana, vessel traffic can contribute to the removal of sediments along beaches through increased wave action. However, because of the small number of vessel trips for site characterization, impacts to barrier beaches would likely be negligible.

5.2.13.3 Construction

The construction of a wind energy generation facility may require the establishment of component assembly areas onshore, construction of new substations, transmission lines, or housing for monitors, although existing substations and monitoring facilities would likely be used. The potential effects on coastal habitats from construction activities would be associated with direct impacts from ground-disturbing activities as well as indirect impacts from decreased water quality or altered hydrology. Coastal habitat, such as estuaries, wetlands, beaches, or dune communities, may be directly lost during land clearing or from the placement of fill material during construction. Indirect impacts associated with construction may include habitat fragmentation, caused by altered hydrology in nearby wetlands due to changes in surface drainage patterns. Hydrologic changes may include isolation of wetlands from water sources, reduced infiltration and increased runoff due to soil compaction, and runoff from impervious surfaces, and may result in the conversion of wetlands to upland areas or open water. The increased volume and velocity of runoff from impervious surfaces can increase water level fluctuations in wetlands and may result in scouring of stream channels and bank erosion. Streams, wetlands, and seagrass beds may also be affected by increased sedimentation and turbidity during construction by disturbance of substrates or erosion of disturbed upland soils. Contaminants may be introduced in stormwater runoff or in discharges from vessels. The deposition of fugitive dust generated by soil disturbance may adversely affect vegetation in coastal terrestrial or wetland habitats. The impacts of soil disturbance, or changes to hydrology or water quality, may also include changes in biotic community structure, reduction in biodiversity, or establishment of invasive species.

Intertidal and shallow subtidal coastal habitats, including seagrass beds, wetlands, mudflats, and beaches, may be directly impacted by the expansion of existing docks and ports to accommodate the number and size of vessels needed for construction of wind energy generation facilities. Port expansion may include dredging, potentially resulting in the loss of habitat.

The installation of electric transmission cables from the generation facilities would likely include the use of cable-laying vessels for subsea installation. The cable may be installed by horizontal directional drilling or may be buried in a continuous trench by using a jet-plow technique. Intertidal habitats, such as tidal marsh, mudflats, beaches, or rocky shores, or shallow subtidal habitats such as submerged aquatic vegetation would be directly impacted by trenching activities, and excavated sediments may cover adjacent substrates, resulting in the disturbance of at least 0.3 m^2 (3 ft^2) for each linear foot of cable. Forested wetlands may be cleared for cable installation. Infauna and epifauna of beach, mudflat or wetland substrates, as well as adjacent wetland or seagrass vegetation, could be indirectly impacted by sedimentation and turbidity associated with the disturbance of bottom sediments during trench excavation and backfilling. Recovery of some invertebrates, such as some species of mussels, following a large disturbance may be slow (NOAA 1998).

Restoration of organic coastal marsh soils to preproject elevations may be difficult because of compaction and oxidation, and re-establishment of the vegetation community may be inhibited. The continued erosion of marsh substrates adjacent to the cable route could result in a widening of the affected area over time and additional marsh losses as marsh becomes converted to open water. Portions of the cable route lacking vegetation reestablishment could promote hydrologic alterations to tidal marsh, affecting the pathway of water flow, increasing the flushing and draining of interior marsh areas, and allowing saltwater intrusion into brackish and freshwater wetlands.

Onshore, a transmission cable would connect the undersea cable with a substation and would also be buried. Disturbance of beaches, dunes, or other coastal habitats would result in direct habitat losses from excavation, as well as indirect impacts. Beach or dune substrates may be difficult to stabilize, and erosion may occur adjacent to the cable route. Establishment of vegetation cover might be slow, possibly resulting in prolonged losses of dune habitat. If directional drilling were used for cable installation, indirect impacts could include accidental losses of bentonite drilling fluid. Federal, State, and many local regulations are designed to protect sensitive ecological resources, such as wetlands or coastal dunes. The installation of an electric transmission cable and construction of facilities for offshore alternative energy projects would typically be located to avoid or minimize impacts to sensitive resources, where location alternatives exist, as is done for oil and gas projects, both for regulatory as well as, in many instances, engineering concerns. As a result, it is very unlikely that trench excavation or onshore facilities would be located where a sensitive resource occurs. Potential indirect impacts of construction would be reviewed during project-specific environmental analyses. Impacts would generally require permitting from Federal, State, or local regulatory agencies. Therefore, impacts from construction of facilities and installation of power cables would likely result in negligible to moderate impacts to coastal habitats.

Maintenance dredging of barrier inlets for vessel passage, if necessary, could contribute to reduced sediment deposition along barrier beaches in those areas of ongoing erosion and contribute to losses of barrier beach habitat. Impacts to barrier beaches could range from negligible to moderate. Impacts from vessel fuel spills would be similar to those discussed under technology testing.

Wind facilities utilizing a central ESP may have transformers that contain large reservoirs of electrical insulating oil, such as mineral oil (up to 150,000 L [40,000 gal] total on an ESP), as well as smaller amounts (7,600 L [2,000 gal]) of additional fluids such as diesel fuel and lubricating oil. In the event of a catastrophic release of all these materials (see Section 5.2.4.4), coastal habitats may be exposed to the spilled fluids. The magnitude of effects from accidental spills would depend on the timing and volume of the spills, the toxicity of the materials released, the habitat types in the vicinity of the spill, and the effectiveness of spill response actions.

5.2.13.4 Operation

Activities associated with the operation of wind energy generation facilities would include monitoring and maintenance. While monitoring would likely be conducted remotely from shore, maintenance of generation facilities would require periodic visits to the offshore locations, at least one trip per day. Impacts of vessel traffic associated with facility maintenance would be similar to those described for technology testing and site characterization and would include effects of increased wave action on barrier beaches and risk of fuel spills from accidents.

The placement of wind facilities in offshore waters would generally result in minor impacts to coastal sedimentary processes (see Section 5.2.1), along with a small decrease in wave height and current energy, limited to the immediate vicinity of the facility (see Section 5.2.3). Subsequent effects on coastal sediment deposition and erosion processes would generally result in a negligible impact to coastal beaches. Where facilities are constructed in nearshore waters, potentially greater impacts could occur and would need to be assessed on a project-specific basis.

The electric transmission cable connecting a wind facility to a shore-based substation would be buried 1 to 3 m (3 to 10 ft) below coastal habitats. The electromagnetic fields produced by submarine transmission lines may be detected by some fish and invertebrate species (see Section 5.2.11.4). Although individual organisms in coastal habitats could be attracted to or avoid buried cables, the potential for population-level effects on fish or invertebrates from such electromagnetic fields is largely unknown.

5.2.13.5 Decommissioning

The decommissioning of wind energy generation facilities would require the removal of all facility components. The removal of the electric generation cable would be expected to result in impacts similar to construction, with direct and indirect disturbance of subtidal and intertidal substrates and terrestrial habitats. Following the restoration of soil elevations and re-establishment of plant communities, these habitats would be expected to fully recover. Decommissioning would also entail the use of vessels for transportation of workers and materials, with subsequent effects of increased wave action on barrier beaches and risk of fuel spills from accidents. See Section 5.2.13.1 for a discussion of these types of impacts. Impacts from decommissioning activities would likely result in negligible to moderate impacts on coastal habitats.

5.2.13.6 Mitigation Measures

The primary impacting factors associated with wind energy development include habitat loss or degradation from construction activities, erosion, and contamination from spills. General measures that could reduce impacts to coastal habitats include the following:

- To reduce the effects of vessel traffic, wave activity could be minimized by maintaining reduced vessel speeds in the vicinity of barrier islands.

- The effects of fuel spills and spill cleanup activities could be reduced by the use of low-impact response technologies. Effective low-impact cleanup actions could include bioremediation, low-pressure flushing, or use of chemical cleaners (Mendelssohn and Lin 2003; Hoff 1995; Proffitt 1998).

- The use of water-based hydraulic fluids or nontoxic, environmentally benign fluids that are rapidly biodegradable would reduce potential effects to coastal organisms from spills near shore.

- The use of greaseless bearings in gearboxes would reduce the use and potential loss of lubrication oils.

- Avoidance of seagrass communities and implementation of turbidity reduction measures would minimize impacts to seagrasses from construction activities. Scarring of seagrass beds could be minimized by the restriction of vessel traffic to established traffic routes.

- Impacts to wetlands from construction could be minimized by maintaining buffers around wetlands, by the use of best management practices for erosion and sedimentation control, and by maintaining natural surface drainage patterns.

- Marsh losses could be reduced by the application of dredged material onto marsh surfaces in areas of high subsidence, such as the northern Gulf of Mexico.

- Impacts to wetlands could also be minimized by the implementation of practices to minimize air quality and water quality impacts.

- Direct impacts to barrier habitats or wetlands may be avoided during installation of transmission cables by the use of nonintrusive construction techniques, such as horizontal directional drilling under barrier islands or other sensitive coastal habitats.

- Coastal habitat losses could be minimized by monitoring the impacts of construction activities, monitoring habitat restoration/creation activities, and applying corrective actions through an adaptive management process.

5.2.14 Seafloor Habitats

This section evaluates potential impacts to seafloor habitats that could occur during the testing, site characterization, construction, operation, and decommissioning phases of OCS wind energy developments. While the following sections identify the activities that would occur during each phase of development and types of direct and indirect impacts that could occur to seafloor habitats from those activities, the potential for impacts can be influenced by site-specific conditions, including physical conditions (e.g., water depth, currents, and topography) and the types of seafloor habitats and associated species present in the vicinity of a particular project. As a consequence, more detailed analyses of potential impacts to seafloor habitats would be conducted as part of site-specific evaluations for proposed projects.

5.2.14.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would likely skip the demonstration phase and move directly toward commercial operation. As a consequence, there would likely be no impacts to seafloor habitats from technology testing activities. However, new technologies and equipment, such as new foundation types, may require offshore field testing.

If testing was conducted, it would likely include the placement of one or two structures in an offshore area, requiring the transportation of components by barge or other vessel. Construction of platforms to support wind structures and placement of transmission lines on the seafloor to transport electricity to shore could affect seafloor habitats by disturbing sediments, crushing benthic organisms, increasing turbidity due to suspension of sediments, and by altering the availability of various habitat types. Depending upon water depth, turbidity caused by activities could result in temporary localized decreases in photosynthesis by phytoplankton. Because of the short-term and localized nature of such effects, impacts on primary productivity and the availability of other planktonic organisms that serve as a base of the food chain for some benthic organisms would be negligible. Some larger mobile invertebrates could move temporarily from affected areas, while other individuals within the footprint of these activities could be killed. Sediment disturbance would be episodic and would not occur throughout the entire construction period.

Although some benthic organisms could be smothered and killed by sediment deposition, mobile species would move before smothering could occur. Although sediment deposition could locally affect benthic organisms for a few years in the project area, test structures for a particular project would result in sediment disturbance and deposition over very small areas compared to the availability of similar seafloor habitat in surrounding areas. Overall, impacts from technology testing activities on seafloor habitats would be negligible to minor.

Fuel spills (i.e., diesel or similar fuels) that could also occur as a result of vessel accidents or leaks during the technology testing phase would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected by such spills.

5.2.14.2 Site Characterization

Likely activities that could affect seafloor habitats during site characterization include geological and geophysical surveys, drilling, and core sampling to evaluate the underlying geological conditions. In addition, one or more meteorological towers would be installed in the area of the proposed facility to measure wind speeds and collect other relevant data to determine whether a site qualifies for a wind turbine facility.

It is assumed that air guns would not be used for geological and geophysical surveys. It is considered unlikely that any seafloor organisms would be harmed by the low-energy acoustic surveys anticipated to occur during site characterization.

In addition to noise from geological and geophysical surveys, there would also be noise generated by other activities during the site characterization phase. Sound sources could include noises associated with geological characterization (e.g., core sampling), noises from vessels associated with surveys or movement of materials and personnel, and noises from construction and placement of meteorological towers. Noises associated with core sampling would likely be short-lived and localized, but could temporarily disturb or displace some mobile benthic organisms. Overall, noise associated with these activities would have no detectable or persistent effects on seafloor habitats or populations of seafloor organisms.

Core samplers and similar devices would disturb seafloor habitat and kill sessile organisms within the sample footprint. However, the area affected by such samplers is small (generally no more than a few square meters), and the overall effect on seafloor habitats and associated organisms within the project area would be negligible. Similarly, impacts from anchoring within project areas are anticipated to be negligible since sensitive seafloor habitats, such as live bottoms and coral reefs, would be avoided.

Pile drivers would be used to install pilings for meteorological towers. The frequency range and peak sound levels for underwater noise associated with pile-driving are presented in Section 5.2.5.3 (Table 5.2.5-2). Thomsen et al. (2006) reported that it typically takes at least 1 to 2 h to drive one piling into the bottom. Therefore, it can be assumed that the total time for pile-driving noises for each meteorological tower would be between 6 and 8 h, occurring intermittently over an estimated 3-day period. Some fish and invertebrates associated with seafloor habitats would temporarily move away from noise sources until work has been completed, although some individual organisms could be harmed or killed (Thomsen et al. 2006). The potential for impacts to populations of seafloor organisms from such losses is unclear, although it is unlikely that measurable proportions would be affected. Recovery would likely occur shortly following installation of pilings.

The entire structure for a meteorological tower can cover an area of approximately 85 m^2 (900 ft^2), although not all of the seafloor habitat within this area would be completely covered by the structure. Although the proportion of the seabed affected would be extremely small considering the expanse of similar seafloor habitats likely to be present in the vicinity, seafloor habitat at the location of the pilings would be unavoidably affected during the entire period that the tower is in place. Such towers are typically in operation for 1 year to 18 months and would likely remain in place for less than 5 years. Once the towers have been placed, they would represent hard substrate that could be colonized by invertebrates and, over time, communities similar to those found on live bottoms could develop. During removal, the piles would likely be cut and removed at some depth below the seabed. Following removal of pilings, the established communities would be lost, and natural habitat conditions would likely return within one to a few years. Thus, assuming that especially uncommon or sensitive benthic habitats are avoided, impacts to seafloor habitats should be minor. If towers were placed on especially uncommon or sensitive seafloor habitats, some effects could be essentially irreversible and represent moderate to major impacts on those habitat types.

Disturbance of seafloor habitats and mortality of seafloor organisms could result if explosives were used for removing the towers as described in Section 5.2.11.2. Studies conducted at platform removal sites in the central and western Gulf of Mexico by the NMFS (Gitschlag 2000) estimated that between 2,000 and 6,000 fishes (associated with the platform structures) were killed during explosive removals in water depths ranging from 14 to 32 m (46 to 105 ft). Sheepshead, spadefish, red snapper, and blue runner accounted for 89% of the mortality estimated by those studies, and the estimates indicated that the overall mortality of red snapper contributed by explosive platform removal, even if doubled, would not add significantly to the mortality estimates already determined for the fished population (Gitschlag et al. 2000). Although the fish species associated with similar structures would likely differ in other OCS regions, similar effects would be anticipated. Given the small number of meteorological towers that would require removal within the project area, affected fish populations would recover without mitigation and impacts would be negligible. If the towers were constructed on sensitive seafloor habitats, measurable damage to those habitats and nearby organisms could occur if explosives were used during removal and could require a considerable amount of time (e.g., 10 or more years for some hard-bottom habitats) for recovery.

The presence of the meteorological towers would not result in hazardous emissions to water and would not result in the release of sanitary or hazardous wastes. Although fuel (i.e., diesel and similar fuels) spills could occur as a result of vessel accidents or leaks, such contaminants would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected by such events.

5.2.14.3 Construction

Construction of platforms to support wind structures, construction of ESPs, and placement of transmission lines on the seafloor to transport electricity between structures and to shore could affect seafloor habitats by disturbing sediments, crushing benthic organisms, increasing turbidity due to suspension of sediments, and altering of the availability of various habitat types. Ecological function within disturbed sediments could be altered for many years depending upon the amount of disturbance, the size affected areas, and the types of communities present. Depending upon water depth, turbidity caused by activities could temporarily decrease photosynthesis by phytoplankton, locally reducing primary productivity and the availability of other planktonic organisms that serve as a base of the food chain for some benthic organisms. Larger mobile invertebrates would likely move temporarily from affected areas, but could return after construction has been completed and after the suspended sediments have settled. Construction time would depend on the number of wind turbine generators included in an individual project; estimated times range from about 6 months to 2 years or more.

Some benthic organisms could be smothered and killed by sediment deposition, although some mobile species would move before smothering could occur. Removal or movement of boulders to prepare for tower construction could kill or displace associated organisms. Impacts to benthic invertebrate communities could indirectly affect demersal fishes and shellfishes that utilize benthic invertebrates for food. Some demersal organisms may relocate to nearby areas until food resources within an affected area recover. Although sediment deposition could locally affect benthic organisms for a few years in the project area, wind structures for a particular project would be dispersed over the project area and the total area affected by seafloor disturbance would usually be quite small compared to the availability of similar seafloor habitat in surrounding areas.

Pile drivers would likely be used to install pilings for platforms. As identified in Section 5.2.14.2, the noise from pile driving could affect fishes for some distance surrounding each work location. Some fish and mobile invertebrates may temporarily move away from noise sources until work has been completed, although some individuals could be harmed or killed (Thomsen et al. 2006). Overall, the noise associated with placement of platforms would not result in measurable changes in benthic fish or invertebrate populations, although distributions of individuals within the project area could be temporarily altered. It is estimated that it would take 4 to 6 h of pile-driving to install each piling. The overall amount of time that noise disturbance would occur would be a function of the number of pilings required for a specific project.

The construction of the platforms is not expected to result in hazardous emissions to water or the release of sanitary or hazardous wastes. Although fuel spills could occur as a result of vessel accidents or leaks during construction activities, such contaminants would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected by such events. Overall, assuming that sensitive areas are avoided, impacts to seafloor habitats from construction activities would be negligible to minor.

5.2.14.4 Operation

Once construction of an offshore wind facility was completed and operation of the constructed facilities had commenced, seafloor habitats and seafloor biota could be affected by the presence of the structures themselves, by noise associated with turbine operation, or by the presence of electromagnetic fields associated with transmission cables.

Construction of platforms would kill sedentary benthic organisms within the immediate footprint of the pilings for individual towers, and recolonization of the underlying sediments would be precluded by the presence of the pilings throughout the life of the project. However, in many cases construction of platforms on the OCS would occur in areas with soft sediments and would introduce an artificial hard substrate that opportunistic benthic species that prefer such substrate could colonize. In addition, minor changes in species associated with softer sediments could occur due to scouring around the pilings (Hiscock et al. 2002). Fishes would likely be attracted to the newly formed habitat complex, and fish population numbers in the immediate vicinity of the platforms are likely to be higher than in surrounding waters away from the structures. The overall change in habitat could result in changes in local community assemblage and diversity. Although construction of an individual platform would represent a relatively small amount of hard-substrate habitat that would likely have little effect on populations of seafloor biota, there is a possibility that major projects that cover large areas (estimated project areas of 10 to 26 km^2 [4 to 10 mi^2] have been reported) with multiple platforms dispersed within the project area could result in substantial changes in the abundance and diversity of benthic organisms within the area. However, monitoring of four existing offshore wind facilities in Europe and the United Kingdom revealed no major effects on benthic communities for up to three years following construction (Michel et al. 2007). There is also a potential that invasive species could colonize such structures. Resulting changes in diversity, abundance, and overall assemblages of fishes and invertebrates could ultimately alter a variety of ecological relationships within some distance of the project area. As a consequence, the ecological function of the affected area could change. Effects on diversity and abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats within surrounding areas.

Noise and vibrations associated with the operation of the turbines would be transmitted into the water column and through the sediment. Depending on the intensity, such noises could potentially disturb or displace some biota within surrounding areas or could mask sounds used by some fish species for communicating and detecting prey. Thomsen et al. (2006) calculated that common dab (*Limanda limanda*) may be able to detect operational noise from a wind turbine up to 1 km (0.6 mi) from the source and that cod could potentially detect such sounds up to 5 km (3 mi) from the source. Westerberg (1994, 2000; as reported in Thomsen et al. 2006) found that catches of some fish species were two times lower within 100 m (328 ft) of operating wind turbine platforms than areas farther away, whereas catches near wind turbine platforms were higher than in areas farther away when the turbines were stopped. However, Wahlberg and Westerberg (2005) estimated that fish would be scared away from operating turbines only up to 4 m (13 ft) from the structure. Habituation of fish to the sounds associated with such structures could also occur (Thomsen et al. 2006).

Electrical cabling to interconnect all of the wind turbines, plus the high voltage (115 kV or greater) cable that delivers the electricity to the existing transmission system on land, would likely be trenched into the seabed. The cables would generally be buried 1 to 3 m (3 to 10 ft) into the seafloor. A potential concern associated with underwater electric transmission cables is the generation of electromagnetic fields that could affect some fish species. Weak electric fields can be detected by certain demersal fish (e.g., rays and sharks) and are used in orientation and prey location. There is some evidence that electric fields from submarine cables are detectable by some fish species and that this detection may result in attraction or avoidance (Gill et al. 2005). Although the cable system likely to be used by OCS wind facility projects would be shielded and buried to effectively block the electric field produced by the conductors, some low-level electric fields may still be detectable by some species. In addition, some fish and invertebrates are sensitive to magnetic fields that could be generated by electricity passing through underwater cables (Gill et al. 2005). Although individual seafloor organisms could be attracted to or avoid cables, the potential for population-level effects on fishes or invertebrates from such electromagnetic fields is largely unknown.

Investigations of the potential effects of the electromagnetic field associated with the cable lines for the Nysted offshore wind facility in Denmark indicated that the migration behavior of some fish species (Baltic herring, common eel, Atlantic cod, and flounder) was altered, but not completely blocked, in the vicinity of the cables (Dong Energy et al. 2006). As long as sufficient numbers of individuals pass over cables to maintain genetic diversity, population-level effects on aquatic organisms would be unlikely to occur. Thus, while it is expected that the impacts of EMF on populations of aquatic species would be negligible to minor, uncertainties remain and additional studies are needed on the potential effects on species that inhabit the U.S. coasts in the vicinity of proposed projects.

During facility operation, it is unlikely that sanitary or hazardous wastes would be released to the water. Antifouling coatings could be utilized on some components but would not substantially affect water quality (see Section 5.2.4). Although fuel spills could occur as a result of vessel accidents or leaks during construction activities, such contaminants would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected by such events. Overall, assuming that sensitive seafloor habitats are avoided, impacts to seafloor habitats from operations are expected to be negligible to minor.

5.2.14.5 Decommissioning

Decommissioning of a wind facility would involve the dismantling and removal of infrastructure from each wind turbine platform, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Platforms would be removed by cutting pilings at a depth of approximately 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, seafloor organisms could be affected by noise generated during dismantling, and there could be alteration and loss of habitat provided by the existing structures.

Decommissioning activities would be similar to construction activities, although largely in reverse and at lower levels. While the major impacting factor associated with construction, namely pile driving, would not occur during decommissioning, explosives could be used for the removal of some platforms. During such platform removal, seafloor habitat organisms close to detonation areas could be injured from pressure- and noise-related effects as discussed in Section 5.2.14.2.

As identified in Section 5.2.14.4, the construction of towers would result in the creation of new hard substrate that would essentially perform as an artificial reef, supplying habitat and supporting the associated biota. Removal of platforms from the project area would remove this artificial habitat. The overall result would be to return the project area to conditions, both physical and biological, similar to those that existed prior to construction of wind facilities.

During decommissioning activities, it is unlikely that sanitary or hazardous wastes would be released to the water. Although fuel spills could occur as a result of vessel accidents or leaks during construction activities, such contaminants would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected by such events.

Notwithstanding the reversion of the seafloor habitat conditions to those that existed prior to wind facility construction, impacts to seafloor habitats from decommissioning are expected to be negligible to minor.

5.2.14.6 Mitigation Measures

The principal impacting factors that could affect seafloor habitats from offshore wind facility development and construction include the introduction of noise, habitat alterations, and the potential for spills of fuels or other hazardous materials. Sensitive seafloor habitats would be identified during site characterization so that future construction activities could be designed to avoid impacts to those habitats. The measures identified in Section 5.2.5 to mitigate noise generated during site characterization and the construction, operation, and decommissioning of a wind facility would also provide mitigation of noise impacts to seafloor organisms. Other general measures that could reduce the likelihood of adverse effects on seafloor habitats include the following:

- Conduct surveys during siting studies to identify and characterize potentially sensitive seafloor habitats and topographic features.

- Avoid locating facilities near known sensitive seafloor habitats, such as coral reefs, hard-bottom areas, gravel pavements, and ridge and swale areas.

- Avoid anchoring of vessels in areas containing sensitive seafloor habitats.

- Minimize seafloor disturbance during construction of towers and during installation of underwater cables.

- Utilize appropriate shielding for underwater cables to control the intensity of electromagnetic fields, especially in areas where more-sensitive shark or ray species are likely to be present.

- Avoid use of explosives for removing pilings when feasible to minimize impacts to benthic fishes and invertebrates.

5.2.15 Areas of Special Concern

As identified in Sections 4.2.15, 4.3.15, and 4.4.15, there are more than 200 marine protected areas located in the Atlantic, Gulf of Mexico and Pacific regions. While many of these areas, including national parks, national seashores, national wildlife refuges, national estuarine research reserves, and National Estuary Program estuaries are located on or along the coast, there are a number of marine sanctuaries, fishery habitat conservation zones, and fishery management zones located in offshore waters. Section 388 prohibits alternative energy leasing "in any area on the Outer Continental Shelf within the exterior boundaries of any unit of the National Park System, National Wildlife Refuge System, or National Marine Sanctuary System, or any National Monument" (43 USC 1337 [p][10]).

Impacts to these areas of special concern could result from activities that disturb lands or waters within the protected area, activities that harm special habitat types or ecological resources (e.g., hard-bottom and coral habitats, fishes, or waterfowl), activities that harm cultural resources, or activities that affect other values for which a particular area of concern was established. Potential impacts of offshore wind energy development to values or resources that such areas of special concern are intended to protect are identified and evaluated in the following sections. However, more detailed analyses of potential impacts to areas of special concern would be conducted as part of site-specific evaluations for proposed projects once specific locations and technical specifications are better understood.

5.2.15.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would skip the demonstration phase and move directly toward commercial operation. As a consequence, there would be no impacts to areas of special concern from technology testing activities.

If testing was conducted, it would likely include the placement of a structure offshore, requiring the transportation of components by barge or other vessel. Although noise generated by vessel traffic could potentially affect behavior of some marine mammal and fish resources within areas of special concern, such as national marine sanctuaries, noise impacts from the small number of vessel trips required for technology testing would be expected to be negligible. Construction noise and vessel traffic near the onshore boundaries of areas of special concern could temporarily disturb some wildlife and could negatively affect recreational values for some people using areas of concern (Sections 6.2.20). Boats passing near areas of special concern that include shorelines could result in wave-associated erosion of shoreline areas. As described in Sections 5.2.13, effects of wakes on coastal habitats are expected to be negligible.

Because placement of experimental wind energy structures would be unlikely to occur within the immediate vicinity of offshore marine protected areas, there would be no impacts to areas of special concern from seafloor disturbance. In some cases, offshore wind towers may be visible from shore and could negatively affect scenic values for some areas (Section 5.2.20).

Trash and debris from OCS operations could wash up on beaches, including beaches associated with areas of special concern (e.g., national seashores). The discharge or disposal of solid debris from both OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]). Assuming that operators comply with regulations, most potential impacts would be avoided, although some accidental loss of materials is inevitable. While it is difficult to estimate the amount of such materials that could result from potential OCS wind energy activities, amounts should be low during technology testing activities because of the limited number of structures and activities that would occur.

Fuel spills (i.e., diesel or similar fuels) could occur as a result of vessel accidents or leaks. Such spills would be unlikely to measurably affect ecological habitats and biota (Sections 5.2.8 to 5.2.14). Because placement of wind energy structures would be unlikely to occur within the immediate vicinity of offshore marine protected areas, there would be no impacts to these areas of special concern from fuel spills.

5.2.15.2 Site Characterization

Likely activities during site characterization include the operation of survey and construction vessels, the performance of geological and geophysical surveys, and drilling and core sampling to evaluate the underlying geological conditions. In addition, one or more meteorological towers would be installed in the area of the proposed facility to measure wind speeds and collect other data to determine whether a site is suitable for a wind turbine facility.

Although noise generated by vessel traffic could potentially affect behavior of some marine mammal and fish resources within areas of special concern, noise impacts from the small number of vessel trips required during site characterization would be expected to be negligible. Noise and vessel traffic near the onshore boundaries of areas of special concern could temporarily disturb some wildlife and negatively affect recreational values for some people using areas of concern (Section 5.2.20). Boats passing near areas of special concern that include shorelines could result in wave-associated erosion of shoreline areas. As described in Section 5.2.13, effects of wakes on coastal habitats are expected to be negligible.

Depending on the distance from project areas to areas of special concern, geological and geophysical surveys could potentially affect fish (Section 5.2.11.2) and marine mammals (Section 5.2.8). Similarly, the use of explosives to remove meteorological towers once site characterization activities have been completed could harm nearby fish and marine mammals. Overall, such impacts would be negligible to minor in terms of potential impacts on populations of organisms. Pile driving, if needed to install meteorological towers, would be unlikely to have more than temporary and negligible effects on populations of fishes or marine mammals within offshore areas of special concern.

Drilling or core sampling to evaluate geological conditions has a potential to harm some benthic organisms as a result of sediment suspension and deposition. However, since project areas would be located outside any offshore areas of special concern, there would be no impacts to these areas from these site characterization activities.

Fuel spills could occur during site characterization as a result of vessel accidents or leaks. If such spills were to occur in OCS waters, they would be unlikely to measurably affect ecological habitats and biota (Sections 5.2.8 to 5.2.14). Spills that reach shoreline habitats could result in larger effects, although this would depend on the nature of the spill and subsequent cleanup response activities (see Section 5.2.13). Because wind energy projects would be unlikely to be sited within the immediate vicinity of offshore marine protected areas, there would be no impacts to these areas of special concern from fuel spills.

5.2.15.3 Construction

Depending on project location, construction of wind energy structures and placement of transmission lines to transport electricity to shore could affect the identified areas of special concern. However, as previously identified, OCS wind energy projects would not be located in areas of special concern.

It is estimated that approximately one vessel trip would occur to the project area each day during the construction period. Construction noise and vessel traffic near the onshore boundaries of areas of special concern could temporarily disturb some wildlife and could negatively affect recreational values for some people using areas of concern (Section 5.2.20). Boats passing near areas of special concern that include shorelines could result in wave-associated erosion of shoreline areas. As described in Section 5.2.13, effects of wakes on coastal habitats are expected to be negligible.

Noise generated by vessel traffic could also potentially affect behavior of some marine mammal and fish resources within offshore areas of special concern, such as national marine sanctuaries. However, noise impacts from the small number of vessel trips required during the construction phase would be expected to be negligible. Furthermore, it is likely that any project construction activities would be located far enough away from protected marine areas that there would be no noise impacts to offshore areas of special concern.

Because wind energy structures are not likely to be placed in the immediate vicinity of offshore areas of special concern, there would be no impacts to areas of special concern from seafloor disturbance. In some cases, the installed offshore wind towers may be visible from shore and could negatively affect scenic values for some park users (Section 5.2.21).

Development of transmission line connections to onshore power transmission facilities and the potential need for construction of additional substations could affect some areas of special concern, depending on the locations selected for these activities. In general, transmission facilities would not be located on National Park properties, although transmission lines may be allowed to pass through some of the other types of areas of special concern (e.g., national wildlife refuges) if the managing agency grants a right-of-way (ROW) to the facility operators. Site-specific evaluations would be required to determine the potential for negative impacts to such properties, although permitting requirements would mitigate most impacts.

Trash and debris from OCS operations could wash up on beaches, including beaches associated with areas of special concern (e.g., national seashores). The discharge or disposal of solid debris from both OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]). Assuming that operators comply with regulations, most potential impacts would be avoided, although some accidental loss of materials is inevitable. While it is difficult to estimate the amount of such materials that could result from OCS wind energy activities, amounts should be low during the construction period.

Fuel spills could occur as a result of vessel accidents or leaks during construction activities. Such spills would be unlikely to measurably affect biota or habitats within marine protected areas (Section 5.2.8 through 5.2.14). Furthermore, because placement of wind energy structures would be unlikely to occur within the immediate vicinity of offshore marine protected areas, there would be no impacts to these areas of special concern from fuel spills.

5.2.15.4 Operation

Depending on project location, wind energy structures have a potential to affect the identified areas of special concern during the operational phase. Because, as previously identified, OCS wind energy projects would generally not be located in areas of special concern, impacts from OCS wind structures are unlikely. During the operations phase, areas of special concern could be affected by the presence of the structures themselves, disturbances resulting from the use of vessels to maintain the structures, and noise associated with turbine operation. In addition, the presence of transmission facilities and the associated maintenance activities have a potential to affect some onshore areas of special concern.

Because wind energy structures are not likely to be placed in the immediate vicinity of offshore areas of special concern, there would be no impacts to areas of special concern from seafloor disturbance. Noise and vessel traffic associated with offshore maintenance activities adjacent to onshore boundaries of areas of special concern could temporarily disturb some wildlife and could negatively affect recreational values for some people (Section 5.2.20). In some cases, the installed offshore wind towers may be visible from shore and could negatively affect scenic values for users of some areas of special concern during the life of the project (Section 5.2.20).

As identified in Sections 5.2.11 and 5.2.14, building platforms for wind energy production on the OCS could introduce an artificial hard substrate that could be colonized by various types of fish and invertebrates. This could result in changes in local community assemblage and diversity. Effects on diversity and fish abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats within surrounding areas. Depending upon the proximity of OCS wind structures to offshore areas of special concern, there may be a potential for interactions with fishery resources and ecological resources within nearby areas of special concern. Such interactions would probably not result in negative effects on offshore areas of special concern, which are often themselves intended to protect natural communities associated with habitats such as hard bottoms or coral reefs. However, a considerable amount of scientific discussion has developed around the question of whether placement of artificial habitats, such as offshore platforms, simply attract and concentrate fish from surrounding areas or whether they actually lead to increases in the numbers of fish associated with all similar habitats in the regional system as a whole (Seaman 1997; Lindberg 1997; Grossman et al. 1997; Johnson et al. 1994; Wilson et al. 2001). There is also a potential for invasive species to colonize such structures.

Noise and vibrations associated with the operation of the turbines would be transmitted into the water column and through the sediment. Depending on the proximity of OCS wind turbines to areas of special concern and the intensity and frequency of the sounds generated, such noises could potentially disturb or displace some marine mammals (Section 5.2.8) or fish (Section 5.2.11) within areas of special concern or could mask sounds used by these species for communicating and detecting prey. The potential for such effects would be project specific and would be considered further during project-specific evaluations.

The presence of transmission lines and other onshore infrastructure would represent a long-term loss of some terrestrial habitat within the footprints of these structures. As noted in Section 5.2.14.3, some areas of special concern could be affected by these structures, depending on the locations selected. In general, such facilities would not be located on National Park properties, although transmission lines may be allowed to pass through some of the other types of areas of special concern (e.g., National Wildlife Refuges) if the managing agency grants a ROW to the facility operators. Maintenance activities associated with shore-based transmission facilities, such as vegetation control with herbicides or mechanical trimming, could also result in impacts to some areas of special concern. Site-specific evaluations would be required to determine the potential for negative impacts to such properties, although it is anticipated that permitting requirements would mitigate most impacts.

During facility operation, hazardous emissions or sanitary or hazardous wastes would not be released to the water. Fuel spills could occur as a result of vessel accidents or leaks during maintenance activities, but such spills would be unlikely to measurably affect biota or habitats within marine protected areas (see Sections 5.2.8 through 5.2.14). The potential for such impacts in areas of special concern is further reduced because placement of wind energy structures would be unlikely to occur within offshore marine protected areas. Overall, impacts to areas of special concern from operations would be negligible.

Wind facilities utilizing a central ESP may have transformers that contain large reservoirs (150,000 L [40,000 gal]) of electrical insulating oil (such as mineral oil), as well as smaller amounts (7,600 L [2,000 gal]) of additional fluids such as diesel fuel and lubricating oil. In the event of a catastrophic release of all these materials (see Section 5.2.4.4), there would be an increased potential for negative effects on areas of special concern.

The magnitude of effects from accidental spills would depend on the location, timing, and volume of the spills, the toxicity of the materials released, and the species (and its ecology) exposed to the spills. For example, spills that reach coastal areas and islands, and especially sheltered coastal habitats such as bays and estuaries, would be more likely to affect protected resources. A large spill that reaches sensitive ecological habitats that are in limited supply, such as coral reefs, could result in substantial effects and recovery from such impacts could be very slow.

Thus, the potential impacts to areas of special concern from a catastrophic spill could range from negligible to major, depending on the size of the spill, the materials released, the species and habitats exposed to the spill, and the effectiveness of spill containment and cleanup activities. As described in Section 5.2.4.4, the likelihood of a large release of hazardous materials from these facilities is considered to be low.

Except for the potential for catastrophic spills of materials stored at an ESP, it is anticipated that the overall impacts to areas of special concern from operation of an offshore wind facility (with implementation of the mitigation measures identified in Section 5.2.15.6) would be negligible.

5.2.15.5 Decommissioning

Decommissioning of a wind facility would involve the dismantling and removal of infrastructure from each wind turbine platform, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Platforms would be removed by cutting pilings at a depth of at least 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, areas of special concern could be affected by noise and vessel activity generated during dismantling, the alteration and loss of habitat provided by the existing structures, and accidental releases of hazardous materials and fuel.

Decommissioning activities would be similar to construction activities, although largely in reverse and at lower levels. Although pile driving would not occur during decommissioning, explosives could be used for the removal of some platforms. Pressure- and noise-related impacts could occur to marine mammals and fish as discussed in Sections 5.2.8.5 and 5.2.11.5, respectively. Depending on the proximity of platforms to areas of special concern, some resources within protected areas could be affected. It is anticipated that OCS wind facilities would not be located within or immediately adjacent to offshore areas of special concern. Consequently, impacts on such areas from platform removal with explosives are considered unlikely.

The construction of towers would result in the creation of new hard substrate that would essentially perform as an artificial reef, supplying habitat for fishes and invertebrates (see Sections 5.2.11 and 5.2.14). Removal of platforms from the project area would remove this artificial habitat. The overall result would be to return the project area to conditions, both physical and biological, similar to those that existed prior to construction of wind facilities. Because wind generation structures are unlikely to be located within or immediately adjacent to offshore areas of special concern, these areas should not be measurably affected.

During decommissioning activities, hazardous emissions or sanitary or hazardous wastes would not be released to the water. Fuel spills could occur during decommissioning as a result of vessel accidents or leaks with potential effects on areas of special concern as described in Section 5.2.15.4. Overall, impacts on areas of special concern from decommissioning activities would be negligible.

5.2.15.6 Mitigation Measures

The principal impacting factors that could potentially affect areas of special concern from offshore wind energy development include noise, habitat disturbance, and the potential for spills of fuel or other hazardous materials. Some general measures that could reduce the likelihood of adverse effects on areas of special concern include the following:

- Avoid locating wind generation facilities close to or in marine protected areas.

- Utilize practices and follow operating procedures that reduce the likelihood of vessel accidents and fuel spills.

- If facilities are located near areas of special concern, avoid use of explosives for removing pilings when feasible to minimize impacts to fishes and marine mammals.

- Avoid, to the extent practicable, placement of OCS wind energy facilities within visible distances from areas of special concern.

- Implement and require compliance with measures to reduce the potential for trash and debris to enter the water during the various phases of development.

5.2.16 Military Use Areas

5.2.16.1 Technology Testing and Site Characterization

Testing and site characterization activities are small and unobtrusive but could be an obstruction to surface use by military units depending upon their location. However, there does not appear to be any potential for conflict with airborne units. Potential impacts would be negligible and avoidable when coordinated with Department of Defense (USDOD).

5.2.16.2 Construction, Operation, and Decommissioning

Commercial wind facility installations would vary in size and location but would be large enough (two 160-MW commercial wind facilities in Europe cover approximately 26 km^2 [10 mi^2] of surface including a buffer area) (Elcock 2006) to create a substantial exclusion area for military uses. Though not restricted to military uses, there may be potential adverse effects on radar operations from the presence of operating WTGs (U.S. Department of Defense 2006). Because of the expected limited development of facilities in the time frame of analysis for this programmatic EIS and the huge amount of ocean surface available, impacts to military operations are expected to be negligible as long as developments are coordinated with the USDOD.

5.2.16.3 Mitigation Measures

The MMS would need to ensure effective coordination with the DOD regarding future alternative energy leases, new areas of industry interest, and current or proposed areas of military operations. As part of this coordination, stipulations would be routinely evaluated and applied, as necessary, to minimize or eliminate conflicts.

5.2.17 Transportation

The Coast Guard has issued a Navigation and Vessel Inspection Circular (USCG 2007), which provides guidance on information and factors the Coast Guard will consider when reviewing applications for permits to build and operate an Offshore Renewable Energy Installation (OREI) in the navigable waters of the United States. The circular identifies information that the Coast Guard will consider when evaluating the potential impacts of an OREI in the areas of navigational safety and the traditional uses of waterways and on Coast Guard missions. Applicants planning to build an OREI are encouraged to refer to this circular to better understand the Coast Guard review process and how to provide information to assist the Coast Guard and expedite this process. The circular also offers guidance on addressing the necessary marine safety and security issues when preparing an application for submission to the MMS. The Coast Guard will provide the MMS with an evaluation of the potential impacts of the proposed facility on the safety of navigation and the traditional uses of the particular waterway and other Coast Guard missions to help the MMS to prepare its NEPA documentation. The Coast Guard will help develop appropriate terms and conditions that provide for navigational safety and minimize potential impacts on other Coast Guard missions in and around the proposed facility and recommend them to the MMS for consideration.

5.2.17.1 Technology Testing

Little testing of offshore WTGs is expected on the OCS, because offshore WTG technology has already been demonstrated (in Europe) and the costs of installation in the United States comprise such a high portion of total costs. Installation costs are high because the WTGs are often larger, further offshore, and in deeper waters with special vessels and equipment needed to transport and install the equipment. Thus, developers proceed to commercial-scale development once the site characterization data indicate the economic viability of the project.

However, as mentioned in Section 3.5.1, there may be testing of new foundation designs to support larger WTGs and/or to allow for installation in deeper water. In such a case, transportation impacts for site characterization, construction, and operation would be similar to those discussed in the following sections. Since construction of a wind facility involves the sequential installation of WTGs as discussed in Section 5.2.17.3, similar construction impacts are expected, but for a shorter length of time depending on the number of WTGs in the demonstration project.

5.2.17.2 Site Characterization

Negligible to minor transportation impacts are expected during site characterization. One or two survey vessels may be deployed to the area at any one time to investigate the marine environment. Local studies would be performed so that potential wind energy generation site locations would minimize environmental impacts (e.g., to aquatic species and ocean floor habitats) and provide suitable ocean floor characteristics for wind turbine foundation installation and submarine cable installation.

For wind generation, the suitability of a specific site is also dependent on meteorological conditions. A meteorological tower is typically installed at the site of a proposed wind facility and data (i.e., wind speed, wind direction, barometric pressure, and ambient temperature) collected for one or more years. Installation of a typical meteorological tower consists of sinking three legs (pile driven) into the seafloor to support an above-water deck that supports the meteorological tower itself. A larger monopile could also be used. Vessel activity would be required during the time that tower construction activities take place, about 8 to 10 weeks with only about the first 3 days needed to sink the three legs (Elcock 2006). Such activity is expected to require only two to three vessels at any one time, such as a purpose-built jack-up barge for driving the pilings and any attendant smaller support craft. Most active commercial ports are expected to be able to handle the additional activity for site characterization.

5.2.17.3 Construction

As an offshore wind energy facility will be composed of multiple wind turbines, onshore staging/lay-down areas with marine access will be required for project materials prior to transport to the facility site. Because the size of the wind turbine blades is too large for ground transport, they would be delivered to the site by marine vessels. Other components may be delivered by truck or rail as well as barge to the onshore staging area.

Onshore impacts would include connection of the offshore power cable to the power grid. If the power cable from the offshore facility is to traverse local roads or railroad rights of way to connect with the onshore power grid, temporary interruptions in local traffic may be required.

Wind turbines are expected to be installed in sequence, in part because of the anticipated need for the use of purpose-built vessels (i.e., a large jack-up barge with a crane and pile driver for monopile installation). Such a schedule allows for an orderly installation resulting in negligible to minor transportation impacts. Up to 10 monopiles may be loaded onto a support barge for delivery to the facility site (Elcock 2006). Alternately, the jack-up barge could return to port for a monopile prior to each installation. After installation of the monopile, each WTG is delivered and installed by a purpose-built vessel with a crane to mount the WTG tower onto its monopile foundation. It takes up to about 40 h to install one WTG at its offshore location (Elcock 2006).

As the WTGs are installed, one or two vessels may be employed in the laying of submarine cable and the electrical connection of each device to an electrical grid. The cable is transported to the launching area in a cable transport vessel. Line cable machines onboard a barge pull the cables from coils on the transport vessel onto the barge, which is then sent to the offshore location. The cable-laying barge is specifically designed for installation of submarine cable and is used for both transport and installation. Installation of the submarine cable is by jet plowing, which uses a positioned cable barge and towed hydraulically powered jet plow device that simultaneously lays and embeds the submarine cable in one continuous trench from WTG to WTG and then to the ESP (Elcock 2006). The ESP-to-shore cable is laid with a similar process. Depending on design, the ESP itself will involve the installation of a few legs into the seafloor to support an above water platform with the electrical equipment necessary for connection to each

WTG at the facility as well as a connection to an onshore substation to which the generated power is delivered. To facilitate maintenance, the ESP may have a helipad on its roof.

Other vessels may be involved with the placement of scour material on the seafloor around the monopiles. Thus, several vessels, including one or two large jack-up barges for monopile and WTG tower installation, would be operating at the wind facility location for about 2 days per WTG installed. Such activity should be easily supported by a commercial port.

WTG installation may also involve round-the-clock operations to maximize use of purpose-built vessels and minimize crew time at the site location. Some construction schedules may call for maintaining the jack-up barges on location with support vessels traveling between port and the offshore facility site to supply parts and equipment and to ferry the work crews back and forth. Crew transport could also be by helicopter rather than marine transport, similar to operations on oil and gas platforms. Thus, the availability of nearby aeronautical support, such as an airport or suitable helipad area, may be important. However, support for only one or two helicopters would be needed.

5.2.17.4 Operation

Little vessel traffic is anticipated during operation of any offshore wind generation facility, resulting in negligible transportation impacts. Monitoring of the facility would be conducted remotely from an onshore location. Visual inspection of the WTGs may be conducted, but such inspections are expected to require the use of a single vessel and occur on a weekly or monthly basis. However, daily trips to a wind facility by a crew boat and work boat may be necessary after initial startup until operational requirements are well understood (Elcock 2006). Support vessel access to port facilities could be limited by vessel traffic at the busier ports and/or by navigational hazards (e.g., the fairways in the Gulf of Mexico as a result of existing oil and gas platforms). Maintenance or repairs of the WTGs may be accomplished in place while others may require partial dismantlement and return to a dock facility. There is also the possibility that maintenance crews could be transported to a wind facility by helicopter for maintenance as is the case for some installations in Europe. Overall, at the most, one or two vessel and/or helicopter trips a day would have a negligible impact on any commercial port or airport.

Because a wind energy facility would be located at the water surface, it would pose a potential hazard to marine navigation. As is also the case with offshore wave generation technologies, the location of a wind energy facility should be selected to not interfere with designated fairways and shipping lanes as well as prime fishing areas. The USCG has statutory authority for promoting the safety of life and property on OCS facilities and adjacent waters (USCG 1989). Therefore, vessels used on waters of the OCS as well as facilities installed on the OCS are subject to USCG licensing and inspection. To mitigate any navigational impacts, such as vessels colliding with wind generation support structures, each supporting platform on the water surface would require appropriate signage and/or lighting as a warning to passing vessels.

In addition to being a potential hazard to marine navigation, offshore wind energy structures also pose a potential aviation hazard, with wind turbine blades that could extend more than 130 m (427 ft) above the ocean surface. Over open water, FAA rules do not specify a minimum altitude at which an aircraft may fly, but the rules do specify that an aircraft may not be operated closer than 152 m (500 ft) to any person, vessel, vehicle, or structure (14 CFR 91.119). Thus, wind turbine generators in offshore locations are expected to be required to have appropriate lighting to warn pilots, especially in areas where planes may be operating under visual flight rules. Also, such wind turbines should not be located along any low-altitude instrument flight rules routes or located so as to pose a problem to a coastal airport's inbound or outbound air traffic operations.

Because of the size of WTGs, their impacts on air traffic operations extend to potential interference with air traffic control and military radar systems (U.S. Department of Defense 2006). Such interference may have negligible to minor impacts when properly mitigated. WTGs are large structures that block transmission of radar signals in a manner similar to tall buildings. However, the effect from a single WTG is small due to its narrow shape. Significant problems may arise when multiple WTGs are situated near a radar installation, especially for smaller objects near the horizon. As the radar return is dependent on signal loss from both the outbound and return trip off a target, the radar signal will be affected twice by any intervening structure such as WTGs in a wind facility. Multiple WTGs in an area will also cause degradation in the radar return because of diffraction effects. An additional complication, Doppler shifts of the radar signal, is added by rotation of the turbine blades. The combination of these effects may obscure the accurate observation of intended targets unless taken into account when siting wind facilities in the vicinity of radar installations. Similar problems are encountered by weather radar systems near wind facilities; impacts may include misidentification of thunderstorm features, false radar estimates of precipitation accumulation, and incorrect storm cell identification and tracking (Vogt et al. 2007).

The impacts of wind facilities on other electromagnetic systems used for communications and navigation are negligible to minor. Global positioning system (GPS) reception relies on multiple satellites in orbit about the earth. A single WTG cannot block a signal from all satellites at once, and no problems with GPS reception, including positional accuracy, were noted in studies conducted at the North Hoyle Windfarm off the coast of the United Kingdom (Brown and Howard 2004). This same study also noted that magnetic compasses, automatic identification systems, and very-high frequency (VHF) communications (ship-to-ship and ship-to-shore) were not affected within the wind facility. Some difficulty in detection of marine targets by ship- and land-based radar systems was observed. A followup study (Brown 2005) on search and rescue operations involving helicopters also showed that radio communications and VHF homing systems worked satisfactorily as did thermal imaging of vessels, turbines, and personnel within the wind facility. However, use of the thermal imaging systems during precipitation events was not tested, and marine radar imaging from vessel- or shore-based radar of helicopter movement within the wind facility was poor.

5.2.17.5 Decommissioning

During decommissioning, transportation impacts would be negligible to minor. The same low number of vessels required for construction (see Section 5.2.17.3) would be used for decommissioning. Removal of a wind energy facility would entail dismantling each WTG unit, removing the WTG from its tower, taking the tower off its foundation (monopile), and removing each monopile from the seafloor. Each section would then be transported to port. However, a vessel to support removal of monopiles rather than driving them in to the seafloor would be needed. Once onshore, the major parts of the wind energy units can be refurbished for use in another location, dismantled for scrap, or disposed of at an appropriate facility. An onshore staging facility may be required depending on the rate of recovery of equipment, the rate of equipment processing, and the availability of land transportation.

5.2.17.6 Mitigation Measures

Vessel traffic in support of the testing, construction, operation, and the decommissioning of an offshore wind facility is expected to be low as discussed above. Thus, most ports and harbors supporting commercial operations and traffic would be able to accommodate the needs of such a facility without significant modifications or upgrades that might affect current operations and the environment.

Attention must be given to proper site selection for a wind facility because of its potential transportation impacts. The Coast Guard requires the performance of a traffic study for all uses of the area affected by a proposed offshore facility (USCG 2007) as part of a detailed risk assessment focusing on navigational safety, traditional uses of the area, and impacts on other Coast Guard missions. In general, wind facilities should be situated to not interfere with major ports, shipping lanes, and fisheries as a hazard to marine navigation. Proper lighting and signage must be present on wind facility structures to aid navigation and reduce the risk of collision. In the interest of aeronautical safety, wind facilities should not be situated near airport flight paths and other controlled airspaces (e.g., military installations), and the WTGs should be marked with appropriate aviation lighting.

Wind facilities may also interfere with commercial air traffic control radar systems as well as national defense and weather radar systems. The solution in most cases is to locate the wind facility at a reasonable distance from a given radar installation. Other options may be to change the spacing/configuration of the WTGs within the wind facility or to optimize radar system logic and analysis algorithms. The use of antireflective coatings on WTGs is also being studied as part of a solution (Appleton 2005). As each project is unique, an in-depth study of potential problems and solutions will be needed at the time a specific project is proposed.

5.2.18 Socioeconomic Resources

For the purposes of this EIS, coastal economies can be placed into six groups in the analysis of population, employment, and regional income:

- Metropolitan
- Small urban

- Single-industry small urban
- Coastal residential
- Rural industrial
- Rural agricultural

Metropolitan areas in each region have highly complex economic structures, containing a wide range of industries, with wide and diverse labor markets. Small urban economies are characterized by fewer economic sectors and a less diversified labor market than in metropolitan areas. The region also includes a number of urban areas that serve specialized economic functions, including maritime shipping, fishing, boatbuilding, recreation, and tourism, and numerous locations featuring residential areas hosting second homes and retirement communities. Outside urban areas, there are a number of economies based on resource extraction, power generation, and transportation industries and economies based on agriculture. These areas have simpler economic structures and contain smaller, less diversified labor markets.

Similarly, coastal sociocultural environments can be placed into five groups:

- Large urban
- Small urban
- Single-industry small urban
- Rural diverse
- Rural

Large urban areas in each region exhibit a high level of diversity, with multiple population groups (races and ethnicities) and heterogeneous sociocultural systems in these areas reflecting a wide variety of cultural groups of African, European, Asian, Latin American, and Middle Eastern origins. Single-industry small urban communities have a sociocultural environment that often closely reflects the dominant economic activities in these locations, including seaport, fishing, boatbuilding, recreation, and tourism activities, and that exhibits some diversity in population and exposure to multiple cultures. Rural diverse communities contain more than one major population group (multiple races and ethnicities) and cultures that are based on economic activities that maintain a relatively large immigrant labor force. Many small rural communities in each region maintain sociocultural environments that are less diverse, often supporting a single or small number of cultural groups associated with the most important community economic activity.

As detailed in the sections below, for each phase of OCS wind energy development, impacts to socioeconomic resources are expected to be minor. For each phase of wind energy development, potential impacts to population, employment, and regional income; sociocultural systems; and environmental justice require consideration.

5.2.18.1 Technology Testing and Site Characterization

Activities associated with the testing of OCS wind energy technologies would include the construction of a small number of offshore test facility towers and associated foundations and shore-based activities, while activities associated with site characterization would include the deployment of survey ships or barges and the construction of meteorological towers. These activities would not employ many workers, would be temporary in nature, and would have low impacts on regional income and population (e.g., less than one direct job per wind turbine and about one direct job per turbine would be created during technology testing and site characterization, respectively [Elcock 2006]). They would have similarly low impacts on sociocultural systems. Potential environmental justice impacts would be site-specific and would be evaluated in future environmental evaluations for individual projects. Any impacts that would occur would be qualitatively similar to those occurring during the construction, operation, and decommissioning phases, but the magnitude of the impacts would be less.

5.2.18.2 Construction, Operation, and Decommissioning

Activities associated with the construction phase of OCS wind energy technologies would include the onshore manufacturing of components and their transportation to offshore sites, the preparation of port facilities, and the installation of components, transformers, and cables. Activities required for operation would include monitoring and maintenance of offshore facilities with the use of small boats and cranes. During decommissioning, the dismantling and removal of offshore facilities, devices, and cables would occur, as would their transportation to shore with the use of special vessels.

***Population, Employment, and Regional Income*.** The impact of employee and contractor wage and salary spending and project procurement expenditures associated with these activities would likely be small. However, because there are a number of contrasting types of economic areas in each region, it is likely that there would be some variation in the magnitude of the impact of OCS energy technologies, depending on the type of economy in which specific projects were to be located.

The impacts of construction, operation, and decommissioning in metropolitan and small urban areas would likely be small, with sufficiently diverse local economic infrastructure and labor markets to provide the required labor force, equipment, materials, and services. Single-industry small urban and coastal residential economies are likely to experience more significant impacts, with wage and salary spending and procurement expenditures larger compared to the local economic base, and with higher demands on local occupational groups. OCS activities in rural industrial and rural agricultural areas would likely have a larger impact than in other types of economies, requiring a relatively large share of labor in key occupational categories and of the available local production capacity for the required material and services.

Construction, operation, and decommissioning activities would create only small direct employment, income, and population growth in the three study regions. About three direct jobs per wind turbine would be created during the construction phase, and one direct job per turbine would be created during the operation phase and during the decommissioning phase (Elcock 2006). Direct income created by wind projects would also be small. Although the locations of wind developments and plants manufacturing wind technologies are not known, the extent to which wind developments would increase population would be small. Indirect impacts during all phases of development, and impacts on income and population, would likely be small. Impacts on property values, tourism, and recreation would be location-specific, minor, and temporary, and could be positive or negative. Impacts to the fishing industry would be minor, depending on coastal location and the placement of OCS structures.

Sociocultural Systems. Construction, operation, and decommissioning would likely require only a small labor force in each location, with few, if any, workers required to relocate into the communities hosting OCS developments. However, there is a potential for some variation in the magnitude of the impact depending on the type of sociocultural environment in which specific projects were to be located.

Aggregate regional effects are expected to be small. Although it is not likely that in-migration of any workers would be required to fill positions, sociocultural impacts may vary by community, with the social organization of some communities leaving them vulnerable to fluctuations in industry activity. In other communities, local sociocultural structures buffer them from any rapid industrial change. In communities where impacts would occur, effects might include alterations in ethnic composition, self-identity, and cultural persistence and overall changes in social institutions, notably family, government, politics, education, and religion. Sociocultural systems in some communities would experience stress (moderate impact), particularly those that are most closely tied to the marine environment. Other communities would have the capacity to cope with rapid industry change (negligible to minor impact).

The impacts in large urban areas would likely be small, with a wide diversity of population groups and cultural systems present and, therefore, little likely contrast with any in-migrating population. Sociocultural impacts are likely to be larger in small urban and single-industry small urban areas than in large urban areas because there is more homogeneity in local cultural systems and more likely to be a contrast with any in-migrating population. Similar impacts might be expected in rural diverse communities, depending on the cultural origin of any in-migrating population.

Environmental Justice. The majority of potential impacts to low-income and minority populations would come as a result of construction and operation of the onshore infrastructure and support facilities. As it is likely that onshore facilities would be located close to industrial port facilities, it is possible that onshore OCS infrastructure could be located near minority and/or low-income populations. Infrastructure that would be constructed in support of OCS developments might include the addition of new landfalls, administration and waste facilities, and switchyard and transmission facilities. Construction, operation, and decommissioning of these facilities could produce noise and visual impacts, increased traffic, air and water pollution, impacts to residential property values, and land-use changes.

Varying degrees of hazard could be associated with the construction and operation of onshore components of wind energy facilities, producing potentially harmful impacts to the environment, subsistence, health, and physical safety. The effect of air emissions associated with wind facilities (e.g., emissions from onshore construction machinery and from construction and operation vessels and helicopters) on coastal air quality may also create environmental justice issues. Such emissions would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Air emissions from the proposed program are not expected to result in air quality impacts to minority or low-income populations.

Although construction, operation, and decommissioning of OCS facilities and their associated coastal infrastructure support facilities might result in environmental justice issues in a number of counties along the coast, in the absence of specific locations for these developments at the programmatic level, it is not possible to identify any specific disproportionately high and adverse impacts on minority and low-income populations. Impacts of offshore energy projects on specific population groups in specific coastal communities and neighborhoods would be part of site-specific analyses undertaken at the individual project level. These analyses would be based on population data at the census block group level for up to 50 mi from a project location, to fully reflect the impact of a particular energy development project on environmental justice given the regional distribution of minority and low-income population groups.

5.2.18.3 Mitigation Measures

Mitigation of economic, sociocultural, and environmental justice impacts associated with the development of OCS wind technologies may be required, depending on the location, scale, and impact of specific projects. However, the magnitude of the economic and sociocultural impacts of wind technologies is likely to be small, with little employment and population in-migration required during each stage of a project. With onshore facilities likely to be located in existing ports, environmental justice issues may arise, depending on the location and nature of impacts of these facilities.

5.2.19 Cultural Resources

Impacts to cultural resources can occur during all phases of offshore wind energy development where there is the potential for seafloor disturbance in previously undisturbed areas. Seafloor disturbance can be either the direct or indirect result of construction activities, such as excavations for offshore turbine installation, offshore drilling, or offshore cable placement. Direct impacts are the result of direct destruction or removal of cultural resources from their primary context. Indirect visual effects could occur to cultural resources on the coast if visual factors are important for maintaining the integrity of the resource (see Section 5.2.19.3). Although the specific types of cultural resources and their potential locations may vary regionally, the types of impacts that could occur to cultural resources are similar across the three regions.

5.2.19.1 Technology Testing and Site Characterization

Impacts to cultural resources could occur during technology testing and site characterization; however, specific impacts would need to be addressed at a site-specific project level. Impacts are expected to be minor to negligible assuming that testing and characterization activities are at a very small scale and related construction activities can be moved to avoid cultural resources. Cultural resources identified in small testing areas can be just as significant as cultural resources in larger-full-scale development areas and require the same level of protection. Because seafloor disturbance occurs during this phase, the same protection measures for cultural resources must be implemented during this phase as with the larger-scale construction phase to meet the requirements of Section 106 of the National Historic Preservation Act (NHPA) (see Section 5.2.19.2). Consultation and cultural resource surveys would be conducted prior to any testing.

5.2.19.2 Construction

Impacts to cultural resources are most likely to occur during large-scale construction of a wind development project; however, specific impacts would need to be addressed at a site-specific project level. Most impacts would result from some form of seafloor disturbance (trenching, dredging, or facility or component placement or installation) that could disrupt shipwrecks and buried prehistoric archaeological sites offshore. The level of impact could range from negligible to moderate depending on the location of the project, the level of seafloor disturbance that has previously occurred in that location, the number and significance of the sites present in that location (if it has been previously undisturbed), the feasibility of moving portions of the development project to avoid important resources, and the expected efficacy of mitigation/data recovery should impacts to some significant sites be unavoidable.

Indirect visual impacts could also result from disruption of a historical setting that is important to the integrity of a historic structure, such as a lighthouse or residential or community building. Visual impacts during construction are anticipated to be negligible to minor since the impacts of construction are temporary; however, see Section 5.2.19.3 for the potential for longer-term visual impacts.

5.2.19.3 Operation

There are few activities during operations that would have the potential to affect cultural resources; impacts would need to be determined on a site-specific basis. The presence of wind turbines within view of the coast, and in particular in view of significant historic properties, could result in a visual impact on historic properties. The level of impact could be considered moderate or even major if the setting of the property is important in maintaining the site's historic character.

Maintenance and inspection activities involve mostly transportation activities and would not likely affect cultural resources. The exception to this would be the replacement or removal of system components. These impacts would be similar to those described in Section 5.2.19.4. The level of impact would be considered negligible to minor as impacts would have already occurred during construction. However, if new areas were disturbed as a result of these activities, the potential for impact would increase and surveys could be necessary if not already completed in the area of new disturbance.

5.2.19.4 Decommissioning

Decommissioning activities are similar to construction activities, although in reverse order. Impacts to cultural resources are expected to be negligible to minor, as most impacts would have likely occurred during construction. Impacts are possible if new areas of the seafloor are disturbed during decommissioning. If new areas are disturbed as a result of these activities, the potential for impact would increase and surveys could be necessary if not already completed in the area of new disturbance. Visual impacts associated with decommissioning would be temporary and of short duration.

5.2.19.5 Mitigation Measures

Cultural resources are nonrenewable and are, therefore, irretrievably lost once they have been impacted. Avoidance of a significant resource is the preferred mitigation option and the MMS's preferred policy. Currently, the MMS has regulations in place for addressing cultural resources prior to oil and gas development (e.g., 30 CFR 250.194); similar regulations are currently being drafted for the development of alternative energy as similar types of impacts could occur. The MMS meets its responsibilities under the NHPA for projects over which it has permitting authority on the OCS through the following procedures: the MMS begins the Section 106 process by initiating consultation with the appropriate States, affected tribes, and other interested parties. Consultation begins with the MMS informing the parties of the project's details and the steps the MMS undertakes to identify and consider cultural resources that may be affected by the proposed project. Consultation is ongoing throughout the project.

The MMS policy requires the performance of marine remote sensing surveys within all areas where MMS archaeological baseline studies indicate a potential for cultural resources (historic and prehistoric) to exist. If the results of these surveys indicate the presence of a potential cultural resource within the project area, the MMS requires that the project either be modified to avoid the location of the potential cultural resource or that further investigations be conducted to conclusively determine the identity of the potential resource. If further investigations indicate that a significant cultural resource exists and cannot be avoided by the proposed project, the MMS would continue Section 106 consultation with the State, affected tribes, and other interested parties to determine the appropriate mitigation. Potential mitigation strategies include, but are not limited to, full data recovery, partial data recovery, monitoring, sampling strategies, remote sensing, mapping, and photography. Confining maintenance and decommissioning activities to areas previously disturbed during project construction activities would be encouraged to minimize additional potential impacts to cultural resources.

The MMS also requires, through regulation and/or lease stipulation, that if any unanticipated cultural resource is encountered during project-related activities, all activities within the area of the discovery be immediately halted and the MMS contacted.

The MMS (BLM prior to 1981) and/or the NPS have tested and refined the survey and mitigation strategies for identification, evaluation, and avoidance of offshore cultural resources through numerous studies over the past 30 years. These studies include, among others, CEI 1977; Institute for Conservation Archaeology 1979; SAI 1981; CEI 1982; CEI 1986; PS Associates 1987; Garrison et al. 1989; Espey, Huston & Associates, Inc., 1990; Pearson et al. 2003; and PBS&J 2006. See Sections 4.2.19, 4.3.19, and 4.4.19 for a discussion of those OCS areas within the Atlantic, Gulf of Mexico, and Pacific regions where MMS baseline studies indicate a potential for historic properties and where the MMS will implement its survey and mitigation requirements.

For onshore cultural resources, including historic architectural resources, districts, and landscapes that may be subject to adverse visual effects from an OCS project, the MMS will develop appropriate mitigation through consultation with the States, affected tribes, and other interested parties in accordance with the procedures outlined in the ACHP regulations at 36 CFR 800.

5.2.20 Land Use and Existing Infrastructure

5.2.20.1 Technology Testing and Site Characterization

Technology testing and site characterization activities are small, and while they require construction and operation effort, the overall amount of work and shore support needed for installation is negligible compared to existing activities in most areas. Installation of the facilities would introduce a small obstruction to navigation that may affect some uses of the area, but this would cause a negligible impact. It is expected there would be negligible shore-based construction/operation impacts associated with these activities. No other impacts are expected.

5.2.20.2 Construction, Operation, and Decommissioning

Depending on the location of the development site, port facilities may need to be expanded to accommodate the large components associated with wind facility development and the size and number of vessels required to transport components to their offshore/onshore locations. Alternatively, larger but more distant ports could be used in the construction phase, but this would increase transportation distances, fuel costs, and construction time. Facilities to transport construction personnel both by boat and helicopter would also be needed. Onshore transportation to the point of embarkation of materials for construction would be required. There are large port facilities along all coasts that could provide necessary construction support with minimal modification, and it is expected that any impacts associated with port and transportation system expansion would be negligible to minor over the analysis period.

The construction phase would require temporary housing and support facilities for all or a portion of the construction crews depending on the availability of qualified local labor. Depending upon the size of the project, a construction period of up to 2 years may be expected. For planning purposes, 0.58 jobs can be expected per WTG during the construction period. For a development of 150 WTGs, this would be approximately 87 jobs. These are jobs directly associated with assembly of the wind facility, not with construction of the WTG components, which would be expected to be out of area. It can be expected that additional, indirect job creation also would occur within the local area, but it is assumed that most of these jobs would be associated with current residents. Because it is expected that offshore wind developments in the planning period would be developed near existing urban areas, the additional demand for housing and infrastructure to support the construction crews and their dependents is expected to be negligible.

Commercial wind facility installations would vary in size and location but would be large enough (two 160-MW commercial wind facilities in Europe cover approximately 26 km^2 [10 mi^2] of surface including a buffer area) to create a substantial area where they dominate other surface uses. Spacing among WTGs within a development is wide enough to allow surface access for boating uses, but there may be some need to restrict uses based on site-specific evaluation. Facilities would exclude commercial shipping from an area, but the effect on fishing and recreational issues would be defined on a site-specific basis. Because existing shipping fairways are well established, it is not expected that any facilities would be constructed that would interfere with those uses. Overall effects on surface uses are expected to be negligible to minor depending on the specific site requirements.

Onshore construction to tie electrical production from an offshore wind facility to the local/regional grid would be required but is expected to have negligible impact on the area. Additional underground and/or overhead transmission lines may be required as well as some additional electrical substation facilities depending on the generation capacity of the new project and the capacity of the existing land-based transmission system. For the analysis period, the overall impact is expected to be negligible.

There are many existing uses along coastal areas and in the nearshore area that are potentially affected by or could affect offshore wind facility development. Examples of existing water uses include shipping fairways, recreational boating, undersea cable installations, shellfish beds or fishery areas, and marine sanctuaries. Examples of onshore uses that may be affected include wildlife refuges; units of the national, State, and local park systems; and areas of high scenic value. All existing uses of areas proposed for development would need to be identified during site-specific project review to determine the potential effects of wind facility development. Additionally, the Coastal Zone Management Act (CZMA), discussed in

Section 1.7, requires a Federal agency to consult with the States regarding consistency with their approved Coastal Zone Management Programs.

Development of offshore wind facilities that are located near coastal communities has the potential to affect existing land uses. Current information on the actual effects of the installation of wind generation facilities either on land or nearshore is incomplete and must be considered at the site-specific level. There is a division of opinion among the public as to the visual effects of nearby wind generation facilities. Because of the visually sensitive nature of many coastal areas (e.g., parks, refuges, recreation areas, valuable beachfront property) and because of the concentration of the U.S. population near coastal areas, there is the possibility for long-term effects in how shore-based communities are perceived, but there is little solid information on which to make generalizations in this regard. It is expected that reactions of individual communities will vary depending on the unique features of each community. Whether installation of offshore wind facilities can, for instance, change the public desirability of individual communities or areas is currently unknown. Because of the expected limited development of wind energy facilities over the analysis period for this project, it is expected that the overall impact will be minor.

Operations activities would require conventional ocean surface transport and possibly helicopter access, but these would require no special facilities beyond those likely already available in most coastal areas. Employment associated with project operation is expected to average 0.3 direct jobs per turbine, with more for smaller facilities and fewer for larger (i.e., possible economies of scale). Based on the European and U.S. land-based wind project experience, various support jobs may be sourced locally or out of area. Development of a local cottage industry for marine and ecotourism may also occur.

Activities associated with decommissioning of a facility would likely be the reverse of the construction process though likely somewhat shorter in duration and would require port, transportation, labor, and employee housing to accomplish the removal. Impacts to land uses would be similar to those in the construction phase and are expected to be temporary and negligible.

5.2.20.3 Mitigation Measures

Public involvement and discussion should be effective in identifying site-specific concerns with any proposed development. Once the concerns/issues are identified, it would be possible to develop effective mitigation measures and/or identify necessary trade-offs in making the decision on requested projects. Importantly, there would be Federal, State, and local processes involved before a final decision could be rendered. Depending upon the specific proposal, impacts could range from negligible to moderate but would be identified in a site-specific NEPA analysis. Project-specific mitigation measures would then be developed depending on the anticipated extent of potential impacts for the project.

5.2.21 Visual Resources

Visual impacts can be defined as the creation of visual contrasts that negatively or positively affect the perceived quality of a landscape or seascape. In the context of the National Historic Preservation Act and implementing regulations (36 CFR 800.5), 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 of Historic places in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. This includes the introduction of visual elements that diminish the integrity of the property's significant historic features. Technology testing, site characterization, construction, operation, and decommissioning of offshore alternative energy technologies and associated onshore facilities and activities potentially would cause a variety of visual impacts. The types of visual impacts of concern include the potential visibility of offshore and onshore structures; the potential visibility of vessels and helicopters associated with transport of workers and equipment for construction, maintenance, and facility decommissioning; and the potential visibility of the construction, maintenance, and decommissioning activities themselves.

Because of the subjective and experiential nature of human visual perception and cognition, the assessment of the magnitude and importance of perceived visual impacts is both subjective and site- and time-specific. Visual impacts are highly dependent on not only physical factors that affect what the impacts are and how they are perceived, but on the number and type of viewers, their sensitivity to the visual environment, and cultural factors that concern both the viewer and the affected landscape/seascape (BLM 1984; DTI 2005; USFS 1995). These factors must be considered in assessing visual impacts.

Factors that influence the perception and evaluation of visual impacts include:

- Viewer distance: Viewer distance from an area is a key factor in determining the level of visual impact, with perceived impact generally diminishing as distance between the viewer and the affected area increases;

- View duration: Duration affects perceived visual impact; impacts that are viewed for a long period of time are generally judged to be more severe than those viewed briefly;

- Visibility factors: These are factors that affect the visibility of an impacting feature to viewers. Circumstances or activities that reduce or eliminate views of the impacting feature will reduce or eliminate perceived visual impact. Atmospheric conditions (night, mist, fog, and rain) may also provide temporary screening. Conversely, projects placed at higher elevations relative to viewers may be conspicuously visible over larger areas and thus have greater visual impact. Viewer elevation and aspect with respect to the impact can also affect impact visibility by increasing or decreasing the viewable area, and reducing or increasing screening effectiveness. The presence of lighting on or near impacting features will enhance visibility;

- Seasonal and lighting conditions: Because visual contrast is a key factor in determining the visual impact of a proposed project, seasonal and lighting conditions that affect contrast may affect perceived visual impact. Sun angle that changes by season and time of day affects shadow casting, specular reflection, and color saturation that affect contrast and perceived impact;

- Landscape/seascape setting: Landscape/seascape setting plays a key role in determining the level of perceived visual impacts because it provides the context for judging the degree of *contrast* in form, line, color, and texture between the proposed project and the existing landscape/seascape (a key factor in visual impact assessment) as well as the appropriateness of the project to the landscape. Some landscapes/seascapes are perceived by most viewers to have intrinsically higher *scenic value* than other landscapes, and physical landscape/seascape properties also determine the *visual absorption capacity* of the landscape, that is, the degree to which the landscape can absorb visual impacts without serious degradation in perceived scenic quality. *Scenic integrity* describes the degree of "intactness" of a landscape/seascape, that is, the existing amount of visual disturbance present; landscapes with high scenic integrity are generally regarded as more sensitive to visual disturbances. A project in a pristine, high-value scenic landscape/seascape with low visual absorption capacity will typically be more conspicuous and perceived as having greater visual impact than if it were in an industrialized setting of low scenic value where similar projects were already visible. Some areas have special meanings to some viewers because of unique scenic, cultural, or ecological values, and are, therefore, perceived as being more sensitive to visual disturbances;

- Number of viewers: Impacts are generally more acceptable in areas that are seldom seen, and conversely, impacts in areas that are heavily used/viewed are generally less acceptable; and

- Viewer activity, sensitivity, and cultural factors: The type of activity a viewer is engaged in when viewing a visual impact may affect their perception of impact level. Some individuals and groups are inherently more sensitive to visual impacts than others, as a result of educational and social background, life experiences, and other cultural factors.

Although there are no commercial offshore wind facilities on the OCS at this time, experience with U.S. and European land-based and European offshore wind facilities has shown that potential visual impacts are often a primary reason for opposition to wind energy developments (Bisbee 2003; Burall 2004; DTI 2005; Dong Energy et al. 2006). Primary public concerns include the potential loss of "naturalness" of landscape/seascape views, and possible effects on land values and tourism.

Offshore structures associated with potential wind facility on the OCS include meteorological towers, WTGs, and ESPs; onshore structures could include transmission lines and construction/assembly facilities. Persons located onshore would generally experience different perceived visual impacts than would persons viewing from offshore locations, who would see wind facilities primarily from boats. Onshore viewers would see offshore WTGs and ESPs from a distance of at least several miles, but might see onshore facilities from much shorter distances. Depending on their location, offshore viewers might see offshore WTGs and ESPs from a wide range of distances, including very short distances. Offshore viewers might also be able to see onshore facilities located near the shore from a wide range of distances.

The presence of wind turbines within view of historic properties could result in visual impacts to those properties. If the historic properties were listed or eligible for inclusion on the National Register of Historic Places, they would be subject to Section 106 of the National Historic Preservation Act. Section 106 requirements would specify activities to be undertaken to identify and assess potential visual impacts to the properties, and, if adverse effects to historic properties were identified, measures to avoid, minimize, or mitigate the impacts would be identified.

A variety of visual impact mitigation measures for offshore wind facilities are presented in Section 5.2.21.6. Although the visual impacts that would be expected to occur from a particular wind energy development would be highly site- and viewer specific, application of appropriate mitigation measures might substantially reduce or even eliminate visual impacts for many viewers/locations.

5.2.21.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would skip the demonstration phase and move directly toward commercial operation. However, new technologies and equipment such as new foundation types would require testing.

Visual impacts associated with testing of new foundation types would include transport of the materials used for construction of the foundation and other components and/or the foundation itself to the testing site, with associated transport of workers and equipment. Because new foundations would be tested in deeper waters, the construction and testing activities would not normally be expected to be visible from shore but, if visible, to be at such great distances that minimal visual impacts would be expected.

Visual impacts from foundation testing to offshore viewers would depend entirely on their distance from the testing site and the nature of the testing activities; if the foundation testing involved a tower, the tower could dominate views from boats sufficiently close, but because boats are generally moving, the close-up views and associated impacts would normally be brief. For both onshore and offshore viewers, vessels and workers would be seen during testing, and vessels and workers might occasionally be seen at the testing site for monitoring and maintenance activities, but these activities would be infrequent, and the visual impact would likely be negligible.

5.2.21.2 Site Characterization

For offshore wind energy development, site characterization includes activities that could involve visual impacts. Typical site characterization activities include the placement of one or a few meteorological towers in or near the proposed wind facility to collect one or more years of meteorological data. Meteorological towers are instrumented towers that vary in height and appearance, but for offshore applications are often 40 m (130 ft) or more in height, generally approximating the hub height of the proposed WTGs (DTI 2005; Ronsten et al. 1999; Antoniou et al. 2006). A variety of meteorological tower designs are available. A typical tower would consist of a steel monopile foundation up to several meters in diameter surmounted by a steel lattice tower. Aviation warning lights would be required for meteorological towers more than 60.9 m (200 ft) tall; normally these would be red lights flashing approximately 24 times per minute. Navigation warning lights would also be present, typically 10.6 m (35 ft) above the water line.

A meteorological tower in a typical seascape would introduce a vertical line that would contrast with the horizon line that dominates most views, as well as introducing a geometrical man-made element into a natural landscape. Some color contrast would also be present. If meteorological towers were constructed on sites near the inner boundary of the OCS, they would likely be visible from shore under some weather conditions, particularly at night, when aviation warning lights on the tower would be visible. Under daylight conditions, a meteorological tower would be expected to have a much smaller visual impact than an individual WTG, because the meteorological tower has no turbine or nacelle, has a more slender support structure (often an open latticework), and it has no moving parts that would be visible from shore. Depending on the distance from shore, earth curvature and waves could screen some or all of the widest and most substantial portion of the tower (the pier), and in other cases weather conditions might render the open latticework top of the tower invisible or nearly so from shore. Overall, visual impacts to onshore viewers of meteorological towers in daylight views would be expected to be negligible to minor. The presence of a flashing light or lights on meteorological towers viewed from several miles away at night would normally be expected to be a minor impact, and could be a negligible impact if other lights were present.

Visual impacts from meteorological towers to offshore viewers would depend entirely on their distance from the meteorological tower; the tower could dominate views from boats sufficiently close, but because boats are generally moving, the close-up views and associated impacts would normally be brief. For both onshore and offshore viewers, vessels and workers would be seen during tower construction, and vessels and workers might occasionally be seen at the tower for maintenance activities, but these activities would be rare and the visual impact would likely be negligible.

5.2.21.3 Construction

Construction activities for a wind facility would involve both onshore and offshore activities associated with potential visual impacts. Onshore activities would include the manufacture, transport and assembly of WTG and ESP components at a facility that likely would be at or near the shore. Offshore construction activities would include transport of towers, turbines, nacelles, and other equipment to the wind facility site, and the assembly and erection of the WTGs at the wind facility.

Manufacture of WTG components for use on the OCS is expected to occur at existing facilities, so that no additional impacts are expected beyond those associated with normal activities. In the vicinity of the assembly point (typically a port facility), there would be increased traffic visible from trucks and/or marine vessels delivering components. If the assembly facility required expansion to accommodate the activities associated with WTG and ESP component assembly and storage, construction activities such as dredging and dock expansion might be visible, and while impact levels would depend on site- and situation-specific factors, impacts could range from negligible to moderate for some viewers. A determination of impacts for construction and operation of these facilities would be conducted during a site-specific National Environmental Policy Act (NEPA) analysis. These construction-related visual impacts would cease when construction was completed, but if the facility expansion resulted in visible permanent structures, the related impacts could be permanent for the lifetime of the facilities.

While it is not anticipated that construction of new conduits, substations, and overhead transmission lines would be required within the time frame of the programmatic EIS, if such construction was needed, related visual impacts would be expected to be negligible to moderate, depending on the size and nature of the facilities, as well as the proximity and visibility of the facilities to viewers. A determination of impacts for construction and operation of these facilities would be conducted during a site-specific NEPA analysis. These construction-related visual impacts would cease when construction was completed, but because the facilities would result in visible permanent structures, the related impacts could be permanent for the lifetime of the facilities.

Transport of WTG components to the wind facility location would involve marine vessels to carry components and construction equipment to the site, and helicopters might be used to transport workers. Nearby onshore and offshore viewers might notice an increase in traffic. The very large WTG tower and turbine components would likely be conspicuous for nearby viewers during transport, but views would typically be of short duration and impacts would be expected to be negligible to minor.

Construction activities at the wind facility would include foundation installation; assembly of towers, nacelles, and rotors; laying of cable; and construction of ESPs. All of these activities could potentially cause both onshore and offshore visual impacts, depending on the distance from shore and from water-based viewers. A variety of marine vessels would be used for these tasks, and one or more might be present on site at a given time. Helicopters might also be present at times, and viewers might notice the activity of the vessels and helicopters; however, the visual impacts directly associated with construction would cease upon completion of construction and are expected to be negligible to minor for onshore viewers, and minor to moderate for boaters in the immediate vicinity of the wind facility. As the wind facility was built, the impacts attributable to the WTGs themselves would gradually increase; these impacts are discussed in the next section.

5.2.21.4 Operation

Operation of an offshore wind facility could potentially cause both onshore and offshore visual impacts. While it is not anticipated that construction of new conduits, substations, and overhead transmission lines would be required within the time frame of the programmatic EIS, onshore impacts would arise if new conduits, substations, and overhead transmission lines were constructed or expanded in association with the new wind facility. In addition to the presence of the structures associated with the conduits, substations, and overhead transmission lines, periodic maintenance activities would require the temporary presence of workers and vehicles. These impacts would be determined during the conduct of the site-specific NEPA analysis, but would generally be expected to be negligible to minor because the maintenance activities are infrequent and of short duration.

Offshore impacts associated with the development of wind energy facilities on the OCS include the presence of the WTG and ESP structures, movement of the rotor blades, the presence of navigational and aviation lighting, and the presence of marine vessels and/or helicopters for maintenance activities. Potential visual impacts would normally be expected to be different for onshore viewers than for offshore viewers; onshore viewers would see offshore WTGs and ESPs from a distance of at least several miles, but might see onshore facilities from much shorter distances. Depending on their location, offshore viewers might see offshore WTGs and ESPs from a wide range of distances, including very short distances.

The magnitude of the visual impacts associated with given offshore wind energy facility would depend on site- and project-specific factors, including:

- Distance of the proposed wind facility from shore;
- The size of the facility (i.e., number of WTGs);
- Size (particularly height) of the WTGs;
- Surface treatment (primarily color) of WTGs and ESPs;
- The number and type of viewers (e.g., residents, tourists, workers);
- Viewer location (onshore vs. offshore);
- Viewer attitudes toward alternative energy and wind power;
- The visual quality and sensitivity of the landscape/seascape;
- The existing level of development and activities in the wind facility area and nearby onshore areas (i.e., scenic integrity and visual absorption capability);
- The presence of sensitive visual and cultural resources;

- Weather conditions;
- Lighting conditions; and
- The presence and arrangements of aviation and navigation lights on the WTGs.

These factors would be evaluated during the course of the site-specific NEPA analysis. A review of several European environmental impact assessments for offshore wind energy developments at distances comparable to the nearshore portion of the OCS indicates that predicted visual impacts ranged from negligible to "significant," with the greatest impacts generally assessed to occur when offshore wind facilities were visible from highly scenic and/or naturally appearing landscapes/seascapes (AMEC 2002; ENERGI E2 A/S 2005; Seascape Energy Ltd. 2002b). It would be expected that similar offshore wind energy developments on the nearshore region of the OCS might cause similar levels of visual impact (i.e., negligible to major).

The theoretical limit of visibility of an offshore structure is determined by the distance between the viewer and the structure, the height of the structure, the elevation of the viewer, and the curvature of the earth. The visibility table (Table 5.2.21-1) allows calculation of the maximum viewing distance of a structure for a given distance, structure height, and viewer elevation, and shows that a theoretical maximum viewing distance value for a 123 m (400 ft) WTG viewed by a person standing at the shore is 42.3 km (26.3 mi). If the viewer was located on a 100-m (328-ft) headland, the theoretical viewing distance would be 56.5 km (35.1 mi). At these maximum distances, the tips of the turbine blades would appear just over the horizon, with the rest of the structure below the horizon. These theoretical distances exceed what is experienced in a real situation, however. In real seascapes, atmospheric haze reduces the practical viewing limit, sometimes significantly, and the presence of waves will also obscure objects very low on the horizon. Furthermore, limits to human visual acuity reduce the ability to discern objects at great distances, suggesting that some WTG components (e.g., blades) would not be discernable at long distances, even though they theoretically would be visible. The color, reflectivity, and other visual characteristics of the object and its contrast with the visual background under varying lighting conditions also affect its visibility (Hill et al. 2001; DTI 2005; Seascape Energy Ltd. 2002a; Elsamprojekt A/S 2000).

While the actual limits of visibility of a wind facility would depend on site-specific factors, some commercial-scale wind facility developments on the nearshore portion of the OCS could be clearly visible under favorable atmospheric conditions. England's Department of Trade and Industry (DTI) (2005) suggests that the distance at which the nacelles, tops of towers, and full rotor blades become visible is the distance at which potentially significant effects on visual amenities could occur. It should be noted that for WTGs of the size likely to be used on the OCS at this distance, the apparent vertical height of even a very tall WTG is relatively small; the tower would be visible on or just above or below the horizon, depending on viewer elevation. For example, Figure 5.2.21-1 is a photosimulation of the Horns Rev wind facility (Denmark) from 7 km (3.8 nautical mi). In this image, the WTGs consist of 70-m towers with 80-m rotor

TABLE 5.2.21-1 Visibility Table (distances at which objects can be seen at sea according to their respective elevations and the elevation of the eye of the observer)

Height (ft)	Distance in Geographic or Nautical mi	Height (ft)	Distance in Geographic or Nautical mi	Height (ft)	Distance in Geographic or Nautical mi	Height (ft)	Distance in Geographic or Nautical mi	Height (ft)	Distance in Geographic or Nautical mi	Height (ft)	Distance in Geographic or Nautical mi
1	1.2	23	5.6	45	7.8	135	13.6	340	21.6	620	29.1
2	1.7	24	5.7	46	7.9	140	13.8	350	21.9	640	29.5
3	2.0	25	5.9	47	8.0	145	14.1	360	22.2	660	30.1
4	2.3	26	6.0	48	8.1	150	14.3	370	22.5	680	30.5
5	2.6	27	6.1	49	8.2	160	14.8	380	22.8	700	31.0
6	2.9	28	6.2	50	8.3	170	15.3	390	23.1	720	31.4
7	3.1	29	6.3	55	8.7	180	15.7	400	23.4	740	31.8
8	3.3	30	6.4	60	9.1	190	16.1	410	23.7	760	32.3
9	3.5	31	6.5	65	9.4	200	16.5	420	24.0	780	32.7
10	3.7	32	6.6	70	9.8	210	17.0	430	24.3	800	33.1
11	3.9	33	6.7	75	10.1	220	17.4	440	24.5	820	33.5
12	4.1	34	6.8	80	10.5	230	17.7	450	24.8	840	33.9
13	4.2	35	6.9	85	10.8	240	18.1	460	25.1	860	34.3
14	4.4	36	7.0	90	11.1	250	18.5	470	25.4	880	34.7
15	4.5	37	7.1	95	11.4	260	18.9	480	25.6	900	35.1
16	4.7	38	7.2	100	11.7	270	19.2	490	25.9	920	35.5
17	4.3	39	7.3	105	12.0	280	19.6	500	26.2	940	35.9
18	5.1	40	7.4	110	12.3	290	19.9	520	26.7	960	36.3
19	5.1	41	7.5	115	12.5	300	20.3	540	27.2	980	36.6
20	5.2	42	7.6	120	12.8	310	20.6	560	27.7	1,000	37.0
21	5.4	43	7.7	125	13.1	320	20.9	580	28.2		
22	5.5	44	7.8	130	13.3	330	21.3	600	28.7		

Continued on next page.

TABLE 5.2.21-1 (Cont.)

Explanation: The line of sight connecting the observer and a distant object is at maximum length tangent with the spherical surface of the sea. It is from this point of tangency that the tabular distances are calculated. The table must accordingly be entered twice to obtain the actual geographic visibility of the object—first with the height of the object, and second with the height of the observer's eye—and the two figures so obtained must be added. Thus, if it is desired to find the maximum distance which a powerful light may be seen from the bridge of a tangent vessel where the height of the eye of the observer is 55 ft above the sea, from the table:

	Nautical mi
55 ft height of observer (visible)	8.7
200 ft of light (visible)	16.5
Distance visible	25.2

Source: Seascape Energy Ltd. (2002a).

FIGURE 5.2.21-1 Visual Simulation of View of Horns Rev Wind Facility (Denmark) from Approximately 7 km (3.8 nautical mi). Wind Turbines Are Approximately 110 m (361 ft) High.

FIGURE 5.2.21-2 Postconstruction Photo of Horns Rev Wind Facility (Denmark) from Approximately 17 km (9.1 nautical mi). Wind Turbines Are Approximately 110 m (361 ft) High. Viewer Elevation Is Approximately 20 m above Sea Level.

diameters for a total height of 110 m. Figure 5.2.21-2 is a photograph of the same wind facility taken from 17 km (9.1 nautical mi).

For wind facilities visible from the shore, visual impacts would be expected to result from the introduction of the numerous vertical lines of the WTGs into a strongly horizontal landscape defined by the horizon line at sea. The visible structures would potentially produce visual contrasts by virtue of their design attributes (form, color, and line) and by virtue of the reflectivity of their surfaces and resulting glare. Objects on or near the horizon tend to draw visual focus, particularly if they break the horizon line (Hill et al. 2001). Frontlighting of the turbines would generally increase perceived impact by heightening contrast between the WTG and the background, while backlighting would increase contrast at sunrise and sunset by silhouetting the WTGs against the bright sky (DTI 2005). Visible rotor movement could attract visual attention as well; additionally, the interposition of WTGs between observers and the sun may produce a strobe-like effect caused by the regular reflection of the sun off rotating blades. This effect could be noticeable at distances of about 10 to 15 km (6.2 to 9.3 mi) (USDOI 2005). Despite their relatively low profile, at the distances from shore that OCS wind energy developments could be located, ESPs could be visible from shore. If so, their form and geometry would contrast with the WTGs. Larger numbers of visible WTGs would be expected to increase perceived impact, and regular spacing (grid layout) vs. nonregular spacing (random layout) could strongly affect the appearance of the wind facility, but the apparent geometry could change significantly as viewer location and distance changes (DTI 2005).

FAA rules would require single lights mounted on nacelles that flash red at night (2,000 candela) on peripheral WTGs, with lights spaced no more than one-half statute mile from each other. Light flashes would be synchronized, and the approximate flash rate would be 24/min. If WTGs were painted white, daytime lights would not be necessary (FAA 2005). White light strobes could be used optionally. White lights would be less obtrusive in daylight, but red lights would likely be conspicuous at great distances against dark skies (Gipe 2002). In addition, navigation lights and markings would be required on the lower portions of towers, but these lights and markings would be relatively inconspicuous to onshore viewers, and at greater distances could be partially or completely concealed below the horizon due to the earth's curvature.

For offshore viewers, potential visual impacts could be much greater than for onshore viewers, because boats could closely approach or potentially move through an offshore wind facility. In a close approach, the very large form and strong geometric lines of both the individual WTGs and the array of WTGs could dominate views, and the large sweep of the moving rotors would command visual attention. Structural details, such as surface textures, could become apparent, and the ESPs could be visible as well, as could strong specular reflections from the towers and moving rotor blades. For viewers close enough to fall within the cast shadows of the WTGs, a phenomenon called *shadow flicker* might be observed. Shadow flicker caused by wind turbines is defined as alternating changes in light intensity caused by the moving rotor blade casting shadows on objects (Wind Engineers, Inc. 2003).

For both onshore and offshore viewers, WTG maintenance activities could potentially cause visual impacts. Technicians would be transported by relatively small boats to the turbine (or ESP) sites where they would either work directly on the turbine or ESP, or remove components to the shore for repair and then return them. In poor weather conditions, the technicians may be transported via helicopter to the OCS location. These activities would result in marine vessel traffic and/or helicopter traffic in and around the wind facility that might be noticed by viewers. Such services may average about a week per year per turbine, so the impacts would be of short duration and would be expected to be negligible to small in most instances.

While describing visual changes that arise from the construction, operation, and decommissioning of offshore wind facilities is relatively straightforward, determining the nature and consequences the impacts is complicated not only by the site-specific nature of visual impacts, but by the sensitivities of affected viewers and the subjective nature of aesthetic judgments (BLM 1984; DTI 2005; NWCC 2002; USFS 1995). Because no offshore wind energy projects have been built in U.S. waters, discussion of visual impacts associated with real-world projects must rely primarily on European offshore wind projects, and it should be noted that cultural differences could affect the transferability of findings from other countries to the United States.

As indicated in Section 5.2.21, potential visual impacts are often a primary reason for opposition to wind energy developments; aesthetic concerns have been a factor in the delay or modification of a number of offshore wind development projects worldwide (IEA 2005). Aesthetic concerns include the potential loss of "naturalness" of landscape/seascape views, and concern about possible effects on land values and tourism. However, a number of research studies on visual impacts of offshore and onshore wind energy developments have indicated that wind power enjoys strong support among the public (Yale University 2005; Dong Energy et al. 2006; Warren et al. 2005; SEI 2003), and unlike most large-scale energy facilities, wind turbines are in some cases viewed as a positive visual impact by significant portions of the public (Minnesota Project 2005; Warren et al. 2005; SEI 2003).

Warren et al. (2005) assessed pre- and postdevelopment attitudes toward visual impacts associated with two onshore wind facilities in Ireland. Their survey found for one location that more than 90% of survey respondents supported the concept of wind power, but 66% of respondents were initially opposed to a local proposed wind facility. Contrary to expectations, persons living closest to the wind facilities, who had originally opposed it on aesthetic grounds, actually increased their acceptance of the visual impacts after its construction, with 62% regarding the visual impact as positive. For a second wind facility, similar results were observed. The results in both cases suggested that familiarity with the wind facilities decreased aesthetic objections. Stated reasons for changing perceptions of visual impacts varied among respondents; some felt the turbines were attractive, while others felt that the actual impacts were less than had been anticipated.

In-depth interviews with residents of two Danish towns with views of offshore wind facilities showed that there was very strong support for the concept of wind power and that more than two-thirds of respondents at both locations felt that the wind facilities would either have a positive effect on the landscape or would be neutral in effect. Interviews conducted after the wind facility were developed showed increased acceptance of the visual impacts of the wind facility in one location, attributed to the actual impacts being less than anticipated prior to wind facility construction. Opposition based on visual impacts was essentially unchanged in the other location. A parallel willingness-to-pay study of 672 respondents at these locations and elsewhere in Denmark indicated that while there was strong support for offshore wind facilities, and neutral-to-positive perceptions of visual impacts, most respondents showed “significant” willingness to pay to have wind facilities moved farther from shore, primarily to lessen potential visual impacts (Danish Energy Authority 2006; Ladenburg et al. 2005).

These studies suggest that while there is generally strong support for wind power development, there are often local concerns relating to the aesthetics of planned wind facilities. The perceptions of visual impacts associated with wind energy development vary among potential viewers and may be positive or negative, and they can change over time, in some cases possibly trending toward more positive perceptions after the installation of wind energy facilities.

5.2.21.5 Decommissioning

Decommissioning of a wind energy project would involve the dismantling and removal of infrastructure associated with each WTG; the removal of ESPs, their foundations, scour protection devices, and transmission cables; and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). In terms of expected visual impacts, decommissioning activities would be similar to construction activities; however, activities would generally proceed in reverse order from construction, and would proceed more quickly than construction, thus the associated impacts would last for a shorter time. Because during decommissioning WTGs and associated offshore facilities and equipment would be removed to below the waterline, the wind facility site would be returned to preconstruction condition, with no evidence of the wind facility’s presence remaining; however, as noted above, impacts associated with any new or expanded permanent onshore facilities resulting from wind facility development would remain.

5.2.21.6 Mitigation Measures

Recommended visual impact mitigation measures for offshore wind energy development on the OCS include the following:

Project siting. The choice of location for an offshore wind facility is the single most important opportunity for visual impact mitigation. Recognizing that resource and economic forces, current state of the technology, as well as other drivers must be considered and balanced against aesthetic concerns when siting developments, consideration should be given to locating developments farther offshore, and farther away from sensitive visual resource areas and/or areas with limited visual absorption capability or high scenic integrity, in order to reduce perceived visual impact. Where possible, developments should be sited in already industrialized and developed seascapes, for example, in areas containing oil and gas platforms or anchored ocean vessels, with due consideration for visual absorption capacity and possible cumulative effects. The relationship of the planned development to other existing or planned wind facilities in the area should be considered, not only for siting but also to achieve consistency in layout to the extent possible. The siting of developments such that intervening headlands screen views from sensitive landscapes/seascapes should be considered where appropriate, and wind facilities should be sited so that they are not framed by landforms in "keyhole" views from highly sensitive inland scenic vistas or other sensitive areas (DTI 2005).

Viewshed mapping, visual impact simulations, and public involvement. Viewshed mapping and visual impact simulations should be used to create accurate depictions of the visibility and appearance of proposed facilities. Simulations should depict proposed project appearance from sensitive/scenic locations as well as more typical viewing locations. These viewshed analyses and visual impact simulations should form key elements of a program to inform and involve the public in evaluation of visual aspects of project design.

Project layout. To the extent possible, the wind facility layout should be designed to minimize the horizontal spread of the layout from shore, particularly from sensitive viewpoints. If a regular grid pattern is chosen for turbine layout, consideration must be given to the aspect of the development from sensitive visual resource areas; the strong geometry visible when turbine grids are viewed along row/column axes or diagonals may be inappropriate for some visual resource areas (DTI 2005).

WTG design and appearance. The WTGs should be uniform in shape, color, size of rotor blades, nacelles, and towers (Gipe 1998). Tubular tower designs should be utilized where possible. Components should be in proper proportion to one another. Nacelles and towers should be combined to achieve an aesthetic balance in size and shape between the rotor, nacelle, and tower (Gipe 1998). Color selections for turbines should be made to reduce visual impact (Gipe 2002) and should be applied uniformly to tower, nacelle, and rotor, unless gradient or other patterned color schemes are used. Color choice should be made after consideration of whether WTGs will be viewed primarily against a sky background (generally calling for lighter colors) or a water background (generally calling for a darker color). Views against a water background are more common when the viewer is substantially elevated (as on a headland) (DTI 2005). The operator should use nonreflective paints and coatings to reduce reflection and glare. Commercial/advertising messages on WTG or other project facilities should be prohibited.

WTG maintenance. WTGs should be well maintained during operation. Inoperative or incomplete turbines could cause the misperception in viewers that "wind power does not work" or that it is unreliable. Inoperative turbines should be promptly repaired, replaced, or removed. Nacelle covers and rotor nose cones should always be in place and undamaged (Gipe 1998). Nacelles and towers should be cleaned regularly to remove spilled or leaking fluids and the dirt and dust that could accumulate, especially in seeping lubricants (Gipe 2002).

Aviation and navigational warning lighting. To the extent possible within the lighting requirements of the FAA, lighting should be minimized. Directional aviation lights that minimize visibility from the shore should be utilized.

5.2.22 Tourism and Recreation

5.2.22.1 Technology Testing and Site Characterization

Because it is likely that testing activities would be located close to industrial port facilities, it is not expected that construction of a support base for vessels and other onshore infrastructure (if needed), use of existing airfields for helicopter support, and other operations activities would impact tourism and recreation. As there have been no negative impacts on tourism and recreation reported from military, commercial, and recreational water and air vessels that currently traverse coastal areas intermittently, it is unlikely that there would be any detrimental impact on tourism and recreation from vessels supporting technology testing and site characterization activities.

5.2.22.2 Construction, Operation, and Decommissioning

The main recreation and tourism activities that could be affected by OCS construction, operations, and decommissioning would be beach recreation, sightseeing, diving, and recreational fishing. The extent of impacts would depend on the proximity of OCS coastal and offshore activities to recreational use areas.

The location of OCS developments and coastal infrastructure might visually affect visitors, although the extent of the impact of the visibility of offshore OCS on tourism and recreation is uncertain. While some visitors may prefer unobstructed views, for others the opportunity to view alternative energy facilities might be attractive. Regardless of structure location, there would be the potential for a visual impact on tourists traveling on cruise ships; however, there appears to be no detrimental visual impact on the cruise industry in other destinations. There would be a potential visual impact to recreational boaters who might not want any structures offshore, and adverse impacts to offshore wildlife may also affect recreation. The displacement of recreational users from areas in which offshore energy development might occur could adversely affect the overall recreational experience in other coastal areas not likely to host offshore energy facilities, as these might become popular recreation locations. Some tourists and recreational users on coastal beaches could be affected by the sight and sound (helicopter and boat traffic) of OCS facility operations, but few, if any, are expected to forgo their visits because of these routine intermittent operations.

Switchyards and transmission lines could exist near important recreational areas, and transmission line landfalls could cause temporary removal of shoreline recreational land from public use for short periods. Except in extreme circumstances, however, impacts are expected to be minor or temporary.

5.2.22.3 Mitigation Measures

Mitigation of impacts on tourism and recreation associated with the development of OCS wind technologies may be required depending on the location, scale, and impact of specific projects. The visibility and audibility of OCS structures from areas in which there is significant recreational activity, tourism, or scenic quality would likely exaggerate the magnitude of impacts, while locations in areas in which these activities were largely absent would likely minimize the magnitude of visual impact of OCS energy developments.

5.2.23 Fisheries

The Atlantic (Section 4.2.23), Gulf of Mexico (Section 4.3.23), and Pacific (Section 4.4.23) regions support diverse and valuable commercial and recreational fisheries. Impacts to fisheries could result from OCS alternative energy development activities that (1) cause changes in the distribution or abundance of fishery resources, (2) reduce the catchability of fish or shellfish, (3) preclude fishers from accessing viable fishing areas, (4) cause losses or damage to equipment or vessels, or (5) reduce the market value of a fishery. Although this section evaluates general types of impacts that could occur due to OCS wind energy development, specific impacts to fisheries would be dependent on various aspects of a particular project, including geographic location, spatial scale, timing of activities, design of energy technology components, and the proximity of that project location to specific fishery resources. Thus, it would be necessary to conduct more detailed analyses of potential impacts to fisheries as part of site-specific evaluations for proposed projects.

As described in Section 5.2.12, there could be localized temporary effects on the distribution or abundance of some fish resources during some phases of wind energy development. However, activities are not expected to measurably affect overall populations of fishes or invertebrates that support commercial or recreational fisheries. It is assumed that sensitive seafloor habitats, which sustain production for many important fishery species, would be avoided during development of OCS wind energy projects (Section 5.2.15). Thus, although individual organisms or small amounts of seafloor habitat could be affected, the populations of organisms that are the targets of commercial fisheries would not be measurably reduced. In addition, it is anticipated that none of the OCS activities would measurably alter the market value of fishery resources. Because of this, the following sections focus on potential effects of OCS wind energy development on catchability of targeted organisms, access to fishing areas, and damage or loss of equipment or vessels.

5.2.23.1 Technology Testing

As described in Section 3.2, developers of offshore wind generation facilities would likely skip the demonstration phase and move directly toward commercial operation. If so, there would be no anticipated impacts to fisheries from technology testing activities.

If testing were conducted, it would likely include the placement of a wind energy structure in offshore waters, requiring the transportation of components by barge or other vessel. As described in Sections 5.2.12 and 5.2.15, impacts on fish resources and seafloor habitats from the small number of vessel trips required for technology testing would be expected to be negligible.

Construction of an offshore wind tower has a potential to result in space-use conflicts with some commercial or recreational fishing activities (Rodmell and Johnson 2005). Fishing vessels could be excluded from a normal fishing area to avoid the potential for gear loss. As identified in Section 5.2.15, wind energy projects would be sited to avoid particularly sensitive or unique seafloor habitats. Consequently, the amount of area that would be lost to fishing activities from a single isolated wind tower would be very small compared to similar surrounding habitat, even if an exclusion area with a radius of 500 m (1,640 ft) was designated for safety purposes.

Placement of an OCS wind tower would represent an additional navigation hazard. Because of the height of wind towers above the ocean surface, they would be visually detectable at a considerable distance during the day and easily detected by vessels equipped with radar regardless of the time of day. Addition of lights and/or radar reflectors would increase the ability to detect such towers. It is anticipated that the navigation hazard caused by the construction of a single wind energy unit during the technology phase would be negligible.

The small increase in vessel activity that would occur during the technology testing phase would not measurably affect commercial or recreational fishing opportunities, catchability of fish and shellfish resources, or navigation. Fuel spills that occurred as a result of vessel accidents or leaks could temporarily close affected areas to fishing. However, the likelihood of such spills is relatively low because of the small number of trips that would be required during the technology testing phase. If spills occurred, the volume of fuel that could be spilled would probably be small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Impacts to fish resources or commercial or recreational fisheries would be negligible.

5.2.23.2 Site Characterization

Fisheries could be affected during site characterization by the presence of survey vessels, by geological and geophysical surveys, by drilling and core sampling, and by the installation of one or more meteorological towers within the project area.

Geological and geophysical surveys could temporarily affect the behavior of some targeted species, thereby affecting catch rates in the immediate area of the survey (see discussion in Thomson and Davis 2001). The geophysical technique with the highest noise intensity is seismic surveys (see Section 5.2.5.2). While some studies indicate that effects of seismic surveys on fish catch rates are likely to be limited to the time of the survey or for short periods (hours) thereafter (e.g., Skalski et al. 1992), catch rates for some fish species could be affected for longer periods (e.g., Engås et al. 1996). Recent studies indicate that seismic surveys would have no detectable effect on catchability of snow crabs (Christian et al. 2003). Noise resulting from the use of pile drivers could have similar effects on fish behavior (Section 5.2.12). Also, high-energy seismic techniques would not generally be needed for site characterization. At most, the effects of geological and geophysical surveys and pile driving on catchability would be temporary and short-lived, and a relatively small fishing area would be affected. All geological and geophysical survey data collection could be completed over a month-long period, although operation of survey equipment would not be continuous over this period. Use of pile-driving equipment would be required for a few hours for each piling needed; assuming that only a few meteorological towers would be installed, overall time of use could be on the order of a few days to a week. Impacts to fisheries from reduced catchability due to geological and geophysical surveys and pile driving would be negligible.

Some characterization activities have a potential to result in space-use conflicts with commercial and recreational fishing activities. Fishing vessels could be excluded from normal fishing grounds to avoid the potential for gear loss or for perceived disturbances to fishery resources. Such conflicts could be avoided by conducting characterization activities during closed fishing periods or seasons.

Most space-use conflicts are avoided by following existing navigation rules. To further address space-use conflicts, a requirement for lessees to review planned activities with potentially affected fishing organizations and port authorities could likely prevent unreasonable fishing gear conflicts. Some lease-related uses could be restricted if deemed necessary to prevent unreasonable conflicts with commercial fishing operations.

Placement of a meteorological tower in OCS waters would represent an additional navigation hazard. Such towers would be visually detectable at a considerable distance during the day and would be easily detected by vessels equipped with radar regardless of the time of day. Addition of lights and/or radar reflectors would increase the ability to detect such towers. The navigation hazard caused by the construction of a small number of meteorological towers during the characterization phase would be negligible.

The small increase in vessel activity that would occur during the characterization phase would not measurably affect commercial or recreational fishing opportunities, catchability of fish and shellfish, or navigation. Fuel spills that occurred as a result of vessel accidents or leaks could temporarily close affected areas to fishing. However, the likelihood of such spills is relatively low because of the small number of trips that would be required. If spills occurred, the volume of fuel that could be spilled would probably be small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Impacts to fish resources or commercial or recreational fisheries would be negligible.

5.2.23.3 Construction

Construction activities and placement of transmission lines on the seafloor could harm or temporarily displace individual organisms from localized areas. However, population-level changes in abundance or distribution are not anticipated, and impacts to seafloor habitats are expected to be negligible (Sections 5.2.12 and 5.2.15). Use of pile driving equipment would be required for a few hours for each piling needed. Depending on the number of wind turbine generators included in an individual project, it is estimated that pile driving could occur intermittently over a period of 6 months to 2 years. Fishery resources would likely return to disturbed areas between construction sessions.

Some construction activities have a potential to result in space-use conflicts with commercial and recreational fishing activities (Rodmell and Johnson 2005). As a consequence, during construction, fishing activities could be temporarily excluded from some areas that might be normal fishing grounds to avoid the potential for gear loss or vessel accident. In other instances, anglers could choose to avoid areas with construction activity because of perceived disturbances to fishery resources. Such conflicts could potentially be avoided by conducting certain construction activities during closed fishing periods or seasons. Most space-use conflicts are easily avoided by following existing navigation rules. To further address space-use conflicts, a requirement for lessees to review planned activities with potentially affected fishing organizations and port authorities could prevent unreasonable fishing gear conflicts.

The small increase in vessel activity that would occur during the construction phase would not measurably affect commercial or recreational fishing opportunities, catchability of fish and shellfish resources, or navigation. Increased vessel traffic could also interfere with some vessel operations by affecting port congestion and traffic at fuel docks (Section 5.2.17.3). Fuel spills that occurred as a result of vessel accidents or leaks could temporarily close affected areas to fishing. However, the likelihood of such spills is relatively low because of the small number of trips that would be required during the construction phase. If spills occurred, the volume of fuel that could be spilled would probably be small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Impacts to fish resources or commercial or recreational fisheries would be negligible.

5.2.23.4 Operation

Once construction of an offshore wind facility was completed and operation of the facility had commenced, fish resources could be affected by the presence of the structures themselves, traffic and noise from vessels used to maintain the structures, and noise associated with turbine operation. In addition, the presence of electromagnetic fields associated with transmission cables has a potential to affect some fish species. As identified in Sections 5.2.12 and 5.2.15, impacts to fish populations and seafloor habitats are expected to be negligible in most cases.

As described in Sections 5.2.11.4 and 5.2.14.4, there is a possibility that projects with multiple platforms dispersed over large areas could act as artificial reefs, thereby resulting in changes in the abundance and diversity of fish and invertebrates within the area. There is also potential for invasive species to colonize such structures. Effects on diversity and fish abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats within surrounding areas.

For safety reasons or to avoid the potential for gear loss, commercial fishing vessels may be excluded from some project areas that were previously within normal fishing grounds. However, such exclusions may not be necessary in all cases or could be applied to only certain types of fishing gears (e.g., towed gears). Such exclusions could remain in effect during the entire life of the project. However, as long as wind energy projects are not sited in areas containing unique and highly productive seafloor habitats, overall effects of such space-use conflicts on commercial fishing would be negligible to moderate. Some areas of the OCS have an array of fishery zoning requirements already in place. Imposing additional restrictions in such areas could result in greater space-use conflicts. Displacement from existing fishing areas could also result in increased fishing pressure in surrounding areas.

Because recreational fishing vessels are typically smaller and because recreational anglers use gear that is less prone to entanglement, less likely to damage underwater components, and/or less expensive, recreational fishing may be possible within project areas. In fact, because the towers associated with the OCS wind energy structures would likely serve as artificial reefs and attract species of pelagic and demersal fish that are popular with recreational anglers, project areas could become desirable recreational fishing areas.

Once undersea transmission lines have been put in place, they could result in entanglement hazards for some types of fishing gear. Assuming that there are some similarities in the entanglement hazards posed by buried pipelines and buried cables, it is expected that the presence of buried subsea cables would not typically interfere with the use of longlines, purse seines, drift nets (USDOI/MMS 2004a), or beach seines. However, bottom trawls, such as those often used in the commercial groundfish industry, have a greater potential to become snagged on underwater components. The potential for snagging crab traps on cables is unknown.

While compensation for loss or damage of commercial fishing gear attributable to offshore oil and gas operations may be available in some cases, the MMS cannot ensure that such reimbursements would occur under the proposed alternative energy program. Most space-use conflicts could be avoided by following existing navigation rules. To further address space-use conflicts, a stipulation for protection of fisheries has been implemented by the OCS oil and gas leasing program that requires lessees to review planned exploration and development activities with potentially affected fishing organizations and port authorities to prevent unreasonable fishing gear conflicts. Under this stipulation, there is also an ability to restrict lease-related uses if deemed necessary to prevent unreasonable conflicts with commercial fishing operations.

Wind towers on the OCS would represent additional navigation hazards. Because of the height of wind towers above the ocean surface, they would be visually detectable at a considerable distance during the day and easily detected by vessels equipped with radar regardless of the time of day. Addition of lights and/or radar reflectors would increase the ability to detect such towers. The overall navigation hazard attributable to construction of an OCS wind energy facility is currently unclear. However, the risk of accidents could be reduced by ensuring that location details are supplied to regional fishing organizations and added to navigational charts.

The small increase in vessel activity that would occur during the operational phase would not be expected to measurably affect commercial or recreational fishing opportunities, catchability of fish and shellfish resources, or navigation. Fuel spills that occurred as a result of vessel accidents or leaks could temporarily close affected areas to fishing. However, the likelihood of such spills is relatively low because of the small number of trips that would be required for maintenance activities. If spills occurred, the volume of fuel that could be spilled would probably be small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Impacts to fish resources or commercial or recreational fisheries would be negligible.

5.2.23.5 Decommissioning

Decommissioning activities would include the dismantling and removal of infrastructure from each wind turbine platform, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Platforms would be removed by cutting pilings at a depth of approximately 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, there could be some effects on fishery resources (Section 5.2.12), especially if explosives were used to remove pilings. Removal of structures that act as artificial reefs would result in loss of recreational fishing opportunities that had developed during the operational phase (Section 5.2.23.4). There is also a small potential for accidental releases of hazardous materials and fuel during decommissioning activities.

Some decommissioning activities have a potential to result in space-use conflicts with commercial and recreational fishing activities. Fishing activities could be temporarily excluded from areas that might be normal fishing grounds during removal activities to avoid the potential for gear loss or vessel accidents. Anglers could also feel compelled to avoid areas with decommissioning activity because of perceived disturbances to fishery resources. Such conflicts could potentially be avoided by conducting decommissioning activities during closed fishing periods or seasons. Most space-use conflicts are easily avoided by following existing navigation rules. To further address space-use conflicts, a requirement for lessees to review planned activities with potentially affected fishing organizations and port authorities could prevent unreasonable fishing gear conflicts.

The small increase in vessel activity that would occur during the decommissioning phase would not be expected to measurably affect commercial or recreational fishing opportunities, catchability of fish and shellfish resources, or navigation. Fuel spills that occurred as a result of vessel accidents or leaks could temporarily close affected areas to fishing. However, the likelihood of such spills is relatively low because of the small number of trips that would be required. If spills occurred, the volume of fuel that could be spilled would probably be small (<50 bbl) and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Impacts to fish resources or commercial or recreational fisheries would be negligible.

Assuming that all infrastructure is removed and that all pilings and entanglement hazards associated with development of the project are below the level of the seabed or buried, fishing conditions within the project area should return to those that existed prior to construction.

5.2.23.6 Mitigation Measures

- Avoid locating energy facilities and cables near known sensitive fish habitats and within known high-use fishing areas.
- Require lessees to review planned activities with potentially affected fishing organizations and port authorities to prevent unreasonable fishing gear conflicts.
- When possible, conduct noise-generating activities during closed fishing periods or seasons.
- Consider the addition of lights and/or radar reflectors to increase the ability of vessel captains to see energy structures.
- Use practices and follow operating procedures that reduce the likelihood of vessel accidents and fuel spills.
- Where possible, bury cables to prevent conflicts with fishing gear.

5.2.24 Nonroutine Conditions

There is a potential for the occurrence of nonroutine conditions that could cause impacts to human health and the environment during all phases of wind energy development on the OCS. The primary hazards common to all project phases are: (1) industrial hazards similar to those of most large industrial facilities and infrastructure projects, (2) collisions between marine vessels and either fixed components of the wind facility or vessels constructing, servicing, or maintaining the facility, (3) natural events, such as hurricanes and earthquakes, and (4) sabotage or terrorism events.

For any activity or facility, the *risk* posed by a nonroutine event depends on two factors: the probability (or expected frequency) of the event occurring and the consequences if the event did occur. Event probabilities can range from very rare events, highly unlikely to occur during the lifetime of a facility, to relatively frequent events that might be expected to occur once or more during the lifetime of a facility. In many cases, nonroutine event probabilities can be estimated from historical statistical data for similar activities, facilities, or locations. The consequences of events could range from essentially no measurable or observable impacts to potentially severe impacts to human health or the environment. Quantifying the risk of nonroutine events requires that both factors be taken into account: likely events with relatively minor consequences might present a similar overall risk as highly unlikely or incredible events with much higher consequences.

Both the probability of nonroutine events occurring and the potential consequences if they did occur are project- and site-specific. Therefore, the risk posed by such events must be evaluated on a project-specific basis. However, because the types of hazards are common to all phases of a project, they are discussed in general terms in this section. Specific hazards and risks for each of the different project phases, as well as mitigation measures, are discussed in subsections.

Industrial Hazards. The industrial hazards during the testing, characterization, construction, operation, and decommissioning of wind projects on the OCS are similar to those of most large industrial facilities and infrastructure projects. The hazards are physical hazards and include working at heights, working on and/or over water, working in confined spaces, working with machinery, and the danger of being hit by falling objects. Under authority established in the Outer Continental Shelf Lands Act (OCSLA) and pursuant to a memorandum of understanding (MOU) between the two agencies, the MMS and USCG regulate safety on fixed OCS facilities. The MMS regulates the structural integrity of fixed OCS facilities, and the USCG regulates marine systems, such as lifesaving, navigation equipment, and workplace safety and health. In February 2002, the USCG issued a final regulation that authorized the MMS to perform inspections on fixed facilities engaged in OCS activities on its behalf and to enforce USCG regulations applicable to those facilities (67 FR 5911-5916; February 7, 2002 [revising 33 CFR 140.103(c)]). The OCSLA also requires that the MMS and the USCG investigate major accidents, deaths, serious injuries, major fires, and major spillages, as well as lesser accidents.

Two of the primary occupational hazards during wind project development are working at heights and working on or over water. Working at heights and over water may be required during construction activities, during assembly of wind tower components, or during maintenance activities. Working at heights can pose a significant risk from falls. In addition, risks are also associated with the use of cranes that are often necessary to support working at heights. Working on or over water can pose a risk of drowning, and requires the additional consideration of wind and weather, the availability of buoyancy devices, and qualified boat and rescue personnel.

A further industrial hazard involves vessel entanglement with undersea gathering or transmission lines. Entanglement or catching undersea cables can occur during trawling and other net fishing, shellfishing on the seabed, or during anchoring. Attempting to lift a cable by a vessel can result in the capsizing of the vessel or in electrocution (Drew and Hopper 1996). Undersea cables are typically buried to minimize risks associated with entanglement as well as potential damage to the cable.

Industrial accidents could result in both worker injuries and fatalities. However, the risks from industrial hazards depend on the magnitude, location, and characteristics of the specific project, health and safety planning and training, and adherence to established regulations and safety and accident prevention and control measures.

Collisions. A wind facility located on the OCS could potentially cause a navigational risk to marine vessels. Applicants for offshore energy facility permits are required to perform an evaluation of all reasonably foreseeable issues related to navigation as set forth in guidelines published by the coast guard (USCG 2007). Collisions between marine vessels and wind facility components could be caused by human error (such as navigation errors), weather, or mechanical failures onboard ships that cause either a steering failure or loss of power (resulting in a drifting collision). Collisions between marine vessels and either fixed components of a wind facility or vessels used in constructing, servicing, or maintaining the facility could have economic, safety, and environmental consequences. A collision between a ship and a wind turbine could result in production loss from a single turbine or the entire wind facility as well as loss of life and spills of hazardous materials.

As discussed above, the risk posed by collisions depends on the probability of a collision occurring and the consequences if a collision does occur. Both of these factors are project- and site-specific. The probability of collisions between marine vessels and components of a wind facility depends in part on (1) physical characteristics of the facility itself, such as the number of WTGs and service platforms, the tower diameters, and the spacing between towers; (2) the location of the wind facility in relation to commercial shipping lanes or recreational marine traffic; and (3) environmental conditions at the facility location, such as wind velocities and direction, currents, water depths, ice, and visibility. The consequences of a collision also depend on project-specific characteristics, including the design of the towers as well as the distribution of ship types and sizes in the vicinity of the facility. Therefore, the risk posed by collisions must be evaluated on a project-specific basis.

Although collision risks are project-specific, the collision history for the Gulf of Mexico indicates that collisions between vessels and fixed facilities located on the OCS (i.e., oil and gas platforms) do occur, even though such facilities are generally clearly marked on navigational maps and are equipped with navigational aids such as lights and fog horns. Section 6.4 of this EIS summarizes historical data for collisions with oil and gas platforms in the Gulf of Mexico for the period 1996 through 2005. Over this 10-year period, 126 collisions between marine vessels and platforms occurred. Nineteen of the 126 collisions resulted in spills and the release of pollutants to the environment. The most common material spilled was diesel fuel from marine vessels damaged during the collision. The two largest spills were estimated to involve 11,000 and 18,000 gallons of diesel fuel and resulted from the sinking of the vessels striking the platforms. Other materials spilled to the environment during collisions included oil, natural gas, hydraulic fluids, and corrosion inhibitors. It should be noted that there are a very large number of oil and gas platforms located in the Gulf and that the area is one of heavy commercial vessel traffic.

It is recognized that there are significant differences in the characteristics of wind facilities and oil and gas platforms. However, the collision data do indicate that during collisions, spills to the environment can occur from both the striking marine vessel as well as the object struck. The potential types and quantities of hazardous materials that would be present at a wind energy project site are summarized in Table 4.2.6-1. Considering the quantities of hazardous materials reported in Table 4.2.6-1, it is unlikely that any single spill from the wind energy facility would exceed 50 bbl. The amount of hazardous material, such as diesel fuel, that could be released by a marine vessel involved in a collision would depend on the type of vessel and severity of the collision. As indicated by the Gulf of Mexico data, releases on the order of 10,000 gal are possible.

Natural Events. There is a potential for natural events to cause impacts to human health and the environment during all phases of wind energy development on the OCS. Such events include hurricanes, earthquakes, tsunamis, and severe storms. Depending on the severity of the event, fixed components of a wind facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. Moreover, marine vessels used in constructing, servicing, or maintaining the facility could also be impacted, potentially resulting in loss of life and the release of hazardous materials (e.g., diesel fuel) to the environment. The potential types and quantities of hazardous materials that would be present at a wind energy project site and potentially could be released to the environment during a natural event were discussed above for collisions.

The probability of a natural event occurring is location-specific and differs among the three OCS regions considered in this study. For example, hurricanes are much more likely to occur in the Gulf of Mexico and Atlantic regions than the Pacific region. Conversely, earthquakes and tsunamis, which undersea earthquakes can cause, are much more likely to occur in the Pacific region. Such differences should be taken into account during project-specific studies and reviews.

Sabotage or Terrorism. In addition to the events described above, there is a potential for intentional destructive acts, such as sabotage or terrorism events, to cause impacts to human health and the environment. As opposed to industrial hazards, collisions, and natural events, where it is possible to estimate event probabilities based on historical statistical data and information, it is not possible to accurately estimate the probability of a malevolent act. Consequently, discussion of the risks from sabotage or terrorist events generally focuses on the consequences of such events.

In general, the consequences of a sabotage or terrorist attack on a wind facility would be expected to be similar to those discussed above for collisions and natural events. Depending on the severity of the event, fixed components of a wind facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. Moreover, marine vessels used in constructing, servicing, or maintaining the facility could also be impacted, potentially resulting in loss of life and the release of hazardous materials (e.g., diesel fuel) to the environment. The potential types and quantities of hazardous materials that would be present at a wind energy project site and potentially could be released to the environment were discussed above for collisions. The potential consequences of such events need to be evaluated on a project- and site-specific basis.

5.2.24.1 Technology Testing

As discussed in Section 3.5.1, if it were deemed necessary to test or demonstrate OCS wind technology in U.S. waters, it would probably be for a new foundation technology. Such a test would likely involve a relatively small number of wind turbines. Although the risks would depend on the specific characteristics of the testing project, the expected limited extent of such activities would likely result in minor to negligible impacts to human health and the environment from nonroutine events.

5.2.24.2 Site Characterization

As discussed in Section 3.5.2, a key component used for characterizing wind conditions is the meteorological tower. To determine whether a site qualifies for a wind turbine facility, a meteorological tower is installed in the area of the proposed facility to measure wind speeds and to collect other relevant data. Scientific measurement devices consist of anemometers, vanes, barometers, and temperature transmitters on the tower. Over the next 5 to 7 years, anchoring would most likely be accomplished by using a monopile driven into the sea bottom or three pilings supporting a single steel pile that supports the deck.

A Danish wind energy consulting company, Ramboll-Wind Energy, provides information on their website concerning operating experience for a 48-m high meteorological tower positioned on a piling rammed into the seabed, constructed to support a wind facility development at Rodsand, Denmark.[13] The meteorological tower was in place from 1996 to 2000. During this time, the meteorological tower was reportedly struck by vessels twice, with the first collision causing only minor damage to the tower and the second collision severely damaging the tower, requiring its removal. No damage was reported to the vessels striking the tower.

Site characterization would also involve geological and geophysical testing of the sea bottom to determine the strength and stability of substrata for drilling and installment of WTGs. As described in Section 3.5.2, most seafloor characterization technologies would either involve the towing of sensors above the seafloor or the sampling of seafloor sediments.

The risk from nonroutine events resulting from site characterization activities is site- and project specific. However, the installation and operation of a meteorological tower and seafloor characterization activities would be unlikely to involve the use or storage of hazardous chemicals, with the exception of fuels onboard vessels used in characterization, construction, or service. Although the risks would depend on the specific characterization project, the expected limited extent of such activities would likely result in minor to negligible impacts to human health and the environment from nonroutine events.

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[13] Information provided in an undated publication, "Ship Collision Risk for an Offshore Wind Farm," C.F. Christensen and L.W. Andersen, available at http://www.ramboll-wind.com/PDF/Referencer/Ship_collision_Risk_Rødsand.pdf. Accessed December 19, 2006.

5.2.24.3 Construction

As described in Section 3.5.3, construction of a wind energy facility would require the use of barges or large, special purpose vessels to install foundations, turbines, transformer/service platforms, and underwater cable. Large cranes would likely also be required. During construction, there would be a risk of occupational injuries and fatalities from industrial hazards, as well as a risk of environmental impacts resulting from the release of hazardous materials (primarily fuels). The risk to human health and the environment would depend on the characteristics of the specific construction project. However, given the relatively limited amounts of hazardous materials expected to be present during construction, and assuming adherence to applicable occupational health and safety regulations, it is expected that nonroutine event impacts during construction would be negligible to minor.

5.2.24.4 Operation

The primary nonroutine event risks during operation of a wind energy facility are related to marine vessel collisions with the wind turbines or service platforms and natural events. As discussed above, the risk and consequences of collisions and natural events is site- and project specific. Consequently, it is not possible to assign a generic level of significance to risks and impacts. However, with proper planning and mitigation, it is expected that risks could be maintained at negligible to minor levels.

In addition, during operations there is also a potential accident risk that could result from a failure of a rotor blade or ice accretion (only in cold climates), which results in the "throwing" of a rotor blade or ice from the wind turbine. However, given the limited amount of time that people are expected to be in the vicinity of a wind facility and the expected low probability of blade failures, the risk is expected to be negligible to minor.

5.2.24.5 Decommissioning

Nonroutine event risks during decommissioning are expected to be similar to those discussed for construction in Section 5.2.24.3.

5.2.24.6 Mitigation Measures

A number of mitigation measures are expected to be employed to minimize nonroutine event risks during wind energy development on the OCS. The primary mitigation measures would be aimed at minimizing the risk of vessel collisions with wind facility components. Wind facilities on the OCS would be noted on updated navigational charts for mariners. Moreover, the turbines and service platforms would be outfitted with navigational aids, such as lighting and sound signals (e.g., fog horns).

To ensure that mitigation measures are taken into account during OCS alternative energy projects, the developers of specific projects are required to conduct a navigational safety and risk assessment during the application process (USCG 2007). Among other items, the assessment must include a maritime traffic survey and an evaluation of collision risk (including likely frequencies and consequences of collisions). In addition, the developer must identify potential measures that could be implemented to mitigate any increased risks associated with the proposed project. The assessment must be submitted to the Coast Guard. The Coast Guard reviews the assessment to determine potential impacts of the proposed facility on the safety of navigation and other Coast Guard missions, such as marine environmental protection, search and rescue, aids to navigation, and maritime security.

In addition, vessels are generally expected to operate under the International Regulations for Preventing Collisions at Sea 1972. These rules require all vessels to duly regard all dangers of navigation and collision, and specify that mariners are responsible for safe operation of their vessels, regardless of the navigational situation.

5.3 WAVE ENERGY DEVELOPMENT ON THE OCS

5.3.1 Ocean Surface and Sediments

This evaluation considers both project impacts to and the hazards posed by particular geologic features and processes. Potential impacts include acceleration of geologic processes (e.g., erosion or mass movement on the seafloor), alteration of seafloor topography, changes in sediment transport along the coast,[14] and interference with the recovery of mineral resources. Locating the wave facility on the basis of site-specific studies that would: characterize the seafloor (Section 3.5.2); identify known areas of mineral resources (e.g., oil and natural gas reserves) and any existing plans for their recovery; and assess wave and current baseline conditions, as would be done during a project-level EIS, would minimize these impacts.

Potential hazards are associated with the scouring action of ocean currents and seafloor instability, which can undermine foundation structures and undersea transmission cables and lead to failure (as described in Sections 4.2.1.5, 4.3.1.5, and 4.4.1.5). Submerged structures on the seafloor increase wave turbulence, causing localized erosion of bottom sediments (scouring) in the immediate vicinity of the structures. Scouring can also be expected to occur on a larger scale,

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[14] Changes in sediment transport along the coast are important potential impacts to consider when developing technologies offshore. When waves hit the coastline at an angle, they create a longshore current (also called littoral drift) that, on a regional scale, transports sediment from updrift coastal areas to downdrift coastal areas. In an evolved littoral system, an equilibrium is established between the processes of erosion and deposition—the result is that beaches, which lose sediment (sand) to downdrift coastal areas via the longshore current are also nourished by new sediment (sand) from updrift coastal areas via the same longshore current. When these processes are interrupted, either by activities offshore (which reduce wave energy) or by structures such as jetties along the shoreline (which capture littoral sediment), deposition becomes the dominant process. The effect of increased deposition in one coastal area, however, usually results in accelerated erosion in downdrift coastal areas.

in the areas between multiple structures. It is important to note that the changes to seafloor topography caused by scouring can affect the wave climate, leading to potential impacts to sediment transport processes along the coast. While proper siting of the wave facility can eliminate or minimize the hazards associated with the reduced load-bearing capacity of water-saturated and gaseous sediments, bottom sediments of variable density, and irregular topography, the risk of seafloor collapse and subsidence triggered by episodic geological and meteorological events (earthquakes, tsunamis, and storm surges) would remain.

5.3.1.1 Technology Testing

Potential Impacts. Because wave technology is in an early stage of development, it is difficult to predict the technology or mix of technologies that will be used in future commercialization. Technologies appropriate for OCS applications include point absorbers, attenuators, overtopping devices, and terminators, as described in Section 3.3. These technologies are designed to capture the energy of waves at offshore and nearshore locations. Their designs include long horizontal floating structures that are either parallel (attenuators) or perpendicular (terminators) to the direction of wave travel. Others (absorbers) use vertical floating structures that capture energy as they rise and fall with the wave height. Overtopping devices generate energy as they release the water that has filled their reservoirs to levels above the surrounding ocean. Point absorbers would be the most likely candidates for commercialization in the next 5 to 7 years (Elcock 2006).

A demonstration-scale test would most likely involve the deployment of one or two devices per test, fixed in place, with or without an undersea transmission connection to shore. Installation may be conducted using barges or specialized installation equipment for larger structures such as overtopping devices. The demonstration units may also test various mooring technologies.

Testing activities would occur within a shorter time period and on a much smaller scale than construction, operation, and decommissioning of the full-scale projects that are addressed in Sections 5.3.1.3 through 5.3.1.5. The primary activity with the potential to adversely affect geologic features and processes on the seafloor would involve the mooring technology that is used. Depending on the particular wave technology, moorings may consist of steel monopiles, multilegged support systems, concrete anchors, or slack mooring systems.

Impacts to geologic features and processes would be minimized through the careful siting of the mooring system on the basis of data collected to characterize the seafloor in the area of interest. Impacts to coastal sediment transport processes would likely be negligible since the test unit would be relatively small and located some distance offshore.

Geohazards. The components of the wave energy facility most vulnerable to geohazards on the OCS are the mooring systems and undersea transmission cables between the facility and shore. The mooring structures are at risk of adverse impacts associated with seafloor instability since they are driven into or rest on top of the seabed. These structures would be most impacted by sediment characteristics affecting load-bearing capacity, displacement caused by earthquakes, and slope failure (slumping and mudslides). They are also vulnerable to the scouring action of ocean currents, which can undermine structures and cause failure. Undersea transmission cables used to deliver power from the facility to shore would be most impacted by displacement caused by earthquakes and slope failure.

5.3.1.2 Site Characterization

Before a technology is installed, site-specific characterization would be conducted to collect data on ocean-bottom characteristics and unidentified hazards, potential environmental impacts, potential archaeological impacts, and possible conflicting uses before commercial development. Activities associated with site characterization, described in Section 3.5.2, may include:

- A deep-tow, side-scan sonar survey to locate shallow hazards, cultural resources, and hard-bottom areas;
- Digital depth sounding to obtain water depth measurements;
- "Boomer" sub-bottom and GeoStar full spectrum CHIRP profiling systems to develop a geologic cross section;
- Bottom sampling, Vibracore shallow sampling, and deep boring to obtain physical and chemical data on surface and subsurface sediments; and
- Magnetic surveys to locate buried pipelines, archaeological items, waste dumps, and other metallic debris.

These activities will assist in identifying the most appropriate site for construction to minimize potential environmental impacts and the hazards associated with seafloor instability (for foundation structures and undersea transmission cables). Impacts to geologic features and processes associated with these activities are expected to be negligible since they mainly involve remote studies that would be of short duration and would not disturb the seafloor. Bottom sampling, Vibracore sampling, and deep boring would result in some disturbance to the seafloor. However, once the activity is completed, recovery would occur at a rate proportional to the rate of sedimentation in the area of interest. Sampling would be avoided in areas prone to intense scouring or mass movement (as determined by remote surveys).

5.3.1.3 Construction

Potential Impacts. The primary activity with the potential to adversely affect geologic features and processes on the seafloor would be the construction of the mooring systems for the floating wave technology devices. Depending on the particular wave technology, moorings may consist of steel monopiles, multilegged support systems, concrete anchors, or slack mooring systems. Site preparation would mainly involve the removal of boulders. A scour protection system, consisting of boulder mounds, cement bags, or seagrass mattresses may be needed for these structures. An OCS commercial facility may consist of up to four rows of floating wave devices (buoys) spaced 100 m (328 ft) apart in water 50 m (164 ft) deep. A typical mooring design would require 2 to 3 mooring lines per device, thus a 100-device facility would require about 200 to 300 mooring lines and anchors. A facility of this scale would occupy an ocean bottom area of about 2 km (1.25 mi) by 305 m (1,000 ft) (Elcock 2006). However, the number of mooring lines is likely to vary by technology and project size.

Impacts to geologic features and processes would be minimized through the careful siting of the mooring system on the basis of data collected in the area of interest to characterize the seafloor in the area of interest. In terms of impacts to coastal sediment transport processes, it is estimated that a large wave energy facility (i.e., a commercial-scale facility such as described here and in Chapter 3) could cause a 10 to 15% reduction in wave height and a lowering of wave energy levels reaching the coast, with the greatest impacts occurring within 2 km (1.2 mi) of the wave device in the direction of wave travel (USDOI/MMS 2006j; Hagerman and Bedard 2004). A reduction in wave energy would result in an interruption of littoral (longshore) sediment transport by creating conditions favorable to sediment deposition between the facility and the shore, while increasing erosion further downdrift. The magnitude of these impacts would depend on the size and design of the wave energy facility and its distance offshore.

Floating devices that extend perpendicular to the direction of wave travel (parallel to the shoreline) have a greater potential to adversely impact coastal processes than those that extend parallel to the direction of wave travel, vertically, or intermittently. Those located within a mile of the shoreline also would have a greater potential impact relative to those further offshore.

Impacts to coastal sediment transport processes could be greater along the Pacific Coast in areas where the shelf is particularly narrow, requiring construction closer to shore, but would need to be assessed on a project-specific basis, taking into account the size and location of the wave energy facility, and the wave energy and predominant wave direction in the area of interest.

Geohazards. The components of the wave energy facility most vulnerable to geohazards on the OCS are the mooring systems and the undersea transmission cables between the facility and shore. The mooring structures are at risk of adverse impacts associated with seafloor instability since they are driven into or rest on top of the seabed. These structures would be most impacted by sediment characteristics affecting load-bearing capacity, displacement caused by earthquakes, and slope failure (slumping and mudslides). They are also vulnerable to the scouring action of ocean currents, which can undermine structures and cause failure.

Undersea transmission cables used to deliver power from the facility to shore would be most impacted by displacement caused by earthquakes and slope failure.

5.3.1.4 Operation

Potential Impacts. Routine operations of wave energy facilities would generally not require offshore personnel. Controlling and monitoring of floating devices and transformers would be done remotely by using fiber-optic cables or other communication devices. However, periodic maintenance and inspection would be required. For wave technologies, operational activities may include conditions monitoring, reliability monitoring, structural monitoring, and repair. Offshore systems may need to be returned periodically to shore for maintenance or replacement.

Project impacts to geologic features and processes during the operational phase of a wave energy facility are expected to be negligible since operations would not involve seafloor-disturbing activities. In terms of impacts to coastal sedimentary processes (i.e., littoral sediment transport), it is estimated that a large wave energy facility (i.e., a commercial-scale facility such as described here and in Chapter 3) could cause a 10 to 15% reduction in wave height and a lowering of wave energy levels reaching the coast, with the greatest impacts occurring within 2 km (1.2 mi) of the wave device in the direction of wave travel (USDOI/MMS 2006j; Hagerman and Bedard 2004). A reduction in wave energy would result in an interruption of littoral (longshore) sediment transport by creating conditions favorable to sediment deposition between the facility and the shore, while increasing erosion further downdrift. The magnitude of these impacts would depend on the size and design of the wave energy facility and its distance offshore.

Floating devices that extend perpendicular to the direction of wave travel (parallel to the shoreline) have a greater potential to adversely impact coastal processes than to those that extend parallel to the direction of wave travel, vertically, or intermittently. Those located within a mile of the shoreline also would have a greater potential impact relative to those further offshore.

Impacts to coastal sediment transport processes could be greater along the Pacific Coast in areas where the shelf is particularly narrow, requiring construction closer to shore. Impacts, however, would need to be assessed on a project-specific basis, taking into account the size and location of the wave energy facility, and the wave energy and predominant wave direction in the area of interest.

Geohazards. Once a wave energy facility is operational, project impacts and the risk of impacts due to seafloor instability are assumed to be minimal, since the facility site would have been chosen to avoid or minimize such hazards. Scouring action by ocean currents would be an ongoing hazard, especially in areas where ocean current energy is high.

5.3.1.5 Decommissioning

During decommissioning, the wave energy facility and its mooring and scour protection systems would be removed and transported to shore. The facility would be dismantled in the same manner that it was assembled utilizing similar equipment, only in reverse. During these activities, the facility would encounter the same project impacts (mainly due to seafloor disturbance) and risk of geological or meteorological events as would be present during the facility's construction.

5.3.1.6 Mitigation Measures

Seafloor mapping conducted in the early phases of a project would help to ensure that the wave technology facility is sited appropriately to avoid or minimize potential impacts and the hazards associated with seafloor instability. Therefore, adverse impacts to geologic features and processes on the seafloor during technology testing, site characterization, operation, and decommissioning would likely be negligible.

Potential impacts to littoral (longshore) sediment transport could be mitigated by altering the design and location of the facility. Because wave devices that extend perpendicular to the direction of wave travel (parallel to the shoreline) would have the greatest potential for impacts, alternative designs may be more suitable in areas where loss of beach sand is of particular importance or concern. Likewise, locating the facility further offshore may also help to mitigate adverse coastal impacts, since the impacts to wave characteristics generally decrease with increased distance from shore (USDOI/MMS 2006j).

Scouring action by ocean currents around mooring structures could be mitigated by using scour protection devices and employing periodic routine inspections to ensure structural integrity. Because hard scour-protection devices such as rip-rap can increase erosion over time, softer approaches, such as natural, softer materials or sediment nourishment, would also be considered as mitigating measures. Controlling scouring effects will also minimize changes to seafloor topography that could ultimately impact sediment transport processes along the coast. Hazards to underwater cables could be mitigated by building cable systems with sufficient slack to reduce the risk of breakage due to increased tension caused by irregular topography or seafloor displacement as a result of mass movement or faulting.

5.3.2 Air Quality

The nature and magnitude of potential impacts on ambient air quality associated with offshore wave energy development depend on many factors, such as location, scope and scale of the project, type and capacity of equipment, and the schedule of each project phase. No detailed information on these site- and project-specific factors is available at the programmatic level for this programmatic EIS. Thus, no emission estimates were made and no air quality modeling was done. Instead, air quality analyses evaluate potential impacts in a qualitative manner.

5.3.2.1 Technology Testing

Wave technologies are less advanced than wind technologies, and proposals to test and demonstrate various forms of these technologies on the OCS can be expected in the next 5 to 7 years. A demonstration test for these technologies would most likely involve the deployment of one or two devices per test—with or without an undersea transmission connection to the shore. Depending on the size of the individual unit, the devices could be towed to their offshore locations or could be shipped by barge or special-purpose vessel, and installation may be conducted either from barges for smaller technologies such as point absorbers or by using specialized installation equipment for large devices such as overtopping devices. The demonstration units may also test various mooring technologies.

These activities would occur in a shorter time period and on a much smaller scale than the construction, operation, and decommissioning of full-scale projects that are addressed in Sections 5.3.2.3 to 5.3.2.5. Primary emission sources associated with testing activities would be from engine exhaust of vessel traffic (e.g., boat or barge) and heavy equipment (e.g., pile driver). In general, most criteria pollutant emissions would be from internal combustion engines burning diesel fuel and would include primarily nitrogen oxides (NO_x) and carbon monoxide (CO), lesser amounts of volatile organic compounds (VOCs) and PM_{10} (mostly in the form of $PM_{2.5}$), and negligible amounts of sulfur oxides (SO_x). These emissions would be emitted from all phases of OCS projects in common; only the amounts would differ with differences in the level of activities between phases.

Source emissions during the technology testing phase would be small in absolute terms but measurable and intermittent and temporary in nature. Accordingly, potential impacts of technology testing activities on ambient air quality would be minor.

5.3.2.2 Site Characterization

No information was found regarding special data collection/monitoring activities on wave and wind. However, existing National Oceanic and Atmospheric Administration (NOAA) buoy data, which are available for a relatively long-term period, may be used. Still, some project-specific data collection may be necessary. Information on the sea bottom for anchoring and cable installation can be collected using a multibeam echosounder and acoustic backscatter devices to develop a three-dimensional image of the seafloor. Grab sampling and/or gravity coring in the vicinity of the anchors and transmission lines would likely be used for identifying the seafloor composition. Benthic surveys may include side-scan sonar, side-mounted video camera, seafloor-mounted acoustic Doppler current profilers (ADCPs), and remotely operated vehicles. These activities would take several weeks at most.

During the site characterization period, emission sources would include engine exhaust mostly from the vessels (boats or barges) conducting the surveys discussed above or providing transportation to and from the project site for the workforce.[15] Minor activity levels would last

15 All vessels used in this phase are expected to be diesel powered.

several weeks and thus, potential air emissions during site characterization would be low. Accordingly, potential impacts on ambient air quality would be minor, and of short duration and intermittent in nature.

5.3.2.3 Construction

Within the scope of this programmatic EIS of 5 to 7 years, the project would likely use existing docks, piers, and other port infrastructure, and thus new construction of such features would be minimal. However, onshore activities such as construction of substations, cable landings, and other onshore facilities necessary to support the OCS facility would nevertheless occur within this planning horizon. In general, onshore and offshore construction activities would generate the highest air emissions in the life of a wave energy project, and thus produce the greatest air impacts.

Onshore construction activities could include site preparation of staging and/or pre-assembly areas, construction of remote control/monitoring buildings, construction of power management facilities (e.g., substations, cable landings), and transport of materials to the location via truck. Other onshore construction activities might address transmission-related needs, such as the installation of new conduits, substations, and overhead transmission lines (connecting the OCS facility to the existing electrical grid).

The largest air emission sources during onshore construction activities would likely be from fugitive dust from heavy equipment operation and vehicular traffic on bare soil surfaces and paved/unpaved roads (e.g., bulldozer, truck) and from wind erosion. Smaller emission sources would include diesel engine exhaust from heavy equipment and vehicular traffic (e.g., bulldozer, truck, boat, barge, crane, generator). Vehicles and equipment utilized in onshore construction activities would include gasoline- and ultra-low-sulfur diesel–powered ICEs.

In general, the highest emissions during onshore construction would be anticipated during site preparation, the earliest phase of construction, which would include clearing, excavation, backfilling, and grading for staging areas and transmission-related facilities. Still, these emission levels would be no higher than those for typical land-based construction activities (e.g., commercial building construction). Fugitive dust emissions could temporarily impact ambient air quality due to near-ground-level release and no buoyancy and thus could contribute to an exceedance of Federal or State ambient air quality standards at the nearest property line. These impacts could range from minor to moderate for short durations. However, potential air quality impacts from engine exhaust emissions would not be expected to contribute to exceedances of air quality standards and would be minor.

Offshore construction activities would involve vessel traffic (boat or barge) from port to the project site and would include installation of anchoring devices, energy conversion devices, transformer/service platforms, and underwater cables using highly specialized equipment (e.g., cable-laying ship). Offshore assembly of individual devices can require a week or more for some wave energy conversion (WEC) devices, but some devices (e.g., point absorbers) can be towed to the project site. Construction time will depend on the number of devices and the number of simultaneous construction actions taking place.

Air emissions from offshore construction activities would result from the motive engines of construction, equipment, and crew vessels navigating between shore and the OCS facility and from the ICEs present in various equipment (e.g., generators, cranes, air compressors) on the construction vessels. Most such equipment would be powered by ultra-low-sulfur diesel. Likewise, vessels will probably burn ultra-low-sulfur diesel; however, larger vessels may utilize bunker fuel (with substantially higher sulfur content). Emissions originating at the OCS location could be transported to onshore communities during daytime sea breeze. However, such emissions would be small compared with onshore emissions in coastal metropolitan areas and would be transported over some distance with relatively high winds (compared with nighttime land breeze) and with relatively high daytime mixing heights of typically 500 to 1,000 m (1,640 to 3,280 ft). Accordingly, potential impacts of these offshore activities on ambient air quality would be typically minor. However, greater impacts to air quality could be anticipated, depending on the number of individual vessels and pieces of equipment and the scheduling of construction activities that would allow all such equipment to be operating simultaneously.

Under certain conditions, it is possible for OCS emissions to contribute to or exacerbate an exceedance episode in areas plagued by high ozone levels, although such contributions would be minor and probably produce undetectable impacts. As an example, the nighttime land breeze combined with aged onshore polluted air masses and OCS sources concentrates ozone precursors (NO_x and VOCs) offshore during the night and early morning, and these polluted air masses can then be transported back onshore and contribute to mid-afternoon peak ozone episodes along with fresh emissions (SAI et al. 1995).

Exceeding 4% of the Prevention of Significant Deterioration (PSD) increment of SO_2 at nearby Class I areas is also significant and quite plausible, in particular when bunker fuel is used in the larger construction vessels.

5.3.2.4 Operation

Routine operations of OCS wave energy generation facilities would generally not require offshore personnel. Controlling and monitoring of devices and transformers would be done remotely by using fiber-optic cables or other communication devices. However, periodic maintenance and inspection would be required. For wave technologies, operational activities can include conditions monitoring, reliability management, structural monitoring, and repair. Offshore systems may need to be returned periodically to shore for maintenance or replacement.

Essentially, no air emissions associated with the actual operation of WEC devices would be expected. Minimal amounts of criteria pollutants may be emitted during testing and (if necessary) operation of the backup diesel generator on the offshore electric service platforms (ESP). (The generator would provide power for aviation and boat navigation lights in the event of a grid power failure.) Other minor air emissions during operation would be from vessel traffic related to infrequent site inspection and maintenance/repair activities. Wave energy operations would generate minor air emissions and, therefore, potential impacts on ambient air quality would be minor.

5.3.2.5 Decommissioning

Decommissioning would occur at the end of the operating life of an offshore wave energy project (currently an unknown length of time). Decommissioning entails dismantling of the WEC devices, ESP, and foundations; removal of associated scour protection structures; and subsequent transportation of these materials to shore for reuse or recycling. The WEC devices would be dismantled in the same manner that they were assembled, with similar equipment, only in reverse.

Accordingly, the types of activities for decommissioning would be similar to those for construction but of lower activity level and shorter in duration. Also, some structures may be left in place to be converted for other uses. In all, potential air quality impacts from decommissioning activities would be less than those from construction and would be anticipated to be minor.

5.3.2.6 Mitigation Measures

As discussed above, adverse potential air quality impacts during technology testing, site characterization, and operation phases would be minor. The greatest potential impacts among the project activities would be from fugitive dust emissions from earth-moving activities and vehicle traffic during construction and decommissioning phases. Generation of fugitive dust would be regulated both through the permitting process and the application of mitigation measures, where applicable.

Albeit of short duration, onshore site preparation activities could generate considerable amounts of fugitive dust emissions and impact neighboring communities and possibly cause Federal or State ambient air quality standards to be exceeded when added to existing sources. Accordingly, these activities would be conducted to minimize potential impacts on ambient air quality. For example, fugitive dust would be controlled by standard dust control practices for construction, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles. On windy or dry days, more frequent application of water spraying would be exercised.

Other general mitigative measures would include proper maintenance of heavy equipment (e.g., bulldozer, crane) and onshore vehicles (e.g., trucks) and offshore vessels (e.g., boat or barge) to minimize air emissions of diesel-powered engines.

The use of low-sulfur fuel (diesel or bunker fuel), especially for operations within 100 km (62 mi) of Class I areas, would reduce potential SO_2 impacts to those areas. During the ozone season, NO_x control in ozone nonattainment areas (e.g., including low-NO_x fuel, power management operations, retarding engine firing, catalytic converters, turbo-chargers/after-coolers) would reduce potential impacts from ozone. Timing source emissions to occur during nonpeak ozone periods would be an option. Use of offsets or emission credits in nonattainment and maintenance areas could reduce potential impacts from several pollutants.

5.3.3 Ocean Currents and Movements

5.3.3.1 Technology Testing

Capturing the energy of ocean waves in offshore locations has been demonstrated to be technically feasible as discussed in Section 3.3. Also, basic research to develop improved designs of wave energy conversion devices is being conducted in regions such as near the Oregon coast, which is a high wave energy resource. A variety of technologies have been proposed to capture the energy from waves; however, each is in too early a stage of development to predict which technology or mix of technologies would be best for future commercialization. Some possible technologies that are appropriate for the offshore applications include terminators, attenuators, point absorbers, and overtopping devices. Technology testing for these technologies could produce a very slight reduction in current energy because of structural drag and a decrease in wave height in the vicinity of any support structures caused by wave interception. Because of the small scale of associated testing equipment, impacts would be negligible, temporary, and very difficult to measure outside of the immediate area of the test equipment.

5.3.3.2 Site Characterization

A wave energy facility could be constructed and operated anywhere in waters of the OCS where conditions are favorable. Favorable conditions include factors such as high, sustained, regular wave action and water depths greater than 20 m (66 ft). In addition, favorable sites correspond to regions that have high wave energy. These regions primarily occur in regions of latitude between 30° and 60° N, near the equator with persistent trade winds, and in high latitudes because of polar storms. As with technology testing, site characterization could produce a very slight reduction in current energy because of structural drag, and a decrease in wave height in the vicinity of any support structures caused by wave interception. Because of the small scale of associated characterization equipment, impacts would be negligible, temporary, and very difficult to measure outside of the immediate area of the equipment.

5.3.3.3 Construction

Construction of a wave energy facility would most likely occur in deeper waters (i.e., greater than about 20 m [66 ft]) of the OCS. Installation activities would not have any measurable impacts on ocean currents or waves, except in the immediate vicinity of the associated wave-energy structures. Potential impacts include a decrease in wave height as waves intercept the structures and an exceedingly small decrease in current energy produced by structural drag. Such impacts would be very local and temporary and would not be measurable outside the area of the structure.

5.3.3.4 Operation

Potential impacts of operating a wave energy facility on physical oceanographic resources include a reduction in wave height and energy and a decrease in current energy produced by structural drag. Reduction in wave height from WECs could be a consideration in some settings; however, the impact on wave characteristics would generally only be observed 1 to 2 km (about 1 mi) away from the device in the direction of wave travel (USDOI/MMS 2006j). Thus, there should not be a significant onshore impact if the devices were much further than this distance from shore. None of the devices currently being developed would extract a large portion of a wave's energy and leave a relatively calm surface behind the devices. A large wave energy facility with a maximum density of devices is estimated to cause a reduction in waves on the order of 10 to 15%. This impact would rapidly dissipate within a few kilometers (roughly, 1 to 2 mi) of the facility, but leave a slight lessening of waves in the overall vicinity of the structure (USDOI/MMS 2006j).

The effects of structural drag would also reduce the energy in associated ocean currents. As with wind energy, this reduction would be very small and not measurable away from the facility.

5.3.3.5 Decommissioning

Decommissioning and removing structures of a wave energy facility would increase wave height and current energy in the vicinity of the removed structures. For similar pre- and post-project conditions, decommissioning and removal of associated structures would return the system to its original condition.

5.3.3.6 Mitigation Measures

Because construction, operation, and decommissioning activities associated with wave energy generation would have only a small, local effect on wave heights and energy if the facilities are built greater than about 1 to 2 km (about 1 mi) from shore and there are no measurable impacts on oceanic currents outside of the immediate vicinity of associated structures, no mitigation measures would be required. If, however, the facility is closer than this distance to the shore, modeling can be performed to develop a design that would reduce potential impacts.

5.3.4 Water Quality

5.3.4.1 Technology Testing

Testing of existing or new wave energy technologies at a demonstration scale would have very minimal impact on water quality. Small numbers of wave energy units would be deployed for days to months to determine their effectiveness. The impacts are the same as those described in Sections 5.3.4.3 and 5.3.4.4, but on a much smaller scale.

5.3.4.2 Site Characterization

Applicants for wave energy projects are not expected to undertake extensive physical site characterization studies. They would most likely rely on existing NOAA data buoys or other existing wave height and frequency information in the vicinity of the proposed projects (Elcock 2006).

Applicants may be required to characterize the seafloor sediments and marine life in the vicinity of the proposed project. Sediment sampling and ecological monitoring would cause temporary disturbance of the seafloor and introduction of sediment into the water column.

Site characterization would necessitate the use of work boats and ships. The process of operating vessels on the OCS can contribute small amounts of fuel or oil to the water column through bilge discharges or leaks, although this should be minimal. The process of anchoring the vessels and anchor removal would cause intermittent disturbance of the seafloor with movement of sediment into the water column. Vessels are expected to comply with USCG requirements on prevention and control of oil spills.

The nature of water quality impacts anticipated during the site characterization phase should be negligible or minor.

5.3.4.3 Construction

In the construction phase, sediment would be temporarily disturbed during installation of anchoring structures and the electrical cables to transmit power to shore. This is expected to have only localized and short-term impacts on water quality.

The construction phase would involve more vessels for longer periods of time than the site characterization phase; there would be a potential for larger or more frequent releases of oil or other chemicals found on the vessels through bilge discharges, leaks, or oil spills. The vessels would most likely be anchored for longer periods or use more significant anchoring structures.

Installation of the wave energy devices could involve minor releases of lubricants, solvents, or other chemical products. Unless containers of materials were accidentally spilled, the quantities of these released through normal operation would be very small.

The nature of water quality impacts anticipated during the construction phase would be negligible or minor, except in the event of a significant spill of oil or chemicals from a work vessel.

5.3.4.4 Operation

Once the wave energy devices are in operation, they should pose little direct water quality impact. Routine wastewater discharges are not anticipated, but if they did occur, they would be regulated under National Pollutant Discharge Elimination System (NPDES) permits.

Some types of wave energy devices may incorporate a hydraulic system that could pose a potential for hydraulic fluid leaks or spills. The potential impact of hydraulic fluid spills can be mitigated to some degree by using environmentally friendly fluids that are nontoxic to marine organisms and rapidly biodegradable. Devices may be configured with isolation valves that can be controlled from shore to minimize the volume of any spill in the event that a leak is reported by the plant monitoring system (EPRI 2004).

All structures submerged in seawater are subject to biofouling by marine organisms. Fouling control can be accomplished by periodic mechanical cleaning by divers or by application of antifouling coatings. Flexible reinforced rubber surfaces, such as hose pumps, cannot be coated. They may be subject to fouling during periods of lower-than-normal wave action. However, EPRI (2004) reports that based on ocean test experience, even a small amount of hose flexing is enough to prevent fouling organisms from taking hold.

There is some possibility for water quality impacts that are not directly related to wave energy installation operation. These impacts would be related to the presence of the structures in the sea. A wave energy installation could contain a few to hundreds of structures attached to the seafloor. This presents greater opportunity for collisions by vessels that attempt to navigate through the area. To reduce this potential impact, institutional controls may be applied to exclude commercial vessels from the area. If commercial vessels are allowed in the area and collisions occur, substantial releases of oil and other chemicals are possible.

The structures and their anchoring devices also can serve as attractants for marine life, which in turn attracts recreational fishermen to the area. Unless recreational vessels are excluded from the area, there is some potential for releases of oil, fuel, trash, and other material from the vessels.

Significant storm events could cause energy devices to break loose from their moorings and either wash up onshore or break open. These events could lead to releases of hydraulic fluids. In a similar fashion, collisions with large pieces of debris, such as floating logs, could damage devices and lead to releases of hydraulic fluids.

Finally, some scientists have suggested that the presence of a large wave energy installation relatively near the shore could remove sufficient energy from the waves that their subsequent impact on shoreline erosion and long-shore transport of sediment could change shoreline contours (EPRI 2004). Changes in sediment transport could lead to more or less sediment remaining in the water column. It is likely that such impacts, although partially caused by the wave energy installation on the OCS, would not themselves occur on the OCS. Instead, if they did occur, they most likely would be found in the nearshore State waters.

Overall, except for the possibility of a spill related to collision or large storm, the impacts related to the operation phase should be negligible to minor.

5.3.4.5 Decommissioning

The water quality impacts associated with decommissioning would be related to vessel operations, any fluids that leak from the device during removal, and sediment resuspension during the removal of the anchoring structure and electrical cables. These are likely to be short-term events without any long-lasting impacts. As long as the operator carefully controls oil and other chemicals before moving structures, the water quality impacts related to decommissioning should be negligible to minor.

5.3.4.6 Mitigation Measures

During the operational phase, regular inspection and maintenance should help in the detection of any hydraulic oil leaks. Operators should consider using antifouling coatings with the lowest practical degree of toxic releases, as long as those coatings provide effective antifouling control.

During the decommissioning phase, all hydraulic oil and other chemicals should be removed or otherwise controlled before the structure is moved.

Vessels should have good maintenance and housekeeping procedures to minimize releases of oil or other chemicals to the sea. They should have up-to-date oil spill response plans. Vessel collisions within the wave energy installation and the resulting spills of oil, fuel, and chemicals can be reduced by excluding commercial and/or recreational vessel from the area.

5.3.5 Acoustic Environment

5.3.5.1 Technology Testing

Technology testing of wave energy technologies would also involve ship and barge noise as well as some high-intensity noises associated with the anchoring of the technologies being tested. These technologies encompass a great variety of devices and designs, while wind turbines vary mainly only in terms of size. All of the wave energy technologies have the common requirement of the need to be anchored. Anchoring methods for technology testing would most likely involve tethering devices to the ocean floor. The placement of large pilings or large foundations would not be expected for the most part.

Wave technologies, including attenuators and point absorbers, typically float on the water surface and so do not require a rigid foundation. Anchoring might involve driving or drilling a single anchor for each tested device, or simply dropping a concrete base on the ocean floor.

Noise for driving or drilling would involve high-intensity pulses, but would be of less impact than that from driving large pilings for wind energy devices. Impacts would be intermittent and of short duration.

Wave energy devices would be expected to emit mechanical noise during operation from the flexing and bobbing action of wave devices and rotation of water turbines and generators. Operational noise would originate in the above-water portion of the devices and would be projected into the water, potentially producing both above-water and below-water noise impacts. Once installed, wave energy technologies would produce low-intensity, broadband noise of a repetitive continuous nature, similar in character to noise from ship operations. Such noise would be expected to have minimal impacts to human and marine populations.

5.3.5.2 Site Characterization

Site characterization activities for wave energy devices might involve seafloor mapping to identify anchoring locations. From a technology perspective, site characterization would likely be focused on measuring wave action in various locations through the use of bobbers or other such devices equipped with recorders. Installing these devices would involve some ship and boat noise. It is not expected that anchoring would require drilling or pile driving, as it could be accomplished by using dropped anchors.

Seafloor characterization might be required to some degree to assess the suitability of anchoring devices for various wave energy conversion technologies. Characterization requirements would vary depending on whether anchoring methods require penetration of the seafloor or whether simply dropping a concrete pad or other anchor onto the surface of the seafloor is needed. Given the modest anchoring requirements of wave energy technologies compared to, for example, wind turbine technologies, it is expected that seafloor characterization would be carried out using relatively low-energy geophysical survey technologies as described in Section 5.3.5.2 (an expanded discussion on each of these survey technologies is provided in Chapter 3). No significant adverse acoustical impacts would be generated from the use of such technologies.

5.3.5.3 Construction

Construction of wave energy projects might involve some limited amount of pile driving for the construction of offshore power-gathering stations. Construction of such facilities could also occur onshore with the assembled component then towed to its final offshore operating location. Pile driving produces high-intensity noise pulses that can impact marine life to various degrees, from minor to fairly severe. The impacts of pile driving are examined in Section 5.2.5.3.

Construction of wave energy projects would also involve above-water or in-water construction that could have noise impacts to both human and marine receptors. In addition to ship noise, discussed in Section 5.2.5.3, such construction could involve helicopter noise, general construction noise from use of hand tools and machinery, such as air compressors, and noise from work boats and small craft used for construction.

As seen in Table 5.2.5-1, construction noise sources above water for a number of activities range from 68 to 99 dB (re-20 μPa). As discussed in Section 5.2.5.3, general construction noise would be of short range and low impact in typical urban or suburban locations near offshore projects or near locations of onshore construction or assembly of project components.

Helicopter noise, if present, might affect human populations in nearshore areas, while it would not be expected to impact marine life. Such noise could produce annoyance in affected areas, but only for relatively short durations. Helicopter noise impacts are characterized in Section 5.2.5.3.

Small boats with outboard motors as well as larger crew boats and small tugs would be noise sources during construction of wave energy projects. Noise from these sources is described in Section 5.2.5.3 and in Table 5.2.5-1. Noise levels would be similar to that for general construction noise and could result, typically, in short-term annoyance of nearby populations. However, boat noise would be largely masked by background boat noise in many nearshore areas.

Construction noise associated with the installation of cables that would interconnect wave energy-generating devices is described in Section 5.2.5.3. As noted there, noise from some cable installation could be intense but would occur over a short period of time.

Finally, noise would be associated with on-shore staging, pre-assembly, hauling, and loading of wave energy technology components and with the construction of onshore facilities that receive power from the offshore wave energy facility and modify and synchronize it for connection to the electric grid or to nearby distributed energy systems. Table 5.2.5-3 shows the noise resulting from construction vehicles and equipment that would likely be used. Depending on the size and complexity of the project, construction may take as long as six months but would typically take less time.

5.3.5.4 Operation

Wave energy technologies include a wide range of devices that would be expected to exhibit a similarly wide range of noise emissions, but few studies on such emissions have been performed on these emerging technologies. However, it is possible to speculate on the general nature and level of noise that might be associated with the operation of wave energy devices and systems.

All wave energy technologies will have certain features in common with respect to noise emissions. All or most will generate mechanical noise from electrical generators and associated drive systems. All will generate noise from service boats and maintenance work. Finally, all will generate some above- and below-water noise. Overall, however, operational noise from proposed technologies is expected to be generally low as a consequence of the low-intensity energy conversion mechanisms involved that drive the technologies.

Operational noise from wave energy technologies would likely have different characteristics for each technology. Terminator and overtopping devices located on or near shore would produce noise from the impact of waves on the devices as well as from compressed air expelled from turbines from oscillating water column devices, for example. As the timing of such noise would correspond to background wave action, much of this noise could be masked. Conversely, as these devices are located close to shore, resident populations might be located nearby. Noise impacts from such devices might be similar to that from background urban or suburban noise sources.

Attenuators and point absorbers, on the other hand, would be located offshore and would be expected to produce generally less mechanical noise than terminators, as these latter devices move up and down with wave action. Mechanical noise from these technologies would be expected from flexing action, from tension against tethers, and from electrical generators and associated drive systems. These technologies would produce both above- and below-water noise. The character and level of the noise generated might be similar to that from the mechanical noise from boats of similar size. Impacts to marine and human populations would be expected to be minor.

All offshore energy conversion technologies would require regular maintenance, and some would require daily commutes by operators. These activities would produce noise from the crew boats or small tugs used. This noise would be indistinguishable from other ship and boat noise in nearshore areas. If helicopters were used to ferry crews, however, noise impacts could be higher.

Finally, noise would be generated from the operation of electrical equipment associated with wave energy facilities. Noise impacts from transformers and shunt reactors used to transform generated electricity into a form compatible with the distribution grid are described in Section 5.2.5.4. It is expected that noise levels emitted from these devices would be within industry standards designed to minimize noise impacts and that no more than minor impacts would be incurred.

5.3.5.5 Decommissioning

Decommissioning of offshore WEC technologies would involve disconnecting energy conversion devices from moorings and electrical connections and likely transporting the devices to shore for final disassembly. Dismantlement of facilities would also involve the removal of above-water equipment and machinery, such as offshore gathering stations, dismantlement of support structures, such as towers, removal of underwater cables, and finally removal of pilings, if present, to below seafloor level. Noise produced from these activities would be similar to that from construction of the facilities.

These activities would produce noise from the use of construction equipment, hand tools, cranes, and compressors. Noise from work boats, barges, and associated equipment, such as power shovels, would be expected for larger projects. Noise impacts from these activities are discussed in Section 5.2.5.3, and noise levels are presented in Tables 5.2.5-1 and 5.2.5-2. Impacts would be expected to be of short duration.

It is unlikely that explosives would be required for the removal of wave energy anchoring devices, but they may be used to remove associated rigid structures, such as gathering station pilings. However, in many cases, simple cutting would suffice for such removals. Rocks and boulders used to protect pilings would be removed by using cranes and shovels. Noise impacts would be similar to those for construction.

5.3.5.6 Mitigation Measures

Impacts from pile driving or the use of explosives may be mitigated by a number of means involving either removing potential receptors from the work area or reducing sound emissions into water. Mitigation of piling noise at the source is possible by various means, including the use of bubble curtains, insulated piles, working inside of caissons or coffer dams, or working during periods of slack tide (Lewis 2005). As was noted in Section 5.2.5.6, not all mitigation techniques will be effective in all circumstances. Operators will be required to consult with appropriate authorities in the development and implementation of mitigation strategies that are circumstantially specific as well as specific to the acoustically sensitive species known to be present within the area of acoustic influence.

Transformers are typically installed in fenced areas that prevent close access by all but authorized personnel or are placed in vaults. In locations where even minor amounts of transformer noise cannot be tolerated, transformers with specially designed noise-mitigating housings are also available. It is reasonable to anticipate that safe stand-off distances incorporated into substation design, vaulting, and transformer design would result in transformer noise being reduced to negligible levels. Further noise reduction can be accomplished by surrounding substations with noise-reducing fencing, shrubs or trees, or other noise barriers.

5.3.6 Hazardous Materials and Waste Management

Each offshore wave energy project would require deliveries and pick-ups of personnel, supplies, and materials to and from its offshore site. Vessels used for this purpose may generate wastes, including bilge and ballast waters, garbage (trash and debris), domestic wastes, and sanitary wastes. The need for vessels to support offshore wave energy projects is not expected to increase the total number of vessels of this type operating in any of the OCS regions. Also, management of wastes from these vessels is regulated by the USCG (33 CFR 151). Accordingly, the impacts of waste generated by support vessels servicing offshore wave energy projects would be negligible in all regions.

As identified in Sections 4.2.6.2, 4.3.6.2, and 4.4.6.2, there is a potential for disposal areas containing chemical weapons to occur in marine waters of the three OCS regions considered for potential development of alternative energy facilities. The exact locations of most of these disposal areas are not readily available to the public, with records typically supplying only references to the general offshore locations, because of the hazardous and sensitive nature of the materials disposed of. Notwithstanding, applicants developing alternative energy facilities in offshore waters should be able to avoid such areas by consulting with the appropriate military agencies during case-specific siting processes. Hence, chemical weapons disposal areas on the OCS are not expected to contribute impacts during the development of offshore wave energy projects.

5.3.6.1 Technology Testing

As Section 3.3 indicates, most wave technologies are at early stages of development so that only demonstration projects are likely during the next 5 to 7 years. Impacts from hazardous materials and waste management during site characterization would be essentially the same for demonstration projects as for commercial facilities because the monitoring and testing requirements would be similar for both (Elcock 2006). These impacts are described in Section 5.3.6.2.

The types of impacts from construction and operation of demonstration wave energy facilities would also be the same as for commercial facilities, but their magnitude would be scaled down. Sections 5.3.6.3 and 5.3.6.4 discuss the impacts from construction and operation of demonstration wave energy facilities.

A demonstration facility would be decommissioned in the same manner as would a commercial facility. Hence, the types of impacts from decommissioning would be the same for both, but the magnitude of the impacts for a demonstration facility would be scaled down. Section 5.3.6.5 discusses the impacts from decommissioning of a demonstration wave energy facility.

5.3.6.2 Site Characterization

Site-specific data collection for determining the suitability of a site for wave energy projects appears to be unnecessary; data from existing ocean monitoring and data collection activities would likely be adequate and available (Elcock 2006). Activities necessary for geological and geophysical characterization, identification of sensitive biological resources, archaeological characterization, etc., would involve the use of vessels for a short duration, and no hazardous materials are expected to be transported to, used on, or stored on the OCS for site characterization. Similarly, no hazardous or nonhazardous wastes would be transported, generated, or otherwise managed either on the OCS or onshore as a result of site characterization activities. Thus, impacts from waste management and the use or storage of hazardous materials during site characterization for wave energy projects would be negligible.

5.3.6.3 Construction

WEC devices would be assembled onshore and then towed through both coastal and OCS waters to the offshore site, where they would be joined together and appropriately anchored. Also, onshore horizontal directional drilling would occur during hookup of the transmission cable to an existing onshore substation. Hazardous materials present during towing and assembly would include lubricants contained in the components of each WEC device and possibly hydraulic fluids. Components containing lubricants are expected to be sealed, and the most likely designs would utilize benign fluids, such as seawater and air, rather than hazardous materials, for hydraulic pumps and systems (Elcock 2006). As was discussed in Section 4.2.6, if an accidental spill of a hazardous material occurred during the process of towing WEC devices to offshore sites or assembling the WEC devices, such a spill must be reported to the National Response Center if it exceeds a reportable quantity set forth in 40 CFR Part 302. If a spill exceeds 50 barrels (bbl) (2,100 gal or 7,949 L) on a Federal lease in the Atlantic or GOM regions, its cause would be investigated by the MMS. In the Pacific region, the MMS would investigate the cause of any hazardous material spill, regardless of size.

It is unlikely that any single spill of a hazardous material during towing activities would exceed 50 bbl, if appropriate precautions are taken. The nature of the impacts from such a spill would depend on factors such as, but not limited to, prevailing winds and currents, quantity spilled, and proximity of the spill to receptors. Regardless of the projected size or likelihood of a hazardous materials spill at a wave facility on the OCS, implementation of appropriate precautions to prevent spills and implementation of proper mitigation measures when a spill occurs would reduce impacts substantially. Accordingly, impacts from hazardous materials spills during construction of a wave facility would be minor to moderate.

Garbage would be generated in very small quantities onboard the vessels used to tow WEC devices to offshore sites. Also, it is assumed that sanitary waste would be generated only on the towing vessels. Small amounts of industrial waste that may be generated during assembly of WEC devices would be returned to shore for disposal in appropriate, permitted, disposal facilities. If bentonite drilling fluid were to be inadvertently released during drilling for the transmission cable hookup, it would be collected as much as practicable and removed to shore for disposal in an appropriate nonhazardous waste facility. As Chapter 4 indicates, disposal facilities for nonhazardous solid wastes are available onshore in all three OCS regions. Hence, impacts that result from management of nonhazardous wastes generated offshore during construction of WEC projects would be negligible.

5.3.6.4 Operation

Section 3.3 describes the components of four types of WEC technologies. While the specific components vary among the four technology types, two WEC technologies have hydraulic pumps or other hydraulic converters, and all four WEC technologies require voltage transformers. Table 4.2.6-1 lists the expected types and estimated amounts of hazardous materials that may be in storage during operation of these components. Wastes defined by the Resource Conservation and Recovery Act (RCRA) as hazardous waste are not expected to be generated at wave facilities. Maintenance vessels would deliver lubricants and hydraulic fluids (unless air, seawater, or other benign fluids were used as hydraulic fluids) to the offshore WEC site, as needed. Alternatively, WEC devices may be towed to shore for maintenance (Elcock 2006). Sections 4.2.6, 4.3.6, and 4.4.6 discuss the total quantity of hazardous materials, including petroleum products and chemical products, shipped on the ocean during 2004 in the three OCS regions. Based on the information in Table 4.2.6-1 and Sections 4.2.6, 4.3.6, and 4.4.6, the total amounts of hazardous materials likely to be used at WEC sites in the three OCS regions would be minuscule compared to the total amount of hazardous materials transported by ocean vessels in those areas.

Impacts from transporting wastes and materials to and from wave facilities during their operating periods are discussed in Section 5.3.17. As during construction, impacts from using and storing hazardous materials at wave facilities for maintenance during operation may occur due to accidental spills. Accidental spills also could occur during towing of WEC components to and from shore for maintenance. Such spills would be like those that might occur during construction, which were discussed in Section 5.3.6.3. Implementation of appropriate precautions to prevent spills and implementation of proper mitigation measures when a spill occurs would reduce impacts substantially. Accordingly, impacts from hazardous materials spills during operation of a WEC project would be minor to moderate.

Operation and maintenance personnel are expected to visit a WEC site only occasionally during the operating stage. Garbage would be generated in very small quantities onboard the vessels used to service the WEC devices. Also, it is assumed that sanitary waste would be generated and managed onboard such vessels. Small amounts of industrial waste that may be generated as a result of maintaining WEC devices on the OCS would be returned to shore for disposal in appropriate, permitted, disposal facilities. If WEC devices are towed to shore for maintenance during their operating stage, the small amount of industrial waste that may be generated as a result of the onshore maintenance also would be disposed of in appropriate, permitted disposal facilities. As Chapter 4 indicates, disposal facilities for nonhazardous solid and industrial wastes are available onshore in all three OCS regions. Hence, impacts that result from management of nonhazardous wastes generated offshore during the operating stages of WEC projects would be minor.

5.3.6.5 Decommissioning

This section addresses impacts that may result from hazardous materials and waste management during decommissioning of WEC projects.

As was explained in Section 5.3.6.4, the total amounts of hazardous materials present at WEC sites on the OCS would be minuscule compared to the total amount of hazardous materials transported by ocean vessels on the OCS. It is assumed that such materials would be stored at a wave facility or contained within the WEC devices and be removed from the site early in decommissioning along with the WEC devices themselves. Impacts from removing the WEC devices during decommissioning may occur due to accidental spills. Such spills would be like those that might occur during construction, which is discussed in Section 5.3.6.3.

Implementation of appropriate precautions to prevent spills and implementation of proper mitigation measures when a spill occurs would reduce impacts substantially. Accordingly, impacts from hazardous materials spills during operation of a WEC project would be minor to moderate.

Nonhazardous wastes, hazardous wastes, and recyclable materials that may be generated as a result of decommissioning of WEC projects are among those indicated in Table 4.2.6-2. The generation of nonrecyclable hazardous wastes is not expected during decommissioning.

Recyclable and reusable materials would be generated in varying amounts. These would be collected and returned to shore for appropriate management. Recyclable or reusable materials that are hazardous as defined under the RCRA must be managed during collection and transportation in compliance with applicable regulations in 40 CFR 261 and 40 CFR 266. Alternatively, they could be collected and returned to shore for appropriate treatment and disposal at permitted hazardous waste treatment and disposal facilities. As Chapter 4 indicates, disposal facilities for hazardous wastes are available onshore in all three OCS regions. Hence, impacts that would result from managing recyclable or reusable materials as hazardous wastes during decommissioning of WEC projects would be negligible on the OCS, and onshore impacts would be minor.

Nonhazardous wastes would all be generated in small quantities, collected, and returned to shore for appropriate treatment and disposal in a permitted disposal facility. As Chapter 4 indicates, disposal facilities for nonhazardous solid and industrial wastes are available onshore in all three OCS regions. Hence, impacts that result from managing nonhazardous wastes during decommissioning of WEC projects would be negligible on the OCS, and onshore impacts would be minor.

5.3.6.6 Mitigation Measures

Impacts from hazardous materials and waste management activities associated with WEC projects would be reduced further by the management practices and mitigation measures listed below.

- Design the hydraulic components in WEC devices to operate using seawater, air, or other benign fluids, rather than hazardous materials such as hydraulic fluids.

- Develop a hazardous materials management plan addressing storage, use, transportation, and disposal of each hazardous material anticipated to be present at the site. Emergency response procedures, including notification requirements, should also be incorporated.

- Develop a waste management plan that includes waste minimization procedures and pollution prevention goals.

- Develop a spill prevention and response plan that includes training and notification requirements.

- Applicants developing alternative energy facilities in offshore waters, including the installation of subsea transmission cables, should consult with the appropriate military agencies during case-specific siting processes to ensure avoidance of disposal areas possibly containing chemical weapons.

- Applicants should substitute environmentally preferable or “green” materials for less environmentally friendly fluids such as dielectric fluid alternatives (e.g., natural esters rather than mineral oil) whenever possible. These materials are derived from renewable, domestically produced seed oils, are not listed as suspected carcinogenic agents, and meet stringent performance requirements.

- Report any oil spilled in State waters, or having the potential to reach State waters, to the appropriate local, State, and Federal authorities.

5.3.7 Electromagnetic Fields

Electromagnetic field (EMF) impacts from submarine power cables associated with wave energy generation facilities are expected to be the same as those for wind and ocean current generation facilities. These impacts are discussed in Section 5.2.7. Additional discussion on EMF impacts to aquatic species can be found in Sections 5.3.11.4 and 5.3.14.4.

5.3.8 Marine Mammals

Not all species of marine mammals that occur off the Atlantic, Pacific, or Gulf of Mexico coasts would be expected to be equally exposed to or affected by activities associated with development of wave energy in OCS waters. A number of species, such as the fin and blue whales, are extremely rare or considered extralimital in some OCS waters but are often observed in other OCS waters. Many other species, such as the Steller sea lion, Guadalupe fur seal, and many of the beaked whales, are very uncommon or very limited in their distributions and thus are unlikely to be found in OCS waters where wave energy development is occurring. In contrast, species such as many of the odontocetes (toothed whales) are considered relatively common and widespread in some of the OCS waters. Thus, there is a greater potential that some of these more common or widespread species may occur in areas where they could be affected by wave energy-related activities.

Potential impacts to threatened or endangered species of marine mammals from wave energy technology testing, site characterization, construction, operation, and decommissioning would be similar in nature to the impacts identified for nonlisted species and could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA and MMPA regulations and coordination with the NMFS and USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.3.8.1 Technology Testing

Site evaluation and technology testing of any of the current types of wave energy devices (Section 3.3) may be expected to have negligible to minor effects on marine mammals. Site selection for possible testing would likely rely on data collected from existing NOAA data buoys near proposed test locations. Mooring of wave energy devices may require geological and geophysical surveys to determine suitability of surface and subsurface conditions for mooring placement, which could affect marine mammals in the area of the surveys. Placement of mooring devices (which may involve pile driving) may also generate noise that could disturb marine mammals in the vicinity of the test site. For both activities, affected animals may temporarily leave the area, cease normal behaviors, or experience masking of auditory signals (Section 5.2.8.3). However, both the surveys and mooring placement would be short-term and limited to a few locations, affecting few animals. Thus, noise generated during technology testing would have negligible to minor impacts on marine mammals.

Marine mammals could be affected by vessel traffic (Section 5.3.17) between onshore facilities and the offshore test site. Affected animals could collide with moving vessels, resulting in injury or death, or be disturbed by the presence and noise of these vessels and leave the vicinity. Because of the small number of vessel trips that might be needed for any testing location, collisions with test vessels would be unlikely. However, such collisions could result in minor to moderate impacts depending on the affected species (such as the endangered West Indian manatee).

No fuels or hazardous materials would be required or generated by the test equipment. Wastes generated by the support vessels would be managed as regulated by the USCG (Section 5.3.6), and any accidental releases of hazardous materials or fuels may be expected to be small and rapidly diluted and dispersed by the receiving waters. Thus, impacts from such releases to marine mammals are expected to be negligible.

During technology testing, marine mammals could be injured by becoming entangled in underwater mooring cables or floating structures. Entanglement could result in serious injury or death of affected individuals. Entanglement of common species would not be expected to result in population-level effects and thus would have a minor effect on many of the marine mammal species. Entanglement of threatened, endangered, or otherwise uncommon species, such as the North Atlantic right whale (Section 4.2.8.1) or many of the *Mesoplodon* beaked whales in Pacific waters (Section 4.4.8), could result in minor to moderate impacts to these species.

5.3.8.2 Site Characterization

Activities associated with site characterization that may affect marine mammals include (1) geological and geophysical surveys and (2) accidental discharges of waste materials and fuel releases.

5.3.8.2.1 Geological and Geophysical Surveys. Geological and geophysical surveys may be employed to characterize ocean-bottom topography and subsurface geology. Species restricted to nearshore coastal marine and freshwater habitats, such as the endangered West Indian manatee in the Gulf of Mexico and southern Atlantic Coast and the threatened sea otter along the Washington and California coasts, would be unlikely to be affected by offshore geological and geophysical surveys. The marine mammals most likely to be exposed to and affected by routine surveys are the cetaceans and possibly some of the more pelagic pinnipeds.

The potential effects of low-energy geological and geophysical surveys (such as those using side-scan sonar) on marine mammals may include behavioral responses such as avoidance and deflections in travel direction (Section 5.2.8.2). While a survey may affect more than one individual, routine surveys are not expected to result in population-level effects. Individuals disturbed by a survey would likely return to normal behavioral patterns after the survey has ceased (or after the animal has left the survey area). Because most of the potentially affected marine mammals are highly mobile species, they may be expected to quickly leave an area when a survey is initiated, thereby greatly reducing their exposure to maximal sound levels and, to a lesser extent, masking frequencies. Little information is available regarding the subsequent health and condition of such displaced individuals.

Because of the limited duration of the geological and geophysical surveys, the low-energy techniques likely to be used for the surveys as well as the likelihood that marine mammals would leave the immediate vicinity of the surveys, impacts to marine mammals in general would be negligible. However, behavioral changes (including alteration of migration paths) may result in minor impacts to threatened or endangered mysticetes.

5.3.8.2.2 Discharge of Waste Materials and Accidental Fuel Leaks. Marine mammals could be exposed to operational discharges or accidental fuel releases from geological and geophysical survey vessels and to accidentally released solid debris. Because of the limited number and duration of geological and geophysical surveys that may be required, only small amounts (if any) may be expected to be accidentally released from the survey vessels. Any discharged liquid wastes and materials would be quickly diluted and dispersed, and thus be expected to have negligible impacts to marine mammals. The release of solid debris is prohibited (see Section 5.2.8.2), and any amount accidentally released would be very small and thus also have a negligible impact on marine mammals.

5.3.8.3 Construction

Construction-related impacting factors that could affect marine mammals include (1) geological and geophysical surveys, (2) noise generated during mooring of wave energy devices, (3) vessel traffic, and (4) waste discharge and accidental fuel releases. These impacting factors would be associated with mooring of the energy devices to the ocean floor and offshore transformers or substations, placement of cables from the turbine towers to the offshore transformer or substation, and placement of cables from offshore facilities to onshore facilities.

5.3.8.3.1 Geological and Geophysical Surveys. Low-energy geological and geophysical surveys, using techniques such as side-scan sonar, conducted to more fully characterize bottom topography and subsurface geology for mooring floating wave energy devices, could affect marine mammals in the same manner as described for site characterization (Section 5.2.8.2). Marine mammals exposed to geological and geophysical surveys could exhibit behavioral changes as well as experience auditory masking. Impacts to marine mammals are expected to be negligible for most species, and minor for species that are threatened or endangered.

5.3.8.3.2 Construction Noise. Noise generated during mooring of wave energy devices could disturb marine mammals that may be present in the vicinity of the construction area. The types of potential impacts from mooring activities would be similar to those described for wind platform construction (Section 5.2.8.3). Noise generated during mooring (which may involve pile driving) could disturb normal behaviors (e.g., feeding, social interactions), mask calls from conspecifics, disrupt echolocation capabilities, and mask sounds generated by predators. Behavioral affects may be incurred at ranges of many miles, and hearing impairment may occur at close range.

For individual wave energy devices, noise impacts would likely be limited to individuals or small groups that are present in the vicinity of the device, and not entire populations. In most cases, affected individuals or groups would be expected to leave the construction area upon arrival of construction equipment and initiation of mooring activities, thereby reducing the likelihood of exposure to noise levels that could impact hearing.

In general, noise impacts to most marine mammals would be minor. However, disturbance of normal behaviors, masking, or hearing damage of individuals during migrations between winter calving areas and summer feeding grounds or in feeding areas could result in moderate impacts to some species. Impacts to species that are threatened or endangered may be minor or moderate, depending on the nature of the effect.

5.3.8.3.3 Vessel and Helicopter Traffic. Marine mammals may be injured or killed as a result of collisions with vessels supporting the placement and mooring of the wave energy devices in offshore waters. Marine mammals in coastal habitats may encounter vessels and helicopter overflights traveling between offshore construction sites and onshore facilities, vessels placing cables between the offshore wave energy devices and associated infrastructure, and onshore electric distribution facilities. Coastal species that could encounter construction vessels or be disturbed by helicopter overflights include the endangered West Indian manatee in the southern Atlantic OCS waters and the California sea otter and Guadalupe fur seal in the southern California OCS waters.

Because of the low level of vessel traffic that could occur during construction, potential impacts from collisions would likely be limited to a few individuals, be largely short-term in nature, and not result in population-level effects. Thus, impacts to marine mammals from ship collisions are expected to be minor. However, injuries to threatened or endangered species could result in moderate impacts to the affected species.

Helicopter overflights, due to their transient nature, could temporarily disturb normal behaviors of marine mammals along the flight path. Such impacts could result in negligible impacts to affected animals. Overflights of pinniped rookery sites could result in reduced pup survival and have minor to moderate impacts to affected species.

5.3.8.3.4 Waste Discharge and Accidental Fuel Releases. Potential impacts to marine mammals from accidental releases of liquid wastes, solid debris, or fuels would be similar to those identified for similar releases during site characterization (Section 5.3.8.2). Only small amounts of liquid operational wastes or fuel may be expected to be present at any given time during construction. Releases of these would be small in volume and become rapidly diluted and dispersed. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]), and entanglement in or ingestion of solid debris by marine mammals would not be expected during normal construction activities. Thus, potential impacts to marine mammals from the release of liquid wastes, solid debris, or fuels are expected to be negligible.

5.3.8.4 Operation

During operation of a wave energy facility, marine mammals may be affected by (1) collision and entanglement in mooring cables or buried transmission cables, (2) device noise, (3) service vessel traffic, and (4) accidental releases of hazardous materials or fuels. Marine mammals may also be affected by the presence of mooring structures and underwater pilings and other project infrastructure that could occupy about 5 km^2 (2 mi^2) of ocean habitat.

5.3.8.4.1 Collision and Entanglement. Wave energy facilities may have as many as 200 to 300 mooring lines securing the wave energy devices to the ocean floor. Thus, marine mammals swimming through a wave energy facility may strike and become entangled in these lines, becoming injured or drowning. Depending on the species affected, contact with mooring or transmission cables may result in minor to major impacts to marine mammals. The gray whale, which feeds on bottom-dwelling invertebrates, may also encounter buried transmission cables that would connect the offshore wave energy project with onshore infrastructure and become entangled or injured. Depending on the number of individuals affected, contact with buried transmission cables may result in minor to moderate impacts to the gray whale.

5.3.8.4.2 Device Noise. During normal operations, underwater noise from a wave energy device may produce airborne noises of 70 to 90 dB (EPRI 2004). While no information is available regarding underwater noise levels, airborne noises may be transmitted underwater via moorings and pilings and affect marine mammals in the vicinity of the facility. Noise levels are expected to be similar to levels associated with ship traffic. If affected, animals may exhibit behavioral modifications such as changes in foraging, socialization, or movement. Affected animals may also experience auditory masking, which in turn could affect foraging and predator avoidance.

In contrast to the relatively short time period during which construction noise would be generated, noise would be generated for a much longer time during normal operations. Under normal operations, there would be continuous or near-continuous noise generation over the area of the wave energy facility (up to 5 km^2 [2 mi^2]). Such noise generation could result in the long-term avoidance of the wave energy facility and surrounding vicinity (depending on the distance operational noises are transmitted underwater to levels actively avoided by, or affecting, marine mammals). This could lead to abandonment of feeding or mating grounds (such as those of the northern right whale off the New England coast) and disruption of migratory routes (such as those followed by the gray whale along the Pacific Coast), which could result in long-term population-level effects. While it is not known if marine mammals would be affected, normal operational noise may result in minor to moderate impacts to some species of marine mammals, especially if the wave energy facility is located in or near an important feeding or mating area or migratory route.

5.3.8.4.3 Service Vessel Traffic. During normal operations, there would be vessel trips to perform device maintenance and repair. Marine mammals may be affected by this traffic either by direct collisions with, or disturbance by, these vessels. Animals may be injured or killed as a result of ship collisions, while ships traveling to and from a wave energy facility may disturb animals in the vicinity of their path. Disturbed individuals may be expected to leave the vicinity of the ship and return to normal behavior following passage of the ship. Because of the low level of vessel traffic that could occur under during normal operations, potential impacts to marine mammals from this traffic would likely be limited to a few individuals, be largely short-term in nature, and not result in population-level effects. Thus, impacts to marine mammals from ship collisions are expected to be minor. Injuries to threatened or endangered species, however, could result in moderate impacts to the affected species.

5.3.8.4.4 Accidental Releases of Hazardous Materials or Fuels. Operational discharges from service vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal (Section 5.2.6.3). Operational discharges would be quickly diluted and dispersed by local currents, and thus are expected to have a negligible impact on marine mammals. Because of the small amount of fuels or other potentially hazardous materials (such as transformer fluid, hydraulic fluid, or lubricating oil) that may be present or used at any given time during normal operations (see Section 5.2.6.4), accidental releases or spills, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents and would not be expected to pose a threat to marine biota. Thus, potential impacts to marine mammals from accidental spills of hazardous materials are expected to be negligible.

5.3.8.4.5 Facility Presence. The presence of a wave energy facility in an area may cause some species of marine mammals to avoid the facility and surrounding area. The presence of a facility within a migratory path of a species such as the gray whale along the Pacific Coast could cause animals to swim around the facilities during their migrations. These facilities thus may act as barriers to effective passage by migrating individuals through an area, and cause migrating animals to swim around the facilities. The effects of such displaced migration are unknown but may result in increased energetics costs and reduced condition, especially in migrating young (Hagerman and Bedard 2004). Facilities sited in important feeding or calving grounds could also displace individuals from these important habitats, which could result in population-level effects to some species. While it is not known how marine mammals might respond to the presence of an operating wave energy facility, there is a potential for minor to moderate impacts to some species, especially those that are threatened or endangered and use specific areas for important portions of their life histories.

5.3.8.5 Decommissioning

Decommissioning of a wave energy facility (whether of demonstration or commercial scale) would involve the dismantling and removal of infrastructure from each wave energy device, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). During decommissioning, marine mammals may be affected by (1) removal of mooring structures (especially pilings), (2) decommissioning vessel traffic, and (3) accidental releases of hazardous materials and fuel.

Decommissioning activities would be similar to construction activities, although largely in reverse and at lower levels. Explosives may be used for the removal of some mooring piles, and marine mammals close to the detonations could be injured from pressure- and noise-related effects.

With the possible exception of explosive mooring removal, impacts to marine mammals from decommissioning are expected to be negligible to minor. Impacts from explosive mooring removal would be similar to those identified for explosive removal of meteorological towers and wind turbine platforms for wind energy projects (Sections 5.2.8.2.5 and 5.2.8.5). The potential for adversely affecting marine mammals may be reduced by the likely absence of marine mammals in the vicinity of the wave energy facility because of the presence of decommissioning vessels and other decommissioning activity noise.

5.3.8.6 Mitigation Measures

The principal factors that could affect marine mammals are entanglement, noise, vessel strikes, and displacement. The measures identified in Section 5.3.5 to mitigate noise generated during site characterization and the construction, operation, and decommissioning might also provide mitigation of noise impacts to marine mammals. Other, general measures that might reduce the likelihood of adverse effects on marine mammals include the following:

- During site characterization, conduct surveys and coordinate project siting with appropriate resource management agencies (NMFS and USFWS) in order to:
  - Avoid locating facilities near known important congregation, mating, or feeding areas (e.g., the six major sites along the Atlantic Coast of the endangered north Atlantic right whale).
  - Avoid locating onshore facilities and helicopter flight paths near known coastal rookeries and haulouts of pinnipeds (e.g., the threatened Steller sea lion and Guadalupe fur seal along the Pacific Coast).
  - Avoid locating facilities at known high use areas along migratory routes or at known migratory route bottlenecks.
- Vessels related to project planning, construction and operation shall travel at reduced speeds when assemblages of cetaceans are observed and maintain a reasonable distance from whales and small cetaceans.
- Project-related vessels will follow NMFS Regional Viewing Guidelines while in transit. Operators will be required to undergo training on applicable vessel guidelines.
- During technology testing, site characterization, construction, and decommissioning, schedule major noise-generating activities, such as pile driving and explosive platform removal, to avoid periods when marine mammals may be more common in the project area. For example, some activities may be prohibited in Mid-Atlantic waters from October to January, when and where the endangered fin whale is believed to be calving.
- Coordinate with NMFS and USFWS to determine if MMPA authorization is warranted.
- At least one qualified marine mammal observer should be posted during construction activities. Additional observers may be required by NMFS under any issued MMPA authorization.

- Entanglement potential may be reduced through the use of sonic pingers, similar to those used to reduce cetacean fishing bycatch, to generate frequencies that cause marine mammals to avoid the cables, or that induce animals to use their sonar so that they detect the cables prior to a collision (Fisher and Tregenza 2003).

- Cutting, rather than the use of explosives, should be preferred for mooring structure removal. If explosives are used to remove mooring structures, MMS guidelines similar to those established for explosive platform removal in the Gulf of Mexico (USDOI/MMS 2004b) should be implemented.

5.3.9 Marine and Coastal Birds

Marine and coastal birds may be affected during wave energy development as a result of (1) offshore structure placement and cable trenching; (2) project-related vessel traffic; (3) releases of liquid wastes, solid debris, hazardous wastes, or fuels; (4) construction and operation of onshore infrastructure; and (5) removal of offshore and onshore structures during decommissioning. Because of the very limited above-water infrastructure that would be associated with a wave energy facility, the collision potential of marine and coastal birds (including migratory birds) is expected to be very low and thus impacts would be negligible.

The nature and magnitude of effects on marine and coastal birds would depend on the specific location of the wave facility and its associated infrastructure, the timing of project-related activities (e.g., device placement, cable trenching), the nature and magnitude of the project-related activities (e.g., several miles of trenching through nearshore coastal habitats), and the species affected.

Potential impacts to threatened or endangered species of marine and coastal birds from wave energy technology testing, site characterization, construction, operation, and decommissioning would be similar in nature to the impacts identified for nonlisted species and could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA regulations and coordination with the USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.3.9.1 Technology Testing

Site evaluation may be expected to have negligible to minor effects on marine and coastal birds. Selection of sites for possible testing would likely rely on data collected from existing NOAA data buoys near proposed test locations.

Marine and coastal birds may be affected by survey and construction vessel traffic between onshore facilities and the offshore test site. Birds may be temporarily displaced from offshore and coastal habitats. Because of the small number of vessel trips that might be needed during technology testing, and the small number of birds that may be affected, impacts to birds from vessel traffic may be expected to be negligible.

No fuels or hazardous materials would be required or generated by the test equipment. Wastes generated by the support vessels would be managed as regulated by the USCG (Section 6.3.7), and any accidental releases of hazardous materials or fuels may be expected to be small, and rapidly diluted and dispersed by the receiving waters. Thus, impacts from such releases to marine and coastal birds are expected to be negligible.

During technology testing, some species of marine and coastal birds may be injured in collisions with underwater structures such as mooring cables. Diving birds such as the brown pelican and terns may be especially vulnerable to collisions with underwater structures, and affected birds may be injured or killed. Because of the relatively small number of mooring cables and limited amount of underwater structure that may be present during technology testing, relatively few birds may be affected. Thus, impacts to birds from entanglement or collisions with mooring cables are expected to be minor.

5.3.9.2 Site Characterization

Site characterization for wave energy development would consist principally of geological and geophysical surveys to identify bottom characteristics for device mooring and cable placement, and current measurements to identify locations of greatest current. During these activities, birds may be affected by the discharge of liquid wastes, hazardous materials, solid debris, or fuel from survey vessels. Marine and coastal birds could be exposed to operational discharges or accidental fuel releases from construction sites and construction vessels and to accidentally released solid debris. Many species of marine birds (such as gulls) often follow ships and forage in their wake on fish and other prey injured or disoriented by the passing vessel. In doing so, these birds may be affected by discharges of waste fluids (such as bilge water) generated by the vessels. Discharges from survey vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal. Sanitary and domestic wastes would be processed through on-site waste treatment facilities before being discharged overboard. Deck drainage would also be processed prior to discharge. Thus, impacts to marine and coastal birds from waste discharges from survey vessels are expected to be negligible.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris (Ryan 1987, 1990) and incur a variety of lethal and sublethal effects (Dickerman and Goelet 1987; Ryan 1988; Derraik 2002). The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Thus, entanglement in or ingestion of solid debris from the survey vessels by marine and coastal birds is not expected, and impacts to marine and coastal birds would be negligible.

5.3.9.3 Construction

Marine and coastal birds may be affected by construction related to mooring of the wave energy devices, by cable trenching, and release of liquid wastes, solid debris, hazardous materials, or fuel from survey and construction vessels. Birds may also be displaced from offshore feeding areas by the noise and activity at the construction location.

5.3.9.3.1 Cable Trenching. The construction of new offshore structures is not expected to adversely affect marine or coastal birds. Cable trenching may affect birds in nearshore coastal areas if trenching occurs in or near foraging, nesting, staging, or resting areas. For many species, the effects would be primarily behavioral in nature, namely, the short-term avoidance or abandonment of habitats in the immediate area of trenching. Cable trenching near nesting colonies (such as seabird rookeries on coastal islands or tern colonies on beaches) may disturb adults that are incubating eggs or feeding young, potentially affecting nesting success. Similarly, trenching in or near migratory staging and nesting areas may disturb birds from these areas, with unknown consequences. Because trenching could result in some long-term loss of coastal habitat, habitat loss may also occur for some coastal birds. However, the amount of habitat disturbed during trenching would be relatively small. Trenching in some coastal habitats may temporarily expose or mobilize food items and attract birds to the trenching locations. Overall, impacts to marine and coastal birds from cable trenching are expected to be negligible to moderate, depending on the species affected and the nature of the effect.

5.3.9.3.2 Waste Discharge and Accidental Fuel Releases. Discharges from construction and geological and geophysical survey vessels would be released into the open ocean as allowed where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal. Operational discharges at a construction site would be quickly diluted and dispersed by local currents, and thus are expected to have a negligible impact on marine or coastal birds. Because of the small amount of fuels or other potentially hazardous materials that may be present at any given time during construction (see Section 5.2.6.3), accidental spills, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents, and thus not expected to pose a threat to marine biota. Thus, potential impacts to marine or coastal birds from accidental spills of hazardous materials or fuel are expected to be negligible.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris from construction or survey vessels. Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), entanglement in or ingestion of trash and solid debris by marine and coastal birds would not be expected during construction and thus have negligible impacts on marine and coastal birds.

5.3.9.3.3 Onshore Construction. Loss or alteration of preferred coastal habitat due to cable landfalls could result in the displacement of individual or groups of birds from important foraging, roosting, overwintering, or nesting habitats. Disturbance of birds from these habitats may affect condition or overwintering survival and disrupt nesting activities and reduce nesting success of affected birds. Coastal construction may also directly disturb coastal habitats. While the disturbance of birds would be expected to be short-term (lasting only until construction was completed), nesting, disturbance of some habitats may be long-term pending natural or engineered recovery, and local population-level effects may be incurred by some species. Thus, impacts to marine and coastal birds are expected to be minor to moderate.

5.3.9.3.4 Offshore Construction. Marine and coastal birds may be displaced during construction from offshore feeding habitats if a wave energy facility is located in such habitats. Birds could be disturbed by construction vessel traffic as well as noise associated with pile-driving and construction of above-water portions of the towers. Affected birds would be expected to leave the area during the construction period, and some may permanently abandon the area due to subsequent presence and operation of the completed facility. While it is not possible to identify how birds would be affected, individual birds may experience increased energetics costs associated with traveling to other (and possibly lower-quality) feeding habitats, which could affect overall condition and survival. Disturbance of birds from overwintering habitats may affect overwintering survival.

Displacement of birds from nesting and foraging areas may disrupt nesting activities and reduce nesting success of affected birds. Population-level effects may result if the wave energy project is located in an important foraging area where adults collect food for young birds. Displacement of parents to other foraging habitats may increase the time of adults away from the nests, increasing the risk of nest predation. The displacement of birds to lower-quality or more-distant foraging habitats could affect foraging success and the quality and quantity of food returned to the nest, affecting the growth and condition of young birds.

Impacts to marine and coastal birds may be negligible to moderate, depending on the habitats and birds affected by the location of the wave energy facility.

5.3.9.4 Operation

During operation of a wave energy facility, marine coastal birds may be affected by service vessel traffic and maintenance activities; changes in coastal sedimentary processes, wave height, and current energy; device noise; releases of liquid wastes, solid debris, hazardous materials, or fuel from service vessels; collisions with underwater structures while diving for food; and noise and human activity at onshore facilities.

5.3.9.4.1 Service Vessel Traffic and Device Maintenance. During normal operations, there would be vessel traffic to and from the wave energy devices to perform maintenance duties. Marine and coastal birds in the vicinity of the devices or near onshore support facilities may be disturbed by the presence of these service vessels and flee the area. Displaced birds would move to other habitats and may or may not return. Because of the low level of vessel traffic that could occur during operations, disturbance of marine and coastal birds would likely be short-term in nature and not be expected to result in adverse effects. Thus, impacts are expected to be negligible.

5.3.9.4.2 Changes in Sediment Processes, Wave Height, and Current Energy. The placement of wave energy facilities in nearshore waters could affect coastal sedimentary processes (Section 5.3.1) and decrease wave height and current energy, primarily near the facility (Section 5.3.3). Such changes could affect the distribution, size, and location of coastal and offshore foraging habitats for some marine and coastal birds by influencing planktonic and benthic productivity of affected areas. The likelihood, nature, magnitude, and extent of such impacts would depend on the size and design of the facility and its distance offshore.

5.3.9.4.3 Device Noise. During normal operations, airborne noises from a wave energy device may reach levels of 70 to 90 dB (EPRI 2004). Much of the wildlife-related noise-effects research has shown that noise may affect territory selection, territorial defense, dispersal, foraging success, fledging success, and song learning (e.g., Andersen et al. 1986; Gladwin et al. 1988; Larkin 1996). In many cases, the effects are temporary, with the birds often becoming habituated to the noise (Brown et al. 1999; Ellis et al. 1991; Delaney et al. 1999; Andersen et al. 1989; Black et al. 1984). On the basis of these studies, which evaluated the effects of higher-level noises (such as from low-level aircraft overflights and weapons testing), noise generated during normal operations could result in affected birds temporarily leaving or avoiding the project area and not have long-term disturbance or population-level effects. Thus, impacts of operational noise on marine and coastal birds are expected to be negligible to minor.

5.3.9.4.4 Accidental Releases of Hazardous Materials or Fuels. Discharges from service vessels would be released into the open ocean as allowed, or collected and taken to shore for treatment and disposal. Discharges would be quickly diluted and dispersed by local currents and thus are expected to have a negligible impact on marine or coastal birds. Because of the small amount of fuels or other potentially hazardous materials, such as hydraulic fluid, transformer fluid, and lubricating oil, that may be present during maintenance activities or in the wave energy device, accidental spills of any of these materials, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents and not be expected to pose a threat to marine biota. Thus, potential impacts to marine or coastal birds from accidental spills of hazardous materials or fuel are expected to be negligible.

Marine and coastal birds may become entangled in or ingest solid debris from service vessels or platforms undergoing maintenance activities. Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), entanglement in or ingestion of trash and solid debris by marine and coastal birds would not be expected during normal operations and thus have negligible impacts on marine and coastal birds.

5.3.9.4.5 Collisions with Underwater Structures. Some species of marine and coastal birds may be injured by colliding with underwater mooring cables or the wave energy devices themselves. Diving birds such as the brown pelican and terns may be especially vulnerable to collisions with underwater mooring lines or structures, and affected birds may be injured or killed. Because of the relatively small number of mooring cables that may be used with each wave energy device, relatively few birds may be affected. Thus, impacts to birds from collisions with underwater structures are expected to be negligible to minor.

5.3.9.5 Decommissioning

Decommissioning of a wave energy facility would involve the removal of the devices and associated offshore infrastructure and the shipment of these materials to shore for reuse, recycling, or disposal. Decommissioning activities would be similar to construction activities, although largely in reverse and at lower levels. Potential impacts to marine and coastal birds would be similar in nature to but lower in magnitude than those identified for construction. Impacts to birds from the removal of offshore infrastructure are expected to be negligible to minor.

5.3.9.6 Mitigation Measures

The principal impacting factors that could affect marine and coastal birds are disturbance of birds and habitats during cable trenching and onshore construction, disturbance of birds by survey, construction, and maintenance vessels, disturbance of birds by device noise, and collisions with underwater structures such as mooring cables. Mitigation measures that might reduce the likelihood of adverse effects on marine and coastal birds include the following:

- Conduct surveys of coastal and offshore areas to identify important feeding, nesting, and wintering areas, and avoid siting facilities, cable paths, and vessel routes in or near these areas.

- Coordinate surveys, project design, siting, and construction, and development of location- and project-specific mitigation measures with USFWS and State natural resource agencies, as appropriate.

- Avoid locating facilities in areas of known important or high bird use (e.g., foraging or overwintering areas, migratory staging or resting areas).

- Avoid locating facilities in areas of known high migratory bird use.

- Cutting, rather than the use of explosives, should be preferred for mooring structure removal.

- Time major noise-generating activities, such as cable trenching and onshore construction, to avoid periods when marine and coastal birds are nesting in the area.

- To reduce potential for birds diving near the wave devices, use antiperching devices or audio devices to deter diving birds from perching on or foraging within the immediate vicinity of the wave energy devices.

- To reduce the attraction of birds to construction and service vessels and thus further reduce potential for ingestion of or entanglement with accidental releases of solid debris from these ships, limit use of steady-burning, bright lighting.

5.3.10 Terrestrial Biota

Development of wave energy facilities is expected to have largely negligible to minor impacts on terrestrial biota. With the exception of construction and operations of cable landfalls and onshore infrastructure (such as electrical substations), most wave energy activities would occur in offshore waters. Migratory birds crossing OCS waters in which wave energy facilities are located are not expected to be affected by collisions with offshore structures because of the limited height of such structures.

Potential impacts to threatened or endangered species of terrestrial biota from wave energy technology testing, site characterization, construction, operation, and decommissioning would be similar in nature to the impacts identified for nonlisted species and could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA regulations and coordination with the USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.3.10.1 Technology Testing

No construction or other surface-disturbing activities would be expected on coastal or inland areas during technology testing. As a consequence, there would be no impacts to terrestrial biota during technology testing.

5.3.10.2 Site Characterization

Site characterization for wave energy development would consist principally of geological and geophysical surveys to identify bottom characteristics for mooring structure placement, and sea level measurements to identify locations of optimal wave activity and intensity. Neither of these activities would affect terrestrial biota. Thus, impacts to terrestrial biota from site characterization are expected to be negligible.

5.3.10.3 Construction

Construction of wave energy facilities may include construction of cable landfalls and onshore substations. These surface-disturbing activities would result in the temporary disturbance or permanent loss of terrestrial habitats and could affect wildlife in the vicinity of the onshore construction activities. Vegetation and wildlife with limited mobility would be killed within the construction footprint. More mobile wildlife would be expected to leave the area to surrounding habitats. However, survival of the displaced biota would be uncertain, depending on the quality of the surrounding habitats and the capacity of those habitats to support additional biota.

Construction of the onshore facilities may also temporarily disturb terrestrial biota in the vicinity of the construction sites, with affected individuals largely moving to other habitats. Displacement from preferred to less optimal habitats could affect overall condition and subsequent survival or reproductive success. Disturbance of terrestrial biota in surrounding habitats during construction would be temporary, affect a relatively small number of individuals, be localized to the immediate vicinity of the construction activity, and not expected to result in long-term impacts to terrestrial wildlife populations. Thus, impacts to most terrestrial biota are expected to be minor.

Potential impacts to threatened or endangered species of terrestrial biota would be similar to those of nonlisted biota. However, compliance with the Endangered Species Act (ESA) would require that any new pipeline landfalls and onshore infrastructure be sited and constructed in a manner that would avoid impacting these species or their habitats. For example, the USFWS and U.S. Army Corps of Engineers (USACE) review proposed dredge-and-fill activities and construction projects in waters of the United States where projects may affect the Florida salt marsh vole or its habitats. In addition, the occurrence of many of the threatened and endangered species within protected areas (such as National Wildlife Refuges and State Parks) further precludes these species or their habitats from incurring adverse impacts from the construction of onshore infrastructure.

5.3.10.4 Operation

Potential impacts to terrestrial biota during operation of a wave energy facility would be similar to those identified for operation of offshore wind energy or current energy facilities (see Sections 5.2.10.4 and 5.4.10.4). Potential impacts would be restricted to the disturbance of terrestrial wildlife from operational noise and human activity. Operation of completed onshore facilities could result in the long-term avoidance of adjacent habitats by species sensitive to noise and human activity. Some species may become habituated to human activities and facilities and be largely unaffected by onshore operations, while other species are sensitive and may permanently leave habitats in the vicinity of the onshore facilities (e.g., Klein et al. 1995; Taylor and Knight 2003; Rodgers and Smith 1995; Lafferty 2004). Thus, depending on the species present in habitats near onshore facilities, impacts to terrestrial wildlife may be negligible to moderate.

5.3.10.5 Decommissioning

Terrestrial biota are not expected to be affected by decommissioning of a wave energy facility, although wildlife could be disturbed by noise generated during any nearshore cable removal activities. Affected wildlife could leave the area, but may return following completion of cable removal activities. Thus, impacts to terrestrial biota from the decommissioning of offshore infrastructure may be negligible to minor.

5.3.10.6 Mitigation Measures

A number of mitigation measures may be employed to reduce or eliminate the potential for impacting terrestrial biota during the development, operation, and decommissioning of onshore components of a wave energy facility. These measures include:

- Conduct surveys of coastal areas to identify important habitats, and avoid siting onshore facilities in or near these areas.

- Avoid siting onshore facilities in natural areas of known important or high wildlife use such as migratory bird staging and resting areas.

- Coordinate siting and construction of onshore construction activities with USFWS and appropriate State natural resources staff to identify and avoid Federal and State-listed plants and wildlife and important habitats.

- Time construction activities to avoid important life history activities such as nesting.

5.3.11 Fish Resources and Essential Fish Habitat

This section evaluates potential impacts to fish resources and essential fish habitat (EFH) that could occur during the testing, site characterization, construction, operation, and decommissioning phases of OCS wave energy developments. While activities that would occur during each phase of development and the types of direct and indirect impacts that could occur to fish resources from those activities are identified, the potential for impacts can be influenced by site-specific conditions, including physical conditions (e.g., water depth, currents, and topography) and the types of habitats and species present in the vicinity of a particular project. As a consequence, more detailed analyses of potential impacts to fish resources and EFH would be conducted as part of site-specific evaluations for proposed wave energy projects. In general, impacts to fish resources and to EFH could occur as a consequence of (1) disturbance of seafloor habitat that provides shelter, reproductive habitat, and food for various species, (2) noise and pressure waves generated during characterization, construction, maintenance, or decommissioning activities, (3) entrainment, impingement, or entrapment of fish or invertebrates on or within structures, and (4) releases of hazardous chemical substances.

If threatened or endangered species occur in the vicinity of individual projects, potential impacts could be greater than those described below for nonlisted fish species, since the populations or distributions of listed species are already greatly reduced. During site-specific planning, consultations with the USFWS and the NMFS would be conducted, as directed by the ESA, to identify and address the potential for impacts on listed fish species from individual projects. During those consultations, appropriate measures to eliminate or reduce the potential for impacts to listed species would be identified.

5.3.11.1 Technology Testing

As described in Section 3.5.1, proposals to test and demonstrate offshore wave energy technologies will likely occur within the next 5 to 7 years. These small-scale tests would likely involve deployment of one or two test devices within an offshore testing area, with or without the construction of an undersea transmission connection to shore. Depending on the technology being tested, test units could use fixed foundations (e.g., monopiles or multilegged support systems) or concrete anchors in various mooring arrangements.

Construction or placement of support and mooring structures and placement of transmission lines on the seafloor could affect fish resources or EFH through sediment disturbance, increased turbidity due to suspension of sediments, crushing of benthic organisms, and changes in the fish communities associated with alteration of the availability of various habitat types. Turbidity caused by activities could result in temporary localized decreases in photosynthesis by phytoplankton. Because of the short-term and localized nature of such effects, impacts on primary productivity and the availability of other planktonic organisms that serve as food for fish resources would be negligible. Individual fish would likely move temporarily from affected areas but would likely return after construction had been completed and after the suspended sediments had settled. The amount of sediment disturbed and suspended would depend on the number and type of mooring and support structures to be placed. In general, the amount of sediment disturbance and sediment suspension would be small and temporary. As a consequence, the resulting impacts to fish resources from this impacting factor would also be temporary and negligible.

Anchoring systems have a potential to crush or displace benthic organisms that live within the anchoring footprint. During the technology testing phase, only a few units are likely to be anchored within the project area, and the overall footprint of the anchoring systems would be relatively small. Although a small number of sessile organisms could be killed by placement of these anchoring structures, some motile organisms, especially fishes and larger crustaceans, would likely move from the affected area once anchoring activities commenced. Therefore, as long as sensitive seafloor habitats (e.g., hard-bottom areas containing unique and spatially limited communities of sessile organisms such as sponges, corals, and anemones) are identified and avoided, impacts to fish resources from anchoring systems used during the technology testing phase would be negligible. If power transmission cables were buried on the seafloor during the technology testing phase, there would be disturbance of sediments along the cable route up to several meters wide. Again, as long as sensitive benthic habitats were avoided, the impacts of sediment disturbance and sediment suspension from cable placement on fish resources or EFH would be negligible and temporary.

Noise generated by construction activities and vessel traffic could potentially affect the behavior of some fish resources during the technology testing phase. If pilings were required to anchor the test units, it is likely that a pile driver would be used to place the pilings. Potential impacts of noise and vibrations from pile driving on fish and invertebrates are described in Section 5.2.11.2. The small number of pilings that would be required to anchor wave energy structures during the technology testing phase would be unlikely to measurably impact populations. Only a small number of vessel trips to the project area are anticipated (perhaps 1/d) during the testing period. The impacts to fish resources from these activities would be expected to be negligible.

Depending on the design of the wave energy units, there could be a potential for fish at various life stages to become impinged on screens, entrained through turbines, or trapped within water collection chambers. Because the number of units deployed during the technology testing phase would be small, only a small number of fish would be subject to impingement, entrainment, or entrapment regardless of the unit design. Consequently, there would be no detectable changes in population levels, and potential impacts to fish resources are expected to be negligible.

Depending on the technology to be tested, small amounts of hydraulic fluids or oils could be released if the containment system in a unit were to fail. However, the quantity of substances that could be released by such an event would be small, and resulting environmental concentrations would be unlikely to detectably harm fish resources. Spills of fuel and oils could also occur as a result of vessel accidents or leaks. Spilled fuels that affect areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some aquatic organisms. Contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required during the technology testing phase. If spills occurred, the volume of fuel that could be spilled during technology testing activities would likely be small (<50 bbl), and relatively small areas would be affected by the resulting concentrations of fuel oils in the environment. Because such spills would be unlikely to measurably affect fish populations, impacts to fish resources or EFH would be negligible.

5.3.11.2 Site Characterization

Likely activities that could affect fish resources during site characterization for wave energy projects include the presence of survey vessels, the performance of geological and geophysical surveys, and drilling and core sampling to evaluate the underlying geological conditions. One or more weather buoys would be installed and used in the area of the proposed facility to measure wave conditions and collect other relevant data to determine whether a site is suitable for a wave energy facility.

Depending on the anchoring system to be implemented, it could be necessary to collect relatively detailed information pertaining to bottom topography and geology with the use of geological and geophysical surveys. The potential area to be covered by such a survey, and, therefore, the potential impacts to fish populations, would be project-specific and would depend, in part, on the number of wave energy units to be deployed and the anchoring systems to be implemented. It is anticipated that information on the sea bottom would be collected by using seafloor sampling technologies such as echosounders, acoustic backscatter devices, grab samples, and gravity coring devices as described in Section 3.5.2. The noise impacts on fish resources of the use of such technologies to evaluate seafloor conditions would be minor.

Fishes displaced because of avoidance behaviors during surveys of seafloor conditions are likely to return to surveyed areas within relatively short periods following cessation of survey activities. In summary, only a small proportion of fish within any given survey area would be affected by noise or activities associated with characterization surveys, and persistent or detectable population-level effects would be unlikely.

During the characterization phase, it is unlikely that releases of sanitary or hazardous wastes would occur. However, fuel spills could occur during site characterization as a result of vessel accidents or leaks. Spilled fuels that affect areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some fish resources by causing injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required. If spills occurred, the volume of fuel that could be spilled by vessels associated with site characterization activities would be small, and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Because such spills would be unlikely to measurably affect fish populations and because recovery would likely occur within one or two seasons, impacts to fish resources or EFH would be negligible to minor.

5.3.11.3 Construction

Construction of structures to support or anchor wave energy units and placement of transmission lines on the seafloor to transport electricity to shore could affect fish resources or EFH through sediment disturbance, crushing of benthic organisms, increased turbidity due to suspension of sediments, and changes in the fish communities associated with alteration of the availability of various habitat types. Turbidity caused by activities could temporarily decrease photosynthesis by phytoplankton, locally reducing primary productivity and the availability of other planktonic organisms that serve as a base of the food chain for fish resources. Individual fish would likely move temporarily from affected areas but would likely return after construction had been completed and after the suspended sediments had settled. Construction time would depend on the number of wave energy units included in an individual project.

Although some benthic organisms could be smothered and killed by sediment deposition, most individual fish would move before smothering could occur. Impacts to benthic invertebrate communities could indirectly affect demersal fishes and shellfishes that utilize benthic organisms for food. These demersal organisms would likely relocate to nearby areas until food resources within an affected area recovered. Although sediment deposition could locally affect benthic organisms for a few years in the project area, wave energy structures for a particular project would be dispersed throughout a project area, and the total area affected by seafloor disturbance would be very small compared to the availability of similar seafloor habitat in surrounding areas.

Noise and activity associated with vessels used during construction activities could disturb fish resources within project areas. For each project, one vessel would be required each day, until construction is completed, to transport personnel and equipment needed to install wave energy generators, anchoring systems, and transmission lines. Movement of construction materials could require several round-trips of a barge to the project area. Although the distribution or activities of some fish species could be temporarily affected, the noise associated with construction vessels would have no detectable or persistent effects on fish resources.

If pilings were required to anchor the devices, it is likely that a pile driver would be used to place the pilings. The number of pilings that would be required to anchor wave energy structures would be determined by the number of units to be utilized, and potential impacts of noise and vibrations from pile driving on fish and invertebrates would be similar to those described in Section 5.2.11.3. In most cases, fish would temporarily move away from noise sources until work had been completed, although some individual fish could be harmed or killed by noise from pile-driving activities. Overall, the noise associated with placement of pilings would not result in measurable changes in fish populations, although distribution of fishes within the project area could be temporarily altered. It is estimated that it would take 4 to 6 h of pile driving to install each piling—the overall amount of time that noise disturbance would occur would be a function of the number of pilings required for a specific project. Mooring of wave energy generators with other anchoring systems would likely generate less noise than driving piles and would consequently result in less noise-related disturbance or harm on fish resources.

Fuel spills could occur during site construction as a result of vessel accidents or leaks. Spilled fuels that affect areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some fish resources by causing injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips and vessels that would be required. If spills occurred, the volume of fuel that could be spilled by vessels associated with site characterization activities would be small, and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Because such spills would be unlikely to measurably affect fish populations and because recovery would likely occur within one or two seasons, impacts to fish resources or EFH would be negligible to minor.

5.3.11.4 Operation

Once construction of an offshore wave energy project were completed and operation had commenced, fish resources (including invertebrate prey for fish) could be affected by the presence of the structures themselves, traffic and noise from vessels used to maintain the structures, and noise associated with turbine operation. Depending on the design of the wave energy facilities, entrainment, impingement, or entrapment of fish or planktonic organisms could occur. Hazardous chemical substances could be introduced into the water column from the units themselves or as a result of accidental releases or leaks from service vessels. In addition, the presence of electromagnetic fields associated with transmission cables has a potential to affect some fish species.

Sedentary benthic organisms within the immediate footprint of pilings or beneath anchors or anchoring lines used for individual wave energy units could be killed or damaged, and recolonization of the underlying sediments would be precluded by the presence of the pilings or anchors throughout the life of the project. However, as identified in Section 5.2.11.4, construction or placement of structures, such as pilings on the OCS, would introduce an artificial hard substrate that opportunistic benthic species that prefer such substrate could colonize, and minor changes in species associated with softer sediments could occur due to scouring around the pilings (Hiscock et al. 2002). Fishes, including pelagic species, would likely be attracted to these artificial habitats, and fish population numbers in the immediate vicinity of the platforms are likely to be higher than in surrounding waters away from the structures. The overall change in habitat could result in changes in local community assemblage and diversity. Although the anchors or pilings needed to install an individual wave energy unit would represent only a small amount of artificial habitat that would likely have little effect on overall fish populations, there is a possibility that major projects that cover large areas could result in substantial changes in the abundance and diversity of particular fish species within the area. Some rare or overfished fish species attracted to such structures could be negatively affected if a concentration of fishing efforts in the vicinity of the structures resulted in increased harvest of these species. There is also a potential that invasive species could colonize such structures. Effects on diversity and fish abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats and fish species within surrounding areas.

Vessels used to perform maintenance during the operational life of a project could disturb fish resources within project areas. For each project, it is anticipated that one vessel would be required daily to conduct maintenance. Although the distribution of some fish resources could be temporarily affected by activity and noises from these vessels, there would be no detectable or persistent effects on fish resources.

Section 5.3.5.4 describes the potential effects of operation of wave energy generation on the acoustic environment. Although underwater noise would be produced by the hydraulic machinery associated with wave energy generation devices, it is currently unclear what the sound levels would be. Noise and vibrations associated with the operation of the generation units would be transmitted into the water column and, depending on the anchoring system used, the sediment. Depending on the intensity, such noises could potentially disturb or displace some fish within surrounding areas or could mask sounds used by fish for communicating and detecting prey.

Except for cables running between surface devices and the seafloor, electrical cabling to interconnect all of the wave energy generation units for a particular project, plus a high-voltage (115 kV or greater) cable that would deliver the electricity to the existing transmission system on land, would likely be trenched into the seabed. The cables would generally be buried 1 to 3 m (3 to 10 ft) into the seafloor. A potential concern associated with the operation of underwater electric transmission cables is the generation of electromagnetic fields that could affect some fish species. Weak electric fields can be detected by certain fish (e.g., rays and sharks) and are used in orientation and prey location. There is some evidence that electric fields from submarine cables are detectable by some fish species and that this detection may result in attraction or avoidance (Gill et al. 2005). However, the cable system likely to be used by OCS wave energy generation projects would be shielded to effectively block the electric field produced by the conductors. Therefore, no electric field impacts are expected for the submarine cables. In addition, some fish and invertebrates are sensitive to magnetic fields that could be generated by electricity passing through underwater cables (Gill et al. 2005). Although individual organisms could be attracted to or avoid cables, the potential for population-level effects on fishes or invertebrates from such electromagnetic fields is largely unknown.

Investigations of the potential effects of the electromagnetic field associated with the cable lines for the Nysted offshore wind facility in Denmark indicated that the migration behavior of some fish species (Baltic herring, common eel, Atlantic cod, and flounder) was altered, but not completely blocked, in the vicinity of the cables (Dong Energy et al. 2006). As long as sufficient numbers of individuals pass over cables to maintain genetic diversity, population-level effects on aquatic organisms would be unlikely to occur. Thus, while it is expected that the impacts of EMF on populations of aquatic species would be negligible to minor, uncertainties remain and additional studies are needed on the potential effects on species that inhabit the U.S. coasts in the vicinity of proposed projects.

As identified in Section 5.3.11.1, there could be a potential for fish at various life stages to become impinged on screens, entrained through turbines, or trapped within water collection chambers, depending on the design of the wave energy units. Similarly, some planktonic organisms could be prone to entrainment. It is unknown how many individuals could be affected or whether there is a potential for localized effects on populations.

There may be a possibility for small amounts of potentially hazardous materials (e.g., hydraulic fluids, transformer fluids, or lubricating oils) to be released if containment systems in components were to fail. However, the quantity of substances that could be released by such an event would be small (<50 bbl) and would be diluted and dispersed by local currents. The resulting environmental concentrations would not be expected to substantially affect water quality (see Section 5.3.4) or detectably harm fish resources on the OCS. Spills of fuel and oils could also occur as a result of vessel accidents or leaks. Spilled fuels that reach areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some aquatic organisms. Contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required to maintain the wave energy facility. If spills occurred, the volume of fuel that could be spilled by vessels associated with maintenance activities would likely be relatively small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Because such spills would be unlikely to measurably affect fish populations, impacts to fish resources or EFH from spills would be negligible to minor.

Assuming that the mitigation measures identified in Section 5.3.11.6 are implemented, overall impacts to fish resources and EFH from operation of a wave energy facility would be negligible to minor. However, it should be recognized that there is uncertainty regarding the potential for fish and invertebrate populations to be affected by impingement, entrainment, or entrapment within energy-generation components.

5.3.11.5 Decommissioning

Decommissioning of a wave energy generation facility would involve the dismantling and removal of the units and the associated infrastructure (including anchoring structures), the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Pilings would be removed by cutting them at a depth of approximately 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, fish resources or EFH could be affected by noise generated during dismantling, the alteration and loss of habitat provided by the existing structures, and accidental releases of hazardous materials and fuel.

While pile driving would not occur during decommissioning, explosives could be used for the removal of some pilings. If explosives were used, fishes close to detonation areas could be injured from pressure- and noise-related effects as discussed in Section 5.2.11.2. Use of explosives would not be necessary to remove units anchored without the use of pilings.

Some of the structures associated with anchoring wave energy facilities could result in creation of new hard substrate that would essentially perform as an artificial reef, supplying habitat and food for fish resources (Section 5.2.11.4). Removal of these structures from the project area would remove this artificial habitat. The overall result would be to return the project area to conditions, both physically and biologically, similar to those that existed prior to construction of wave energy facilities.

Depending on the technology to be tested, there may be a possibility for small amounts of hydraulic fluids or oils to be released if the containment system in a unit were to fail during decommissioning. However, the quantity of substances that could be released by such an event would be small, and resulting environmental concentrations would be unlikely to substantially affect water quality (see Section 5.3.4) or detectably harm fish resources. Fuel spills could occur during decommissioning activities as a result of vessel accidents or leaks with potential effects on fish resources similar to those described in Section 5.3.11.4.

Notwithstanding the reversion of the biological conditions to those that existed prior to installation of wave energy facilities, impacts to fish resources and EFH from decommissioning are expected to be short-term and negligible to minor.

5.3.11.6 Mitigation Measures

The principal impacting factors that could affect fish populations from offshore wave energy facility development and construction include the introduction of noise; habitat alterations; entrainment, entrapment, or impingement of organisms; and the potential for spills of fuels or other hazardous materials. The measures identified in Section 5.3.5 to mitigate noise generated during site characterization and during construction, operation, and decommissioning of wave energy generation facilities would also provide partial mitigation of noise impacts to fish resources. Other, general measures that could reduce the likelihood of adverse effects on fish resources include the following:

- Conduct surveys during siting studies to identify and characterize potentially sensitive habitats.
- Avoid anchoring wave energy generation units on known sensitive fish habitats or within marine protected areas and ensure that hard-bottom habitats will not be harmed by movements of anchor chains or cables.
- Minimize seafloor disturbance during installation of wave energy generation units and during installation of underwater cables.
- Design wave energy generation units to reduce the potential for leaks of hydraulic fluids.
- Design wave energy generation units to reduce potential for entrainment, entrapment, or impingement of fish and invertebrates.
- Utilize practices and follow operating procedures that reduce the likelihood of vessel accidents and fuel spills.
- Utilize appropriate shielding for underwater cables to control the intensity of electromagnetic fields, especially in areas where more-sensitive shark or ray species are likely to be present.
- Avoid use of explosives for removing pilings when feasible.

5.3.12 Sea Turtles

Sea turtles may be affected by all phases of wave energy development. While adults may be found in all the Pacific, Atlantic, and Gulf of Mexico regions, they are generally more numerous in warmer waters. Thus, sea turtles may be more likely to encounter, and thus be affected by, wave energy-related activities in the South Atlantic and Straits of Florida, the northern Gulf of Mexico, and in Central and Southern California Pacific waters. Because no nesting occurs on the U.S. Pacific coast, wave energy development is not expected to affect sea turtle nest sites or hatchlings. Sea turtles could be affected by (1) offshore structure placement and cable trenching, (2) geological and geophysical survey noise, (3) collisions with OCS vessels, (4) operational discharges and wastes, (5) construction and operation of onshore infrastructure, and (6) removal of offshore and onshore structures during decommissioning.

Potential impacts to threatened or endangered sea turtle species from wave energy technology testing, site characterization, construction, operation, and decommissioning could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA and MMPA regulations and coordination with the NMFS and USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.3.12.1 Technology Testing

Site evaluation may be expected to have negligible to minor effects on sea turtles. Selection of sites for possible testing would likely rely on data collected from existing NOAA data buoys near proposed test locations.

Construction (i.e., placement) of wave energy devices for testing has the potential for impacting sea turtles. Mooring of wave energy devices may require geological and geophysical surveys to determine suitability of surface and subsurface conditions for mooring placement, which could affect sea turtles in the area of the surveys. Placement of mooring devices (which may involve pile driving) may also generate noise that could disturb sea turtles in the vicinity of the test site. However, both the surveys and mooring placement would be short-term and limited to a few locations, affecting few animals. Thus, noise generated during construction of test devices would have negligible to minor impacts on sea turtles.

Sea turtles could be affected by construction- and operation-related vessel traffic between onshore facilities and the offshore test site. Affected animals could collide with moving vessels, resulting in injury or death, or be disturbed by the presence and noise of these vessels and leave the vicinity. Because of the small number of vessel trips that might be needed during technology testing, collisions with test vessels would be unlikely.

No fuels or hazardous materials would be required or generated by the test equipment. Wastes generated by the support vessels would be managed as regulated by the USCG (Section 5.3.6), and any accidental releases of hazardous materials or fuels may be expected to be small and rapidly diluted and dispersed by the receiving waters. Thus, population-level impacts from such releases to sea turtles are expected to be negligible.

During technology testing, sea turtles may be injured by becoming entangled in underwater mooring cables or floating structures. However, given the relatively slow swim speeds of sea turtles, it is expected that they would be able to navigate around or through mooring cables and avoid entanglement. This, together with the relatively small number of mooring cables that may be used, entanglement of sea turtles during testing is considered unlikely and to result in negligible population-level effects.

The different types of wave energy devices vary in their potential to affect sea turtles. Because they are sealed devices and have a relatively small profile, operating point absorbers are not expected to affect sea turtles. While also sealed devices, attenuators may impede movement of hatchlings, which are weakly swimming or are passively carried on the water's surface; adults and juveniles should be able to actively swim beneath the devices. Because attenuators are placed parallel to the direction of wave travel, passively transported hatchlings may be expected to be transported along the length of the devices and not have their transport impeded. Unlike attenuators, terminators are oriented perpendicular to the direction of wave travel and thus have a greater potential for impeding the passive transport of hatchlings. Overtopping devices have the potential to not only impede the passive transport of hatchlings, but they may also entrain hatchlings and small juveniles into the overtopping reservoir, and entrained animals may incur injury or death. Because of the limited nature (smaller numbers of devices than in commercial scale) of testing that could occur, potential population-level impacts to sea turtles from the operating test devices are expected to be negligible for point absorbers and attenuators, and minor to moderate for terminators and overtopping devices.

5.3.12.2 Site Characterization

Activities associated with site characterization that may affect sea turtles include (1) geological and geophysical surveys and (2) discharges of liquid wastes, solid debris, and fuels.

5.3.12.2.1 Geological and Geophysical Surveys. Geological and geophysical surveys may be employed to characterize ocean bottom topography and subsurface geology. Surveys using air-gun arrays may generate low-frequency noise at levels up to 250 dB re (1 μPa-m), and these may be detected by sea turtles within the survey area (Geraci and St. Aubin 1987). In contrast, site-scan sonar generates noise at much lower intensity and high frequencies. Potential responses to survey noises would be behavioral in nature, and include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as feeding. However, few studies are available that have examined sea turtle hearing sensitivity or noise-induced stress (Ridgway et al. 1969; Bartol et al. 1999); thus, it is largely unknown how sea turtles may respond to and be affected by geological and geophysical surveys. Because of the limited location and duration of geological and geophysical surveys that may be conducted during site characterization, few individuals may be expected in most cases to be present within the survey areas. Thus, potential population-level impact to sea turtles from such surveys is expected to be minor. However, surveys in areas where hatchling turtles have passively aggregated or where females are gathering in preparation for nesting, have the potential to affect relatively large numbers of individuals, and could result in moderate population-level impacts to the affected species.

5.3.12.2.2 Releases of Liquid Waste, Solid Debris, or Fuel. During the geological and geophysical surveys, a variety of sanitary and other waste fluids, and miscellaneous trash and debris, may be generated onboard the survey vessels. Hatchling, juvenile, and adult sea turtles may be exposed to these wastes via allowed and accidental releases from the survey vessels. If released into the open ocean, liquid wastes would be rapidly diluted and dispersed. Sanitary and domestic wastes generated onboard would be processed through shipboard waste treatment facilities before being discharged overboard. Deck drainage would also be processed prior to discharge. Thus, waste discharges from survey vessels would be expected to have negligible population-level impacts to sea turtles.

Ingestion of, or entanglement with, accidentally discarded solid debris can adversely impact sea turtles. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]). Assuming compliance with these regulations and laws and only accidental releases, very little exposure of sea turtles to solid debris generated during site characterization may be expected. In addition, the amount of solid debris that could be accidentally released would be very small because of the small number of survey vessels that would likely be used during site characterization. Thus, entanglement in or ingestion of OCS-related trash and debris by sea turtles would not be expected during the surveys.

5.3.12.3 Construction

Construction-related impacting factors that could affect sea turtles include (1) geological and geophysical surveys; (2) noise generated during mooring of wave energy devices; (3) vessel traffic; (4) the allowed or accidental release of liquid wastes; solid debris, and fuel; (5) direct contact with, or location of, offshore construction; and (6) onshore construction. These impacting factors would be associated with mooring of the energy devices and offshore transformers or substations to the ocean floor, trenching and cable laying from the wave energy facility to onshore substations, and onshore construction of cable landfalls and substations.

5.3.12.3.1 Geological and Geophysical Surveys. Surveys conducted to more fully characterize sea bottom topography and subsurface geology for the mooring of floating wave energy devices could affect sea turtles in the same manner as described for site characterization (Section 5.3.12.2). Sea turtles exposed to such surveys could exhibit behavioral changes as well as experience hearing damage. Very few sea turtles may be expected to be present in the immediate vicinity of a construction site, and thus impacts would be limited to no more than a few individuals at any one site. However, because of the threatened or endangered status of all sea turtle species, population-level impacts may be minor to moderate rather than negligible for these species.

5.3.12.3.2 Construction Noise. Noise generated during mooring of wave energy devices and the placement of underwater cables could disturb sea turtles that may be present in the vicinity of the construction area. The types of potential impacts from mooring activities would be similar to those described for wind platform construction (Section 5.2.12.3). Noise generated during mooring (which may involve pile driving) and cable trenching could disturb normal behaviors such as feeding. The biological importance of behavioral responses of sea turtles to construction noise (e.g., effects on energetics, survival, reproduction, population status) is unknown, and there is little information regarding short-term or long-term effects of behavioral reactions on sea turtle populations. While noise generated during construction may affect more than one individual, population-level effects are not anticipated. Because very few individuals would likely be exposed to construction generated noise, potential population-level impacts to sea turtles from the mooring and cable-laying activities are expected to be minor.

5.3.12.3.3 Vessel Traffic. Sea turtles may be killed or injured by collisions with construction vessels traveling to and from the offshore wave energy site and vessels involved in trenching and cable placement. Because of their limited swimming abilities, hatchlings may be more susceptible than juveniles or adults to vessel collisions, especially if aggregated in convergence zones or patches of *Sargassum*.

The likelihood of such a collision would vary depending on species and life stage present, the location of the vessel and its speed, and visibility. Hatchling turtles, including those aggregated, would be difficult to spot from a moving vessel because of their small size and generally cryptic coloration patterns, which blend with the color and patterns of the *Sargassum*. While adult and juvenile turtles are difficult to observe at the surface during periods of daylight and clear visibility, they are very difficult to spot from a moving vessel when resting below the water surface, and during nighttime and periods of inclement weather.

Because of the small amount and short duration of vessel traffic that would be associated with the placement of wave energy devices and with trenching and cable placement, population-level impacts to sea turtles from vessel collisions during construction are expected to be minor.

5.3.12.3.4 Releases of Liquid Waste, Solid Debris, and Fuel. Potential impacts to sea turtles from releases during construction of liquid wastes, solid debris, or fuels would be similar to those identified for similar releases during site characterization (Section 5.3.12.2). Only small amounts of liquid operational wastes or fuel may be expected to be present at any given time during construction. Releases of these would be small in volume and become rapidly diluted and dispersed. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]), and entanglement in or ingestion of solid debris by sea turtles would not be expected during normal construction activities. Thus, potential population-level impacts to sea turtles from the release of liquid wastes, solid debris, or fuels are expected to be negligible.

5.3.12.3.5 Direct Contact with and Location of Construction. Individuals coming in contact with construction or trenching equipment may be injured or killed; construction and trenching activities may temporarily affect habitat use; and habitats may experience short-term and long-term changes in abundance and quality.

Sea turtles have been known to be killed or injured during dredging operations (Dickerson 1990; Dickerson et al. 1992) and thus may also be affected during trenching activities. Juveniles or adults may also be affected if the placement of new structures occurs in foraging or developmental habitats or offshore of nesting beaches (see Section 4.2.12 for a discussion of these habitats and areas). Following several years out in open water as growing hatchlings, juvenile sea turtles move into nearshore habitats for further growth and maturation. Adults also utilize nearshore habitats for feeding and may mate in nearshore habitats directly off of nesting beaches. In addition, females may become residents in the vicinity of nesting beaches. Offshore construction and trenching may reduce the quality or availability of foraging habitat for juveniles and adults and may affect adult nesting behavior or access to nest sites. It is assumed that habitats such as seagrass beds and live-bottom areas commonly used by turtles for feeding or resting would be avoided during facility siting and cable placement, and that some soft-bottom areas affected by construction or trenching would recover.

Construction and trenching activities would be of relatively short duration. Thus, any impacts incurred from structure placement or trenching would be short-term and localized to the construction area and immediate surroundings, and, therefore, likely affect relatively few juveniles or adults. Because they are passively aggregated by currents, a greater number of hatchlings may be affected if present in a construction or trenching area. Thus, potential population-level impacts to sea turtles from the placement of wave energy devices and undersea cables could be minor to moderate.

5.3.12.3.6 Onshore Construction. Along the Gulf and southern Atlantic coastlines, nests and emerging hatchlings may be affected by the construction of new onshore infrastructure such as cable landfalls and substations. Because no nesting occurs along the U.S. Pacific Coast, onshore construction would not be expected to affect sea turtle nests or hatchlings in Pacific waters. If present in a construction area, nests containing eggs or emerging hatchlings could be destroyed by clearing, grading, and other construction activities. Lighting from nearby construction areas or completed infrastructure may also affect hatchlings emerging from nearby nests. Disorientation by nearby lights could increase exposure to predators, cause entanglement in vegetation, or lead hatchlings away from the surf (National Research Council 1990). Onshore lighting may also draw hatchlings back out of the surf. However, given the small amount of onshore construction that could occur with the development of an offshore wave energy facility, it is unlikely that onshore construction would impact more than a few nests. Thus, population-level impacts to sea turtles on the Atlantic and Gulf coasts could be negligible to moderate, depending on the presence of nesting beaches in the vicinity of the onshore facilities.

5.3.12.4 Operation

During operation of a wave energy facility, sea turtles may be affected by (1) entanglement, (2) entrainment, (3) impediment of movement, (4) device noise, (5) service vessel traffic, (6) accidental releases of hazardous materials or fuels, and (7) lighting of onshore facilities.

5.3.12.4.1 Entanglement. Wave energy facilities may have as many as 200 to 300 mooring lines securing the wave energy devices to the ocean floor. Thus, sea turtles swimming through a wave energy facility may strike and become entangled in these lines, becoming injured or drowning. However, because sea turtles are relatively slow and deliberate swimmers, they may be expected to readily swim around mooring cables. The relatively wide spacing between groups of cables mooring point absorbers would further reduce the likelihood of sea turtles becoming entangled while swimming through a facility. Thus, population-level impacts to sea turtles from cable entanglement are expected to be negligible.

5.3.12.4.2 Entrainment. As discussed under technology testing (Section 5.3.12.1), overtopping wave energy devices may entrain hatchling and small juvenile sea turtles into the overtopping reservoir, where the entrained animals may incur injury or death. Thus, population-level impacts to sea turtles may be minor to moderate for overtopping devices, depending on the species and number of turtles entrained.

5.3.12.4.3 Impediment of Movement. As previously discussed (Section 5.3.12.2), some types of wave energy devices may affect the movement of sea turtles. Adult turtles regularly move to and from nesting beaches, while adults and juveniles move among foraging and developmental habitats. Hatchling turtles leave nest sites, move out into the open water, and are passively transported to convergence zones. Some wave energy devices may interfere with these active and passive movements. Attenuators may impede movement of hatchlings that are weakly swimming or are passively carried on the water's surface, but because attenuators are placed parallel to the direction of wave travel, passively transported hatchlings may be expected to be transported along the length of the devices and not have their transport impeded. Attenuators may interfere with adults and juveniles moving between foraging and developmental habitats, causing animals to expend additional energy to swim around or under the devices. The energetics costs and effects of these additional movements on the condition of affected turtles are unknown. However, because of the relatively small size of the individual attenuators, adult and juvenile turtles may be expected to readily swim around the devices with minimal additional energetics costs. Thus, potential impacts of attenuators on the movement of adult and juvenile turtles, as well as potential interference with the transport of hatchling turtles, is expected to be negligible to minor, and no population-level effects are anticipated.

Unlike attenuators, terminators are oriented perpendicular to the direction of wave travel, and thus have a greater potential for impeding the passive transport of hatchlings, as well as interfering with the access of adults to nesting beaches and other nearshore habitats. Overtopping devices have the potential to not only impede the passive transport of hatchlings or access of adults to nesting beaches and other habitats, but also to entrain hatchlings and small juveniles into the overtopping reservoir. Entrained animals may incur injury or death.

Thus, potential population-level impacts to sea turtles from the operating terminators and overtopping wave energy devices are expected to be minor to moderate.

5.3.12.4.4 Device Noise. During normal operations, airborne noise from a wave energy device may reach levels of 70 to 90 dB or greater (EPRI 2004). While no information is available regarding underwater noise levels, airborne noises may be transmitted underwater via moorings and piling and affect sea turtles in the vicinity of the facility. Noise levels are expected to similar to levels associated with ship traffic. If affected, animals may exhibit behavioral modifications such as changes in foraging or site avoidance. In contrast to the relatively short time period during which construction noise would be generated, noise would be generated for a much longer time during normal operations. Under normal operations, there could be continuous or near-continuous noise generation over the area of the wave energy facility (up to 5 km^2 [2 mi^2]). Such noise generation could result in the long-term avoidance of the wave energy facility and surrounding vicinity. This could lead to abandonment of feeding areas, offshore developmental areas, or staging areas off of nesting beaches, which could result in long-term population level effects. While it is not known if sea turtles would be affected, normal operational noise may result in minor to moderate population-level impacts to some, especially if the wave energy facility is located in or near an important developmental or staging area.

5.3.12.4.5 Vessel Traffic. During normal operations, there would be at least one vessel trip to and from the wave facility each day to perform maintenance duties. Sea turtles may be injured or killed as a result of ship collisions. Because of the low level of vessel traffic that could occur during normal operations, potential impacts to sea turtles from this traffic would likely be limited to no more than a few juveniles or adults. However, a greater number of turtles may be affected by ships traveling through waters where hatchling sea turtles may have passively aggregated. Collisions with any of the threatened or endangered species of sea turtles may result in minor to moderate population-level impacts.

5.3.12.4.6 Accidental Release of Hazardous Materials or Fuels. Operational discharges from service vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal. Operational discharges, as well as accidental releases of wastes, would be quickly diluted and dispersed by local currents, and thus may have a negligible impact on sea turtles. Because of the small amount of fuels or other potentially hazardous materials (such as hydraulic fluids, transformer fluids, and lubricating oils) that may be present or used at any given time during normal operations, accidental releases or spills, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents, and thus not expected to pose a threat to juvenile or adult sea turtles. In addition, juvenile and adult turtles may be able to leave the immediate vicinity of an accidental spill and thus limit their level of exposure. Thus, potential impacts to these individuals are expected to be negligible. Because hatchlings are passively aggregated and may be incapable of actively leaving the immediate area of an accidental spill, they may incur greater exposure to an accidental release. While there is limited information regarding the levels of some contaminants in sea turtle tissues, little is known about what concentrations are within normal ranges of a particular species or what tissue levels may result in acute or chronic effects (Pugh and Becker 2001; NOAA 2003).

The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]). Thus, entanglement in or ingestion of OCS-related trash and debris by sea turtles would not be expected during normal operations.

5.3.12.4.7 Onshore Operations. Lighting from onshore infrastructure such as cable landfalls and substations may affect hatchlings emerging from nearby nests. Disorientation by nearby lights could increase exposure to predators, cause entanglement in vegetation, or lead hatchlings away from the surf (National Research Council 1990). Onshore lighting may also draw hatchlings back out of the surf. Population-level impacts to nearby nests may be moderate to major.

5.3.12.5 Decommissioning

Decommissioning of a wave energy facility (whether of demonstration- or commercial-scale) would involve the dismantling and removal of infrastructure from each wave energy device, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). During decommissioning, sea turtles may be affected by (1) noise generated by removal of mooring structures (especially pilings), (2) decommissioning vessel traffic, and (3) accidental releases of hazardous materials and fuel.

Decommissioning activities would be similar to construction activities, although largely in reverse and at lower levels. Explosives may be used for the removal of some mooring piles, and sea turtles close to the detonations could be injured from pressure- and noise-related effects. Population-level impacts to sea turtles from decommissioning are expected to be negligible to minor.

5.3.12.6 Mitigation Measures

The principal impacting factors that could affect sea turtles are entanglement, entrainment, interference with movements, noise from geological and geophysical surveys, explosive platform demolition, vessel strikes, and onshore lighting and facilities near nesting beaches. Since all sea turtle species are either threatened or endangered, mitigation measures would be developed during site-specific consultations with the NMFS and USFWS. General measures that might reduce the likelihood and/or magnitude of the potential impacts of these impacting factors on sea turtles include the following:

- Avoid locating cable landfalls and onshore facilities near known, important nesting beaches.

- Avoid facilities offshore of known, important nesting beaches, or in known and important coastal foraging areas and developmental habitats.

- Avoid locating offshore facilities in areas where hatchlings are known to be passively aggregated by currents.

- To minimize potential vessel impacts to sea turtles, project-related vessels should follow NMFS Viewing Guidelines while in transit, and vessel operators should undergo training on applicable vessel guidelines.

- Use appropriate procedures for pile-driving to minimize potential impacts to sea turtles associated with underwater sound levels created by pile-driving activities.

- Avoid the use of attenuators and overtopping devices in areas where hatchlings are passively aggregated by currents.

- Platform removal should employ cutting rather than the use of explosives. If explosives are used, platform removal should be conducted in a manner similar to that identified in the MMS guidelines for the explosive removal of oil and gas platforms in the Gulf (NTL No. 2004-G06) and to the conservation recommendations identified in the NMFS biological opinion on the removal of offshore structures in the Gulf of Mexico (NOAA 2006g). In particular, visual surveys and physical removal of sea turtles from the blast zone should be conducted, and structure removal should be immediately delayed until the observed turtle leaves the area or is captured and moved.

- The potential for affecting sea turtle nests and emerging hatchlings by onshore construction would be greatly reduced through compliance with applicable Federal and State statutes, regulations, and stipulations. The implementation of all mitigation measures required by these statutes and regulations would greatly limit the potential for impacts to nests and emerging hatchlings.

- Conduct onshore preconstruction surveys for nest sites and delay construction activities until hatchlings have emerged and moved into open water.

- Development and implementation of a turtle excluder device, similar to such devices used in shrimp trawling, to prevent entrainment of hatchling turtles by overtopping wave energy devices.

5.3.13 Coastal Habitats

Although many of the activities associated with wave energy facilities would occur in offshore waters, coastal habitats could be directly or indirectly impacted by a number of factors associated with wave energy development. These factors include vessel traffic, construction and operation of onshore facilities, installation and operation of electric transmission cables, expansion of ports and docks, and operation of offshore wave energy components. The potential for impacts would be largely influenced by site-specific factors, such as the habitat types and distribution in the vicinity of a wave energy project.

5.3.13.1 Technology Testing

Construction on nearshore land areas would not likely be required for technology testing for wave energy conversion. Therefore, direct impacts to coastal habitats would not be expected to result from associated activities.

The placement of structures offshore during construction of a wave energy demonstration project would include towing or shipping of components by barge or other vessels. Although waves generated by vessel traffic can affect some habitats, such as barrier beaches, impacts to coastal habitats from the small number of vessel trips would be expected to be negligible. Vessel traffic could result in long-term scarring of seagrass beds if vessels traveled outside of established traffic routes. Seagrass beds may require considerable periods of time to recover, particularly in areas of low-density seagrass vegetation. Turbidity resulting from vessel traffic or maintenance dredging of traffic routes may also adversely affect seagrass beds. Impacts to seagrass beds from vessel traffic and maintenance dredging would likely range from negligible to moderate.

Fuel spills could occur as a result of vessel accidents or leaks. Spilled fuels that reach barrier beaches or coastal wetlands could result in impacts to associated organisms (Hayes et al. 1992; Dahlin et al. 1994; Petrae 1995, Hoff 1995; NOAA 1998, 2000; Hensel et al. 2002; Mendelssohn and Lin 2003; Proffitt 1998). The toxicity of lighter hydrocarbons such as diesel fuel is generally greater than that of crude oil. Contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of wetland vegetation or wildlife, or biota associated with sand or gravel beaches or rocky shores. Loss of tidal marsh vegetation could result in erosion of marsh substrates, with subsequent conversion of marsh habitat to open water. Spilled fuels could penetrate beach substrates or persist in protected areas such as lagoons. Cleanup operations may also result in long-term impacts to barrier beaches or wetlands, such as from trampling of vegetation, incorporation of petroleum deeper into substrates, increased erosion, or removal of substrates. Fuel spills would likely be relatively small and spill response would likely minimize impacts, allowing for habitat recovery. Therefore, impacts to coastal habitats from fuel spills could range from negligible to moderate. The degree of impact from fuel spills and length of recovery time would depend on the amount and type spilled, degree of weathering prior to contact with coastal habitats, time of year, the site-specific characteristics of the affected habitat, and the clean-up response.

5.3.13.2 Site Characterization

Direct impacts to coastal habitats would not be expected during site characterization for a wave energy facility. Required components for site characterization would be installed offshore. The potential impacts from vessels used for the installation of required components would be similar to those for technology testing.

5.3.13.3 Construction

Impacts to coastal habitats may result from activities associated with construction of a commercial-scale wave energy facility. Facility construction would be expected to require the installation of an electric transmission cable, the establishment of component assembly areas onshore, and construction of onshore facilities, such as housing for monitors or a substation and transmission lines, although existing facilities would likely be used. Additional WECs would be towed to the offshore location for the commercial-scale project. Potential impacts associated with vessel traffic would be similar to those for technology testing.

The potential effects on coastal habitats from construction of onshore facilities would be associated with direct impacts from ground-disturbing activities as well as indirect impacts from decreased water quality or altered hydrology. Coastal habitat, such as estuaries, wetlands, beaches, or dune communities, may be lost during land clearing or from the placement of fill material during construction. Indirect impacts associated with construction may include habitat fragmentation or altered hydrology in nearby wetlands due to changes in surface drainage patterns. Hydrologic changes may include isolation of wetlands from water sources, reduced infiltration and increased runoff due to soil compaction, and runoff from impervious surfaces. Such changes may result in the conversion of wetlands to upland areas or open water. The increased volume and velocity of runoff from impervious surfaces can increase water-level fluctuations in streams and wetlands and may result in scouring of stream channels and bank erosion. Streams, wetlands, and seagrass beds may also be affected by increased sedimentation and turbidity during construction by disturbance of substrates or erosion of disturbed upland soils. Contaminants may be introduced in stormwater runoff or in discharges from vessels. The deposition of fugitive dust generated by soil disturbance may adversely affect vegetation and other biota in coastal terrestrial or wetland habitats. The impacts of soil disturbance, or changes to hydrology or water quality, may also include changes in biotic community structure, reduction in biodiversity, or establishment of invasive species.

The installation of an electric transmission cable from the demonstration facility would likely include the use of cable-laying vessels for subsea installation. The cable may be installed by horizontal directional drilling or may be buried in a continuous trench by using a jet-plow technique. Intertidal habitats, such as tidal marsh, mudflats, beaches, or rocky shores, or shallow subtidal habitats such as submerged aquatic vegetation would be directly impacted by trenching activities, and excavated sediments could cover adjacent substrates, resulting in the disturbance of at least 0.3 m^2 (3 ft^2) for each linear foot of cable. Infauna and epifauna of beach, mudflat, or wetland substrates, as well as adjacent wetland or seagrass vegetation, could be indirectly impacted by sedimentation and turbidity during trench excavation and backfilling. Recovery of some invertebrates, such as some species of mussels, following a large disturbance may be slow (NOAA 1998). Restoration of organic coastal marsh soils to preproject elevations may be difficult because of compaction and oxidation, and re-establishment of the vegetation community may be inhibited. The continued erosion of tidal marsh substrates adjacent to the cable route could result in a widening of the affected area over time and additional marsh losses as marsh becomes converted to open water. Portions of the cable route lacking vegetation re-establishment could promote hydrologic alterations to tidal marsh, affecting the pathway of water flow, increasing the flushing and draining of interior marsh areas, and allowing saltwater intrusion into brackish and freshwater wetlands. Onshore, a transmission cable would connect the undersea cable with a substation and would also be buried. Disturbance of beaches, dunes, or other coastal habitats would result in direct habitat losses from excavation, as well as indirect impacts. Beach or dune substrates may be difficult to stabilize, and erosion may occur adjacent to the cable route. Establishment of vegetation cover might be slow, possibly resulting in prolonged losses of dune habitat. If directional drilling were used for cable installation, indirect impacts could result from accidental losses of bentonite drilling fluid.

Federal, State, and many local regulations are designed to protect sensitive ecological resources, such as wetlands or coastal dunes. The installation of an electric transmission cable and construction of facilities for offshore alternative energy projects would typically be located to avoid or minimize impacts to sensitive resources, where location alternatives exist, as is done for oil and gas projects, both for regulatory as well as, in many instances, engineering concerns. As a result, it is very unlikely that trench excavation or onshore facilities would be located where a sensitive resource occurs. Potential indirect impacts of construction would be reviewed during project-specific environmental analyses. Impacts would generally require permitting from Federal, State, or local regulatory agencies. Therefore, impacts from construction of facilities and installation of power cables would likely result in negligible to moderate impacts to coastal habitats.

Intertidal and shallow subtidal coastal habitats, including seagrass beds, wetlands, mudflats, and beaches, may be directly impacted by the expansion of existing docks and ports to accommodate the number and size of vessels needed for construction of wave energy conversion facilities. Port expansion may include dredging, potentially resulting in habitat losses.

5.3.13.4 Operation

Activities associated with the operation of wave energy conversion facilities would include monitoring and maintenance. While monitoring would likely be conducted remotely from shore, maintenance of generation facilities would require periodic visits to the offshore locations, at least one trip per day. WEC devices may be periodically towed to port for maintenance or repair. Impacts of vessel traffic associated with facility maintenance would be similar to those described for technology testing and would include effects of increased wave action on barrier beaches and risk of fuel spills from accidents. Spills of hydraulic fluids from WEC devices may also occur. Spills at offshore mooring locations would not be expected to impact coastal habitats. However, spills from devices being towed to or from port facilities may be transported by currents or tides to coastal wetlands or beaches. Because of the small amount of fluids that would be present, impacts would likely be negligible to moderate.

The placement of wave energy facilities in nearshore waters could result in impacts to coastal sedimentary processes (Section 5.3.1), along with a decrease in wave height and current energy, primarily near the facility (Section 5.3.3). Subsequent effects on coastal sediment deposition and erosion processes and subsequent impacts to coastal beaches would depend on the size and design of the facility and distance offshore.

The electric transmission cable connecting a wave energy facility to a shore-based substation would be buried 1 to 3 m (3 to 10 ft) below coastal habitats. The electromagnetic fields produced by submarine transmission lines may be detected by some fish and invertebrate species (see Section 5.2.11.4). Although individual organisms in coastal habitats could be attracted to or avoid buried cables, the potential for population-level effects on fish or invertebrates from such electromagnetic fields is largely unknown.

5.3.13.5 Decommissioning

The decommissioning of wave energy conversion facilities would require the removal of all facility components and transportation to shore. The removal of the electric generation cable would be expected to result in impacts similar to construction, with direct and indirect disturbance of subtidal and intertidal substrates and terrestrial habitats. Following the restoration of soil elevations and re-establishment of plant communities, these habitats would be expected to fully recover. Decommissioning would also entail the use of vessels for transportation of workers and materials, with subsequent effects of increased wave action on barrier beaches and risk of fuel spills from accidents or spills of hydraulic fluids. See Section 5.3.13.1 for a discussion of these types of impacts. Impacts from decommissioning activities would likely result in negligible to moderate impacts to coastal habitats.

5.3.13.6 Mitigation Measures

The primary impacting factors associated with wave energy development include habitat loss or degradation from construction activities, erosion, and contamination from spills. General measures that could reduce impacts to coastal habitats include the following:

- To reduce the effects of vessel traffic, wave activity could be minimized by maintaining reduced vessel speeds in the vicinity of barrier islands.

- The effects of fuel spills and spill cleanup activities could be reduced by the use of low-impact response technologies. Effective low-impact cleanup actions could include bioremediation, low-pressure flushing, or use of chemical cleaners (Mendelssohn and Lin 2003; Hoff 1995; Proffitt 1998).

- The use of water-based hydraulic fluids or nontoxic, environmentally benign fluids that are rapidly biodegradable would reduce potential effects to coastal organisms from spills near shore.

- The use of greaseless bearings in gearboxes would reduce the use and potential loss of lubrication oils.

- Avoidance of seagrass communities and implementation of turbidity reduction measures would minimize impacts to seagrasses from construction activities.

Scarring of seagrass beds could be minimized by the restriction of vessel traffic to established traffic routes.

- Impacts to wetlands from construction could be minimized by maintaining buffers around wetlands, by the use of best management practices for erosion and sedimentation control, and by maintaining natural surface drainage patterns.

- Marsh losses could be reduced by the application of dredged material onto marsh surfaces in areas of high subsidence, such as the northern Gulf of Mexico.

- Impacts to wetlands could also be minimized by the implementation of practices to minimize air quality and water quality impacts.

- Direct impacts to barrier habitats or wetlands may be avoided during installation of transmission cables by the use of nonintrusive construction techniques, such as horizontal directional drilling under barrier islands or other sensitive coastal habitats.

- Coastal habitat losses could be minimized by monitoring the impacts of construction activities, monitoring habitat restoration/creation activities, and applying corrective actions through an adaptive management process.

5.3.14 Seafloor Habitats

This section evaluates potential impacts to seafloor habitats that could occur during the testing, site characterization, construction, operation, and decommissioning phases of OCS wave energy developments. While the activities that would occur during each phase of development and types of direct and indirect impacts that could occur to seafloor habitats from those activities are identified, the potential for impacts can be influenced by site-specific conditions, including physical conditions (e.g., water depth, currents, and topography) and the types of seafloor habitats and associated species present in the vicinity of a particular project. As a consequence, more detailed analyses of potential impacts to seafloor habitats would be conducted as part of site-specific evaluations for proposed projects.

5.3.14.1 Technology Testing

As described in Section 3.5.1, proposals to test and demonstrate offshore wave energy technologies will likely occur within the next 5 to 7 years. These small-scale tests would likely involve deployment of one or two test devices within an offshore testing area, with or without the construction of an undersea transmission connection to shore. Depending on the technology being tested, test units could utilize fixed foundations (e.g., monopiles or multilegged support systems) or concrete anchors in various mooring arrangements.

Construction or placement of support and mooring structures and placement of transmission lines on the seafloor could affect seafloor habitats and organisms that utilize those habitats by disturbing sediment, increasing turbidity due to suspension of sediments, crushing benthic organisms, and changes in the fish communities associated with alteration of the availability of various habitat types. Depending on water depth, turbidity caused by activities could temporarily decrease photosynthesis by phytoplankton, locally reducing primary productivity and the availability of other planktonic organisms that serve as a base of the food chain for some benthic organisms. Larger mobile invertebrates would likely move temporarily from affected areas, but could return after construction has been completed and after the suspended sediments have settled. Sediment disturbance would be episodic and would not occur continuously during the technology testing period.

Although some benthic organisms could be smothered and killed by sediment deposition, mobile species would move before smothering could occur. Sediment deposition could locally affect sessile benthic organisms for a few years in some portions of the project area, but wave energy structures for a particular project would be dispersed within the project area and the total area affected by sediment disturbance and deposition should be small compared to the availability of similar seafloor habitat in surrounding areas.

Fuel spills that could occur as a result of vessel accidents or leaks during the technology testing phase would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected by such spills.

5.3.14.2 Site Characterization

Likely activities that could affect seafloor habitats and biota during site characterization for wave energy projects include the presence of survey vessels, geological and geophysical surveys, and drilling and core sampling to evaluate the underlying geological conditions. One or more buoys would likely be installed in the area of the proposed facility to measure wave conditions and collect other relevant data to determine whether a site is suitable for a wave energy facility.

Depending on the anchoring system to be implemented, it could be necessary to collect relatively detailed information pertaining to bottom topography and geology. The potential area to be covered by a geological and geophysical survey and, therefore, the potential impacts to biota would be project-specific and would depend, in part, on the number of wave energy units to be deployed and the anchoring systems to be implemented. Studies have indicated that geological and geophysical surveys can affect at least some fish and invertebrate species in various ways. High-energy seismic techniques would not generally be needed for site characterization.

In addition to noise from geological and geophysical surveys, there would be noise generated by other activities during the site characterization phase. Sound sources could include noises associated with geological characterization (e.g., core sampling), noises from vessels associated with surveys or movement of materials and personnel, and noises from construction and placement of characterization buoys. Noises associated with these activities would be short-lived and localized, but could temporarily disturb or displace some mobile benthic organisms. Overall, noise associated with these activities would have no detectable or persistent effects on seafloor habitats or populations of seafloor organisms.

Core samplers and similar devices would disturb seafloor habitat and kill sessile organisms within the sample footprint. However, the area affected by such samplers is small (generally no more than a few square meters), and the overall effect on seafloor habitats and associated organisms within the project area would be negligible.

Depending on the technology to be tested, there may be a possibility for small amounts of hydraulic fluids or oils to be released if the containment system in a unit were to fail. However, the quantity of substances that could be released by such an event would be small, and resulting environmental concentrations would be unlikely to substantially affect water quality (see Section 5.3.4). Although fuel or oil spills could occur as a result of vessel accidents or leaks, such contaminants would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected.

5.3.14.3 Construction

Placement of supports or anchors for wave energy units and placement of transmission lines on the seafloor to transmit electricity to shore could affect seafloor habitats by disturbing sediments, crushing benthic organisms, increasing turbidity due to suspension of sediments, and altering the availability of various habitat types. Ecological function within disturbed sediments could be altered for many years depending on the amount of disturbance, the size of the affected areas, and the types of communities present. Depending on water depth, turbidity caused by activities could temporarily decrease photosynthesis by phytoplankton, locally reducing primary productivity and the availability of other planktonic organisms that serve as a base of the food chain for some benthic organisms. Larger mobile invertebrates would likely move temporarily from affected areas but could return after construction had been completed and after the suspended sediments had settled. Construction time would depend on the number of wave energy units included in an individual project.

Some benthic organisms could be smothered and killed by sediment deposition, although many mobile species would move before smothering could occur. Removal or movement of boulders to prepare for placement of pilings could kill or displace associated organisms. Impacts to benthic invertebrate communities could indirectly affect demersal fishes and shellfishes that utilize benthic invertebrates for food. These demersal organisms would likely relocate to nearby areas until food resources within an affected area recovered. Sediment deposition could locally affect benthic organisms for a few years in some portions of the project area. However, wave energy units and the associated anchoring structures for a particular project would be dispersed over the project area, and the total area affected by seafloor disturbance would likely be small compared to the availability of similar seafloor habitat in surrounding areas.

If pilings were required to anchor the wave energy units, it is likely that a pile driver would be used to place the pilings. The number of pilings that would be required to anchor wave energy structures would be determined by the number of units to be utilized. Potential impacts of noise and vibrations from pile driving on benthic fish and invertebrates would be similar to those described in Section 5.2.11.3. Some fish and invertebrates associated with seafloor habitats would temporarily move away from noise sources until work had been completed, although some individuals could be harmed or killed. Immediate or delayed mortality of fish from pile-driving activities has been observed at 10 to 30 m (33 to 98 ft) from the source (depending on the size of the hammer used), and it is has been estimated that delayed mortality could occur up to 150 to 1,000 m (490 to 3,000 ft) from the source, although this remains somewhat speculative (Thomsen et al. 2006). The potential for impacts to populations of seafloor organisms from such losses of individuals is unclear, although it is unlikely that substantial proportions of populations would be affected as long as unique habitat areas are identified and avoided.

Construction activities would not result in hazardous emissions to water and would not result in the release of sanitary or hazardous wastes. Antifouling coatings could be utilized on some vessels and components, but would not substantially affect water quality (see Section 5.3.4). Although fuel or oil spills could occur as a result of vessel accidents or leaks during construction activities, such contaminants would remain at or near the surface. Consequently, habitats on the OCS would not be affected by such events.

5.3.14.4 Operation

Once construction of an offshore wave energy project had been completed and operation had commenced, seafloor habitats and seafloor biota could be affected by the presence of the structures themselves, traffic and noise from vessels used to maintain the structures, and noise associated with device operation. Depending on the design of the wave energy units, entrainment, impingement, or entrapment of fish or invertebrates could occur. Hazardous chemical substances could be introduced into the water column from the units themselves or as a result of accidental releases or leaks from service vessels. In addition, the presence of electromagnetic fields associated with transmission cables has a potential to affect some benthic species.

Sedentary benthic organisms within the immediate footprint of pilings or beneath anchors or anchoring lines used for individual wave energy units could be killed or harmed and recolonization of the underlying sediments would be precluded by the presence of the pilings or anchors throughout the life of the project. However, construction or placement of structures, such as pilings, on the OCS would introduce an artificial hard substrate that opportunistic benthic species that prefer such substrate could colonize. Minor changes in species associated with softer sediments could also occur due to scouring around pilings (Hiscock et al. 2002). Fishes and invertebrates would likely be attracted to the newly formed habitat complex, and the abundance of seafloor organisms in the immediate vicinity of pilings is likely to be higher than in areas away from the structures. The overall change in habitat could result in changes in local community assemblages. Although the anchors or pilings needed to install an individual wave energy unit would represent only a small amount of artificial habitat and would likely have little effect on overall populations of seafloor biota, there is a possibility that major projects that cover large areas could result in substantial changes in the abundance of individual organisms and in the number of species within the project area. There is also a potential for invasive species to colonize such structures. Effects on diversity and abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats within surrounding areas.

Noise and vibrations associated with the operation of the turbines would be transmitted into the water column and, depending on the method for anchoring, could be transmitted into sediments. Depending on the intensity, such noises could disturb or displace some biota within surrounding areas or could mask sounds used by some fish species for communicating and detecting prey.

Many species that live in association with seafloor habitats as adults have larval or juvenile stages that live within the pelagic zone. There could be a potential for fish and invertebrates within various life stages to become impinged on screens, entrained through turbines, or trapped within water collection chambers of wave energy units, depending on the design. It is unknown how many individuals could be affected or whether there is a potential for population-level effects.

Electrical cabling to interconnect all of the wave energy units, plus the high voltage (115 kV or greater) cable that delivers the electricity to the existing transmission system on land, would likely be trenched into the seabed. The cables would generally be buried 1 to 3 m (3 to 10 ft) into the seafloor. A potential concern associated with underwater electric transmission cables is the generation of electromagnetic fields that could affect some fish species that use such fields for orientation or prey location. There is evidence that electric fields from submarine cables are detectable by some demersal fish species (e.g., rays and sharks) and that this could result in attraction or avoidance (Gill et al. 2005). In addition, some fish and invertebrates are sensitive to magnetic fields that could be generated by electricity passing through underwater cables (Gill et al. 2005). Although individual seafloor organisms could be attracted to or avoid cables, the potential for population-level effects on fishes or invertebrates from such electromagnetic fields is largely unknown.

Investigations of the potential effects of the electromagnetic field associated with the cable lines for the Nysted offshore wind facility in Denmark indicated that the migration behavior of some fish species (Baltic herring, common eel, Atlantic cod, and flounder) was altered, but not completely blocked, in the vicinity of the cables (Dong Energy et al. 2006). As long as sufficient numbers of individuals pass over cables to maintain genetic diversity, population-level effects on aquatic organisms would be unlikely to occur. Thus, while it is expected that the impacts of EMF on populations of aquatic species would be negligible to minor, uncertainties remain and additional studies are needed on the potential effects on species that inhabit the U.S. coasts in the vicinity of proposed projects.

There may be a possibility for small amounts of potentially hazardous materials (e.g., hydraulic fluids, transformer fluids, or lubricating oils) to be released if containment systems in components were to fail. However, the quantity of substances that could be released by such an event would be small (<50 bbl) and would be diluted and dispersed by local currents. The resulting environmental concentrations would not be expected to substantially affect water quality (see Section 5.3.4) or seafloor habitats.

Spills of fuel and oils could also occur as a result of vessel accidents or leaks. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required to maintain the wave energy facility, and the volume of fuel that could be spilled by vessels associated with maintenance activities would likely be relatively small (<50 bbl). Fuels and oils spilled on the OCS would be expected to remain at or near the surface until they were dispersed or diluted by wave activity and local currents. As a consequence, contact with seafloor habitats on the OCS is unlikely and impacts to such areas would be negligible; spilled fuels that reach shallower nearshore areas with sensitive seafloor habitats such as seagrass beds or oyster bars could result in greater impacts. In those areas, contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of seafloor biota or their prey, but it is expected that only small areas could be affected by the volumes of fuels anticipated. Consequently, impacts to seafloor habitats from such spills would be negligible.

5.3.14.5 Decommissioning

Decommissioning of a wave energy generation facility would involve the dismantling and removal of the units and the associated infrastructure (including anchoring structures), the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Pilings would be removed by cutting at a depth of approximately 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, seafloor organisms could be affected by noise generated during dismantling, and there could be alteration and loss of habitat provided by the existing structures.

While pile driving would not occur during decommissioning, explosives could be used for the removal of some pilings. If explosives were used, organisms close to detonation areas could be injured from pressure- and noise-related effects as discussed in Sections 5.3.11.2. Use of explosives would not be necessary to remove units anchored without the use of pilings.

As identified in Section 5.3.14.4, some of the structures associated with anchoring wave energy facilities could result in the creation of new hard substrate that would essentially perform as an artificial reef, supplying habitat and supporting the biota. Removal of structures from the project area would remove this artificial habitat. The overall result would be to return the project area to conditions, both physically and biologically, similar to those that existed before construction of wave energy facilities.

Depending on the technology to be tested, there may be a possibility for small amounts of hydraulic fluids or oils to be released if the containment system in a unit were to fail during decommissioning. However, the quantity of substances that could be released by such an event would be small, and resulting environmental concentrations would be unlikely to substantially affect water quality (see Section 5.3.4). In addition, fuel spills could occur as a result of vessel accidents or leaks during decommissioning activities; such contaminants would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected.

Notwithstanding the reversion of the biological conditions to those that existed prior to installation of wave energy facilities, impacts to seafloor habitats from decommissioning are expected to be negligible to minor.

5.3.14.6 Mitigation Measures

The principal impacting factors that could affect seafloor habitats as a result of offshore wave energy facility development and construction include the introduction of noise, habitat alterations, and the potential for spills of fuel or other hazardous materials. The measures identified in Section 5.3.5 to mitigate noise generated during site characterization and during construction, operation, and decommissioning of a wave energy facility would also provide at least partial mitigation of noise impacts to organisms on the seafloor. Other general measures that could reduce the likelihood of adverse effects on seafloor habitats include the following:

- Conduct surveys during siting studies to identify and characterize potentially sensitive seafloor habitats.

- Avoid locating facilities near known sensitive seafloor habitats, such as coral reefs and hard-bottom areas.

- Ensure that anchor chains and cables will not drag across sensitive seafloor habitats.

- Minimize seafloor disturbance during anchoring of units and during installation of underwater cables.

- Consider the potential for impingement, entrainment, or entrapment of organisms during the design of wave energy generation units and incorporate features to reduce the potential where feasible.

- Utilize appropriate shielding for underwater cables to control the intensity of electromagnetic fields, especially in areas where more sensitive shark or ray species are likely to be present.

- Avoid the use of explosives for removing pilings when feasible to minimize impacts to nearby fishes and invertebrates.

5.3.15 Areas of Special Concern

As identified in Sections 4.2.15, 4.3.15, and 4.4.15, there are more than 200 marine protected areas located in the Atlantic, Gulf of Mexico and Pacific regions. While many of these areas, including national parks, national seashores, national wildlife refuges, national estuarine research reserves, and National Estuary Program estuaries are located on or along the coast, there are a number of marine sanctuaries, fishery habitat conservation zones, and fishery management zones located in offshore waters. Section 388 prohibits alternative energy leasing "in any area on the Outer Continental Shelf within the exterior boundaries of and unit of the National Park System, National Wildlife Refuge System, or National Marine Sanctuary System, or any National Monuments" (43 USC 1337 [p] [10]).

Impacts to these areas of special concern could result from activities that disturb lands or waters within the protected area, activities that harm special habitat types or ecological resources (e.g., hard-bottom and coral habitats, fishes, or waterfowl), activities that harm cultural resources, or activities that affect other values for which a particular area of concern was established. Potential impacts of offshore wave energy development to values or resources that such areas of special concern are intended to protect are identified and evaluated in the following sections. However, more detailed analyses of potential impacts to areas of special concern would be conducted as part of site-specific evaluations for proposed projects once specific locations and technical specifications are better understood.

5.3.15.1 Technology Testing

As described in Section 3.5.1, proposals to test and demonstrate offshore wave energy technologies will likely occur within the next 5 to 7 years. These small-scale tests would likely involve deployment of one or two test devices within an offshore testing area, with or without the construction of an undersea transmission connection to shore. Depending on the technology being tested, test units could utilize fixed foundations (e.g., monopiles or multilegged support systems), or could use concrete anchors in various mooring arrangements.

In many respects, potential impacts to areas of special concern from technology testing for wave energy development would be similar to those presented for wind energy development in Section 5.2.15.1. However, wave energy structures are anticipated to be less visible from shore than wind energy towers because they would not extend as high above the water surface.

Testing would require the transportation of test components by barge or other vessel to offshore project areas. Noise generated by vessel traffic could potentially affect the behavior of some marine mammal and fish resources within areas of special concern, such as national marine sanctuaries, although noise impacts from the small number of vessel trips required for technology testing would be expected to be negligible. Construction noise and vessel traffic near the onshore boundaries of areas of special concern could temporarily disturb some wildlife and could negatively affect recreational values for some people using areas of concern (Section 5.3.20). Boats passing near areas of special concern that include shorelines could result in wave-associated erosion of shoreline areas. As described in Section 5.3.13, effects of wakes on coastal habitats are expected to be negligible.

Placement of experimental wave energy structures would be unlikely to occur within the immediate vicinity of offshore marine protected areas, and it is anticipated that there would be no impacts to areas of special concern from seafloor disturbance.

Trash and debris from OCS operations could wash up on beaches, including beaches associated with areas of special concern (e.g., national seashores). The discharge or disposal of solid debris from both OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Assuming that operators comply with regulations, most potential impacts would be avoided, although some accidental loss of materials is inevitable. While it is difficult to estimate the amount of such materials that could result from potential OCS wave energy development activities, amounts should be low during technology testing activities because of the limited number of structures and activities that would occur.

Fuel spills could occur as a result of vessel accidents or leaks. Such spills would be unlikely to measurably affect ecological habitats and biota (Sections 5.3.8 to 5.3.11). Because placement of wave energy structures would be unlikely to occur within the immediate vicinity of offshore marine protected areas, there would be no impacts to these areas of special concern from fuel spills.

5.3.15.2 Site Characterization

Likely activities during site characterization include the operation of survey and construction vessels, the performance of geological and geophysical surveys, and drilling and core sampling to evaluate the underlying geological conditions. In addition, one or more buoys would be installed in the area of the proposed facility to measure oceanographic conditions and collect other relevant data to determine whether a site is suitable for a wave energy facility.

Although noise generated by vessel traffic could potentially affect behavior of some marine mammal and fish resources within areas of special concern, noise impacts from the small number of vessel trips required during site characterization would be expected to be negligible. Noise and vessel traffic near the onshore boundaries of areas of special concern could temporarily disturb some wildlife and could negatively affect recreational values for some people using areas of concern (Section 5.3.20). Boats passing near areas of special concern that include shorelines could result in wave-associated erosion of shoreline areas. As described in Section 5.3.13, effects of wakes on coastal habitats are expected to be negligible.

Depending on the distance from project areas to areas of special concern, geological and geophysical surveys could potentially affect fish (Section 5.3.11) and marine mammals (Section 5.3.8). Overall, such impacts would be negligible to minor in terms of potential impacts on populations of organisms. Pile driving, if needed to install pilings to anchor wave energy structures, would be unlikely to have more than temporary and negligible effects on populations of fishes or marine mammals within offshore areas of special concern.

Drilling or core sampling to evaluate geological conditions has a potential to harm some benthic organisms as a result of sediment suspension and deposition. However, since project areas would be located outside any offshore areas of special concern, there would be no impacts to these areas from these site characterization activities.

Fuel spills could occur during site characterization as a result of vessel accidents or leaks. Such spills would be unlikely to measurably affect ecological habitats and biota (Sections 5.3.8 to 5.3.14). Because wave energy projects would be unlikely to be sited within the immediate vicinity of offshore marine protected areas, there would be no impacts to these areas of special concern from fuel spills.

5.3.15.3 Construction

Depending on project location, placement of wave energy structures and placement of transmission lines to transport electricity to shore could affect areas of special concern. However, as previously identified, OCS wave energy projects would not be located in areas of special concern.

It is estimated that approximately one vessel trip would occur to the project area each day during the construction period. Construction noise and vessel traffic near the onshore boundaries of areas of special concern could temporarily disturb some wildlife and negatively affect recreational values for some people using the areas (Section 5.3.20). Boats passing near areas of special concern that include shorelines could result in wave-associated erosion of shoreline areas. As described in Section 5.3.13, effects of wakes on coastal habitats are expected to be negligible.

Noise generated by vessel traffic could also potentially affect behavior of some marine mammal and fish resources within offshore areas of special concern, such as national marine sanctuaries. However, noise impacts from the small number of vessel trips required for construction would be expected to be negligible. Furthermore, it is likely that any project construction activities would be located far enough away from protected marine areas that there would be no noise impacts to offshore areas of special concern.

Because wave energy structures are not likely to be placed in the immediate vicinity of offshore areas of special concern, there would be no impacts to areas of special concern from seafloor disturbance. Development of transmission line connections to onshore power transmission facilities and the potential need for construction of additional substations could affect some areas of special concern, depending on the locations selected for these activities. In general, transmission facilities would not be located on National Park properties, although transmission lines may be allowed to pass through some of the other types of areas of special concern (e.g., national wildlife refuges) if the managing agency grants a ROW to the facility operators. Site-specific evaluations would be required to determine the potential for negative impacts to such properties, although permitting requirements would mitigate for most impacts.

Trash and debris from OCS operations could wash up on beaches, including beaches associated with areas of special concern (e.g., national seashores). The discharge or disposal of solid debris from both OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Assuming that operators comply with regulations, most potential impacts would be avoided, although some accidental loss of materials is inevitable. While it is difficult to estimate the amount of such materials that could result from OCS wave energy development activities, amounts should be low during the construction period.

Fuel spills could occur as a result of vessel accidents or leaks during construction activities. Such spills would be unlikely to measurably affect biota or habitats within marine protected areas (Section 5.3.8 through 5.3.14). Furthermore, because placement of wave energy units would be unlikely to occur within the immediate vicinity of offshore marine protected areas, there would be no impacts to these areas of special concern from fuel spills.

5.3.15.4 Operation

Depending on project location, wave energy structures have a potential to affect the identified areas of special concern during the operational phase. Because, as previously identified, OCS wave energy projects would generally not be located in areas of special concern, impacts from OCS wave energy units are unlikely. During the operations phase, areas of special concern could be affected by the presence of offshore energy units themselves, disturbances resulting from the use of vessels to maintain the units, and noise associated with operations. In addition, the presence of transmission facilities and the associated maintenance activities have a potential to affect some onshore areas of special concern.

Because wave energy structures are not likely to be placed in the immediate vicinity of offshore areas of special concern, there would be no impacts to areas of special concern from seafloor disturbance. Noise and vessel traffic associated with offshore maintenance activities adjacent to onshore boundaries of areas of special concern could temporarily disturb some wildlife and could negatively affect recreational values for some people (Section 5.3.20).

As identified in Sections 5.3.11 and 5.3.14, installation of anchoring structures for wave energy production on the OCS could introduce an artificial hard substrate that could be colonized by various types of fish and invertebrates. This could result in changes in local community assemblage and diversity. Effects on diversity and fish abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats within surrounding areas. Depending upon the proximity of OCS wave energy structures to offshore areas of special concern, there may be a potential for interactions with fishery resources and ecological resources within nearby areas of special concern. Such interactions would not result in negative effects on offshore areas of special concern, which are often themselves intended to protect natural communities associated with habitats such as hard bottoms or coral reefs. However, a considerable amount of scientific discussion has developed around the question of whether placement of artificial habitats, such as offshore platforms, simply attract and concentrate fish from surrounding areas or whether they actually lead to increases in the numbers of fish associated with all similar habitats in the regional system as a whole (e.g., Seaman 1997; Lindberg 1997; Grossman et al. 1997; Johnson et al. 1994; Wilson et al. 2001).

Noise and vibrations associated with the operation of the wave energy units would be transmitted into the water column and, depending upon the method used for anchoring, potentially into the sediment. Depending on the proximity of the energy generation units to areas of special concern and the intensity and frequency of the sounds generated, such noises could potentially disturb or displace some marine mammals (Section 5.3.8) or fish (Section 5.3.11) within areas of special concern or could mask sounds used by these species for communicating and detecting prey. The potential for such effects would be project-specific and would be considered further during project-specific evaluations.

The presence of transmission lines and other onshore infrastructure would represent a long-term loss of some terrestrial habitat within the footprints of these structures. As noted in Section 5.3.15.3, some areas of special concern could be affected by these structures, depending on the locations selected. In general, such facilities would not be located on National Park properties, although transmission lines may be allowed to pass through some of the other types of areas of special concern (e.g., National Wildlife Refuges) if the managing agency grants a ROW to the facility operator. Maintenance activities associated with shore-based transmission facilities, such as vegetation control with herbicides or mechanical trimming, could also result in impacts to some areas of special concern. Site-specific evaluations would be required to determine the potential for negative impacts to such properties, although permitting requirements would mitigate for most impacts.

There may be a possibility for small amounts of potentially hazardous materials (e.g., hydraulic fluids, transformer fluids, or lubricating oils) to be released if containment systems in components were to fail. However, the quantity of substances that could be released by such an event would be small (<50 bbl) and would be diluted and dispersed by local currents. The resulting environmental concentrations would not be expected to substantially affect water quality (see Section 5.3.4) or biota within areas of special concern. Fuel spills could occur as a result of vessel accidents or leaks during maintenance activities, but such spills would be unlikely to harm biota or habitats within marine protected areas (see Sections 5.3.8 through 5.3.14). The potential for such impacts in areas of special concern is further reduced because placement of wave energy units within offshore marine protected areas would be unlikely.

5.3.15.5 Decommissioning

Decommissioning of a wave energy project would involve the dismantling and removal of infrastructure associated with each wave energy unit, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Pilings would be removed by cutting at a depth of approximately 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, areas of special concern could be affected by noise and vessel activity generated during dismantling, the alteration and loss of habitat provided by the existing structures, and accidental releases of hazardous materials and fuel.

Decommissioning activities would be similar to construction activities, although largely in reverse and at lower levels. Although pile driving would not occur during decommissioning, explosives might be used for the removal of some pilings. Pressure- and noise-related impacts could occur to marine mammals and fish as discussed in Sections 5.2.8.5 and 5.2.11.5, respectively. Depending on the proximity of pilings to areas of special concern, some resources within protected areas could be affected. It is anticipated that OCS wave energy facilities would not be located within or immediately adjacent to offshore areas of special concern. Consequently, impacts on such areas from the use of explosives to remove pilings are considered unlikely.

Placement of anchoring structures could result in the creation of new hard substrate that would essentially perform as an artificial reef, supplying habitat for fishes and invertebrates (see Sections 5.3.11 and 5.3.14). Removal of platforms from the project area would remove this artificial habitat. The overall result would be to return the project area to conditions, both physically and biologically, similar to those that existed prior to development of the wave energy project. Because wave energy generation units are unlikely to be located within or immediately adjacent to offshore areas of special concern, these areas should not be measurably affected.

During decommissioning activities, hazardous emissions or sanitary or hazardous wastes would not be released to the water. Fuel spills could occur during decommissioning as a result of vessel accidents or leaks with potential effects on areas of special concern as described in Section 5.3.15.4.

5.3.15.6 Mitigation Measures

The principal impacting factors that could potentially affect areas of special concern from offshore wave energy development include noise, habitat disturbance, and the potential for spills of fuel or other hazardous materials. Some general measures that could reduce the likelihood of adverse effects on areas of special concern include the following:

- Avoid locating energy generation units close to or in marine protected areas.

- Utilize practices and follow operating procedures that reduce the likelihood of vessel accidents and fuel spills.

- If facilities are located near areas of special concern, avoid the use of explosives for removing pilings when feasible to minimize impacts to fishes, and marine mammals.

- Implement and require compliance with measures to reduce the potential for trash and debris to enter the water during the various phases of development.

5.3.16 Military Use Areas

5.3.16.1 Technology Testing and Site Characterization

There are several different types of wave energy facilities currently undergoing testing and development. All of these testing and site characterization activities are small and unobtrusive but could be an obstruction to surface and subsurface use by military units depending on their location. However, there does not appear to be any potential for conflict with airborne units. Potential impacts are expected to be negligible.

5.3.16.2 Construction, Operation, and Decommissioning

Developments employing wave energy conversion devices are expected largely to remain at the demonstration-scale level during the analysis period. Some commercial-scale installations are possible. Proposals have been made for installations both in the Atlantic and Pacific regions. During the analysis period, it appears that systems likely to be deployed would occupy areas of less than 4 to 6 ha (10 to 15 acres) and would pose a very small likelihood of interfering with or affecting military use of the OCS. Possible commercial-scale installations could occupy up to 5 km^2 (2 mi^2) of surface (Elcock 2006) and, depending upon the area, would effectively bar military uses. Overall, impacts of wave energy development on military uses are expected to be negligible as long as developments are coordinated with the U.S. Department of Defense (USDOD).

5.3.16.3 Mitigation Measures

The MMS would need to ensure effective coordination with the USDOD regarding future alternative energy leases, new areas of industry interest, and current or proposed areas of military operations. As part of this coordination, stipulations would be routinely evaluated and applied, as necessary, to minimize or eliminate conflicts.

5.3.17 Transportation

The Coast Guard has issued a Navigation and Vessel Inspection Circular (USCG 2007), which provides guidance on information and factors the Coast Guard will consider when reviewing applications for permits to build and operate an Offshore Renewable Energy Installation (OREI) in the navigable waters of the United States. The circular identifies information that the Coast Guard will consider when evaluating the potential impacts of an OREI in the areas of navigational safety and the traditional uses of waterways and on Coast Guard missions. Applicants planning to build an OREI are encouraged to refer to this circular to better understand the Coast Guard review process and how to provide information to assist the Coast Guard and expedite this process. The circular also offers guidance on addressing the necessary marine safety and security issues when preparing an application for submission to the MMS. The

Coast Guard will provide the MMS with an evaluation of the potential impacts of the proposed facility on the safety of navigation and the traditional uses of the particular waterway and other Coast Guard missions to help the MMS to prepare its NEPA documentation. The Coast Guard will help develop appropriate terms and conditions that provide for navigational safety and minimize potential impacts on other Coast Guard missions in and around the proposed facility and recommend them to the MMS for consideration.

5.3.17.1 Technology Testing

All current types of wave energy devices can be towed to a test site. The number of vessels such as tugboats that would be required is about one per point absorber or attenuator device, multiple tugs for an overtopping device, and one or more tugs in concert with a special flotation barge for an oscillating water column (OWC) (Elcock 2006). Thus, the addition of one to several vessels with devices in tow in a region's vessel traffic is not significant and is expected to have negligible to minor impacts. All technologies are designed for remote monitoring from onshore locations, but an occasional visit to the test site may be required to monitor the technology's performance and interaction with the marine environment, as well as to make repairs during the test phase.

Onshore support would be limited to truck, rail, or barge delivery of a power device and limited support equipment such as cabling and monitoring devices. Devices may be delivered intact to the onshore support location, as in the case of the point absorbers, or in sections that may be readily assembled at the onshore support location.

5.3.17.2 Site Characterization

Negligible to minor transportation impacts are expected during site characterization. One or two survey vessels may be deployed to the area at any one time to investigate the marine environment. Local studies would be performed so that potential wave energy-generation site locations would minimize environmental impacts (e.g., to aquatic species and ocean floor habitats) and provide suitable ocean floor characteristics for power device mooring and submarine cable installation.

5.3.17.3 Construction

As discussed in Section 5.3.17.1, all devices may be towed to the power generation site with a small number of support vessels. With the deployment of multiple power generation devices (e.g., 80 point absorbers), devices would be installed in sequence or only a few at a time to allow for an orderly installation, resulting in negligible to minor transportation impacts. Up to one week may be required for the installation of each device (Elcock 2006). One or two vessels may also be employed in the laying of submarine cable and the electrical connection of each device to an electrical grid. However, onshore staging areas near the supporting dock facilities may be necessary if large numbers of devices are to be installed.

Onshore impacts would include connection of the offshore power cable to the power grid. If the power cable from the offshore facility were to traverse local roads or railroad rights-of-way to connect with the onshore power grid, temporary interruptions in local traffic could be required.

5.3.17.4 Operation

Negligible transportation impacts are expected. Little vessel traffic is anticipated during operation of any offshore wave generation facility. However, support vessel access to port facilities could be limited by vessel traffic at the busier ports and/or by navigational hazards (e.g., the fairways in the Gulf of Mexico as a result of existing oil and gas platforms). Monitoring of the facility would be conducted remotely from an onshore location. Visual inspection of the devices and their moorings may be conducted, but such inspections are expected to require the use of a single vessel and occur weekly or monthly. Maintenance or repairs of point absorbers may be accomplished in place or by returning them to a dock facility, depending on the situation. One prototype attenuator device is designed for easy disconnection of the power and mooring lines with maintenance designed to occur at a nearby dock facility (Elcock 2006). The severity of any problem would dictate whether OWC or overtopping devices can be serviced in-place or would need to be returned to a dock location.

Because a wave energy facility would be located at the water surface, it would pose a potential hazard to marine navigation. As is also the case with offshore wind technology, the location of a wave energy facility should be selected to not interfere with designated fairways and shipping lanes as well as prime fishing areas. The USCG has statutory authority for promoting the safety of life and property on OCS facilities and adjacent waters (USCG 1989). Therefore, vessels used on waters of the OCS as well as facilities installed on the OCS are subject to USCG licensing and inspection. To mitigate any navigational impacts, such as vessels colliding with wave energy conversion devices or support structures, each device or structure (individually or in groups) on the water surface would require appropriate signage and/or lighting as a warning to passing vessels.

5.3.17.5 Decommissioning

Removal of a wave generation facility would entail towing the wave devices back to port with negligible to minor impacts expected. The same low number of vessels required for construction (see Sections 5.3.17.1 and 5.3.17.3) would be used for decommissioning. A vessel to support removal of mooring lines and anchors would also be needed. Once onshore, the wave generation devices could be refurbished for use in another location or dismantled for scrap, and/or disposed of at an appropriate facility. An onshore staging facility may be required depending on the rate of recovery of devices, the rate of device processing, and the availability of land transportation.

5.3.17.6 Mitigation Measures

Vessel traffic in support of the testing, construction, operation, and decommissioning of an offshore wave facility is expected to be low. Thus, most ports and harbors supporting commercial operations and traffic would be able to accommodate the needs of such a facility without significant modifications or upgrades that might affect current operations and the environment.

The Coast Guard requires the performance of a traffic study for all uses of the area affected by a proposed offshore facility (USCG 2007) as part of a detailed risk assessment focusing on navigational safety, traditional uses of the area, and impacts on other Coast Guard missions. Because a wave energy facility would be located at the water surface, it would pose a potential hazard to marine navigation. As is the case with offshore wind and current generation technologies, the location of a wave energy facility should be selected so as not to interfere with designated fairways and shipping lanes as well as prime fishing areas. The USCG has statutory authority for promoting the safety of life and property on OCS facilities and adjacent waters (USCG 1989). Therefore, vessels used on waters of the OCS as well as facilities installed on the OCS are subject to USCG licensing and inspection. To mitigate any navigational impacts, such as vessels colliding with wave generation devices, each device or supporting platform on the water surface would require appropriate signage and/or lighting as a warning to passing vessels.

5.3.18 Socioeconomic Resources

A short description of the coastal economies (metropolitan, small urban, single-industry small urban, coastal residential, rural industrial, and rural agriculture) and sociocultural systems (large urban, small urban, single-industry small urban, rural diverse, and rural) used in this analysis can be found at the beginning of Section 5.2.18.

As detailed in the sections below, for each phase of OCS wave energy development, impacts to socioeconomic resources are expected to be minor. For each phase of wave energy development, potential impacts to population, employment, and regional income; sociocultural systems; and environmental justice require consideration.

5.3.18.1 Technology Testing and Site Characterization

Activities associated with the testing of OCS wave energy technologies would include the deployment of a small number of wave energy devices with the use of barges, and the associated shore-based activities, while activities associated with site characterization would include the deployment of survey ships or barges. Although the number of workers required for testing and site characterization is not known (Elcock 2006), these activities would not employ many workers, would be temporary in nature, and would have low impacts on regional income and population. They would have similarly low impacts on sociocultural systems. Potential environmental justice impacts would be site-specific and would be evaluated in future environmental evaluations for individual projects. Any impacts that would occur would be qualitatively similar to those occurring during the construction, operation, and decommissioning phases, but the magnitude of the impacts would be less.

5.3.18.2 Construction, Operation, and Decommissioning

Activities associated with the construction of OCS wave energy technologies would include the onshore manufacturing of components and their transportation to offshore sites, the preparation of port facilities, and the installation of components, transformers, and cables. Activities required for operation would include monitoring and maintenance of offshore facilities with the use of small boats and cranes. During decommissioning, the dismantling and removal of offshore facilities, devices, and cables and their transportation to shore with the use of special vessels would occur.

Population, Employment, and Regional Income. The impact of employee and contractor wage and salary spending and project procurement expenditures associated with these activities would likely be small. However, because there are a number of contrasting types of economic areas in each region, there would likely be some variation in the magnitude of the impact of OCS wave energy technologies depending on the type of economy in which specific projects were to be located.

The impacts of these activities in metropolitan and small urban areas would likely be small, with sufficiently diverse local economic infrastructure and labor markets to provide the required labor force, equipment, materials, and services. Single-industry small urban and coastal residential economies are likely to experience more significant impacts, with wage and salary spending and procurement expenditures larger compared to the local economic base, and with higher demands on local occupational groups. OCS activities would likely have a larger impact in rural industrial and rural agricultural areas than in other types of economies, requiring a relatively large share of labor in key occupational categories and of available local production capacity for the required material and services.

The economic impacts of the construction, operation, and decommissioning of wave technologies are not known (Elcock 2006). However, it is likely that wave technologies would create only small direct employment, income, and population growth in the Atlantic coastal region, and that impacts would be localized in the communities located near each development. The relevant job skills for device fabrication, installation, and maintenance could be present in most coastal communities (Elcock 2006), while some components may be manufactured elsewhere.

Sociocultural Systems. Construction, operation, and decommissioning of OCS wave energy technologies would likely require only a small labor force in each location, with few, if any, workers required to relocate into the communities hosting OCS developments. However, because there are a number of contrasting types of sociocultural areas in each region, there is the potential for some variation in the magnitude of the impact of OCS energy technologies depending on the type of sociocultural environment in which specific projects were to be located.

Aggregate regional effects can be expected to be small. Although it is not likely that in-migration of any workers would be required to fill positions, sociocultural impacts may vary by community, with the social organization of some communities leaving them vulnerable to fluctuations in industry activity. In other communities, local sociocultural structures buffer them from any rapid industrial change. In communities where impacts would occur, effects might include alterations in ethnic composition, self-identity, and cultural persistence and overall changes in social institutions, notably family, government, politics, education, and religion. Sociocultural systems in some communities would experience stress (moderate impact), particularly those that are most closely tied to the marine environment. Other communities would have the capacity to cope with rapid industry change (negligible to minor impact).

The impacts of wave energy technology activities in large urban areas would likely be small, with a wide diversity of population groups and cultural systems present and, therefore, little likely contrast with any in-migrating population. Sociocultural impacts are likely to be larger than in large in small urban and single-industry small urban areas urban areas, with more homogeneity in local cultural systems and more likely contrast with any in-migrating population. Similar impacts might be expected in rural diverse communities, depending on the cultural origin of any in-migrating population.

Environmental Justice. The majority of potential impacts to low-income and minority populations would come as a result of the construction and operation of the onshore infrastructure and support facilities. As it is likely that onshore facilities would be located close to industrial port facilities, it is possible that onshore wave facility infrastructure could be located near minority and/or low-income populations. Infrastructure that would be constructed in support of OCS developments might include the addition of new landfalls, administration and waste facilities, and switchyard and transmission facilities. Construction of new facilities could produce noise and visual impacts, increased traffic, air, and water pollution, impacts to residential property values, and land-use changes.

Varying degrees of hazard could be associated with the construction of the onshore components of wave energy facilities, producing potentially harmful impacts to the environment, subsistence, health, and physical safety. The effect of air emissions from OCS development on coastal air quality may also create environmental justice issues. The effect of air emissions associated with wave facilities (e.g., emissions from onshore construction machinery and from construction and operation vessels and helicopters) on coastal air quality may also create environmental justice issues. Such emissions would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Air emissions from the proposed program are not expected to result in air quality impacts to minority or low-income populations.

Although construction, operation, and decommissioning of OCS facilities and their associated coastal infrastructure support facilities might result in environmental justice issues in a number of counties along the coast, in the absence of specific locations for these developments at the programmatic level, it is not possible to identify any specific disproportionately high and adverse impacts on minority and low-income populations. Impacts of offshore energy projects on specific population groups in specific coastal communities and neighborhoods would be part of site-specific analyses undertaken at the individual project level. These analyses would be based on population data at the census block group level for up to 50 mi from a project location, to fully reflect the impact of a particular energy development project on environmental justice given the regional distribution of minority and low-income population groups.

5.3.18.3 Mitigation Measures

Mitigation of economic, sociocultural, and environmental justice impacts associated with the development of OCS wave technologies may be required, depending on the location, scale, and impact of specific projects. However, the magnitude of the economic and sociocultural impacts of wave technologies is likely to be small, with little employment and population in-migration required during each stage of a project. With onshore facilities likely to be located in existing ports, environmental justice issues may arise, depending on the location and nature of impacts of these facilities.

5.3.19 Cultural Resources

Impacts to cultural resources can occur during all construction-related phases of offshore wave energy development where there is the potential for seafloor disturbance in previously undisturbed areas. Seafloor disturbance can be either the direct or indirect result of construction activities, such as securing or anchoring the wave devices to the ocean floor or offshore cable placement. Direct impacts are the result of direct destruction or removal of cultural resources from their primary context. Indirect visual effects could occur to historic resources on the coast if visual factors are important for maintaining the integrity of the resource (see Section 5.2.19.3). Although the specific types of cultural resources and their potential locations may vary regionally, the types of impacts that could occur to cultural resources are similar across the three regions.

5.3.19.1 Technology Testing and Site Characterization

Impacts to cultural resources could occur during technology testing and site characterization; however, specific impacts would need to be addressed at a site-specific project level. Impacts are expected to be minor to negligible assuming testing and characterization activities are at a very small scale and related construction activities can be moved to avoid cultural resources. Cultural resources identified in small testing areas can be just as significant as cultural resources in larger full-scale development areas and require the same level of protection. Since some ground disturbance occurs during this phase, the same protection measures for cultural resources must be implemented during this phase as with the larger-scale construction phase in order to meet the requirements of Section 106 of the National Historic Preservation Act (NHPA) (see Section 5.3.19.2).

5.3.19.2 Construction

Impacts to cultural resources are most likely to occur during construction of a wave energy development project; however, specific impacts would need to be addressed at a site-specific project level. Most impacts would result from some form of seafloor disturbance (trenching, dredging, or facility or component placement or installation) that could disrupt shipwrecks and buried prehistoric archaeological sites offshore. The level of impact could range from negligible to moderate depending on the location of the project, the level of seafloor disturbance that has previously occurred in that location, and the number and significance of the sites present in that location if it has been previously undisturbed, the feasibility of moving portions of the development project to avoid important resources, and the expected efficacy of mitigation/data recovery should impacts to some significant sites be unavoidable.

Indirect visual impacts could also result from disruption of a historical setting that is important to the integrity of a historic structure, such as a lighthouse or residential or community building. Visual impacts during construction are anticipated to be negligible to minor since the impacts of construction are temporary.

5.3.19.3 Operation

There are few activities during operations that would have the potential to impact cultural resources; impacts would need to be determined on a site-specific basis. Maintenance and inspection activities involve mostly transportation activities for workers and equipment and would not likely affect cultural resources. The exception to this would be the replacement or removal of system components. These impacts would be similar to those described in Section 5.3.19.4. The level of impact would be considered negligible to minor as impacts would have already occurred during construction. However, if new areas are disturbed as a result of these activities, the potential for impact would increase and surveys could be necessary if not already completed in the area of new disturbance. Indirect visual impacts to historic structures are not expected with this technology.

5.3.19.4 Decommissioning

Decommissioning activities are similar to construction activities, although in reverse order. Impacts to cultural resources are expected to be negligible to minor, as most impacts would have likely occurred during construction. Impacts are possible if new areas of the seafloor are disturbed during decommissioning. If new areas are disturbed as a result of these activities, the potential for impact would increase and surveys could be necessary if not already completed in the area of new disturbance.

5.3.19.5 Mitigation Measures

Cultural resources are nonrenewable and are, therefore, irretrievably lost once they have been impacted. Avoidance of a significant resource is the preferred mitigation option and the MMS's preferred policy. Currently, the MMS has regulations in place for addressing cultural resources prior to oil and gas development (e.g., 30 CFR 250.194); similar regulations are currently being drafted for the development of alternative energy as similar types of impacts could occur. The MMS meets its responsibilities under the NHPA for projects over which it has permitting authority on the OCS through the following procedures: the MMS begins the Section 106 process by initiating consultation with the appropriate States, affected tribes, and other interested parties. Consultation begins with the MMS informing the parties of the project's details and the steps the MMS undertakes to identify and consider cultural resources that may be affected by the proposed project. Consultation is ongoing throughout the project.

The MMS policy requires the performance of marine remote sensing surveys within all areas where MMS archaeological baseline studies indicate a potential for cultural resources (historic and prehistoric) to exist. If the results of these surveys indicate the presence of a potential cultural resource within the project area, the MMS requires that the project either be modified to avoid the location of the potential cultural resource or that further investigations be conducted to conclusively determine the identity of the potential resource. If further investigations indicate that a significant cultural resource exists and cannot be avoided by the proposed project, the MMS would continue Section 106 consultation with the State, affected tribes, and other interested parties to determine the appropriate mitigation. Potential mitigation strategies include, but are not limited to, full data recovery, partial data recovery, monitoring, sampling strategies, remote sensing, mapping, and photography. Confining maintenance and decommissioning activities to areas previously disturbed during project construction activities would be encouraged to minimize additional potential impacts to cultural resources.

The MMS also requires, through regulation and/or lease stipulation, that if any unanticipated cultural resource is encountered during project-related activities, all activities within the area of the discovery be immediately halted and the MMS contacted.

The MMS (BLM prior to 1981) and/or the NPS have tested and refined the survey and mitigation strategies for identification, evaluation, and avoidance of offshore cultural resources through numerous studies over the past 30 years. These studies include, among others, CEI 1977; Institute for Conservation Archaeology 1979; SAI 1981; CEI 1982; CEI 1986; PS Associates 1987; Garrison et al. 1989; Espey, Huston & Associates, Inc., 1990; Pearson et al. 2003; and PBS&J 2006. See Sections 4.2.19, 4.3.19, and 4.4.19 for a discussion of those OCS areas within the Atlantic, Gulf of Mexico, and Pacific regions where MMS baseline studies indicate a potential for historic properties and where the MMS will implement its survey and mitigation requirements.

For onshore cultural resources, including historic architectural resources, districts, and landscapes that may be subject to adverse visual effects from an OCS project, the MMS will develop appropriate mitigation through consultation with the States, affected tribes, and other interested parties in accordance with the procedures outlined in the ACHP regulations at 36 CFR 800.

5.3.20 Land Use and Existing Infrastructure

5.3.20.1 Technology Testing and Site Characterization

Technology testing and site characterization activities are small, and while they require construction and operation effort, the overall amount of work and shore support needed for installation is negligible compared to existing activities in most areas. Installation of the facilities would introduce a small obstruction to navigation that may affect some uses of the area but this would cause a negligible impact. Negligible shore-based construction/operation impacts associated with these activities are expected. No other impacts are expected.

5.3.20.2 Construction, Operation, and Decommissioning

Unlike the support requirements for wind energy development, most wave energy developments would require standard-size port facilities to support construction and placement, so no modification of existing facilities is expected. Vessel types and sizes to handle the equipment would also be "normal."

There are currently no available estimates of the amount of labor that would be required to construct, maintain, or decommission a wave energy facility, but generally it is expected that job skills for installation are present in most coastal communities. Individual components for a facility would likely be constructed elsewhere and shipped to the area by truck. With the expected small number of likely commercial developments during the analysis period, impacts on local labor, housing, and infrastructure are expected to be negligible.

The area occupied by a wave energy development could be highly variable depending both on the design capacity and the technology employed. Spacing of individual units would be less than the units within a wind energy facility, and there is an expectation that the amount of ocean surface occupied by a wave energy facility may be less than for comparably sized wind energy facility. Based on available information, it appears that commercial-scale wave energy facilities would occupy less than 5 km^2 (2 mi^2) (Elcock 2006). Because these facilities employ various anchoring strategies and the density of the units within a facility may be higher than a wind energy facility, the actual surface area occupied by the facility may be unavailable for all other uses. Facilities would exclude commercial shipping, but other possible restrictions would be developed on a project-specific basis. Overall impacts are expected to be negligible to minor.

Onshore construction to connect electrical production from an offshore facility to the local/regional grid would be required but is expected to have negligible impact on the area. Additional underground and/or overhead transmission lines may be required as well as some additional electrical substation facilities depending on the generation capacity of the new project and the capacity of the existing land-based transmission system. For the analysis period, the overall impact is expected to be negligible.

There are many existing uses along coastal areas and in the nearshore areas that are potentially affected by or could affect a wave energy development. Examples of existing water uses include shipping fairways, recreational boating, undersea cable installations, shellfish beds or fishery areas, and marine sanctuaries. Examples of onshore uses that may be affected include wildlife refuges; units of the national, State, and local park systems; and areas of high scenic value. All existing uses of areas proposed for development would need to be identified during site-specific project review to determine the potential effects of any proposed development. Additionally, Coastal Zone Management Act (CZMA) requires a Federal agency to consult with States regarding consistency with their approved Coastal Zone Management Programs.

Operations activities would require conventional ocean surface transport but no special facilities beyond those likely already available in most coastal areas. Employment associated with project operation is unknown and would need to be defined at the project level.

Activities associated with decommissioning of a facility would likely be the reverse of the construction process, although likely somewhat shorter in duration, and would require port, transportation, labor, and housing to accomplish the removal. Impacts to land uses would be similar to those in the construction phase and are expected to be temporary and negligible.

5.3.20.3 Mitigation Measures

Public involvement and discussion should be effective in identifying site-specific concerns with any proposed development. Once the concerns/issues are identified, it will be possible to develop effective mitigation measures and/or identify necessary trade-offs in making the decision on requested projects. Importantly, there will be Federal, State, and local processes involved before a final decision can be rendered. Depending upon the specific proposal, impacts could range from negligible to moderate but would be identified in a site-specific National Environmental Policy Act (NEPA) analysis. Project-specific mitigation measures could then be developed depending on the expected impacts of the project.

5.3.21 Visual Resources

Technology testing, site characterization, construction, operation, and decommissioning of WEC technologies and associated onshore facilities and activities on the OCS potentially would cause a variety of visual impacts. The types of visual impacts of concern include the potential visibility of offshore and onshore structures; the potential visibility of vessels, helicopters, and other water- and aircraft associated with transport of workers and equipment for construction, maintenance, and facility decommissioning; and the potential visibility of the construction, maintenance, and decommissioning activities themselves.

Because of the subjective and experiential nature of human visual perception and cognition, the assessment of the magnitude and importance of perceived visual impacts is both subjective and site- and time-specific. Visual impacts are highly dependent not only on physical factors that affect what the impacts are and how they are perceived, but also on the number and type of viewers, their sensitivity to the visual environment, and cultural factors that concern both the viewer and the affected landscape/seascape (BLM 1984; DTI 2005; USFS 1995); the reader is referred to Section 5.2.21 for a discussion of the these factors. It should be noted that due to the general lack of established commercial wave energy facilities, little is known about the perception of visual impacts arising from wave energy facilities, especially at distances offshore comparable to those on the OCS. It should not be assumed that all or even most viewers would perceive WEC devices or wave energy facilities negatively, although it could be reasonably assumed that some people would perceive the devices or facilities as having negative visual impacts. Several authors have identified visual impacts as a potential environmental issue, but only in a nearshore context (DBEDT 2002; Petroncini and Yemm 2001; Global Energy Partners LLC 2004), and more research is needed to assess individuals' perception of the positive or negative visual impacts of wave energy facilities at commercial scale and at distances applicable to the OCS.

Offshore structures associated with potential wave energy facilities include WEC devices; onshore structures could include transmission lines and construction/assembly facilities. Persons located onshore would generally experience different visual impacts than persons viewing from offshore locations, who would see WEC facilities primarily from boats. Onshore viewers would see offshore WEC facilities from a distance of at least several miles, but might see onshore facilities from much shorter distances. Depending on their location, offshore viewers might see offshore WEC facilities from a wide range of distances, including very short distances. Offshore viewers might also be able to see onshore facilities located near the shore from a wide range of distances.

A variety of visual impact mitigation measures for WEC facilities are presented in Section 5.3.21.6. Although the visual impacts that would be expected to occur from a particular WEC development would be highly site- and viewer-specific, application of appropriate mitigation measures may substantially reduce or even eliminate visual impacts for many viewers/locations.

5.3.21.1 Technology Testing

As discussed in Section 3.5.1, a small-scale test for a WEC facility would most likely involve the deployment of one or two devices per test. The devices would be installed in the offshore environment, and depending on the size of the individual unit, they could be towed to their offshore locations or shipped by barge or special-purpose vessel. Again depending on the size of the unit, installation could be conducted using barges or specialized installation equipment for larger structures such as overtopping devices. Depending on the distance from shore, these activities might be visible from shore, but because the tops of the WEC devices would likely be under 10 m (33 ft) in height above the water surface, some or all of the devices would likely be hidden from view due to the curvature of the earth (see Table 5.2.21-1). Waves and the presence of fog, rain, or haze would sometimes provide further screening. Onshore viewers thus might see the marine vessels transporting the WEC devices and equipment to the site, but not see the devices in place, however, this would depend on the height of the devices and site-specific factors, such as viewer elevation and distance from shore. Navigation warning lights on the WEC devices might be visible from shore under clear conditions in some cases. Visual impacts would be determined at the site-specific level, but would be expected to be negligible for onshore viewers in most cases. Boaters could approach the WEC facility closely, and thus the WEC devices could become visually prominent, but the view duration would normally be very brief, and the expected impacts negligible unless boaters were close to the WEC devices for extended periods.

5.3.21.2 Site Characterization

It is not expected that site characterization activities for WEC facilities would involve placement of structures or floating devices on or above the water that would be visible from shore. Boaters and onshore viewers with elevated viewpoints might see buoys and equipment as well as marine vessels involved in subsurface characterization, but the duration of these activities would be brief, the extent of the activities would be small in visual terms, and the activity level would be likely not be above normal for many locations; thus, the expected visual impact level would be negligible.

5.3.21.3 Construction

Construction activities for a WEC facility would involve both onshore and offshore activities associated with potential visual impacts. Onshore activities would include the manufacture, transport, and assembly of WEC components at a facility that likely would be at or near the shore. Offshore construction activities would include transport of WEC devices and related equipment to the WEC facility site, and the assembly of the WEC devices at the site.

Manufacture of WEC components for use on the OCS is expected to occur at existing facilities, so that no additional impacts are expected beyond those associated with normal activities. In the vicinity of the assembly point (typically a port facility), there would be increased traffic visible from trucks and/or marine vessels delivering components. If the assembly facility required expansion to accommodate the activities associated with WEC component assembly and storage, construction activities such as dredging and dock expansion might be visible, and while impact levels would depend on site- and situation-specific factors, they could range from negligible to moderate for some viewers. A determination of impacts for construction and operation of these facilities would be conducted during a site-specific NEPA analysis. These construction-related visual impacts would cease when construction was completed, but if the facility expansion resulted in visible permanent structures, the related impacts could be permanent for the lifetime of the facilities.

While it is not anticipated that construction of new conduits, substations, and overhead transmission lines would be required within the time frame of the programmatic EIS, if such construction was needed, related visual impacts would be expected to be negligible to moderate, depending on the size and nature of the facilities, as well as the proximity and visibility of the facilities to viewers. A determination of impacts for construction and operation of these facilities would be conducted during a site-specific NEPA analysis. These construction-related visual impacts would cease when construction was completed, but because the facilities would result in visible permanent structures, the related impacts could be permanent for the lifetime of the facilities.

Transport of WEC components to the WEC facility location would involve marine vessels to carry components and construction equipment to the WEC facility site, and helicopters might be used to transport workers. Nearby onshore and offshore viewers might notice an increase in traffic. Views would typically be of short duration, and impacts would be expected to be negligible to minor.

Construction activities at the WEC facility could include mooring installation, assembly of WEC devices, and laying of cable. All of these activities could potentially cause both onshore and offshore visual impacts, depending on the distance from shore- and from water-based viewers. A variety of marine vessels would be used for these tasks, and one or more might be present on site at a given time. Helicopters might also be present at times, and viewers might notice the activity of the vessels and helicopters; however, the visual impacts directly associated with construction would cease upon completion of construction, and are expected to be negligible to minor for onshore viewers, and minor to moderate for boaters in the immediate vicinity of the facility. As the WEC facility was built, the impacts attributable to the WEC devices themselves would gradually increase; these impacts are discussed in the next section.

5.3.21.4 Operation

Operation of a WEC facility could potentially cause both onshore and offshore visual impacts. While it is not anticipated that construction of new conduits, substations, and overhead transmission lines would be required within the time frame of the programmatic EIS, onshore impacts would arise if new conduits, substations, and overhead transmission lines were constructed or expanded in association with the new WEC facility. In addition to the presence of the structures associated with the conduits, substations, and overhead transmission lines, periodic maintenance activities would require the temporary presence of workers and vehicles. These impacts would be determined during the conduct of the site-specific NEPA analysis, but would generally be expected to be negligible to minor because the maintenance activities are infrequent and of short duration.

Offshore impacts associated with the development of WEC facilities on the OCS include the presence of the WEC devices, the presence of navigational lighting on the WEC devices, and the presence of marine vessels and/or helicopters for maintenance activities. Potential visual impacts would normally be expected to be different for onshore viewers than for offshore viewers; onshore viewers would see the WEC facility from a distance of at least several miles, but might see onshore facilities from much shorter distances. Depending on their location, offshore viewers might see the WEC facility from a wide range of distances, including very short distances.

The magnitude of the visual impacts associated with a given WEC facility would depend on site- and project-specific factors, including:

- Distance of the proposed WEC facility from shore;
- The size of the facility (i.e., number of WEC devices);
- Size (particularly height) of the WEC devices;
- Surface treatment (primarily color) of WEC devices;
- The number and type of viewers (e.g., residents, tourists, workers);
- Viewer location (onshore vs. offshore);
- Viewer attitudes about alternative energy and WEC power;
- The visual quality and sensitivity of the landscape/seascape;
- The existing level of development and activities in the WEC facility area and nearby onshore areas (i.e., scenic integrity and visual absorption capability);
- The presence of sensitive visual and cultural resources;
- Weather conditions;
- Lighting conditions; and
- The presence and arrangement of navigation lights on the WEC devices.

WEC devices considered likely for commercial development in the time frame considered in the programmatic EIS are low-profile structures under 10 m (33 ft) in height. The theoretical limit of visibility of an offshore structure is determined by the distance between the viewer and the structure, the height of the structure, the elevation of the viewer, and the curvature of the earth. Table 5.2.21-1 allows calculation of the maximum viewing distance of a structure for a given distance, structure height, and viewer elevation. Views at these theoretical distances exceed what is experienced in a real situation, however. In real seascapes, atmospheric haze, fog, and rain reduce the practical viewing limit, sometimes significantly, and the presence of waves will also obscure objects very low to the horizon. Furthermore, limits to human visual acuity reduce the ability to discern objects at great distances, suggesting that some WEC facilities would not be discernable, even though they theoretically would be visible. If they were visible, significant portions of the facility would be hidden by view by the earth's curvature. The color, reflectivity, and other visual characteristics of the object and its contrast with the visual background under varying lighting conditions also affect its visibility (Hill et al. 2001; DTI 2005; Seascape Energy Ltd. 2002a; Elsamprojekt A/S 2000).

For WEC facilities visible from the shore, visual impacts would be expected to result from the introduction of the manmade structures with “hard” geometry into the ocean view. The visible structures would potentially produce visual contrasts by virtue of their design attributes (form, color, and line) and by virtue of the reflectivity of their surfaces and resulting glare. Objects on or near the horizon tend to draw visual focus, particularly if they break the horizon line (Hill et al. 2001). Frontlighting of the WEC devices would generally increase perceived impact by heightening contrast between the WEC device and the background, while backlighting would increase contrast at sunrise and sunset by silhouetting the WEC devices against the bright sky (DTI 2005). Larger numbers of visible WEC devices would be expected to increase perceived impact. For onshore viewers, expected visual impacts due to visible WEC devices would be determined during a site-specific NEPA analysis but would be expected to be negligible to moderate in most cases.

Because of their low height above the water surface, aviation warning lights would not be required on WEC devices considered likely for commercial development in the time frame considered in the programmatic EIS. Navigation lights and markings would be required, but these lights and markings would be relatively inconspicuous to onshore viewers, and at greater distances could be partially or completely concealed below the horizon due to the earth’s curvature. Expected visual impacts caused by navigational lighting would be determined during a site-specific NEPA analysis but would be expected to be negligible to minor in most cases.

For offshore viewers, potential visual impacts could be much greater than for onshore viewers, because boats could closely approach or potentially move through a WEC facility. In a close approach, the individual WEC devices and the array of WEC devices in the facility could dominate views. Structural details, such as surface textures, could become apparent, as could strong specular reflections from the device surfaces. However, views from passing boats would be brief, and consequently visual impacts would be expected to be negligible for most boaters, but potentially minor for boaters in the vicinity of the WEC facility for extended periods.

For both onshore and offshore viewers, WEC facility maintenance activities could potentially cause visual impacts. Technicians would be transported by relatively small boats to the facility where they would either work directly on the WEC devices, or remove components to the shore for repair and then return them. In poor weather conditions, the technicians might be transported via helicopter to the OCS location. These activities would result in marine vessel traffic and/or helicopter traffic in and around the WEC facility that might be noticed by viewers. Such services would be of short duration, and associated impacts would be expected to be negligible in most instances.

5.3.21.5 Decommissioning

Decommissioning of a WEC facility would involve the dismantling and removal of infrastructure associated with each unit, their foundations or moorings, scour protection devices, and transmission cables, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). In terms of expected visual impacts, decommissioning activities would be similar to construction activities; however, activities would generally proceed in reverse order from construction, and would proceed more quickly than construction, thus the associated impacts would last for a shorter time. Because WEC facilities and equipment would be removed to below the waterline during decommissioning, the WEC facility site would be returned to preconstruction condition, with no evidence of the WEC facility's presence remaining; however, as noted above, impacts associated with any new or expanded permanent onshore facilities resulting from WEC facility development would remain.

5.3.21.6 Mitigation Measures

Recommended visual impact mitigation measures for wave energy development on the OCS include the following:

Project siting. The choice of location for a WEC facility is the single most important opportunity for visual impact mitigation. Recognizing that resource and economic as well as other drivers must be considered and balanced against aesthetic concerns, consideration should be given to locating developments farther offshore and farther from sensitive visual resource areas, or areas with limited visual absorption capability or high scenic integrity, in order to reduce perceived visual impacts. Where possible, developments should be sited in seascapes that are already industrialized and developed, with due consideration for visual absorption capacity and possible cumulative effects. The relationship of the planned development to other existing or planned WEC facilities in the area should be considered, in terms of siting but also to achieve consistency in layout to the extent possible. The use of headlands to screen views of developments from sensitive landscapes/seascapes should be considered, and WEC facilities should be sited so that they are not framed by landforms in "keyhole" views from highly sensitive inland scenic vistas or other sensitive areas.

Viewshed mapping, visual impact simulations, and public involvement. Viewshed mapping and visual impact simulations should be used to create accurate depictions of the visibility and appearance of proposed facilities. Simulations should depict proposed project appearance from sensitive/scenic locations as well as more typical viewing locations. These viewshed analyses and visual impact simulations should form key elements of a program to inform and involve the public in evaluation of visual aspects of project design.

Project layout. To the extent possible, the WEC facility layout should be designed to minimize the horizontal spread of the layout from shore, particularly from sensitive viewpoints.

WEC device design and appearance. The WEC devices should be uniform in shape, color, and size. Color selections should be made to reduce visual impact (with consideration to navigational safety requirements) and should be applied uniformly to components to the extent possible, unless gradient or other patterned color schemes are used. Nonreflective paints and coatings should be used in order to reduce reflection and glare. Commercial/advertising messages on project facilities should be prohibited.

WEC facility maintenance. WEC facilities should be well maintained during operation. Inoperative or incomplete devices could cause the misperception in viewers that "wave power does not work" or that it is unreliable. Inoperative devices should be promptly repaired, replaced, or removed. Devices should be cleaned regularly.

Navigational warning lighting. To the extent possible within lighting requirements of the Coast Guard, lighting should be minimized, and navigation lights with minimal visibility from shore should be considered.

5.3.22 Tourism and Recreation

5.3.22.1 Technology Testing and Site Characterization

Because it is likely that testing activities would be located close to industrial port facilities, it is not expected that construction of a support base for vessels and other onshore infrastructure (if needed), use of existing airfields for helicopter support, and other operations activities would impact tourism and recreation. As there have been no negative impacts on tourism and recreation reported from military, commercial, and recreational water and air vessels that currently traverse coastal areas intermittently, it is unlikely that there would be any detrimental impact on tourism and recreation from vessels supporting technology testing and site characterization activities.

5.3.22.2 Construction, Operation, and Decommissioning

The main recreation and tourism activities that could be affected by OCS construction, operations and decommissioning would be beach recreation, sightseeing, diving, and recreational fishing. The extent of impacts would depend on the proximity of OCS coastal and offshore activities to recreational use areas.

The location of OCS developments and coastal infrastructure might visually affect visitors, although the extent of the impact of the visibility of offshore OCS on tourism and recreation is uncertain. While some visitors may prefer unobstructed views, for others the opportunity to view alternative energy facilities might be attractive. Regardless of structure location, there would be the potential for a visual impact on tourists traveling on cruise ships; however, there appears to be no detrimental visual impact on the cruise industry in other destinations. There would be a potential visual impact to recreational boaters who might not want any structures offshore, and adverse impacts to offshore wildlife may also affect recreation. The displacement of recreational users from areas in which offshore energy development might occur could adversely affect the overall recreational experience in other coastal areas not likely to host offshore energy facilities, as these might become popular recreation locations. Some tourists and recreational users on coastal beaches could be affected by the sight and sound (helicopter and boat traffic) of OCS facility operations, but few, if any, are expected to forgo their visits because of these routine intermittent operations.

Switchyards and transmission lines could exist near important recreational areas, and transmission line landfalls could cause temporary removal of shoreline recreational land from public use for short periods. Except in extreme circumstances, however, impacts are expected to be minor or temporary.

5.3.22.3 Mitigation Measures

Mitigation of impacts on tourism and recreation associated with the development of OCS wave technologies may be required depending on the location, scale, and impact of specific projects. The visibility and audibility of OCS structures from areas in which there is significant recreational activity, tourism, or scenic quality would likely exaggerate the magnitude of impacts, while locations in areas in which these activities were largely absent would likely minimize the magnitude of visual impact of OCS energy developments.

5.3.23 Fisheries

The Atlantic (Section 4.2.23), Gulf of Mexico (Section 4.3.23), and Pacific (Section 4.4.23) regions support diverse and valuable commercial and recreational fisheries. Impacts to fisheries could result from OCS alternative energy development activities that (1) cause changes in the distribution or abundance of fishery resources, (2) reduce the catchability of fish or shellfish, (3) preclude fishers from accessing viable fishing areas, (4) cause losses or damage to equipment or vessels, or (5) reduce the market value of a fishery. Although this section evaluates general types of impacts that could occur due to OCS wave energy development, specific impacts to fisheries would be dependent on various aspects of a particular project, including geographic location, spatial scale, timing of activities, design of energy technology components, and the proximity of that project location to specific fishery resources. Thus, it would be necessary to conduct more detailed analyses of potential impacts to fisheries as part of site-specific evaluations for proposed projects.

As described in Sections 4.3.11, there could be localized temporary effects on the distribution or abundance of some fish resources during some phases of OCS wave energy development. However, activities are not expected to measurably affect overall populations of fishes or invertebrates that support commercial or recreational fisheries. It is assumed that sensitive seafloor habitats, which sustain production for many important fishery species, would be avoided during development of OCS wave energy projects (Section 4.3.14). Thus, although individual organisms or small amounts of seafloor habitat could be affected, the populations of organisms that are the targets of commercial fisheries would not be measurably reduced. In addition, none of the OCS activities would measurably alter the market value of fishery resources. Because of this, the following sections focus on potential effects of OCS wave energy development on catchability of targeted organisms, access to fishing areas, and damage or loss of equipment or vessels.

5.3.23.1 Technology Testing

As described in Section 3.5.1, proposals to test and demonstrate offshore wave energy technologies will likely occur within the next 5 to 7 years. These small-scale tests would likely involve deployment of one or two test devices within an offshore testing area, with or without the construction of an undersea transmission connection to shore. Depending on the technology being tested, test units could utilize fixed foundations (e.g., monopiles or multilegged support systems), or could use concrete anchors in various mooring arrangements. As described in Sections 5.3.11 and 5.3.14, impacts on fish resources and seafloor habitats from the small number of vessel trips required for technology testing would be expected to be negligible.

Placement of experimental wave energy units in OCS waters has a potential to result in space-use conflicts with some commercial or recreational fishing activities. Fishing vessels could be excluded from a normal fishing area in order to avoid the potential for gear loss. As identified in Section 5.3.14, wave energy projects would not be located in particularly sensitive or unique seafloor habitats. Consequently, the amount of area that would be lost to fishing activities from placement of several wave energy units would be very small compared to similar surrounding habitat, even if an exclusion area with a radius of 500 m (1,640 ft) was designated for safety purposes.

Placement of wave energy units in OCS waters would represent an additional navigation hazard. Because wave energy units do not typically extend far above the ocean surface, they would not be easily detectable, either visually or by radar. Addition of lights and/or radar reflectors would increase the ability to detect the units. Assuming that such navigational aids are utilized, the navigation hazard caused by wave energy units during the technology testing phase would be negligible.

The small increase in vessel activity that would occur during the technology testing phase would not measurably affect commercial or recreational fishing opportunities, catchability of fish and shellfish resources, or navigation. Increased vessel traffic could also interfere with some vessel operations by affecting port congestion and traffic at fuel docks (Section 5.3.17.3). Fuel spills that occur as a result of vessel accidents or leaks could temporarily close affected areas to fishing. However, the likelihood of such spills is relatively low because of the small number of trips that would be required during the technology testing phase. If spills occurred, the volume of fuel that could be spilled would probably be small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Impacts to fish resources or commercial or recreational fisheries would be negligible.

5.3.23.2 Site Characterization

Fisheries could be affected during site characterization by the presence of survey vessels, by geological and geophysical surveys, by drilling and core sampling, and by the installation of one or more sampling buoys within the project area.

As identified in Section 5.2.23.2, impacts to commercial and recreational fisheries from reduced catchability due to geological and geophysical surveys and pile driving would be negligible.

Some characterization activities have a potential to result in space-use conflicts with commercial and recreational fishing activities. Fishing vessels could be excluded from normal fishing grounds to avoid the potential for gear loss or for perceived disturbances to fishery resources. Such conflicts could be avoided by conducting characterization activities during closed fishing periods or seasons.

Most space-use conflicts are avoided by following existing navigation rules. To further address space-use conflicts, a requirement for lessees to review planned activities with potentially affected fishing organizations and port authorities could likely prevent unreasonable fishing gear conflicts. Some lease-related uses could be restricted if deemed necessary to prevent unreasonable conflicts with commercial fishing operations.

Placement of sampling buoys in OCS waters would represent an additional navigation hazard. Such buoys may not be easily detectable, either visually or by vessels equipped with radar. The addition of lights and/or radar reflectors would increase the ability to detect such buoys. Overall, the navigation hazard caused by placement of a small number of sampling buoys in the project area would be negligible.

The small increase in vessel activity that would occur during the characterization phase would not measurably affect commercial or recreational fishing opportunities, catchability of fish and shellfish, or navigation. Fuel spills that occur as a result of vessel accidents or leaks could temporarily close affected areas to fishing. However, the likelihood of such spills is relatively low because of the small number of trips that would be required. If spills occurred, the volume of fuel that could be spilled would probably be small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Impacts to fish resources or commercial or recreational fisheries would be negligible.

5.3.23.3 Construction

Construction activities and placement of transmission lines on the seafloor could harm or temporarily displace individual organisms from localized areas. However, population-level changes in abundance or distribution are not anticipated, and impacts to seafloor habitats are expected to be negligible (Sections 5.3.11 and 5.3.14). If pilings are required to anchor the wave energy structures, the use of pile-driving equipment would be required for a few hours for each piling needed. It is estimated that pile driving would occur only intermittently during the construction period and that fishery resources would likely return to disturbed areas between construction sessions. Other anchoring options would likely result in smaller effects.

Some construction activities have a potential to result in space-use conflicts with commercial and recreational fishing activities (Rodmell and Johnson 2005). As a consequence, fishing activities could be temporarily excluded from some areas that might be normal fishing grounds during construction activities to avoid the potential for gear loss or vessel accident. In other instances, anglers could choose to avoid areas with construction activity because of perceived disturbances to fishery resources. Such conflicts could potentially be avoided by conducting certain construction activities during closed fishing periods or seasons. Most space-use conflicts could be avoided by following existing navigation rules. To further address space-use conflicts, a requirement for lessees to review planned activities with potentially affected fishing organizations and port authorities could potentially reduce fishing gear conflicts.

As described in Section 5.2.23.3, the impacts to commercial or recreational fisheries from vessel activity or accidental fuel spills would be negligible during the construction period.

5.3.23.4 Operation

Once construction of an offshore wave energy facility were completed and operation of the facility commenced, fisheries could be affected by the presence of the structures, by traffic and noise from vessels used to maintain the structures, and by noise associated with operations. In addition, the presence of electromagnetic fields associated with transmission cables has a potential to affect some fish species. As identified in Sections 5.3.11 and 5.3.14, impacts to fish populations and seafloor habitats from these impacting factors are expected to be negligible in most cases.

As described in Section 5.3.11 and 5.3.14, there is a possibility that projects with multiple wave energy units deployed over large areas could act as artificial reefs, thereby affecting the abundance and diversity of fish and invertebrates within the area. There is also a potential for invasive species to colonize such structures. Effects on diversity and fish abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats within surrounding areas.

For safety reasons or to avoid the potential for gear loss, commercial fishing vessels could be excluded from project areas that may have previously been within normal fishing grounds. Such exclusions could remain in effect during the entire life of the project. However, as long as wave energy projects are not sited in areas containing unique and highly productive seafloor habitats, overall effects of such space-use conflicts on commercial fisheries would be negligible to moderate. Some areas of the OCS have an array of fishery zoning requirements already in place. Imposing additional restrictions in such areas could result in greater space-use conflicts. Displacement from existing fishing areas could also result in increased fishing pressure in surrounding areas.

Because recreational fishing vessels are typically smaller and because recreational anglers use gear that is less prone to entanglement, less likely to damage underwater components, and/or less expensive to replace, recreational fishing may be possible within project areas depending on the design and spacing of the individual energy units. In fact, because the structures associated with the OCS wave energy facility would likely serve as artificial reefs and would attract species of pelagic and demersal fish that are popular with recreational anglers, project areas could become desirable recreational fishing areas.

Undersea transmission lines could result in entanglement hazards for some types of fishing gear. Assuming that there are some similarities in the entanglement hazards posed by buried pipelines and buried cables, it is expected that the presence of buried subsea cables would not typically interfere with the use of longlines, purse seines, drift nets (Continental Shelf Associates 2004), or beach seines. However, bottom trawls, such as those often used in the commercial groundfish industry, have a greater potential to become snagged on underwater components. Because crab or fish traps are not actively dragged across the bottom, these gears are less likely to be snagged on underwater components.

While compensation for loss or damage of commercial fishing gear attributable to offshore oil and gas operations may be available in some cases, the MMS cannot ensure that such reimbursements would occur under the proposed alternative energy program. Most space-use conflicts could likely be avoided by following existing navigation rules. To further address space-use conflicts, a stipulation for protection of fisheries has been implemented by the OCS oil and gas leasing program that requires lessees to review planned exploration and development activities with potentially affected fishing organizations and port authorities to prevent unreasonable fishing gear conflicts. Under this stipulation, there is also an ability to restrict lease-related uses if deemed necessary to prevent unreasonable conflicts with commercial fishing operations.

Placement of wave energy units in OCS waters would represent an additional navigation hazard. Because wave energy units do not typically extend far above the ocean surface, they would not be easily detectable, either visually or by radar. The addition of lights and/or radar reflectors would increase the ability to detect the units. The overall navigation hazard due to placement of OCS wave energy units over a large area is currently unclear. However, the risk of accidents could be reduced by ensuring that location details are supplied to regional fishing organizations and added to navigational charts.

There may be a possibility for small amounts of potentially hazardous materials (e.g., hydraulic fluids, transformer fluids, or lubricating oils) to be released if containment systems in components were to fail. However, the quantity of substances that could be released by such an event would be small (<50 bbl) and would be diluted and dispersed by local currents. The resulting environmental concentrations would not be expected to substantially affect water quality (see Section 5.3.4) or fishery resources. Depending upon the nature of the materials and the locations of a facility, there is a potential for small areas to be closed to fishery activities until the released materials disperse. Given the small volume of materials expected to be present at the site, the time required for dispersion would likely be short and impacts to commercial or recreational fisheries from such releases would be negligible.

The small increase in vessel activity that would occur during the operational phase would not be expected to measurably affect commercial or recreational fishing opportunities, catchability of fish and shellfish resources, or navigation. Fuel spills that occur as a result of vessel accidents or leaks could temporarily close affected areas to fishing. However, the likelihood of such spills is relatively low because of the small number of trips that would be required for maintenance activities. If spills occurred, the volume of fuel that could be spilled would probably be small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Impacts to fish resources or commercial or recreational fisheries would be negligible.

5.3.23.5 Decommissioning

Decommissioning activities would include the dismantling and removal of wave energy generation units, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Platforms (if needed) would be removed by cutting pilings at a depth of approximately 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, there could be some localized effects on fishery resources (Section 6.3.12), especially if explosives were needed to remove pilings. Removal of structures that act as artificial reefs would result in loss of recreational fishing opportunities that had developed during the operational phase (Section 5.3.23.4). There is also a small potential for accidental releases of hazardous materials and fuel during decommissioning activities.

Some decommissioning activities have a potential to result in space-use conflicts with commercial and recreational fishing activities. To avoid the potential for gear loss or vessel accidents, fishing activities could be temporarily excluded during removal activities from areas that might be normal fishing grounds. Anglers could also feel compelled to avoid areas near decommissioning activities because of perceived disturbances to fishery resources. Such conflicts could potentially be avoided by conducting activities during closed fishing periods or seasons. Most space-use conflicts are easily avoided by following existing navigation rules. To further address space-use conflicts, a requirement for lessees to review planned activities with potentially affected fishing organizations and port authorities could likely prevent unreasonable fishing gear conflicts.

The increase in vessel activity that would occur during the decommissioning phase would not be expected to measurably affect commercial or recreational fishing opportunities, catchability of fish and shellfish resources, or navigation. Fuel spills that occur as a result of vessel accidents or leaks could temporarily close affected areas to fishing. However, the likelihood of such spills is relatively low because of the small number of trips that would be required. If spills occurred, the volume of fuel that could be spilled would probably be small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Impacts to fish resources or commercial or recreational fisheries would be negligible.

Assuming that all infrastructure was removed and that all pilings and entanglement hazards associated with development of the project were cut off below the level of the seabed or buried, fishing conditions within the project area should return to those that existed prior to construction.

5.3.23.6 Mitigation Measures

- Avoid locating OCS energy generation facilities and cables near known sensitive fish habitats and within known high-use fishing areas.

- Require lessees to review planned activities with potentially affected fishing organizations and port authorities to prevent unreasonable fishing gear conflicts.

- When possible, conduct noise-generating activities during closed fishing periods or seasons.

- Consider the addition of lights and/or radar reflectors to increase the ability of vessel captains to detect and avoid OCS energy structures.

- Ensure that locations of energy projects are supplied to regional fishing organizations and are added to navigational charts.

- Utilize practices and follow operating procedures that reduce the likelihood of vessel accidents and fuel spills.

- Where possible, bury cables to prevent conflicts with fishing gear.

5.3.24 Nonroutine Conditions

As discussed for wind energy in Section 5.2.24, there is the potential for the occurrence of nonroutine conditions that could cause impacts to human health and the environment during all phases of wave energy development on the OCS. The primary hazards common to all project phases are: (1) industrial hazards, (2) collisions between marine vessels and either components of the wave energy facility or vessels constructing, servicing, or maintaining the facility, (3) natural events, such as hurricanes and earthquakes, and (4) sabotage or terrorism events.

For any activity or facility, the *risk* posed by a nonroutine event depends on two factors: the probability (or expected frequency) of the event occurring and the consequences if the event did occur. Event probabilities can range from very rare events, highly unlikely to occur during the lifetime of a facility, to relatively frequent events that might be expected to occur once or more during the lifetime of a facility. In many cases, nonroutine event probabilities can be estimated from historical statistical data for similar activities, facilities, or locations. The consequences of events could range from essentially no measurable or observable impacts to potentially severe impacts to human health or the environment. Quantifying the risk of nonroutine events requires that both factors be taken into account: likely events with relatively minor consequences might present a similar overall risk as highly unlikely or incredible events with much higher consequences.

Both the probability of nonroutine events occurring and the potential consequences if they did occur are project- and site-specific. Therefore, the risk posed by such events must be evaluated on a project-specific basis. As discussed in Section 3.3, wave energy technologies are in too early a stage of development to predict which technology or mix of technologies would be most prevalent in future commercialization. The current types of WEC technologies vary in size, anchoring method, spacing, interconnection, array patterns, and water depth limitations. Consequently, risks from nonroutine events are discussed in general terms in this section.

Industrial Hazards. The primary industrial hazard during the testing, characterization, construction, operation, and decommissioning of wave energy projects on the OCS is working on and/or over water. Working on or over water can pose a risk of drowning and requires the additional considerations of wind and weather and the availability of buoyancy devices and qualified boat and rescue personnel.

A further industrial hazard involves vessel entanglement with undersea gathering or transmission lines. Entanglement or catching undersea cables can occur during trawling and other net fishing, shellfishing on the seabed, or during anchoring. Attempting to lift a cable by a vessel can result in the capsizing of the vessel or in electrocution (Drew and Hopper 1996). Undersea cables are typically buried to minimize risks associated with entanglement as well as potential damage to the cable.

Industrial accidents could result in both worker injuries and fatalities. However, the risks from industrial hazards depend on the magnitude, location, and characteristics of the specific project, health and safety planning and training, and adherence to established regulations and safety and accident prevention and control measures. Under authority established in the Outer Continental Shelf Lands Act (OCSLA) and pursuant to a memorandum of understanding (MOU) between the two agencies, the MMS and USCG regulate safety on fixed OCS facilities. The MMS regulates the structural integrity of fixed OCS facilities, and the USCG regulates marine systems, such as lifesaving, navigation equipment, and workplace safety and health. In February 2002, the USCG issued a final regulation that authorized the MMS to perform inspections on fixed facilities engaged in OCS activities on their behalf, and to enforce USCG regulations applicable to those facilities (67 FR 5911-5916; February 7, 2002 [revising 33 CFR 140.103(c)]). The OCSLA also requires that the MMS and the USCG investigate major accidents, deaths, serious injuries, major fires, and major spillages, as well as lesser accidents.

Collisions. A wave energy facility located on the OCS could potentially cause a navigational risk to marine vessels. Applicants for offshore energy facility permits are required to perform an evaluation of all reasonably foreseeable issues related to navigation as set forth in guidelines published by the Coast Guard (USCG 2007). Collisions between marine vessels and wave energy facility components could be caused by human error (such as navigation errors), weather, or mechanical failures onboard ships that cause either a steering failure or loss of power (resulting in a drifting collision). Collisions between marine vessels and either components of a wave energy facility or vessels used in constructing, servicing, or maintaining the facility could have economic, safety, and environmental consequences. A collision between a ship and a wave energy device could result in production loss from a single device or the entire facility as well as loss of life and spills of hazardous materials.

As discussed above, the risk posed by collisions depends on the probability of a collision occurring and the consequences if a collision does occur. Both of these factors are project- and site-specific. The probability of collisions between marine vessels and components of a wave energy facility depends in part on (1) physical characteristics of the facility itself, such as the type and number of devices, the geometry of the devices, and the spacing between devices, (2) the location of the facility in relation to commercial shipping lanes or recreational marine traffic, and (3) environmental conditions at the facility location, such as wind velocities and direction, currents, water depths, ice, and visibility. The consequences of a collision also depend on project-specific characteristics, including the design of the wave energy devices as well as the distribution of ship types and sizes in the vicinity of the facility. Therefore, the risk posed by collisions must be evaluated on a project-specific basis.

During a collision, spills to the environment can occur from both the striking marine vessel as well as the object struck. The potential types and quantities of hazardous materials that might be present at a wave energy facility are summarized in Table 4.2.6-1. Considering the quantities of hazardous materials reported in Table 4.2.6-1, it is likely that any single spill from a wave energy facility would be small. The amount of hazardous material, such as diesel fuel, that could be released by a marine vessel involved in a collision would depend on the type of vessel and severity of the collision. As indicated by the Gulf of Mexico data for collisions with oil and gas platforms (see Section 6.5.2), releases on the order of 10,000 gal are possible.

It should be noted that collisions between marine vessels and wave energy devices might be less severe than those discussed in Section 5.2.24 for wind facilities and in Section 6.5.2 for alternative use of existing oil and gas platforms. Both wind turbines and oil and gas platforms utilize rigid foundations and structures (i.e., monopiles) anchored in the seafloor that protrude above the surface of the water. Such structures are generally unyielding and can cause significant damage to vessels striking them. On the other hand, many of the wave energy technologies utilize floating components anchored to the seafloor with a system of mooring cables. The fact that such devices are able to move during a collision may reduce the severity of the collision and limit damage to the striking vessel and the device itself.

Natural Events. There is a potential for natural events to cause impacts to human health and the environment during all phases of wave energy development on the OCS. Such events include hurricanes, earthquakes, tsunamis, and severe storms. Depending on the severity of the event, components of a wave energy facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. Moreover, marine vessels used in constructing, servicing, or maintaining the facility could also be impacted, potentially resulting in loss of life and the release of hazardous materials (e.g., diesel fuel) to the environment. The potential types and quantities of hazardous materials that would be present at a wave energy project site and potentially could be released to the environment during a natural event were discussed above for collisions.

The probability of a natural event occurring is location-specific and differs among the three OCS regions considered. For example, hurricanes are much more likely to occur in the Gulf of Mexico and Atlantic regions than in the Pacific region. Conversely, earthquakes and the tsunamis that undersea earthquakes can cause are much more likely to occur in the Pacific region. Such differences should be taken into account during project-specific studies and reviews.

Sabotage or Terrorism. In addition to the events described above, there is a potential for intentional destructive acts, such as sabotage or terrorism events, to cause impacts to human health and the environment. As opposed to industrial hazards, collisions, and natural events, where it is possible to estimate event probabilities based on historical statistical data and information, it is not possible to accurately estimate the probability of a malevolent act. Consequently, discussion of the risks from sabotage or terrorist events generally focuses on the consequences of such events.

In general, the consequences of a sabotage or terrorist attack on a wave energy facility would be expected to be similar to those discussed above for collisions and natural events. Depending on the severity of the event, components of the facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. Moreover, marine vessels used in constructing, servicing, or maintaining the facility could also be impacted, potentially resulting in loss of life and the release of hazardous materials (e.g., diesel fuel) to the environment. The potential types and quantities of hazardous materials that would be present at a wave energy project site and potentially could be released to the environment were discussed above for collisions. The potential consequences of such events need to be evaluated on a project- and site-specific basis.

5.3.24.1 Technology Testing

As discussed in Section 3.5.1, wave technologies are less advanced than wind technologies, and proposals to test and demonstrate various forms of these technologies in the OCS can be expected in the next 5 to 7 years. A demonstration-scale test for these technologies would most likely involve the deployment of one or two devices per test—with or without an undersea transmission connection to the shore. Although the risks would depend on the specific characteristics of the testing project, the expected limited extent of such activities would likely result in minor to negligible impacts to human health and the environment from nonroutine events.

5.3.24.2 Site Characterization

As discussed in Section 3.5.2, for wave energy technologies, wave site characterization data may be obtained from existing weather buoys. Site characterization might also involve geological and geophysical testing of the sea bottom to determine the strength and stability of substrata for the drilling and installation of anchoring devices. As described in Section 3.5.2, most seafloor characterization technologies would either involve the towing of sensors above the seafloor or the sampling of seafloor sediments. Although the risks would depend on the specific characterization project, the expected limited extent of such activities would likely result in minor to negligible impacts to human health and the environment from nonroutine events.

5.3.24.3 Construction

Construction of a wave energy facility may require the use of barges or special purpose vessels to install mooring systems. The devices themselves would likely be constructed onshore and towed into place within the facility. The risk to human health and the environment from nonroutine events would depend on the characteristics of the specific construction project. However, given the relatively limited amounts of hazardous materials expected to be present during construction, and assuming adherence to applicable occupational health and safety regulations, it is expected that impacts during construction would be negligible to minor.

5.3.24.4 Operation

The primary nonroutine event risk during operation of a wave energy facility is related to marine vessel collisions with the devices. As discussed above, the risk and consequences of collisions are site- and project-specific. Consequently, it is not possible to assign a generic level of significance to risks and impacts. However, with proper planning and mitigation, it is expected that risks could be maintained at negligible to minor levels.

5.3.24.5 Decommissioning

Nonroutine event risks during decommissioning are expected to be similar to those discussed for construction in Section 5.3.24.3.

5.3.24.6 Mitigation Measures

A number of mitigation measures are expected to be employed to minimize nonroutine event risks during wave energy development on the OCS. The primary mitigation measures would be aimed at minimizing the risk of vessel collisions with facility components. Wave energy facilities on the OCS would be noted on updated navigational charts for mariners. Moreover, the components would be outfitted with navigational aids, such as lighting and sound signals (e.g., fog horns).

To ensure that mitigation measures are taken into account during OCS alternative energy projects, the developers of specific projects are required to conduct a navigational safety and risk assessment during the application process (USCG 2007). Among other items, the assessment must include a maritime traffic survey and an evaluation of collision risk (including likely frequencies and consequences of collisions). In addition, the developer must identify potential measures that could be implemented to mitigate any increased risks associated with the proposed project. The assessment must be submitted to the Coast Guard. The Coast Guard reviews the assessment to determine potential impacts of the proposed facility on the safety of navigation and other Coast Guard missions, such as marine environmental protection, search and rescue, aids to navigation, and maritime security.

In addition, vessels are generally expected to operate under the International Regulations for Preventing Collisions at Sea 1972. These rules require all vessels to duly regard all dangers of navigation and collision and specify that mariners are responsible for safe operation of their vessels, regardless of the navigational situation.

5.4 OCEAN CURRENT ENERGY DEVELOPMENT ON THE OCS

The extraction of energy from ocean currents requires a location that has strong, steady currents. As discussed in Sections 4.2.3, 4.3.3, and 4.4.3, the only applicable ocean current on the OCS that has these characteristics is the Florida Current, located off the eastern coast of North America. Discussions presented in this section will, therefore, be limited to impacts associated with the geographic area of the Florida Current.

5.4.1 Ocean Surface and Sediments

This evaluation considers both project impacts to and the hazards posed by particular geologic features and processes. Potential impacts include acceleration of geologic processes (e.g., erosion or mass movement on the seafloor), alteration of seafloor topography, changes in sediment transport along the coast,[16] and interference with the recovery of mineral resources. Locating the ocean current facility on the basis of site-specific studies that would: characterize the seafloor (Section 3.5.2); identify known areas of mineral resources (e.g., oil and natural gas reserves) and any existing plans for their recovery; and assess wave and current baseline conditions, as would be done during a project-level EIS, would minimize these impacts.

Potential hazards are associated with the scouring action of ocean currents and seafloor instability that can undermine foundation structures and undersea transmission cables and lead to failure (as described in Sections 4.2.1.5, 4.3.1.5, and 4.4.1.5). Submerged structures on the seafloor increase wave turbulence, causing localized erosion of bottom sediments (scouring) in the immediate vicinity of the structures. Scouring can also be expected to occur on a larger scale

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16 Changes in sediment transport along the coast are important potential impacts to consider when developing technologies offshore. When waves hit the coastline at an angle, they create a longshore current (also called littoral drift) that, on a regional scale, transports sediment from updrift coastal areas to downdrift coastal areas. In an evolved littoral system, an equilibrium is established between the processes of erosion and deposition—the result is that beaches, which lose sediment (sand) to downdrift coastal areas via the longshore current are also nourished by new sediment (sand) from updrift coastal areas via the same longshore current. When these processes are interrupted, either by activities offshore (which reduce wave energy) or by structures like jetties along the shoreline (which capture littoral sediment), deposition becomes the dominant process. The effect of increased deposition in one coastal area, however, usually results in accelerated erosion in downdrift coastal areas.

in the areas between multiple structures. It is important to note that the changes to seafloor topography caused by scouring can affect the wave climate, leading to potential impacts to sediment transport processes along the coast. While proper siting of the ocean current facility can eliminate or minimize the hazards associated with the reduced load-bearing capacity of water-saturated and gaseous sediments, bottom sediments of variable density, and irregular topography, the risk of seafloor collapse and subsidence triggered by episodic geological and meteorological events (earthquakes, tsunamis, and storm surges) would remain.

5.4.1.1 Technology Testing

Potential Impacts. Ocean current technologies are less advanced than wind technologies; however, proposals to test and demonstrate various forms of these technologies on the OCS can be expected in the next 5 to 7 years. Technologies appropriate for OCS applications include submerged turbines that are similar in function to wind turbines, with either horizontal or vertical axes of rotation, as described in Section 3.4. Submerged turbines capture energy through the process of hydrodynamic, rather than aerodynamic, lift or drag, as described in Section 3.4.

A demonstration-scale test would most likely involve the deployment of one or two devices per test, fixed in place, with or without an undersea transmission connection to shore. Installation may be conducted using barges or specialized installation equipment for larger structures such as overtopping devices. The demonstration units may also test various mooring technologies.

Testing activities would occur within a shorter time period and on a much smaller scale than construction, operation, and decommissioning of the full-scale projects that are addressed in Sections 5.4.1.3 through 5.4.1.5. The primary activity with the potential to adversely affect geologic features and processes on the seafloor would be the mooring technology used. Depending on the particular ocean current technology, moorings may consist of steel monopiles, multilegged support systems, concrete anchors, or slack mooring systems.

Impacts to geologic features and processes would be minimized through the careful siting of the mooring system on the basis of data collected to characterize the seafloor in the area of interest. Impacts to coastal sediment transport processes would likely be negligible since the test unit would be relatively small and located some distance offshore.

Geohazards. The components of an ocean current test facility most vulnerable to geohazards on the OCS are the mooring systems and the undersea transmission cables between the facility and shore. The mooring structures are at greatest risk of adverse impacts associated with seafloor instability since they are drilled into the seabed. These structures would be most impacted by sediment characteristics affecting load capacity, displacement caused by earthquakes, and slope failure (slumping and mudslides). They are also vulnerable to the scouring action of ocean currents, which can undermine structures and cause failure.

5.4.1.2 Site Characterization

Before a technology is installed, site-specific characterization would be conducted to collect data on ocean-bottom characteristics and unidentified hazards, potential environmental impacts, potential archaeological impacts, and possible conflicting uses before commercial development. Activities associated with site characterization, described in Section 3.5.2, may include:

- A deep-tow, side-scan sonar survey to locate shallow hazards, cultural resources, and hard-bottom areas;
- Digital depth sounding to obtain water depth measurements;
- "Boomer" sub-bottom and GeoStar full-spectrum CHIRP profiling systems to develop a geologic cross section;
- Bottom sampling, Vibracore shallow sampling, and deep boring to obtain physical and chemical data on surface and subsurface sediments; and
- Magnetic surveys to locate buried pipelines, archaeological items, waste dumps, and other metallic debris.

These activities would assist in identifying the most appropriate site for construction to minimize potential environmental impacts and the hazards associated with seafloor instability (for foundation structures and undersea transmission cables). Impacts to geologic features and processes associated with these activities are expected to be negligible since they mainly involve remote studies that would be of short duration and would not disturb the seafloor. Bottom sampling, Vibracore sampling, and deep boring would result in some disturbance to the seafloor. However, once the activity is completed, recovery would occur at a rate proportional to the rate of sedimentation in the area of interest. Sampling would be avoided in areas prone to intense scouring or mass movement (as determined by remote surveys).

5.4.1.3 Construction

Potential Impacts. The primary activity with the potential to adversely affect geologic features and processes on the seafloor or interfere with the recovery of mineral resources would be the construction of the mooring systems for the submerged turbines. Depending on the particular wave technology, moorings may consist of steel monopiles, multilegged support systems, concrete anchors, or slack mooring systems. Site preparation would mainly involve the removal of boulders. A scour protection system, consisting of boulder mounds, cement bags, or seagrass mattresses may be needed for these structures. The area of ocean-bottom disturbance would depend on the number of turbines within the facility and the mooring systems employed.

Impacts to geologic features and processes would be minimized through the careful siting of the mooring system on the basis of data collected to characterize the seafloor in the area of interest. Impacts to coastal sediment transport processes would likely be negligible since the facility would be located some distance offshore. Impacts to coastal processes would need to be assessed on a project-specific basis taking into account the size and location of the ocean current facility, and the wave energy and predominant wave direction in the area of interest.

Geohazards. The components of an ocean current energy facility most vulnerable to geohazards on the OCS are the mooring systems and the undersea transmission cables between the facility and shore. The mooring structures are at greatest risk of adverse impacts associated with seafloor instability since they are driven into or rest on top of the seabed. These structures would be most impacted by sediment characteristics affecting load capacity, displacement caused by earthquakes, and slope failure (slumping and mudslides). They are also vulnerable to the scouring action of ocean currents, which can undermine structures and cause failure.

Undersea transmission cables used to deliver power from the facility to shore would be most impacted by displacement caused by earthquakes and slope failure.

5.4.1.4 Operation

Potential Impacts. Routine operations of ocean current facilities would generally not require offshore personnel. Control and monitoring of submerged turbines and transformers would be done remotely by using fiber-optic cables or other communication devices. However, periodic maintenance and inspection would be required. For ocean current technologies, operational activities may include conditions monitoring, reliability monitoring, structural monitoring, and repair. Offshore systems may need to be returned periodically to shore for maintenance or replacement.

Project impacts to geologic features and processes during the operational phase of an ocean current facility are expected to be negligible since operations would not involve seafloor-disturbing activities. Impacts to coastal sediment transport processes would likely be negligible since the facility would be located some distance offshore. Impacts to coastal processes would need to be assessed on a project-specific basis taking into account the size and location of the ocean current facility, and the wave energy and predominant wave direction in the area of interest.

Geohazards. Once an ocean current energy facility is operational, project impacts and the risk of impacts due to seafloor instability are assumed to be minimal, since the facility site would have been chosen to avoid or minimize such hazards. Scouring action by ocean currents would be an ongoing hazard, especially in areas where ocean current energy is high.

5.4.1.5 Decommissioning

During decommissioning, the ocean current facility and its mooring and scour protection systems would be removed and transported to shore. The facility would be dismantled in the same manner that it was assembled with similar equipment, only in reverse. During these activities, the facility would encounter the same project impacts (mainly due to seafloor disturbance) and risk of geological and meteorological events as would be present during the facility's construction.

5.4.1.6 Mitigation Measures

Seafloor mapping conducted in the early phases of a project would help to ensure that the ocean current technology facility is sited appropriately to avoid or minimize potential impacts and the hazards associated with seafloor instability. Therefore, adverse impacts to geologic features and processes on the seafloor during technology testing, site characterization, operation, and decommissioning would likely be negligible.

Scouring action by ocean currents around mooring structures could be mitigated by using scour protection devices and employing periodic routine inspections to ensure structure integrity. Because hard scour-protection devices such as rip-rap can increase erosion over time, softer approaches, such as natural, softer materials or sediment nourishment, would also be considered as mitigating measures. Controlling scouring effects would also minimize changes to seafloor topography that could ultimately impact sediment transport processes along the coast. Hazards to underwater cables could be mitigated by building cable systems with sufficient slack to reduce the risk of breakage due to increased tension caused by irregular topography or seafloor displacement as a result of mass movement or faulting.

5.4.2 Air Quality

The nature and magnitude of potential impacts on ambient air quality associated with offshore ocean current energy development depend on many factors, such as location, scope and scale of project, type and capacity of equipment, and schedule of each project phase. No detailed information on these site- and project-specific factors is available at the programmatic level for this EIS. Thus, no emission estimates were made and no air quality modeling was done. Most analysis evaluates potential impacts in a qualitative manner.

5.4.2.1 Technology Testing

Ocean current technologies are less advanced than wind technologies, and proposals to test and demonstrate various forms of these technologies on the OCS can be expected in the next 5 to 7 years. A demonstration-scale test for these technologies would most likely involve the deployment of one or two devices per test—with or without an underwater transmission connection to the shore. Depending on the size of the individual unit, the devices could be towed to their offshore locations or could be shipped by barge or special-purpose vessel, and installation may be conducted either barges or specialized installation equipment. The demonstration units may also test various mooring technologies.

These activities would occur over a shorter time period and on a much smaller scale than construction, operation, and decommissioning, which are described in Sections 5.4.2.3 to 5.4.2.5. Associated with these activities, primary emission sources would be engine exhaust from vessel traffic (e.g., boat or barge) and heavy equipment (e.g., pile driver). In general, these engines, which mostly burn diesel fuel, emit most of the criteria pollutants, including primarily nitrogen oxides (NO_x) and carbon monoxide (CO), lesser amounts of volatile organic compounds (VOCs) and PM_{10} (mostly in the form of $PM_{2.5}$), and negligible amounts of sulfur oxides (SO_x). These emissions would occur in all phases of OCS projects in common, although differences in levels of activities exist between phases.

Source emissions during technology testing phase would be small in absolute terms but measurable, intermittent, and temporary in nature. Accordingly, potential impacts of technology testing activities on ambient air quality would be minor.

5.4.2.2 Site Characterization

Information on the sea bottom for anchoring and cable installation can be collected using a multibeam echosounder and acoustic backscatter devices to develop a three-dimensional image of the seafloor. Grab sampling and/or gravity coring in the vicinity of the anchors and transmission lines would likely be used for identifying the seafloor composition. Benthic surveys may include side-scan sonar, side-mounted video camera; seafloor-mounted acoustic Doppler current profiler (ADCPs); and remotely operated vehicles. These activities would take several weeks at most.

During the site characterization period, emission sources would include engine exhaust mostly from the vessels (boats or barges) conducting these surveys.[17] Minor activity levels would last several weeks and, thus, potential air emissions during site characterization would be low level. Accordingly, potential impacts on ambient air quality impacts would be minor and of short duration and intermittent in nature (several weeks at most).

5.4.2.3 Construction

Within the time frame of this programmatic EIS (5 to 7 years), the project would likely use existing docks, piers, and other port infrastructure, and thus new construction of such features would be minimal. However, onshore activities such as construction of substations, cable landings, and other onshore facilities to support the OCS facility would nevertheless occur within the planning horizon. In general, onshore and offshore construction activities would

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17 All vessels that are used during the site characterization phase are expected to be diesel powered.

generate the highest air emissions in the life of an ocean current project and thus produce the greatest air impacts.

Onshore construction activities could include site preparation of staging and component assembly areas, construction of remote control/monitoring buildings, construction of power management/distribution facilities (e.g., substations, individual transformers, cable landings), transport of materials to the location via truck, and transport of the construction workforce to and from the construction site from residences expected to be in the local area. Other onshore construction activities might address power transmission-related needs, such as installing new conduits, substations, and overhead transmission lines (connecting the OCS facility to the existing electrical grid). Vehicles (which may include small boats or barges) and equipment used in onshore construction would burn either gasoline or ultra low sulfur diesel fuel.

The largest air emission sources during onshore construction activities would likely be from fugitive dust from heavy equipment operation and vehicular traffic on bare soil surfaces and paved/unpaved roads (e.g., bulldozer, truck) and from wind erosion. Smaller emission sources would include diesel engine exhaust from heavy equipment and vehicular traffic (e.g., bulldozer, truck, boat, barge, crane, generator).

In general, the highest emissions would be anticipated during site preparation (the earliest phase of construction), which would include clearing, excavation, backfilling, and grading for access roads, staging areas, and transmission-related facilities. Expansion of port facilities may also be required. Still, these emission levels would be no higher than those for typical land-based construction activities of similar types and scales (e.g., commercial building construction). Fugitive dust emissions could temporarily impact ambient air quality because of near-ground-level release and no buoyancy and thus could contribute to an exceedance of Federal or State ambient air quality standards at the nearest property line. These impacts could range from minor to moderate for short durations. However, potential air quality impacts from engine exhaust emissions[18] would not be expected to contribute to exceedances of air quality standards and would be minor.

Offshore construction activities would involve vessel traffic (boat or barge) from port to the project site, and would include installation of anchoring devices, energy conversion devices, transformer/service platforms, and underwater cables with the use of the highly specialized equipment (e.g., cable-laying ship). Large components of ocean current devices can be ferried to the project site and may require additional assembly once at their offshore locations. Offshore impacts result from the operation of motive engines of construction, equipment, and crew vessels and from ICEs in equipment present on some vessels (e.g., generators, cranes, air compressors). All such ICEs would likely use ultra-low-sulfur diesel fuel; however, larger vessels may use bunker fuel (with substantially higher sulfur content) for motive engines. Offshore air impacts would also result from the transport of the construction crew to and from the offshore location and transport of additional components to the offshore location. Overall air impacts would depend on the number and types of equipment and vessels in use and the time frame of the construction phase.

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18 All internal combustion engines used in onshore construction are expected to be diesel or gasoline powered.

Air emissions from offshore construction activities (mostly from diesel-powered engine exhaust and probably bunker fuel-burning larger construction vessels) could be transported to onshore communities during the daytime sea breeze. However, such emissions would be small compared with onshore emissions in coastal metropolitan areas and would be transported over some distance with relatively high winds (compared with the nighttime land breeze) and with relatively high daytime mixing heights of typically 500 to 1,000 m (1,640 to 3,280 ft). Accordingly, potential impacts of these offshore activities on ambient air quality would be typically minor. However, greater impacts to air quality could be anticipated, depending on the number of individual vessels and pieces of equipment and scheduling of construction activities that would allow all such equipment to be operating simultaneously.

Under certain conditions, it is possible for OCS emissions to contribute to or exacerbate an exceedance episode in areas plagued by high ozone levels, although such contributions would be minor and probably produce undetectable impacts. As an example, the nighttime land breeze combined with aged onshore polluted air masses and OCS sources concentrates ozone precursors (NO_x and VOCs) offshore during the night and early morning, and these polluted air masses can then be transported back onshore and contribute, along with fresh emissions, to mid-afternoon peak ozone episodes (SAI et al. 1995).

Activities associated with current energy development are limited to off the coast of lower Florida. Exceeding 4% of the Prevention of Significant Deterioration (PSD) increment of sulfur dioxide (SO_2) at a nearby Class I area such as Everglade National Park is also significant and quite plausible, in particular when bunker fuel is used in the larger construction vessels.

5.4.2.4 Operation

Routine operations of OCS ocean current energy generation facilities would generally not require offshore personnel. Control and monitoring of devices and transformers would be done remotely with fiber-optic cables or other communication devices. However, periodic maintenance and inspection would be required. For ocean current technologies, operational activities can include conditions monitoring, reliability management, structural monitoring, and repair. Offshore systems may need to be returned periodically to shore for maintenance or replacement.

Essentially, no air emissions associated with the actual operation of ocean current facilities would be expected. Minimal amounts of criteria pollutants may be emitted during testing and (if necessary) operation of the backup diesel generator on the offshore electric service platforms (ESPs).[19] (The generator would provide power for aviation and boat navigation lights in the event of a grid power failure.) Other minor air emissions during operation would be from vessel traffic related to infrequent site inspection and maintenance/repair activities. Ocean

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19 Diesel emergency generators can also be expected to be enrolled in a preventive maintenance program. In a typical preventive maintenance program, generators are run once each month for periods of 30 min to 1 h to ensure the proper performance of both the engine and the power generation equipment.

current operations would generate minor air emissions and, therefore, potential impacts on ambient air quality would be anticipated to be also minor.

5.4.2.5 Decommissioning

Decommissioning would occur at the end of the operating life of an offshore ocean current project (currently an unknown length of time). Decommissioning entails dismantling of the devices, ESP, and foundations or moorings; removal of associated scour protection structures; and subsequent transportation of these materials to shore for reuse or recycling. The devices would be dismantled in the reverse manner in which they were assembled, with similar equipment. However, dismantlement is expected to take less time than initial construction.

Accordingly, types of activities for decommissioning would be similar to those for construction but of lower activity level and shorter duration. Also, some structures may be left in place to be converted for other uses. In all, potential air quality impacts from decommissioning activities would be less than those from construction and would be anticipated to be minor.

5.4.2.6 Mitigation Measures

As discussed above, adverse potential air quality impacts during technology testing, site characterization, and operation phases would be minor. The greatest potential impacts among the project activities would be from fugitive dust emissions from earthmoving activities and vehicle traffic during construction and decommissioning phases. Generation of fugitive dust would be regulated both through the permitting process and the application of mitigation measures, where applicable.

Albeit of short duration, onshore site preparation activities could generate considerable amounts of fugitive dust emissions and impact neighboring communities and possibly cause Federal or State ambient air quality standards to be exceeded when added to existing sources. Accordingly, these activities would be conducted to minimize potential impacts on ambient air quality. For example, fugitive dust would be controlled by standard dust control practices for construction, primarily by watering unpaved roads, disturbed surfaces, and temporary stockpiles, or by suspending certain dust-generating activities during high-wind periods. On windy or dry days, more frequent application of water spraying would be exercised to ensure continuous fugitive dust control.

Other general mitigative measures would include proper maintenance of heavy equipment (e.g., bulldozer, crane) and onshore vehicles (e.g., trucks) and offshore vessels (e.g., boat or barge) to minimize air emissions of diesel-powered engines.

The use of low-sulfur fuel (diesel or bunker fuel), especially for operations within 100 km (62 mi) of Class I areas, would reduce potential SO_2 impacts to those areas. During the ozone season, NO_x control in ozone nonattainment areas (e.g., including low NO_x fuel, power management operations, retarding engine firing, catalytic converters, turbo-chargers/after-coolers), would reduce potential impacts from ozone. Timing source emissions to occur during nonpeak ozone periods would be an option. Use of offsets or emission credits in nonattainment and maintenance areas could reduce potential impacts from several pollutants.

5.4.3 Ocean Currents and Movements

5.4.3.1 Technology Testing

Ocean current energy is at an early stage of development, with only a small number of prototypes and demonstration units having been tested to date (see Section 3.4). Some of these technologies have been developed for use with tidal currents in nearshore environments; however, these nearshore tidal current energy technologies are not evaluated in this EIS. Technology testing for a current energy extraction system could produce a very slight reduction in current energy because of structural drag, and a decrease in wave height in the vicinity of any support structures caused by wave interception. Because of the small scale of associated testing equipment, impacts would be negligible, temporary, and very difficult to measure outside of the immediate area of the test equipment.

5.4.3.2 Site Characterization

The principal consideration for site selection for a current energy facility is locating an area of strong, steady currents. Such conditions are found only in the region of the Florida Current. As with technology testing, site characterization could produce a very slight reduction in current energy because of structural drag, and a decrease in wave height in the vicinity of any support structures caused by wave interception. Because of the small scale of associated characterization equipment, impacts would be negligible, temporary, and very difficult to measure outside of the immediate area of the equipment.

5.4.3.3 Construction

Construction of a current energy facility could use fixed bottom supports in shallow waters of the OCS or floating platforms in deeper waters. Installation activities associated with either form of support would not have any measurable impacts on ocean currents or waves, except in the immediate vicinity of the support. Potential impacts include a decrease in wave height as waves intercept the support and an exceedingly small decrease in current energy produced by support structure drag. Such impacts would be very local, temporary, and not measurable outside the area of the support.

5.4.3.4 Operation

Potential impacts of operating a current energy facility on physical oceanographic resources include a reduction in current energy and velocity, and a potential reduction in wave height in the vicinity of the structures. The magnitude of the loss of current energy and the resulting reduction in current velocity would depend on the technology chosen, the specific system design, and spacing employed. Impacts to the current's energy could affect temperature of the water, aquatic organisms, interactions with estuaries, inlets, bays, and other near shore waters, and weather patterns. Previous studies performed and reported in 1974 (von Arx et al. 1974) indicated that a honeycomb of turbines producing 1,000 MW of continuous power from the Florida Current would extract about 4% of its total kinetic energy (25,000 MW). Significantly larger amounts of continuously extracted energy were reported to have a potential to seriously disrupt climatic conditions to the north and east, particularly in Europe. The magnitude of the effects produced by this type of technology would depend on the type of system used and its design, its location, the number and locations of similar systems in operation (i.e., potential cumulative impacts produced by more than one operational unit extracting energy from the same current), current characteristics, and climatic conditions. These impacts and their associated uncertainties would be quantified in appropriate, site-specific EISs.

Reductions in wave heights derived from interception with associated structures would be expected to be small and localized. Such impacts would rapidly dissipate within a few kilometers (roughly, 1 to 2 mi) of the facility, but slightly lessen wave heights in the vicinity of the structure.

5.4.3.5 Decommissioning

Decommissioning and removing structures of a current energy facility would increase wave height and current energy and velocity in the vicinity of the removed structures. For similar pre- and post-project conditions, decommissioning and removal of associated structures would return the system to its original condition.

5.4.3.6 Mitigation Measures

Because construction and decommissioning activities associated with current energy generation would have no measurable impacts on currents or waves outside of the immediate vicinity of associated structures, no mitigation measures would be required. In the case of normal operations, extraction of ocean current energy could adversely affect water quality (i.e., water temperature), aquatic organisms, interactions with estuaries, inlets, bays, and other nearshore waters, and weather patterns. The magnitude of the impacts would be quantified in appropriate, site-specific EISs, as would potential mitigation measures. Such measures could include limiting the size of the facility, limiting the quantity of energy extracted from the current, maximizing the efficiency of the extraction system, and limiting the number of similar facilities that could extract energy from the same current system.

5.4.4 Water Quality

5.4.4.1 Technology Testing

Testing of existing or new ocean current energy technologies at a demonstration scale would have very minimal impact on water quality. Small numbers of ocean current energy units would be deployed for days to months to determine their effectiveness. The impacts are the same as those described in Sections 5.4.4.3 and 5.4.4.4, but on a much smaller scale.

5.4.4.2 Site Characterization

Applicants may be required to characterize the seafloor sediments and marine life in the vicinity of the proposed project. Sediment sampling and ecological monitoring would cause temporary disturbance of the seafloor and introduction of sediment into the water column. Ocean currents can be characterized by ADCPs (Elcock 2006).

Site characterization would necessitate the use of work boats and ships. The process of operating vessels on the OCS can contribute small amounts of fuel or oil to the water column through bilge discharges or leaks, although this should be minimal. The process of anchoring the vessels and anchor removal would cause intermittent disturbance of the seafloor with movement of sediment into the water column. Vessels are expected to comply with U.S. Coast Guard (USCG) requirements relating to prevention and control of oil spills.

The nature of water quality impacts anticipated during the site characterization phase should be negligible or minor.

5.4.4.3 Construction

The types of water quality impacts anticipated during the construction phase are similar to those described for the site characterization phase. The locations selected for current energy devices are likely to be those that experience regular high-velocity currents. Because the construction phase would involve more vessels for longer periods of time than the site characterization phase, there would be a potential for larger or more frequent releases of oil or other chemicals found on the vessels through bilge discharges, leaks, or oil spills.

Current energy devices can be attached to a series of anchors or can be installed in a permanent foundation and tower. If anchors are employed, sediment would be temporarily disturbed during installation of anchoring structures and the electrical cables to transmit power to shore. This is expected to have only localized and short-term impacts on water quality.

If foundations and towers are employed (EU 2005), the vessels would most likely be anchored for longer periods or use heavier anchoring structures to allow preparation and installation of the tower foundations, installation of the towers, and installation of the current energy devices in high-velocity areas. Construction of the foundation could release some sediment to the nearby seafloor, although the local high-current velocity should help to disperse the disturbed sediment rapidly.

Installation of the current energy devices could involve minor releases of lubricants, solvents, or other chemical products. Unless containers of materials were accidentally spilled, the quantities of these released through normal operation should be very small.

The nature of water quality impacts anticipated during the construction phase should be negligible or minor except in the event of a significant spill of oil or chemicals from a work vessel.

5.4.4.4 Operation

Once the current energy devices were in operation, they would have little direct water quality impact. Routine wastewater discharges are not anticipated, but if they did occur, they would be regulated under National Pollutant Discharge Elimination System (NPDES) permits.

For those facilities that employ towers, the tower structure may need periodic painting or other maintenance. Through maintenance activities, minor amounts of paint, solvent, lubricant, or other chemicals could enter the water column.

Most of the current energy structures would be submerged in saltwater. To protect the surface and minimize drag, most structures would be treated with antifouling coatings. Some of the current energy technology developers propose to use copper-based antifouling coatings similar to those used as bottom paint on recreational boats. Copper-based antifouling paints must be renewed each year or so.

There is some possibility for water quality impacts that are not directly related to current energy operations. Such impacts would be related to the presence of the structures in the sea. Current energy installations employing towers extending above the sea surface could present greater opportunity for collisions by vessels that attempt to navigate through the area. To reduce this potential impact, institutional controls may be applied to exclude commercial vessels from the area. If commercial vessels are allowed in the area and collisions occur, substantial releases of oil and other chemicals are possible (Devine Tarbell and Associates 2006).

Current energy devices utilizing anchoring systems should be located deep enough to avoid accidental collisions. However, the structures and their anchoring devices also can serve as attractants for marine life, which in turn attracts recreational fishermen to the area. Unless recreational vessels are excluded from the area, there is some potential for releases of oil, fuel, trash, and other material from the vessels.

Significant storm events could cause current energy devices to break loose from their moorings and either wash up onshore or break open, releasing lubricants or other chemicals.

Overall, except for a spill related to a vessel collision, the impacts related to the operation phase should be negligible to minor.

5.4.4.5 Decommissioning

Decommissioning would likely involve complete removal of any tower structure to 4.6 m (15 ft) below the seafloor. For anchored devices, decommissioning would involve removal of the device and the anchors. The water quality impacts associated with decommissioning would be related to vessel operations, any fluid leakage from the device during removal, and sediment resuspension during the removal of the tower and/or anchoring structure and electrical cables. These are likely to be short-term events without any long-lasting impacts. As long as the operator carefully controls oil and other chemicals before moving structures, the water quality impacts related to decommissioning should be negligible to minor.

5.4.4.6 Mitigation Measures

During the operational phase, regular inspection and maintenance would help to detect components that are leaking hydraulic oil. Operators should consider using antifouling coatings with the lowest practical degree of toxic releases, as long as those coatings provide effective antifouling control.

During the decommissioning phase, all oil and other chemicals would be removed or otherwise controlled before the structure is moved.

Vessels should follow good maintenance and housekeeping procedures to minimize releases of oil or other chemicals to the sea. They should have up-to-date oil spill response plans. Vessel collisions within the current energy installation and the resulting spills of oil, fuel, and chemicals can be reduced by excluding commercial and/or recreational vessel from the area.

5.4.5 Acoustic Environment

5.4.5.1 Technology Testing

Technology testing of ocean current energy technologies would involve ship and barge noise as well as some high-intensity noises associated with anchoring the technologies being tested. Proposed technologies involve underwater turbines that are either rigidly anchored to the seafloor or tethered, allowing some degree of movement. Rigid designs would require driving pilings into the seafloor, while tethering might be accomplished by less intrusive means such as drilling or dropping an anchor. In either case, only one or a few such anchorings would be required during technology testing.

Noise for driving or drilling would involve high-intensity pulses, but would be of less impact than that from driving large pilings for wind energy devices. Impacts would be intermittent and of short duration. Ship noise during installation would involve few vessels, be of short duration, and be masked by background ship noise. Hence, impacts would be negligible.

During testing operations, ocean current devices would be expected to emit underwater noise from turbine blade rotation and mechanical noise from the rotation of drive gear and electrical generators. Technologies would be expected to produce continuous, low-intensity, broadband underwater noise. Above-water noise would be limited to that produced by operating test equipment from boats or barges. Such noise would be expected to have minimal impacts to human and marine populations.

5.4.5.2 Site Characterization

Site characterization activities for ocean current devices would probably not involve the installation of a meteorological tower or seafloor mapping, but would likely be focused on measuring ocean currents in prospective locations through the use of appropriate recording devices. Installing these devices would involve some ship and boat noise. It is expected, however, that anchoring would be accomplished by using dropped anchors and not require pile driving or drilling.

Characterization of the seafloor for the purpose of assessing the needs of foundation structures for ocean current energy conversion technologies would have similar requirements as that for wind energy since both require strong foundation structures. Seafloor characterization for wind turbine foundations is described in Section 5.2.5.2. It is expected that such characterization would be carried out using relatively low-energy geophysical survey technologies (an expanded discussion on each of these survey technologies is provided in Chapter 3) as described in the same section. No significant adverse acoustical impacts would be generated from the use of such technologies.

5.4.5.3 Construction

Construction of ocean current energy projects could involve pile driving for installing ocean current turbines and for the construction of offshore power-gathering stations. However, construction of offshore power-gathering components could occur onshore before the assembled component is towed to its final offshore operating location. Pile driving produces high-intensity noise pulses that can impact marine life to various degrees, from minor to fairly severe. The impacts of pile driving are examined in Section 5.2.5.3.

Construction of ocean current projects would also involve above-water or in-water construction that could have noise impacts on both human and marine receptors. In addition to ship noise, discussed in Section 5.2.5.3, such construction could also involve helicopter noise, general construction noise from use of hand tools and machinery, such as air compressors, and noise from work boats and small craft used for construction.

As seen in Table 5.2.5-1, construction noise sources above water for a number of activities range from 68 to 99 dB (re-20 μPa). As discussed in Section 5.2.5.3, general construction noise would be of short range and low impact in typical urban or suburban locations near offshore projects or near locations of onshore construction or assembly of project components.

Helicopter noise, if present, might affect human populations in near shore areas, while it would not be expected to impact marine life. Such noise could produce annoyance in affected areas, but only for relatively short durations. Helicopter noise impacts are characterized in Section 5.2.5.3.

Small boats with outboard motors as well as larger crew boats and small tugs would be a noise source during construction of ocean current energy projects. Noise from these sources is described in Section 5.2.5.3 and in Table 5.2.5-1. Noise levels would be similar to that for general construction noise and could result, typically, in short-term annoyance of nearby populations. However, boat noise would be largely masked by background boat noise in many nearshore areas.

Construction noise associated with the installation of cables that would interconnect ocean current turbines is described in Section 5.2.5.3. As noted there, noise from some cable installation could be intense, but it would be of short duration.

Finally, noise would be associated with on-shore staging, pre-assembly, hauling, and loading of wind turbine components and with the construction of onshore facilities that receive power from the offshore wind energy facility and modify and synchronize it for connection to the electric grid or to nearby distributed energy systems. Table 5.2.5-3 shows the noise resulting from construction vehicles and equipment that would likely be used. Depending on the size and complexity of the project, construction may take as long as six months but would typically take less time.

5.4.5.4 Operation

Ocean current energy technologies involve a fairly limited number of types of devices, and in this respect they are more like wind energy than wave energy technologies. However, few, if any, studies of underwater noise emissions have been performed on these emerging technologies. Nonetheless, it is possible to speculate on the general nature of noise that might be associated with the operation of ocean current technologies.

Like wind and wave energy technologies, ocean current turbines will generate mechanical noise from electrical generators and associated drive systems, noise from service boats and maintenance work, and, finally, both above- and below-water noise to some extent.

Ocean current energy conversion devices are in early stages of development, so noise impacts can be only roughly estimated. Proposed technologies include turbines similar in design to wind turbines, but much smaller in scale, given the much greater density of water. Noise resulting from cavitation by a ship's propellers represents an overall decrease in operating efficiency, and typical designs attempt to minimize cavitation, thus noise. Likewise, for land-based wind turbines, aerodynamic noise from rotating turbine blades represents a reduction in overall efficiency, and the design basis for such turbines involves minimizing or eliminating that noise source. Analogous design considerations can be expected for underwater turbines. Consequently, noise from underwater turbines constructed against the most advanced design standards available can be expected to be low and noise impacts minimal. Nevertheless, noise projections would need to be verified in each case through the actual measurement of noise emanating from operating turbines.

All offshore energy conversion technologies would require regular maintenance, and some would require daily commutes by operators. These activities would produce noise from the crew boats or small tugs used. This noise would be indistinguishable from other ship and boat noise in nearshore areas. If helicopters were used to ferry crews, however, noise impacts could be higher.

Finally, noise would be generated from the operation of electrical equipment associated with ocean current energy facilities. Noise impacts from transformers and shunt reactors used to transform generated electricity into a form compatible with the distribution grid are described in Section 5.3.5.4. It is expected that noise levels emitted from these devices would be within industry standards designed to minimize noise impacts and that no more than minor impacts would be incurred.

5.4.5.5 Decommissioning

Decommissioning of ocean current energy technologies would involve disconnecting turbines from underwater moorings and electrical connections and likely transporting the devices to shore for final disassembly. Dismantlement of facilities would also involve the removal of above-water equipment and machinery and structures such as offshore gathering stations, removal of underwater cables, and finally removal of pilings for turbines and gathering stations to below seafloor level. Noise produced from these activities would be similar to that from construction of the facilities.

These activities would produce noise from the use of construction equipment, hand tools, cranes, and compressors. Noise from work boats, barges, and associated equipment, such as power shovels, would be expected for larger projects. Noise impacts from these activities are discussed in Section 5.2.5.3, and noise levels are presented in Tables 5.2.5-1 and 5.2.5-2. Impacts would be expected to be of short duration.

It is possible that explosives would be used for removing ocean current anchoring devices and gathering station pilings. However, in many cases, simple cutting would suffice for such removals. Rocks and boulders used to protect pilings would be removed by using cranes and shovels. Noise impacts would be similar to those for construction.

5.4.5.6 Mitigation Measures

Impacts from pile driving or the use of explosives may be mitigated by a number of means involving either removing potential receptors from the work area or reducing sound emissions into water. Mitigation of piling noise at the source is possible by various means, including the use of bubble curtains, insulated piles, working inside of caissons or coffer dams, or working during periods of slack tide (Lewis 2005). As was noted in Section 5.2.5.6, not all mitigation techniques will be effective in all circumstances. Operators will be required to consult with appropriate authorities in the development and implementation of mitigation strategies that are circumstantially specific as well as specific to the acoustically sensitive species known to be present within the area of acoustic influence.

Transformers are typically installed in fenced areas that prevent close access by all but authorized personnel or are placed in vaults. In locations where even minor amounts of transformer noise cannot be tolerated, transformers with specially designed noise-mitigating housings are also available. It is reasonable to anticipate that safe stand-off distances incorporated into substation design, vaulting, and transformer design would result in transformer noise being reduced to negligible levels. Further noise reduction can be accomplished by surrounding substations with noise-reducing fencing, shrubs or trees, or other noise barriers.

5.4.6 Hazardous Materials and Waste Management

Each offshore ocean current energy project would require deliveries and pick-ups of personnel, supplies, and materials to and from its offshore site. Vessels used for this purpose may generate wastes, including bilge and ballast waters, garbage (trash and debris), domestic wastes, and sanitary wastes. The need for vessels to support offshore ocean current energy projects is not expected to increase the total number of vessels of this type operating in the vicinity of the Florida Current,[20] which is the only area in any of the OCS regions where current conditions are sufficiently strong and steady to support such projects. Also, management of wastes from these vessels is regulated by the USCG (33 CFR 151). Accordingly, the impacts of waste generated by support vessels servicing offshore ocean current energy projects would be negligible.

As discussed in Sections 4.2.6.2 and 4.3.6.2, there is a potential for disposal sites containing chemical weapons to occur in marine waters in the Atlantic and GOM regions considered for potential development of alternative energy facilities. The exact locations of most of these disposal sites are not readily available to the public, with records typically supplying only references to the general offshore locations, because of the hazardous and sensitive nature of the materials disposed of at these sites. Figure 4.2.17.2 shows several potential chemical weapons disposal areas in the vicinity of the Florida Current. Notwithstanding, applicants developing alternative energy facilities in offshore waters should be able to avoid such areas by consulting with the appropriate military agencies during case-specific siting processes. Hence,

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20 The Florida Current is a well-defined component of the Gulf Stream system that originates southwest of the Florida Keys and flows up the east coast of Florida.

chemical weapons disposal areas are not expected to contribute impacts during the development of offshore ocean current energy projects.

5.4.6.1 Technology Testing

As Section 3.4 indicates, because ocean current technologies are at an early stage of development, only demonstration projects are likely during the next 5 to 7 years. Impacts from hazardous materials and waste management during site characterization would be essentially the same for demonstration projects as for commercial facilities because the monitoring and testing requirements would be similar for both (Elcock 2006). These impacts are described in Section 5.4.6.2.

The types of impacts from construction and operation of demonstration ocean current energy facilities would also be the same as for commercial facilities, but their magnitude would be scaled down. Sections 5.4.6.3 and 5.4.6.4 discuss the impacts from construction and operation, respectively, of demonstration ocean current energy facilities.

A demonstration facility would be decommissioned in the same manner as would a commercial facility. Hence, the types of impacts from decommissioning would be the same for both, but the magnitude of the impacts for a demonstration facility would be scaled down. Section 5.4.6.5 discusses the impacts from decommissioning of a demonstration ocean current energy facility.

5.4.6.2 Site Characterization

Site-specific data collection for determining the suitability of a site for ocean current energy projects would be conducted by using vessels and various data collection devices at the proposed site location (Elcock 2006). Applicants should substitute environmentally preferable or “green” materials for less environmentally friendly fluids such as dielectric fluid alternatives (e.g., natural esters rather than mineral oil) whenever possible. These materials are derived from renewable, domestically produced seed oils, are not listed as suspected carcinogenic agents, and meet stringent performance requirements. No hazardous materials are expected to be transported to, used on, or stored on the OCS for site characterization purposes. Similarly, no hazardous wastes would be transported, generated, or otherwise managed either on the OCS or onshore as a result of site characterization activities. Hence, impacts from hazardous waste management and the use or storage of hazardous materials during site characterization for ocean current energy projects would be negligible. Support vessels used for ocean current energy site characterization activities would have impacts as discussed in Section 5.4.6.

5.4.6.3 Construction

Ocean current energy devices would be assembled onshore and then barged through both coastal and OCS waters to the offshore site, where they would be joined and appropriately anchored. Also, onshore horizontal directional drilling would occur during hookup of the transmission cable to an existing onshore substation. Hazardous materials present during barging and assembly would include lubricants contained in the components of each ocean current energy device and possibly hydraulic fluids. Ocean current energy components containing lubricants are expected to be sealed, and most likely designs would utilize air, water-based fluids, or other benign fluids, rather than hazardous materials, for hydraulic pumps and systems (Elcock 2006).

As was discussed in Section 4.2.6, if an accidental spill of a hazardous material occurred during the process of barging ocean current energy devices to offshore sites or while assembling the devices, such a spill must be reported to the National Response Center if it exceeds a reportable quantity set forth in 40 CFR Part 302; if a spill exceeds 50 bbl (2,100 gal or 7,949 L) on a Federal lease in the Atlantic and GOM regions, its cause would be investigated by the MMS. It is unlikely that any single spill of a hazardous material during barging activities would exceed 50 bbl. Also, if appropriate precautions are taken, the number of smaller accidental spills should be insignificant. Even so, in the event that a spill of hazardous materials occurred, localized impacts could result. The nature of the impacts would depend on factors such as, but not limited to, prevailing winds and currents, quantity spilled, and proximity of the spill to receptors. Regardless of the projected size or likelihood of a hazardous materials spill during barging and assembly of an ocean current facility on the OCS, implementation of appropriate precautions to prevent spills and implementation of proper mitigation measures when a spill occurred would reduce impacts substantially. Accordingly, impacts from hazardous materials spills during barging and assembly of an ocean current project would be minor to moderate. No hazardous waste would be generated by the assembly process. Accordingly, impacts from hazardous waste management and hazardous materials spills during barging and assembly of ocean current energy devices would be negligible to minor.

Garbage would be generated in very small quantities onboard the vessels used to tow ocean current energy devices to offshore sites. Also, it is assumed that sanitary waste would be generated only on the towing vessels. Small amounts of industrial waste that may be generated during assembly of ocean current energy devices would be returned to shore for disposal in appropriate, permitted, disposal facilities. If bentonite drilling fluid were to be inadvertently released during drilling for the transmission cable hookup, it would be collected as much as practicable and removed to shore for disposal in an appropriate nonhazardous waste facility. As Chapter 4 indicates, disposal facilities for nonhazardous solid wastes are available onshore in all three OCS regions. In January 2002, there were 60 operating municipal solid-waste landfills in Florida approved to receive nonhazardous solid wastes, including household, commercial, industrial, and agricultural wastes (Florida DEP 2002). Hence, impacts that result from management of nonhazardous wastes generated offshore during construction of ocean current energy projects would be negligible.

5.4.6.4 Operation

Section 3.4 describes the components of ocean current energy devices. Table 4.2.6-1 lists the expected types of hazardous materials that may be associated with these components. No hazardous materials would be stored at offshore ocean current energy sites, and no hazardous wastes would be generated at such sites. Maintenance vessels would deliver lubricants and hydraulic fluids to the offshore ocean current energy site, as needed. Alternatively, ocean current energy devices may be towed to shore for maintenance (Elcock 2006). Section 4.2.6 discusses the total quantity of hazardous materials, including petroleum products and chemical products, shipped on the ocean during 2004 in the Atlantic region, which is where the Florida Current is located. Based on the information in Table 4.2.6-1 and Section 4.2.6, the total amounts of hazardous materials likely to be used at ocean current energy sites in the Atlantic region would be minuscule compared to the total amount of hazardous materials transported by ocean vessels in that region.

Impacts from transporting wastes and materials to and from ocean current projects during their operating periods are discussed in Section 5.4.17. As during construction, accidental spills of hazardous materials could occur during operation and maintenance of ocean current energy devices at offshore sites, or during towing of ocean current energy devices to and from shore for maintenance during the operating stage. Such spills would be like those that might occur during construction, which are discussed in Section 5.4.6.3. Implementation of appropriate precautions to prevent spills and implementation of proper mitigation measures when a spill occurs would reduce impacts substantially. Accordingly, impacts from hazardous materials spills during operation of an ocean current project would be to minor to moderate.

Operation and maintenance personnel are expected to visit an ocean current energy site only occasionally during the operating stage. Garbage would be generated in very small quantities onboard the vessels used to service the ocean current energy devices. Also, it is assumed that sanitary waste would be generated and managed onboard such vessels. Small amounts of industrial waste that may be generated as a result of maintaining ocean current energy devices on the OCS would be returned to shore for disposal in appropriate, permitted disposal facilities. If ocean current energy devices were towed to shore for maintenance during their operating stage, the small amount of industrial waste that may be generated as a result of the onshore maintenance also would be disposed of in appropriate, permitted disposal facilities. As Section 5.4.6.3 indicates, disposal facilities for nonhazardous solid and industrial wastes are available onshore in Florida. Hence, impacts that result from management of nonhazardous wastes generated offshore during the operating stages of ocean current energy projects would be minor.

5.4.6.5 Decommissioning

This section addresses impacts that may result from hazardous materials and waste management during decommissioning of ocean current energy projects.

As was explained in Section 5.4.6.4, the total amount of hazardous materials present at ocean current energy sites on the OCS would be minuscule compared to the total amount of hazardous materials transported by ocean vessels on the OCS in the Atlantic region. It is assumed that such materials would be contained within the ocean current energy devices and would be removed from the site early in decommissioning along with the ocean current energy devices themselves. Impacts from removing the ocean current energy devices during decommissioning may occur due to accidental spills. Such spills would be like those that might occur during construction, which is discussed in Section 5.4.6.3. Implementation of appropriate precautions to prevent spills and implementation of proper mitigation measures when a spill occurs would reduce impacts substantially. Accordingly, impacts from hazardous materials spills during operation of an ocean current energy project would be minor to moderate.

Nonhazardous wastes, hazardous wastes, and recyclable materials that may be generated as a result of decommissioning of ocean current energy projects are among those indicated in Table 4.2.6-2. The generation of nonrecyclable hazardous wastes is not expected during decommissioning.

Recyclable and reusable materials would be generated in varying amounts. These would be collected and returned to shore for appropriate management. Recyclable or reusable materials that are hazardous as defined under the Resource Conservation and Recovery Act (RCRA) must be managed during collection and transportation in compliance with applicable regulations in 40 CFR 261 and 40 CFR 266. Alternatively, they could be collected and returned to shore for appropriate treatment and disposal at permitted hazardous waste treatment and disposal facilities. As Chapter 4 indicates, disposal facilities for hazardous wastes are available onshore in the Atlantic region. Also, in January 2006, the Florida Department of Environmental Protection reported that, based on an estimated annual generation rate of approximately 1.7 billion kg (380,000 tons), the available state and national hazardous waste treatment, storage, disposal, and recycling capacity would be adequate to meet the needs of Florida into the foreseeable future (Florida DEP 2006). Decommissioning of ocean current energy projects is not expected to substantially increase Florida’s annual hazardous waste generation rate. Hence, impacts that would result from managing recyclable or reusable materials as hazardous wastes during decommissioning of ocean current energy projects would be negligible on the OCS, and onshore impacts would be minor.

Nonhazardous wastes would all be generated in small quantities, collected, and returned to shore for appropriate treatment and disposal in a permitted disposal facility. As Section 5.4.6.3 indicates, disposal facilities for nonhazardous solid and industrial wastes are available onshore in Florida. Hence, impacts that result from managing nonhazardous wastes during decommissioning of ocean current energy projects would be negligible on the OCS, and onshore impacts would be minor.

5.4.6.6 Mitigation Measures

Impacts from hazardous materials and waste management activities associated with ocean current projects would be reduced further by the management practices and mitigation measures listed below.

- Design the hydraulic components in ocean current energy devices to operate with the use of seawater, air, or other benign fluids, rather than hazardous materials, as hydraulic fluids.

- Develop a hazardous materials management plan that addresses storage, use, transportation, and disposal of each hazardous material anticipated at the site.

- Emergency response procedures, including notification requirements, should also be incorporated.

- Develop a waste management plan that includes waste minimization procedures and pollution prevention goals.

- Develop a spill prevention and response plan that includes training and notification requirements.

- Applicants developing alternative energy facilities in offshore waters, including the installation of subsea transmission cables, should consult with the appropriate military agencies during case-specific siting processes to ensure avoidance of disposal areas possibly containing chemical weapons.

- Applicants should substitute environmentally preferable or “green” materials for less environmentally friendly fluids such as dielectric fluid alternatives (e.g., natural esters rather than mineral oil) whenever possible. These materials are derived from renewable, domestically produced seed oils, are not listed as suspected carcinogenic agents, and meet stringent performance requirements.

- Report any oil spilled in State waters, or having the potential to reach State waters, to the appropriate local, State, and Federal authorities.

5.4.7 Electromagnetic Fields

Electromagnetic (EMF) impacts from submarine power cables associated with ocean current generation facilities are expected to be the same as those for wind and wave generation facilities. These impacts are discussed in Section 5.2.7. Additional discussion on EMF impacts to aquatic species can be found in Sections 5.4.11.4 and 5.4.14.4.

5.4.8 Marine Mammals

As with wind and wave energy development, not all of the marine mammals that occur off the Atlantic coasts would be expected to be equally exposed to or affected by activities associated with the development of current energy in OCS waters. A number of species are extremely rare or considered extralimital, while others are very uncommon or very limited in their distributions. As a result, it is unlikely that these species would be regularly present, if at all, where current energy facilities may be implemented. In contrast, there are a number of marine mammal species that are relatively common and widespread in OCS waters, and these species would have a greater potential for being affected by current energy-related activities.

Potential impacts to threatened or endangered species of marine mammals from current energy technology testing, site characterization, construction, operation, and decommissioning would be similar in nature to the impacts identified for nonlisted species and could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA and MMPA regulations and coordination with the NMFS and USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.4.8.1 Technology Testing

During technology testing (Section 3.3), marine mammals may be most affected by geological and geophysical survey and construction noise. Marine mammals may also be affected by collisions with rotating turbines. Marine mammals may also be affected by collisions with survey and construction vessels and by the accidental release of wastes, lubricating oils, hydraulic fluids, or fuel.

5.4.8.1.1 Noise. Noise generated during geological and geophysical surveys and placement of mooring devices (which may involve pile driving) could disturb marine mammals in the vicinity of the test site. Affected animals may temporarily leave the area, cease normal behaviors, or experience masking of auditory signals (Section 5.2.8.3). Because the surveys and mooring placement would be short-term and limited to a few locations, relatively few animals may be expected to be affected. Thus, noise generated during these activities is expected to have a negligible to minor impact on marine mammals.

The level or frequency of underwater noise that would be generated during turbine operations is not known. Noise levels are expected to be similar to levels associated with ship traffic. If affected, marine mammals in the vicinity of the demonstration project may experience effects similar to those associated with construction noise.

5.4.8.1.2 Collisions with Turbines. Horizontal axis turbine blade rotors with diameters up to 10 m (33 ft) are of sufficient size to permit passage by many marine mammal species, including young of the larger whale species. However, animals passing through the turbines could be struck by the rotating blades and incur injury or death. It is currently not known to what extent marine mammals would avoid working turbines, especially vertical axis turbines, which may be more detectable by marine mammals. While it may be assumed that in most cases operating turbines would be avoided by healthy animals, fast-swimming cetaceans pursuing prey could inadvertently swim into the path of a rotating turbine and be struck. While rotational speeds would be much less than those of ship propellers, turbine tip speeds may reach up to 48 km/h (30 mph) (Fraenkel 2006). An animal being struck by a turbine tip traveling at that speed could incur significant injury or death. Because of the relatively few turbines that would be used during technology testing, the likelihood of collisions is expected to be low, and impact would be negligible to minor.

5.4.8.1.3 Vessel Collisions. While marine mammals could be affected by vessel traffic between onshore facilities and the offshore test site, the small number of vessel trips that might be needed during technology testing would limit the potential for ship strikes to occur. Such collisions could result in negligible to minor impacts for most species, but minor to moderate for threatened or endangered species such as the endangered West Indian manatee.

5.4.8.1.4 Accidental Releases of Hazardous Liquids and Fuel. No fuels or hazardous materials would be required or generated by the test equipment. Wastes generated by the support vessels would be managed as regulated by the USCG (Section 5.3.6), and any accidental releases of lubricating oils, hydraulic fluids, and vessel fuel may be expected to be small. Accidental releases may be expected to be rapidly diluted and dispersed by the receiving waters. Thus, impacts from such releases to marine mammals are expected to be negligible.

5.4.8.2 Site Characterization

Impacts to marine mammals during site characterization would be similar to those identified from site characterization for wind and wave energy development (see Sections 5.2.8.2 and 5.3.8.2). Impacts would be primarily associated with geological and geophysical surveys, vessel collisions, and accidental discharges of waste materials and fuel releases.

5.4.8.2.1 Geological and Geophysical Surveys. Geological and geophysical surveys might be employed to characterize ocean-bottom topography and subsurface geology. Noise generated by such surveys might have physical and/or behavioral effects on marine mammals, such as (1) hearing loss, discomfort, and injury; (2) masking of important sound signals; and (3) behavioral responses such as fright, avoidance, changes in physical or vocal behavior, including deflection of travel direction (see Section 5.2.8.2). Species restricted to nearshore coastal marine and freshwater habitats, such as the endangered West Indian manatee along the southern Atlantic Coast, would be unlikely to be affected by offshore surveys. The marine mammals most likely to be exposed to and affected by routine surveys are the cetaceans and possibly some of the more pelagic pinnipeds.

While a geological and geophysical survey may affect more than one individual, routine surveys are not expected to result in population-level effects. Individuals disturbed by or experiencing masking due to a survey would likely return to normal behavioral patterns after the survey had ceased (or after the animal had left the survey area). Because most of the potentially affected marine mammals are highly mobile species, they may be expected to quickly leave an area when a survey is initiated, thereby greatly reducing their exposure to maximal sound levels and, to a lesser extent, masking frequencies. Little information is available regarding the subsequent health and condition of such displaced individuals.

Because of the limited duration of the geological and geophysical surveys, as well as the likelihood that marine mammals would leave the immediate vicinity of the surveys, impacts to marine mammals in general would be negligible to minor. However, hearing damage, auditory masking, or behavioral changes (including alteration of migration paths) may result in moderate impacts to species that are threatened or endangered mysticetes.

5.4.8.2.2 Discharge of Waste Materials and Accidental Fuel Leaks. Marine mammals could be exposed to operational discharges and accidentally released solid debris or fuel. Any discharged liquid wastes and materials would be quickly diluted and dispersed, and thus be expected to have negligible impacts to marine mammals. The release of solid debris is prohibited (see Section 5.2.8.2), and any amount accidentally released would be very small and thus have a negligible impact on marine mammals.

5.4.8.3 Construction

Construction-related impacting factors that could affect marine mammals include (1) geological and geophysical surveys, (2) noise generated during mooring of current turbines and supporting infrastructure, (3) construction vessel traffic, and (4) waste discharge and accidental fuel releases. These impacting factors are similar to those identified for construction of wind and wave energy facilities (see Sections 5.2.8.3 and 5.3.8.3); they would be associated with anchoring of the turbines and associated infrastructure to the ocean floor, placement of cables from the turbines to an offshore transformer or substation, and placement of cables from offshore facilities to onshore facilities.

5.4.8.3.1 Geological and Geophysical Surveys. Additional geological and geophysical surveys may be needed to more fully characterize bottom topography and subsurface geology for anchoring individual turbine structures. These surveys could affect marine mammals in the same manner as described for site characterization (Section 5.4.8.2). Marine mammals exposed to geological and geophysical surveys could exhibit behavioral changes. Impacts to marine mammals are expected to be negligible to minor for most species, and may be moderate for species that are threatened or endangered.

5.4.8.3.2 Construction Noise. Noise generated during anchoring of turbines and associated infrastructure could affect marine mammals that may be present in the vicinity of the construction area. Noise generated during anchoring (which may involve pile driving) could disturb normal behaviors (e.g., feeding, social interactions), mask calls from conspecifics, disrupt echolocation capabilities, and mask sounds generated by predators. Behavioral effects may be incurred at ranges of many miles (especially if pile driving is conducted), and hearing impairment may occur at close range.

Noise impacts associated with construction of turbine structures and undersea cable placement would likely be limited to individual animals or small groups that may be present in the vicinity of the construction activity, and not entire populations of animals. In most cases, affected individuals or groups would be expected to leave the construction area upon arrival of construction equipment and initiation of anchoring activities, thereby reducing the likelihood of exposure to noise levels that could impact hearing. Noise generation during construction and cable laying would be temporary.

In general, noise impacts to most marine mammals would be minor. However, disturbance of individuals during migrations between winter calving areas and summer feeding grounds or in feeding areas, as well as to species that are threatened or endangered, could result in moderate impacts to some species.

5.4.8.3.3 Vessel and Helicopter Traffic. During construction activities, marine mammals may be injured or killed as a result of collisions in offshore waters with construction vessels. Marine mammals could also be disturbed by overflights of helicopters traveling to and from offshore construction sites. The response of disturbed individuals would be largely behavioral in nature. Marine mammals in coastal waters may also encounter construction vessels and helicopter overflights as they travel between offshore construction sites and onshore facilities, and also vessels placing cables between the offshore turbines and onshore electric distribution facilities. Coastal species that could encounter construction vessels include the endangered West Indian manatee along the southern Atlantic Coast.

Because of the low level of vessel traffic that could occur during construction and cable placement, potential impacts from collisions would likely be limited to a few individuals and not result in population-level effects. The potential for collisions with construction vessels would be short-term in nature, and cease following completion of offshore facility construction and cable placement. Thus, impacts to marine mammals from ship collisions are expected to be minor. However, injuries to threatened or endangered species could result in moderate impacts to the affected species. Helicopter overflights are expected to result in temporary disturbance of normal behaviors of affected individuals, and result in negligible impacts to affected biota.

5.4.8.3.4 Waste Discharge and Accidental Fuel Releases. Potential impacts to marine mammals from accidental releases of liquid wastes, solid debris, or fuels would be similar to those identified for similar releases during site characterization (Section 5.3.8.2). Releases of liquid materials would be small in volume and become rapidly diluted and dispersed, while the release of solid debris is prohibited. Thus, potential impacts to marine mammals from the release of liquid wastes, solid debris, or fuels are expected to be negligible.

5.4.8.4 Operation

During operation of a current energy facility, marine mammals may be affected by (1) collisions with moving turbine rotors, (2) turbine noise, (3) collision and entanglement in mooring cables or buried transmission lines, (4) collisions with service vessel traffic, and (5) exposure to accidental hazardous materials or fuels releases. Marine mammals may also be affected by the presence of mooring structures and underwater pilings and other project infrastructure that could occupy several square miles of ocean habitat and include up to 100 or more generating units (Elcock 2006). The World Energy Council (WEC 2001) has estimated a density of up to 37 turbines/km^2 to avoid water-interaction effects between turbines and to allow for access by maintenance vessels.

5.4.8.4.1 Rotor Collisions. As discussed under technology testing (Section 5.4.8.1), turbine tip speeds may reach up to 48 km/h (30 mph) (Fraenkel 2006), and an animal being struck by a turbine tip traveling at that speed could incur significant injury or death. While it may be expected that most marine mammals would avoid the turbine structures, fast-swimming animals pursuing prey may inadvertently swim into operating turbines and thus risk being struck. While such impacts to most cetaceans may be minor, impacts to threatened or endangered species may be moderate or major. While many of the endangered cetaceans are large, their young may be small enough to enter an operating turbine and be struck.

5.4.8.4.2 Turbine Noise. While no information is available regarding underwater noise levels of operating turbines, noise levels are expected to be similar to levels associated with ship traffic. If affected, animals may exhibit behavioral modifications such as changes in foraging, socialization, or movement. Affected animals may also experience auditory masking, which in turn could affect foraging and predator avoidance.

In contrast to the relatively short time period during which construction noise would be generated, noise generated during normal operations would be continuous or near continuous and be produced over the area of the current energy facility (up to 3 km^2 [1 mi^2]. Such noise generation could result in the long-term avoidance of the current energy facility and surrounding vicinity (depending on the distance operational noises are transmitted underwater at levels actively avoided by, or affecting, marine mammals). This could lead to abandonment of feeding or mating grounds. Such disruptions could result in long-term population level effects to affected species. While it is not known if marine mammals would be affected, normal operational noise may result in minor to moderate impacts to some species of marine mammals, especially if the facility is located in or near an important feeding or mating area or migratory route.

5.4.8.4.3 Collision and Entanglement. Current energy facilities may utilize mooring lines to secure the turbines to the ocean floor, and marine mammals swimming through a current energy facility may strike and become entangled in these lines, becoming injured or drowning. Smaller, more agile animals such as dolphins and seals may be expected to readily navigate around mooring cables, while larger animals (such as the mysticete whales) may be more prone to entanglement. For facilities where individual turbines may be spaced as much as 610 m (2,000 ft) from one another (Elcock 2006), most animals would have sufficient room to travel between turbines and avoid anchoring cables. In contrast, interturbine spacing may be as little as 12 m (40 ft) at facilities with linear turbine placement. Such a placement scheme could effectively create a wall of mooring cables, increasing the potential for collisions and entanglement and thus injury to large marine mammals moving through the area. This may be especially of concern for facilities with 100 or more generating units with densities up to 37 turbines/km^2 (Elcock 2006). Depending on the species affected, entanglement may result in minor to moderate impacts to most marine mammals but moderate to major for endangered or threatened species, such as the North Atlantic right whale.

5.4.8.4.4 Service Vessel Traffic. During normal operations, there would be vessel trips to perform device maintenance and repair. Marine mammals may be affected by this traffic either by direct collisions with, or disturbance by, these vessels. Animals may be injured or killed as a result of ship collisions, while ships traveling to and from a current energy facility may disturb animals in the vicinity of their path. Disturbed individuals may be expected to leave the vicinity of the ship and return to normal behavior following passage of the ship. Because of the low level of vessel traffic that could occur during normal operations, potential impacts to marine mammals from this traffic would likely be limited to a few individuals, be largely short-term in nature, and not result in population-level effects. Thus, impacts to marine mammals from ship collisions are expected to be minor. Injuries to threatened or endangered species, however, could result in moderate impacts to the affected species.

5.4.8.4.5 Accidental Releases of Hazardous Materials or Fuels. Operational discharges from service vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal (Section 5.2.6.3). Operational discharges would be quickly diluted and dispersed by local currents, and thus are expected to have a negligible impact on marine mammals. Because of the small amount of fuels or other potentially hazardous materials (such as hydraulic fluids, transformer fluids, and lubricating oils) that may be present or used at any given time during normal operations (see Section 5.2.6.4), accidental releases or spills, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents, and thus not expected to pose a threat to marine biota. Thus, potential impacts to marine mammals from accidental spills of hazardous materials are expected to be negligible.

5.4.8.4.6 Facility Presence. The presence of a current energy facility with 100 or more generating units (Elcock 2006) may cause some species of marine mammals to avoid the facility and surrounding area. Depending on their location, some facilities may act as barriers to effective passage by migrating individuals through an area and cause migrating animals to swim around the facilities. Linear facilities, which may result in a turbine “wall” that may be up to 1 km (0.6 mi) in length, may be especially likely to act as barriers. The effects of a displaced migration on affected individuals is unknown but may result in increased energetics costs and reduced condition of affected animals, especially in migrating young. Facilities sited in important feeding or calving grounds could also displace individuals from these important habitats, which could result in population-level effects to some species. While it is not known how marine mammals might respond to the presence of an operating current energy facility, there is a potential for minor to moderate impacts to some species, especially those that are threatened or endangered and utilize specific areas for important portions of their life histories.

5.4.8.5 Decommissioning

Decommissioning of a current energy facility (whether of demonstration- or commercial-scale) would involve the dismantling and removal of infrastructure from each turbine location, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). During decommissioning, marine mammals may be affected by (1) noise generated by removal of anchoring structures (especially pilings), (2) decommissioning vessel traffic, and (3) accidental releases of hazardous materials and fuel.

Decommissioning activities would be similar to construction activities, although largely in reverse and at lower levels. Explosives may be used for the removal of some mooring piles, and marine mammals near the detonations could be injured from pressure- and noise-related effects.

With the possible exception of explosive mooring removal, impacts to marine mammals from decommissioning are expected to be negligible to minor. The potential for adverse effects on marine mammals may be further reduced by the likely absence of marine mammals in the vicinity of the current energy facility during normal operations because of operational noise.

5.4.8.6 Mitigation Measures

The principal impacting factors that could affect marine mammals are entanglement, noise, vessel strikes, and displacement. The measures identified in Section 5.3.5 to mitigate noise generated during site characterization and construction, operation, and decommissioning may also provide mitigation of noise impacts to marine mammals. Other general measures that might reduce the likelihood of adverse effects on marine mammals include:

- During site characterization, conduct surveys and coordinate project siting with appropriate resource management agencies (NMFS) to:
  - Avoid locating facilities near known important congregation, mating, or feeding areas, such as the six major sites along the Atlantic Coast of the endangered North Atlantic right whale.
  - Avoid locating facilities at known high use areas along marine mammal migratory routes or at known migratory route bottlenecks.
- Vessels related to project planning, construction, and operation shall travel at reduced speeds when assemblages of cetaceans are observed and maintain a reasonable distance from whales and cetaceans.
- Project-related vessels will follow NMFS Regional Viewing Guidelines while in transit. Operators will be required to undergo training on applicable vessel guidelines.

- Coordinate with NMFS and USFWS to determine if MMPA authorization is warranted.

- At least one qualified marine mammal observer should be posted during construction activities. Additional observers may be required by NMFS under any issued MMPA authorization.

- Schedule major noise-generating activities (such as geological and geophysical surveys, pile driving, and explosive platform removal) to avoid periods when marine mammals may be more common in the project area. For example, some activities may be prohibited or limited in duration or extent in Mid-Atlantic OCS waters from October to January, when and where the endangered fin whale is believed to be calving.

- To reduce the potential for entanglement or turbine collisions, sonic pingers may be used to generate frequencies that cause marine mammals to avoid operating turbines and mooring cables, or that induce animals to use their sonar so that they detect these structures prior to a collision (Fisher and Tregenza 2003).

- Cutting, rather than the use of explosives, should be preferred for mooring structure removal. If explosives are used to remove mooring structures, MMS guidelines similar to those established for explosive platform removal in the Gulf of Mexico (USDOI/MMS 2004b) should be implemented.

5.4.9 Marine and Coastal Birds

Marine and coastal birds may be affected during current energy development as a result of (1) offshore structure placement and cable trenching; (2) project-related vessel traffic; (3) releases of liquid wastes, solid debris, hazardous wastes, or fuels; (4) construction and operation of onshore infrastructure; and (5) removal of offshore and onshore structures during decommissioning.

The nature and magnitude of effects on marine and coastal birds would depend on the specific location of the current energy facility and associated infrastructure, the timing of project-related activities (e.g., device placement, cable trenching), and the nature and magnitude of the project-related activities (e.g., several miles of trenching through nearshore coastal habitats).

Potential impacts to threatened or endangered species of marine and coastal birds from current energy technology testing, site characterization, construction, operation, and decommissioning would be similar in nature to the impacts identified for nonlisted species and could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA regulations and coordination with the USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.4.9.1 Technology Testing

During technology testing, marine and coastal birds may be affected by placement of offshore facilities, collisions with turbines and mooring structures, survey and construction vessel traffic, and the release of liquid wastes, solid debris, hazardous materials, or fuel from survey and construction vessels.

5.4.9.1.1 Placement of Offshore Facilities. Testing would require the anchoring of current energy devices to the ocean bottom, which may involve the placement of mooring devices. Noise generated during placement of mooring devices (which may involve pile-driving) could disturb marine and coastal birds in the vicinity of the test site. Affected animals may temporarily leave the area or cease normal behaviors. Because mooring placement would be short-term and limited to a few locations, relatively few birds may be expected to be affected. Thus, noise generated during these activities is expected to have a negligible impact on marine and coastal birds.

5.4.9.1.2 Collisions with Turbines and Mooring Structures. During technology testing, diving species marine and coastal birds may be injured by colliding with rotating turbines and mooring structures (such as cables). Affected birds may be injured or killed by such collisions. While turbines would likely be located at depths (>20 m [>66 ft]) greater than the diving depths of many birds, reported diving depths of marine birds range from 3 m (10 ft) to more than 200 m (656 ft) (Barrett and Furness 1990; Prince et al. 1994; Croll et al. 1992), and thus birds may encounter turbines while diving. Because of the relatively small number of turbines and associated mooring structures and limited amount of underwater structures that may be present during technology testing, relatively few birds may be affected. Thus, impacts to birds from collisions with underwater structures during technology testing are expected to be negligible.

5.4.9.1.3 Disturbance by Survey and Construction Vessels. Marine and coastal birds may be affected by survey and construction vessel traffic between onshore facilities and the offshore test site. Birds may be temporarily displaced from offshore and coastal habitats. Because of the small number of vessel trips that might be needed during technology testing, and the small number of birds that may be affected, impacts to birds from vessel traffic may be expected to be negligible.

5.4.9.1.4 Releases of Liquid Wastes, Solid Debris, Hazardous Materials, or Fuel. No fuels or hazardous materials would be required or generated by the test equipment. Wastes generated by the support vessels would be managed as regulated by the USCG (Section 5.3.6), and any accidental releases of hazardous materials or fuels may be expected to be small and rapidly diluted and dispersed by the receiving waters. Thus, impacts from such releases to marine and coastal birds are expected to be negligible.

5.4.9.2 Site Characterization

Site characterization for current energy development would consist principally of geological and geophysical surveys to identify bottom characteristics for device mooring and cable placement, and current measurements to identify locations of greatest current. During these activities, birds may be affected by the discharge of liquid wastes, hazardous materials, solid debris, or fuel from survey vessels. Discharges from survey vessels would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal. Sanitary and domestic wastes would be processed through on-site waste treatment facilities before being discharged overboard. Deck drainage would also be processed prior to discharge. Thus, impacts to marine and coastal birds from releases from survey vessels are expected to be negligible.

The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]). Thus, entanglement in or ingestion of solid debris from the survey vessels by marine and coastal birds is not expected, and impacts to marine and coastal birds would be negligible.

Any accidental releases of hazardous materials (such as hydraulic fluids) or fuels may be expected to be small and rapidly diluted and dispersed by the receiving waters. Thus, impacts from such releases to marine and coastal birds are expected to be negligible.

5.4.9.3 Construction

Marine and coastal birds may be affected by construction related to mooring the current energy devices, by cable trenching, and by release of liquid wastes, solid debris, hazardous materials, or fuel from construction vessels. Birds may also be displaced from offshore feeding areas by the noise and activity at the construction location.

5.4.9.3.1 Cable Trenching. The construction of new offshore structures is not expected to adversely affect marine or coastal birds. Cable trenching may temporarily affect birds in nearshore coastal areas if trenching occurs in or near foraging or nesting areas. For many species, the effects would be primarily behavioral in nature, namely, the short-term avoidance or abandonment of habitats in the immediate area of trenching. Cable trenching near nesting colonies (such as seabird rookeries on coastal islands or tern colonies on beaches) may disturb adults that are incubating eggs or feeding young, potentially affecting nesting success. Because trenching could result in some long-term loss of coastal habitat, habitat loss may also occur for some coastal birds. However, the amount of habitat disturbed during cable trenching would be relatively small. Trenching in some coastal habitats may temporarily expose or mobilize food items and attract birds to the trenching locations. Overall, impacts to marine and coastal birds from cable trenching are expected to be negligible to moderate, depending on the species affected and the nature of the effect.

5.4.9.3.2 Waste Discharge and Accidental Fuel Releases. Discharges from construction vessels would be released into the open ocean when allowed where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal. Operational discharges at a construction site would be quickly diluted and dispersed by local currents, and thus are expected to have a negligible impact on marine or coastal birds. Because of the small amount of fuels or other potentially hazardous materials that may be present at any time during construction (see Section 5.2.6.3), accidental spills, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents, and thus not expected to pose a threat to marine biota. Thus, potential impacts to marine or coastal birds from accidental spills of hazardous materials or fuel are expected to be negligible.

Marine and coastal birds may become entangled in or ingest floating, submerged, and beached debris from construction or survey vessels. Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]), entanglement in or ingestion of trash and solid debris by marine and coastal birds would not be expected during construction and thus have negligible impacts on marine and coastal birds.

5.4.9.3.3 Onshore Construction. Loss or alteration of coastal habitat due to cable landfalls and electrical substation construction may result in the displacement of individual or groups of birds from important foraging, roosting, overwintering, or nesting habitats. Disturbance of birds from these habitats may affect condition or overwintering survival and disrupt nesting activities and reduce nesting success of affected birds. Coastal construction may also directly disturb coastal habitats. While the disturbance of birds would be expected to be short-term (lasting only until construction was completed), long-term disturbance of habitats may result in local population-level impacts to some species. Thus, impacts to marine and coastal birds are expected to by minor to moderate.

5.4.9.3.4 Offshore Construction. Marine and coastal birds may be displaced during construction from offshore feeding habitats if the current energy facility is located in such habitats. Birds could be disturbed by construction vessel traffic as well as noise associated with pile driving and construction of above-water portions of the towers. Affected birds would be expected to leave the area during the construction period, and some may permanently abandon the area due to the subsequent presence and operation of the completed current energy project. While it is not possible to identify how birds would be affected, individual birds may experience increased energetics costs associated with traveling to other (and possibly lower-quality) feeding habitats, which could affect overall condition and survival. Disturbance of birds from overwintering habitats may affect overwintering survival.

Displacement of birds from nesting and foraging areas may disrupt nesting activities and reduce nesting success of affected birds. Population-level effects may result if the current energy project is located in an important foraging area where adults collect food for young birds.

Displacement of parents to other foraging habitats may increase the time of adults away from the nests, increasing the risk of nest predation. The displacement of birds to lower-quality or more distant foraging habitats could affect foraging success and the quality and quantity of food returned to the nest, affecting the growth and condition of young birds. However, offshore current turbines would likely not be located near coastal or island nesting areas.

Thus, impacts to marine and coastal birds from offshore construction activities may be negligible to minor, depending on the habitats and birds affected by the location of the current energy facility.

5.4.9.4 Operation

During operation of a current energy facility, marine coastal birds may be affected by service vessel traffic and maintenance activities, collisions with turbine rotors and mooring structures, collisions with above-water structures, releases of liquid wastes, solid debris, hazardous materials, or fuel from service vessels, by collisions with underwater structures while diving for food, and by noise and human activity at onshore facilities.

5.4.9.4.1 Service Vessel Traffic and Maintenance Activities. During normal operations, there would be at least one vessel trip to and from the current facility each day to perform maintenance duties. Marine and coastal birds in the vicinity of the devices or near onshore support facilities may be disturbed by these service vessels and flee an area. Displaced birds would move to other habitats and may or may not return. Because of the low level of vessel traffic that could occur under during operations, disturbance of marine and coastal birds would likely be short-term and not be expected to result in adverse effects. However, if the displaced birds were occupying active rookeries or nest sites, even a short-term absence of the adult birds could increase predation of eggs or unfledged young, or reduce hatching success. Such an effect may result in local, population-level effects to the affected birds. Thus impacts to marine and coastal birds may be negligible to minor.

5.4.9.4.2 Collisions with Turbine Rotors and Mooring Structures. Similar to technology testing (Section 5.4.9.1), some species of diving marine and coastal birds may be injured when diving for food by colliding with underwater structures such as mooring cables, support structures, or rotating turbines. The potential for turbine collisions would be greater than during technology testing because of the greater number of turbines that would be in operation. Depending on the number of turbines operational within a facility and the number and species of birds that may be diving in the immediate area, impacts to diving birds from collisions with underwater structures may be negligible to minor.

5.4.9.4.3 Collisions with Above-Water Structures. Some turbine devices may include a monopile along which the turbine may be raised out of the water for maintenance. It is possible that marine and coastal birds, as well as migratory terrestrial birds, may collide with these support structures and be injured or killed. Impacts would be similar to those identified for collisions with meteorological and turbine towers for offshore wind energy development (Section 5.2.9). Impacts to marine and coastal birds would depend on the species and numbers affected and the number and density of such structures at a current energy facility, and may be minor to moderate.

5.4.9.4.4 Accidental Releases of Hazardous Materials or Fuels. Any discharges from service vessels would be released into the open ocean or collected and taken to shore for treatment and disposal (Section 5.2.6.3). Discharges would be quickly diluted and dispersed by local currents, and thus are expected to have a negligible impact on marine or coastal birds. Because of the small amount of fuels or other potentially hazardous materials (e.g., hydraulic fluid, transformer fluid, and lubricating oil) that may be present during maintenance activities or in the current turbines and associated infrastructure, accidental spills of any of these materials, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents and not be expected to pose a threat to marine biota. Thus, potential impacts to marine or coastal birds from accidental spills of hazardous materials or fuel are expected to be negligible.

Marine and coastal birds may become entangled in or ingest solid debris from service vessels or platforms undergoing maintenance activities. Because the discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100-220 [101 Statute 1458]), entanglement in or ingestion of trash and solid debris by marine and coastal birds would not be expected during normal operations and thus have negligible impacts on marine and coastal birds.

5.4.9.5 Decommissioning

Decommissioning of current energy projects would involve the removal of the devices and associated offshore infrastructure and the shipment of these materials to shore for reuse, recycling, or disposal. Potential impacts to marine and coastal birds would be similar to those identified for decommissioning of offshore wind and wave energy projects (Sections 6.2.10.5 and 6.3.10.5). Impacts to birds from the removal of offshore infrastructure are expected to be negligible. Decommissioning of onshore infrastructure may result in the temporary disturbance of nearby birds, and impacts from such disturbance are expected to be negligible. However, if onshore decommissioning disturbed birds from nearby rookeries, nesting beaches, or overwintering habitats, population-level effects may be incurred by some species. Thus, overall impacts from decommissioning may be negligible to moderate.

5.4.9.6 Mitigation Measures

The principal impacting factors that could affect marine and coastal birds are noise and habitat disruption by cable trenching and construction, noise from vessel traffic, collisions with underwater structures such as turbines and mooring cables, and collisions with above water structures. Mitigation measures that might reduce the likelihood of adverse effects on marine and coastal birds include the following:

- Conduct surveys of coastal and offshore areas to identify important feeding, nesting, and wintering areas, and avoid siting facilities, cable paths, and vessel routes in or near these areas.

- Coordinate surveys, project design, siting, and construction, development of location- and project-specific mitigation measures, with USFWS and State natural resource agencies, as appropriate.

- Avoid locating facilities in areas of known important or high bird use (e.g., foraging or overwintering areas, migratory staging or resting areas).

- Time major noise-generating activities, such as cable trenching, placement of mooring structures, and onshore construction, to avoid periods when marine and coastal birds are nesting in the area.

- To reduce the attraction of birds to construction and service vessels and thus reduce potential for ingestion of or entanglement with accidental releases of solid debris from these ships, limit use of steady-burning, bright lighting.

- To reduce attractiveness of above-water structures to birds, avoid use of bright lights. Use low-intensity strobe lights instead of more commonly used medium-intensity incandescent blinking lights when complying with FAA lighting guidelines.

- Use antiperching devices or audio devices to deter diving birds from perching on or foraging within the immediate vicinity of the current energy structures.

- Cutting, rather than the use of explosives, should be preferred for mooring structure removal.

5.4.10 Terrestrial Biota

Development of current energy facilities is expected to have largely negligible to minor impacts on terrestrial biota. With the exception of construction and operations of cable landfalls and onshore infrastructure (such as electrical substations), most current energy activities would occur in offshore waters.

Potential impacts to threatened or endangered species of terrestrial biota from current energy technology testing, site characterization, construction, operation, and decommissioning would be similar in nature to the impacts identified for nonlisted species and could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA regulations and coordination with the USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.4.10.1 Technology Testing

No construction or other surface-disturbing would be expected on coastal or inland areas during technology testing. As a consequence, there would be no impacts to terrestrial biota during technology testing.

5.4.10.2 Site Characterization

Site characterization for current energy development would consist principally of geological and geophysical surveys to identify bottom characteristics for mooring structure placement, and current measurements to identify locations of greatest current. Neither of these activities would affect terrestrial biota. Thus, impacts to terrestrial biota from site characterization are expected to be negligible.

5.4.10.3 Construction

Construction of current energy facilities may include construction of cable landfalls and onshore substations. These surface-disturbing activities would result in the temporary disturbance or permanent loss of terrestrial habitats and could disturb wildlife in the vicinity of the onshore construction activities. Vegetation and wildlife with limited mobility would be killed within the construction footprint. More mobile wildlife would be expected to leave the area for surrounding habitats. However, survival of the displaced biota would be uncertain, depending on the quality of the surrounding habitats and the capacity of those habitats to support additional biota.

Construction of the onshore facilities may also temporarily disturb terrestrial biota in the vicinity of the construction sites, with affected individuals largely moving to other habitats. Displacement from preferred to less-optimal habitats could affect overall condition and affect subsequent survival or reproductive success. Disturbance of terrestrial biota in surrounding habitats during construction would be temporary, affect a relatively small number of individuals, be localized in the immediate vicinity of the construction activity, and not be expected to result in long-term impacts to terrestrial wildlife populations. Thus, impacts to terrestrial wildlife may be negligible to minor.

Potential impacts to threatened or endangered species of terrestrial biota would be similar to those of nonlisted biota. However, compliance with the Endangered Species Act would require that any new pipeline landfalls and onshore infrastructure be sited and constructed in a manner that would avoid impacts on these species or their habitats. For example, the USFWS and U.S. Army Corps of Engineers (USACE) review proposed dredge-and-fill activities and construction projects in waters of the United States where projects may affect the Florida salt marsh vole or its habitats. In addition, the occurrence of many of the threatened and endangered species within protected areas (such as National Wildlife Refuges and State parks) further precludes these species or their habitats from incurring adverse impacts from the construction of onshore infrastructure.

5.4.10.4 Operation

Potential impacts to terrestrial biota during operation of a current energy facility would be similar to those identified for operation of offshore wind energy or wave energy facilities (see Sections 5.2.10.3 and 5.3.10.4). Potential impacts would be restricted to the disturbance of terrestrial wildlife from operational noise and human activity at onshore locations and collisions of migratory birds and bats with above-water offshore infrastructure. Operation of completed onshore facilities could result in the long-term avoidance of adjacent habitats by species sensitive to noise and human activity. Some species may become habituated to human activities and facilities and be largely unaffected by onshore operations, while other species are sensitive and may permanently leave habitats in the vicinity of the onshore facilities (e.g., Klein et al. 1995; Taylor and Knight 2003; Rodgers and Smith 1995; Lafferty 2004). Thus, depending on the species present in habitats near onshore facilities, impacts to terrestrial wildlife may be negligible to moderate.

5.4.10.5 Decommissioning

Terrestrial biota are not expected to be affected by decommissioning of a current energy facility, although wildlife could be disturbed by noise generated during any nearshore cable removal activities. Affected wildlife could leave the area, but may return following completion of cable removal activities. Thus, impacts to terrestrial biota from decommissioning activities may be negligible to minor.

5.4.10.6 Mitigation Measures

A number of mitigation measures may be employed to reduce or eliminate the potential for impacting terrestrial biota during the development, operation, and decommissioning of onshore components of a current energy project. These measures include the following:

- Avoid siting onshore facilities in natural areas, especially in areas of known important or high wildlife use (such as migratory bird staging or resting areas).

- Avoid locating offshore facilities in areas of known high migratory bird use.

- Coordinate siting and construction of onshore construction activities with USFWS and appropriate State natural resources staff to identify and avoid Federal and State-listed plants and wildlife and important habitats.

- Time construction activities to avoid important life history activities such as nesting.

5.4.11 Fish Resources and Essential Fish Habitat

This section evaluates potential impacts to fish resources and Essential Fish Habitat (EFH) that could occur during the testing, site characterization, construction, operation, and decommissioning phases of OCS current energy development. While activities that would occur during each phase of development and the types of direct and indirect impacts that could occur to fish resources from those activities are identified, the potential for impacts can be influenced by site-specific conditions, including physical conditions (e.g., water depth, currents, and topography) and the types of habitats and species present in the vicinity of a particular project. As a consequence, more detailed analyses of potential impacts to fish resources and EFH would be conducted as part of site-specific evaluations for proposed current energy projects. In general, impacts to fish resources and to EFH could occur as a consequence of (1) disturbance of seafloor habitat that provides shelter, reproductive habitat, and food for various species; (2) noise and pressure waves generated during characterization, construction, operation, maintenance, or decommissioning for current energy facilities; (3) turbine strikes, entrainment, impingement, or entrapment of fish or invertebrates on or within structures; and (4) releases of hazardous chemical substances.

If threatened or endangered species occur in the vicinity of individual projects, potential impacts could be greater than those described below for nonlisted fish species, since the populations or distributions of listed species are already greatly reduced. During site-specific planning, consultations with the USFWS and the NMFS would be conducted, as directed by the ESA, to identify and address the potential for impacts on listed fish species from individual projects. During those consultations, appropriate measures to eliminate or reduce the potential for impacts to listed species would be identified.

5.4.11.1 Technology Testing

As described in Sections 3.4 and 3.5.1, prototypes of horizontal axis current turbines have been built and tested and it is anticipated that proposals to test and demonstrate offshore current energy technologies on the OCS will likely occur within the next 5 to 7 years. These small-scale tests would likely involve deployment of one or two devices per test within an offshore testing area, with or without the construction of an undersea transmission connection to shore. Depending on the technology being tested, test units could utilize fixed foundations (e.g., monopiles), use anchors in various mooring arrangements, or be deployed from a floating structure such as a moored barge.

Construction or placement of support and mooring structures and placement of transmission lines on the seafloor could affect fish resources or EFH through sediment disturbance, increased turbidity due to suspension of sediments, crushing of benthic organisms, and changes in the fish communities associated with alteration of the availability of various habitat types. Turbidity caused by these activities could result in temporary localized decreases in photosynthesis by phytoplankton. Because of the short-term and localized nature of such effects, impacts on primary productivity and the availability of other planktonic organisms that serve as food for fish resources would be negligible. Individual fish and most mobile macroinvertebrates would likely move temporarily from affected areas, but would likely return after construction had been completed and after the suspended sediments had settled. The amount of sediment disturbed and suspended would depend on the number and type of mooring and support structures placed. In general, the amount of sediment disturbance and sediment suspension would be small and temporary. As a consequence, the resulting impacts to fish resources from this impacting factor would also be temporary and negligible.

Anchoring systems have a potential to crush or displace benthic organisms that live within the anchoring footprint. During the technology testing phase, only a few units would likely be anchored within the project area, and the overall footprint of the anchoring systems would be relatively small. Although a small number of sessile organisms could be killed by placement of these anchoring structures, motile organisms, such as fishes and larger crustaceans, would likely move from the affected area once anchoring activities commenced. Therefore, as long as sensitive seafloor habitats (e.g., hard-bottom areas containing unique and spatially limited communities of sessile organisms such as sponges, corals, and anemones) are identified and avoided, impacts to fish resources would be negligible. If power transmission cables were buried on the seafloor during the technology testing phase, there would be disturbance of sediments along the cable route up to several meters wide. Again, as long as sensitive and unique benthic habitats were avoided, the impacts of sediment disturbance and sediment suspension from cable placement on fish resources or EFH would be small and temporary.

Noise generated by construction activities and vessel traffic could potentially affect behavior of some fish resources during the technology testing phase. If pilings are required to anchor the test units, it is likely that a pile driver would be used to place the pilings. Potential impacts of noise and vibrations from pile driving on fish and invertebrates are described in Section 6.2.11.2. The small number of pilings that would be required to anchor current energy structures during the technology testing phase would be unlikely to measurably impact populations. Only a small number of vessel trips to the project area are anticipated (perhaps one per day) during the testing period. The impacts to fish resources or EFH from pile-driving and vessel use during the technology testing phase would be expected to be negligible.

Depending on the design of the current energy units, there could be a potential for fish or invertebrates within various life stages to become impinged on screens, entrained through concentrators or shrouds designed to increase the flow through the turbines, or trapped within components. In addition, some organisms could be struck and harmed by the rotors of the turbine. The potential impacts to fish resources from these factors are not known at this time.

Depending on the design of the current energy units to be tested, there may be a possibility for small amounts of hydraulic fluids or lubricating oils to be released if the containment system in a unit were to fail. However, the quantity of substances that could be released by such an event would be small, and resulting environmental concentrations would be unlikely to detectably harm fish resources. Spills of fuel and oils could also occur as a result of vessel accidents or leaks. Spilled fuels that affect areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some aquatic organisms. Contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required during the technology testing phase. If spills occurred, the volume of fuel that could be spilled by vessels associated with technology testing activities would likely be small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils. Because such spills would be unlikely to measurably affect fish populations, impacts to fish resources or essential fish habitat would be negligible.

5.4.11.2 Site Characterization

Likely activities that could affect fish resources during site characterization for current energy projects include the presence of survey vessels, the performance of geological and geophysical surveys, and drilling and core sampling to evaluate the underlying geological conditions. One or more weather buoys would be installed and used in the area of the proposed facility to measure oceanographic conditions and collect other relevant data to determine whether a site is suitable for a current energy facility.

Depending on the anchoring system to be implemented, it could be necessary to collect relatively detailed information pertaining to bottom topography and geology with the use of geological and geophysical surveys. The potential area to be covered by such a survey, and, therefore, the potential impacts to fish populations, would be project-specific and would depend, in part on the number of current energy units to be deployed and the anchoring systems to be implemented. It is anticipated that information on the sea bottom could be collected by using seafloor sampling technologies such as echosounders, acoustic backscatter devices, grab samples, and gravity coring devices as described in Section 3.5.2. For fish resources, the noise impacts of the use of such technologies to evaluate seafloor conditions would be minor.

Fishes displaced because of avoidance behaviors during surveys of seafloor conditions are likely to return to surveyed areas within relatively short periods following cessation of survey activities. In summary, only a small proportion of fish within any given survey area would be affected by noise or activities associated with characterization surveys, and persistent or detectable population-level effects would be unlikely to occur.

During the characterization phase, there would be no releases of sanitary or hazardous wastes. However, fuel spills could occur during site characterization as a result of vessel accidents or leaks. Spilled fuels that affect areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some fish resources by causing injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required. If spills occurred, the volume of fuel that could be spilled by vessels associated with site characterization activities would be small, and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Because such spills would be unlikely to measurably affect fish populations and because recovery would likely occur within one or two seasons, impacts to fish resources or EFH would be negligible to minor.

5.4.11.3 Construction

Construction of structures to support or anchor current energy units and placement of transmission lines on the seafloor to transport electricity to shore could affect fish resources or EFH through sediment disturbance, crushing of benthic organisms, increased turbidity due to suspension of sediments, and changes in the fish communities associated with alteration of the availability of various habitat types. Individual fish would likely move temporarily from affected areas, but would likely return after construction had been completed and after the suspended sediments had settled. Construction time would depend on the number of current energy units included in an individual project.

Although some benthic organisms could be smothered and killed by sediment deposition, most individual fish would move before smothering could occur. Impacts to benthic invertebrate communities could indirectly affect demersal fishes and shellfishes that utilize benthic organisms for food. These demersal organisms would likely relocate to nearby areas until food resources within an affected area recovered. Although sediment deposition could locally affect benthic organisms for a few years in the project area, current energy structures for a particular project would be dispersed throughout a project area, and the total area affected by seafloor disturbance would very small compared to the availability of similar seafloor habitat in surrounding areas.

Noise and activity associated with vessels used during construction activities could disturb fish resources within project areas. For each project, it is anticipated that one vessel would be required each day until construction were completed to transport personnel and equipment needed to install current energy generators, anchoring systems, and transmission lines. Movement of construction materials could require several round-trips of barges to the project area. Although the distribution or activities of some fish species could be temporarily affected, the noise associated with construction vessels would have no detectable or persistent effects on fish resources.

If pilings were required to anchor the devices, it is likely that a pile driver would be used to place the pilings. The number of pilings that would be required to anchor current energy structures would be determined by the number of units to be utilized, and potential impacts of noise and vibrations from pile driving on fish and invertebrates would be similar to those described in Section 5.2.11.3. In most cases, fish would temporarily move away from noise sources until work had been completed, although some individual fish could be harmed or killed by noise from pile-driving activities. Overall, the noise associated with placement of pilings would not result in measurable changes in fish populations, although distribution of fishes within the project area could be temporarily altered. It is estimated that it would take 4 to 6 hours of pile driving to install each piling—the overall amount of time that noise disturbance would occur would be a function of the number of pilings required for a specific project. Mooring of current energy generators with other anchoring systems would likely generate less noise than driving piles and would consequently result in less noise-related disturbance or harm to fish resources.

Fuel spills could occur during site construction as a result of vessel accidents or leaks. Spilled fuels that affect areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some fish resources by causing injury or death to fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips and vessels that would be required. If spills occurred, the volume of fuel that could be spilled by vessels associated with site characterization activities would be small, and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Because such spills would be unlikely to measurably affect fish populations and because recovery would likely occur within one or two seasons, impacts to fish resources or EFH would be negligible to minor.

5.4.11.4 Operation

Once construction of an offshore current energy project had been completed and operation has commenced, fish resources (including invertebrate prey for fish) could be affected by the presence of the structures themselves, traffic and noise from vessels used to maintain the structures, and noise associated with turbine operation. Depending on the design of the current energy facilities, entrainment, impingement, or entrapment of fish or invertebrates could occur. Hazardous chemical substances could be introduced into the water column from the units themselves or as a result of accidental releases or leaks from service vessels. In addition, the presence of electromagnetic fields associated with transmission cables has a potential to affect some fish species.

Sedentary benthic organisms within the immediate footprint of pilings or beneath anchors or anchoring lines used for individual current energy units could be killed or damaged, and recolonization of the underlying sediments would be precluded by the presence of the pilings or anchors throughout the life of the project. However, construction or placement of structures, such as pilings, on the OCS would introduce an artificial hard substrate that opportunistic benthic species that prefer such substrate could colonize, and minor changes in species associated with softer sediments could occur due to scouring around the pilings (Hiscock et al. 2002). Fishes, including pelagic species, would likely be attracted to these artificial habitats, and fish population numbers in the immediate vicinity of the platforms are likely to be higher than in waters away from the structures. The overall change in habitat could result in changes in local community assemblage and diversity. Although the anchors or pilings needed to install an individual current energy unit would represent only a small amount of artificial habitat that would likely have little effect on overall fish populations, there is a possibility that major projects that cover large areas could result in substantial changes in the abundance and diversity of particular fish species within the area. Some rare or overfished fish species attracted to such structures could be negatively affected if a concentration of fishing efforts near the structures resulted in increased harvest of those species. There is also a potential for invasive species to colonize such structures. Effects on diversity and fish abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats and fish species within surrounding areas.

Vessels used to perform maintenance during the operational life of a project could disturb fish resources within project areas. For each project, it is anticipated that one vessel would be required daily to conduct maintenance. The use of lights on maintenance vessels at night could attract some species or life stages to the surface. Although the distribution of some fish resources could be temporarily affected by activity and noises from these vessels, there would be no detectable or persistent effects on fish resources.

Section 5.4.5.4 describes the potential effects of operation of current energy generation on the acoustic environment. Although underwater noise would be produced by the machinery associated with current energy generation devices, it is currently unclear what the sound levels would be. Noise and vibrations associated with the operation of the generation units would be transmitted into the water column and, depending on the anchoring system used, the sediment. Depending on the intensity, such noises could potentially disturb or displace some fish within surrounding areas or could mask sounds used by fish for communicating and detecting prey.

Electrical cabling to interconnect all of the current energy generation units for a particular project, plus a high-voltage (115-kV or greater) cable that would deliver the electricity to the existing transmission system on land, would likely be trenched into the seabed. The cables would generally be buried 1 to 3 m (3 to 10 ft) into the seafloor. A potential concern associated with the operation of underwater electric transmission cables is the generation of electromagnetic fields that could affect some fish species. Weak electric fields can be detected by certain fish (e.g., rays and sharks) and are used in orientation and prey location. There is some evidence that electric fields from submarine cables are detectable by some fish species and that this detection may result in attraction or avoidance (Gill et al. 2005). However, the cable system likely to be used by OCS current energy generation projects would be shielded to effectively block the electric field produced by the conductors. Therefore, no electric field impacts are expected for the submarine cables. In addition, some fish and invertebrates are sensitive to magnetic fields that could be generated by electricity passing through underwater cables (Gill et al. 2005). Although individual organisms could be attracted to or avoid cables, the potential for population-level effects on fishes or invertebrates from such electromagnetic fields is largely unknown.

Investigations of the potential effects of the electromagnetic field associated with the cable lines for the Nysted offshore wind facility in Denmark indicated that the migration behavior of some fish species (Baltic herring, common eel, Atlantic cod, and flounder) was altered, but not completely blocked, in the vicinity of the cables (Dong Energy et al. 2006). As long as sufficient numbers of individuals pass over cables to maintain genetic diversity, population-level effects on aquatic organisms would be unlikely to occur. Thus, while it is expected that the impacts of EMF on populations of aquatic species would be negligible to minor, uncertainties remain and additional studies are needed on the potential effects on species that inhabit the U.S. coasts in the vicinity of proposed projects.

As identified in Section 5.4.11.1, there could be a potential for fish and invertebrates within various life stages to become impinged on screens, entrained through concentrators or shrouds designed to increase the flow through the turbines, or trapped within components, depending on the design of the current energy units. Turbines for current energy units are likely to turn considerably slower than ship props (Section 3.4). However, the tip of the rotor is likely to be traveling at a high rate of speed (10–12 m/s [22–27 mph]) (Fraenkel 2006). Consequently, a fish struck by the rotor could be harmed or killed. Potential impacts to fish or invertebrate populations are not known at this time.

There may be a possibility for small amounts of potentially hazardous materials (e.g., hydraulic fluids, transformer fluids, or lubricating oils) to be released if containment systems if components were to fail. However the quantity of substances that could be released by such an event would be small (<50 bbl) and would be diluted and dispersed by local currents. The resulting environmental concentrations would not be expected to substantially affect water quality (see Section 5.3.4) or detectably harm fish resources on the OCS. Spills of fuel and oils could also occur as a result of vessel accidents or leaks. Spilled fuels that reach areas important for supporting fish resources (e.g., nursery areas) could result in impacts to some aquatic organisms. Contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of fishes or their prey. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required to maintain the current energy facility. If spills occurred, the volume of fuel that could be spilled by vessels associated with maintenance activities would likely be relatively small (<50 bbl), and relatively small areas could be affected by the resulting concentrations of fuel oils in the environment. Because such spills would be unlikely to measurably affect fish populations, impacts to fish resources or EFH would be negligible to minor.

5.4.11.5 Decommissioning

Decommissioning of a current energy generation facility would involve the dismantling and removal of the units and the associated infrastructure (including anchoring structures), the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Pilings would be removed by cutting at a depth of at least 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, fish resources or EFH could be affected by noise generated during dismantling, the alteration and loss of habitat provided by the existing structures, and accidental releases of hazardous materials and fuel.

While pile driving would not occur during decommissioning, explosives could be used for the removal of some pilings. If explosives were used, fishes close to detonation areas could be injured from pressure- and noise-related effects as discussed in Section 5.2.11.2. Use of explosives would not be necessary to remove units anchored without the use of pilings.

Some of the structures associated with anchoring current energy facilities could result in creation of new hard substrate that would essentially perform as an artificial reef, supplying habitat and food for fish resources (Section 5.2.11.4). Removal of these structures from the project area would remove this artificial habitat. The overall result would be to return the project area to conditions, both physical and biological, similar to those that existed prior to construction of current energy generation facilities.

Depending on the type of current energy units used, there may be a possibility for small amounts of hydraulic fluids or oils to be released if the containment system in a unit were to fail during decommissioning. However, the quantity of substances that could be released by such an event would be small, and resulting environmental concentrations would be unlikely to substantially affect water quality (see Section 5.4.4) or detectably harm fish resources. Fuel spills could occur during decommissioning activities as a result of vessel accidents or leaks with potential effects on fish resources similar to those described in Section 5.4.11.4.

Notwithstanding the reversion of the biological conditions to those that existed prior to installation of current energy generation facilities, impacts to fish resources and EFH from decommissioning are expected to be short-term and negligible to minor.

5.4.11.6 Mitigation Measures

The principal impacting factors that could affect fish populations from offshore current energy facility development and construction include the introduction of noise, habitat alterations, and the potential for spills of fuels or other hazardous materials. The measures identified in Section 5.4.5 to mitigate noise generated during site characterization and during construction, operation, and decommissioning of current energy generation facilities would also provide partial mitigation of noise impacts to fish resources. Other general measures that could reduce the likelihood of adverse effects on fish resources include the following:

- Conduct surveys during siting studies to identify and characterize potentially sensitive habitats.

- Avoid anchoring current energy generation units on known sensitive fish habitats or within marine protected areas and ensure that hard-bottom habitats will not be harmed by movements of anchor chains or cables.

- Minimize seafloor disturbance during installation of current energy generation units and during installation of underwater cables.

- Consider the potential for impingement, entrainment, entrapment, or fish strikes during design of current energy generation units and incorporate features to reduce the potential where feasible.

- Design current generation units to reduce the potential for leaks of hydraulic fluids.

- Utilize practices and follow operating procedures that reduce the likelihood of vessel accidents and fuel spills.

- Utilize appropriate shielding for underwater cables to control the intensity of electromagnetic fields, especially in areas where more-sensitive shark or ray species are likely to be present.

- Avoid use of explosives for removing pilings when feasible.

5.4.12 Sea Turtles

Sea turtles may be especially vulnerable to adverse impacts from ocean current energy development. Hatchling turtles are thought to rely on ocean currents to reach their pelagic nursery habitats (Luschi et al. 2003). For example, loggerhead turtles born in eastern Florida beaches entrain in the Florida current and then the Gulf Stream and eventually move to the eastern Atlantic (Carr 1987).

Sea turtles may be affected by all phases of current energy development. One or more sea turtle life stages could be affected by (1) offshore structure placement and cable trenching; (2) geological and geophysical survey noise; (3) contact with turbine rotors; (4) collisions with OCS vessels; (5) operational discharges and wastes; (6) entanglement with mooring cables; (7) construction and operation of onshore infrastructure; and (8) removal of offshore and onshore structures during decommissioning.

Potential impacts to threatened or endangered species sea turtles from current energy technology testing, site characterization, construction, operation, and decommissioning could range from negligible to major, depending on the species affected and the nature, duration, and magnitude of the effect. Compliance with the ESA and MMPA regulations and coordination with the NMFS and USFWS would ensure that project activities would be conducted in a manner that would greatly minimize or avoid impacting listed species or their habitats.

5.4.12.1 Technology Testing

During technology testing (Section 3.3), sea turtles may be affected by geological and geophysical survey and construction noise, contact with turbine rotors, collisions with survey and construction vessels, the accidental release of wastes, lubricating oils, hydraulic fluids, or fuel, and by entanglement with mooring cables.

5.4.12.1.1 Noise. Noise generated during geological and geophysical surveys (see Section 5.4.12.2.1 for more detailed discussion of such surveys) and placement of mooring devices (which may involve pile driving) could disturb sea turtles in the vicinity of the test site. Affected animals may temporarily leave the area or cease normal behaviors. Because the surveys and mooring placement would be short-term and limited to a few locations, relatively few animals may be expected to be affected. The level or frequency of underwater noise that would be generated during turbine operations is unknown. Noise levels are expected to be similar to levels associated with ship traffic. If affected, sea turtles in the vicinity of the demonstration project may experience effects similar to those associated with construction noise. Thus, noise generated during technology testing is expected to have a negligible to minor population-level impacts on sea turtles.

5.4.12.1.2 Contact with Turbine Rotors. Horizontal axis turbine blade rotors with diameters up to 10 m (33 ft) are of sufficient size to permit passage by all life stages of the sea turtles. However, juveniles and adults passing through the turbines could be struck by the rotating blades and incur injury or death. It is currently not known to what extent sea turtles would avoid working turbines. While rotational speeds would be much less than those of ship propellers, turbine tip speeds may reach 48 km/h (30 mph) (Fraenkel 2006). An animal being struck by a turbine tip traveling at that speed could incur significant injury or death. Because of their small size, hatchlings being passively carried by the same currents that are being targeted by the current energy turbines may pass through the operating turbines without being struck, although it is not known to what extent this would actually occur. Because of the small number of turbines likely to be used during technology testing, impacts from turbine collisions are expected to be minor to moderate.

5.4.12.1.3 Vessel Collisions. Sea turtles could be affected by construction- and operation-related vessel traffic between onshore facilities and the offshore test site. Affected animals could collide with moving vessels, resulting in injury or death, or be disturbed by the presence and noise of these vessels and leave the vicinity. Because of their limited swimming abilities, hatchlings may be more susceptible than juveniles or adults to vessel collisions, especially if aggregated in areas of current convergence or in mats of floating *Sargassum*. Because of the small number of vessel trips that might be needed during technology testing, collisions with test vessels would be unlikely, and impacts are expected to be negligible to minor.

5.4.12.1.4 Release of Liquid Wastes, Solid Debris, or Fuel. No fuels would be required or generated by the test equipment, while current energy devices may use small quantities of hydraulic fluid. Wastes generated by the support vessels would be managed as regulated by the USCG (Section 5.3.6). Any accidental releases of hazardous materials (such as hydraulic fluids) or fuels may be expected to be small and rapidly diluted and dispersed by the receiving waters. Thus, population-level impacts from such releases to sea turtles are expected to be negligible.

5.4.12.1.5 Entanglement in Mooring Cables. During technology testing, sea turtles may be injured by becoming entangled in underwater mooring cables. However, given the relatively slow swim speeds of sea turtles, it is expected that they would be able to detect and navigate around or through mooring cables and avoid entanglement. This, together with the relatively small number of mooring cables that may be needed, entanglement of sea turtles during testing is considered unlikely and to result in negligible population-level effects.

5.4.12.2 Site Characterization

Impacts to sea turtles during site characterization would be similar to those identified from site characterization for wind and wave energy development (see Sections 5.2.12.2 and 5.3.12.2). Impacts would be primarily associated with geological and geophysical surveys, vessel collisions, and accidental discharges of waste materials and fuel releases.

5.4.12.2.1 Geological and Geophysical Surveys. Few studies are available that have examined sea turtle hearing sensitivity or noise-induced stress (Ridgway et al. 1969; Bartol et al. 1999); thus, it is largely unknown how sea turtles may respond to and be affected by geological and geophysical surveys. Such surveys may be employed to characterize ocean-bottom topography and subsurface geology. Surveys using air-gun arrays generate low-frequency noise at levels up to 250 dB re 1 μPa-m, and these may be detected by sea turtles within the survey area (Geraci and St. Aubin 1987). In contrast, side-scan sonar generates noise at much lower intensity and high frequencies. Potential responses to survey noise would be behavioral in nature and include avoidance of the noise source, disorientation, and disturbance of normal behaviors such as feeding. Sea turtles immediately below an air gun (if used) may experience sound pressure levels that could cause hearing damage. In contrast, sea turtles may not be affected by surveys using low-energy, high-frequency signals (such as those generated by side-scan sonar). Because of the limited location and duration of geological and geophysical surveys that may be conducted during site characterization, few individuals may be expected in most cases to be present within the survey areas. Thus, the potential population-level impact to sea turtles from geological and geophysical surveys is expected to be negligible. However, geological and geophysical surveys in areas where hatchling turtles have passively aggregated or where females are gathering in preparation for nesting have the potential to affect relatively large numbers of individuals and could result in minor to moderate population-level impacts to the affected species.

5.4.12.2.2 Releases of Liquid Waste, Solid Debris, or Fuel. During the geological and geophysical surveys, a variety of sanitary and other waste fluids, and miscellaneous trash and debris, may be generated onboard the survey vessels. Hatchling, juvenile, and adult sea turtles may be exposed to these wastes via releases from the survey vessels. Liquid wastes would be rapidly diluted and dispersed. Sanitary and domestic wastes generated onboard would be processed through shipboard waste treatment facilities before being discharged overboard. Deck drainage would also be processed prior to discharge. Thus, allowed waste discharges from survey vessels would be expected to have negligible population-level impacts to sea turtles.

The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]). Assuming compliance with these regulations and laws and only accidental releases, very little exposure of sea turtles to solid debris generated during surveys is expected. Thus, entanglement in or ingestion of OCS-related trash and debris by sea turtles would not be expected during the surveys.

5.4.12.3 Construction

Construction-related impacting factors that could affect sea turtles include: (1) geological and geophysical surveys; (2) noise generated during mooring of current turbines and supporting infrastructure; (3) vessel traffic; (4) cable trenching; (5) release of liquid wastes, solid debris, or fuel; (6) contact with construction equipment; and (7) onshore construction. These impacting factors are similar to those identified for construction of wind and wave energy facilities (see Sections 5.2.12.3 and 5.3.12.3), and would be associated with the anchoring of the turbines and associated infrastructure to the ocean floor, placement of cables from the turbines to an offshore transformer or substation, and placement of cables from offshore facilities to onshore facilities.

5.4.12.3.1 Geological and Geophysical Surveys. Surveys conducted to more fully characterize bottom topography and subsurface geology for mooring current energy devices could affect sea turtles in the same manner as described for site characterization (Section 5.4.12.2). Sea turtles exposed to geological and geophysical surveys could exhibit behavioral changes. Very few sea turtles may be expected to be present in the immediate vicinity of a construction site, and thus any impacts would be limited to no more than a few individuals at any one site. However, because of the threatened or endangered status of all the sea turtle species, population-level impacts may be minor to moderate for these species.

5.4.12.3.2 Construction Noise. Noise generated during mooring of current energy devices and the placement of underwater cables could disturb sea turtles that may be present in the vicinity of the construction area. The types of potential impacts from mooring activities would be similar to those described for wind platform construction (Section 5.2.12.3). Noise generated during mooring (which may involve pile driving) and cable trenching could disturb normal behaviors such as feeding. The biological importance of behavioral responses of sea turtles to construction noise (e.g., effects on energetics, survival, reproduction, population status) is unknown, and there is little information regarding short-term or long-term effects of behavioral reactions on sea turtle populations. While noise generated during construction may affect more than one individual, population-level effects are not anticipated. Because very few individuals would likely be exposed to construction-generated noise, potential population-level impacts to sea turtles from the mooring and cable-laying activities are expected to be minor.

5.4.12.3.3 Vessel Traffic. Sea turtles may be killed or injured by collisions with construction vessels traveling to and from the offshore current energy site and with vessels involved in trenching and cable placement. Because of their limited swimming abilities, hatchlings may be more susceptible than juveniles or adults to vessel collisions, especially if aggregated in convergence zones or patches of *Sargassum*.

The likelihood of such a collision would vary depending on species and life stage present, the location of the vessel and its speed, and visibility. Hatchling turtles, including those aggregated, would be difficult to spot from a moving vessel because of their small size and generally cryptic coloration patterns, which blend with the color and patterns of the Sargassum.

While adult and juvenile turtles are generally difficult to observe at the surface during periods of daylight and clear visibility, they are very difficult to spot from a moving vessel when they are resting below the water surface and at night and during periods of inclement weather.

Because of the small amount and short duration of vessel traffic that would be associated with the placement of current energy devices and with trenching and cable placement, population-level impacts to sea turtles from vessel collisions during construction is expected to be minor.

5.4.12.3.4 Cable Trenching. Cable trenching may disturb habitats used by juvenile and adult sea turtles, and habitats may experience short-term and long-term changes in abundance and quality. Juvenile sea turtles move into nearshore habitats for further growth and maturation, while adults utilize nearshore habitats for feeding and may mate in nearshore habitats directly off of nesting beaches. In addition, females may become residents in the vicinity of nesting beaches. Cable trenching may reduce the quality or availability of foraging habitat for juveniles and adults, and may affect adult nesting behavior or access to nest sites. It is assumed that habitats such as seagrass beds and live-bottom areas commonly used by turtles for feeding or resting would be avoided during facility siting and cable routing, and that some soft-bottom areas affected by construction or trenching would recover. Thus impacts of cable trenching on sea turtles are expected to be negligible to minor.

5.4.12.3.5 Releases of Liquid Waste, Solid Debris, and Fuel. Potential impacts to sea turtles from releases during construction of liquid wastes, solid debris, or fuels would be similar to those identified for similar releases during site characterization (Section 5.4.12.2). Only small amounts of liquid operational wastes or fuel may be expected to be present at any given time during construction. Releases of these would be small in volume and become rapidly diluted and dispersed. The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public Law 100–220 [101 Statute 1458]), and entanglement in or ingestion of solid debris by sea turtles would not be expected during normal construction activities. Thus, potential population-level impacts to sea turtles from the release of liquid wastes, solid debris, or fuels are expected to be negligible.

5.4.12.3.6 Direct Contact with Construction Equipment. Individual sea turtles coming in contact with construction or trenching equipment may be injured or killed. Sea turtles have been known to be killed or injured during dredging operations (Dickerson 1990; Dickerson et al. 1992) and thus may be affected during trenching activities. Juveniles or adults may also be affected if the placement of new structures occurs in foraging or developmental habitats or offshore of nesting beaches.

Construction and trenching activities would be of relatively short duration, and most related impacts would be short-term and localized to the construction area and immediate surroundings. However, because some individuals may be injured or killed, potential population-level impacts from direct contact with construction equipment may be minor to moderate.

5.4.12.3.7 Onshore Construction. Along the southern Atlantic Coast, nests and emerging hatchlings may be affected by the construction of new onshore infrastructure such as cable landfalls and electrical substations. If present in a construction area, nests containing eggs or emerging hatchlings could be destroyed by clearing, grading, and other construction activities. Lighting from nearby construction areas or completed infrastructure may also affect hatchlings emerging from nearby nests. Disorientation by nearby lights could increase exposure to predators, cause entanglement in vegetation, or lead hatchlings away from the surf (National Research Council 1990). Onshore lighting may also draw hatchlings back out of the surf. However, given the small amount of onshore construction that could occur with the development of an offshore current energy facility, it is unlikely that onshore construction would impact more than a few nests. Thus, population-level impacts to sea turtles could be negligible to moderate along the southern Atlantic Coast, depending on the presence of nesting beaches in the vicinity of the onshore facilities.

5.4.12.4 Operation

During operation of a current energy facility, sea turtles may be affected by (1) collisions with moving turbine rotors; (2) turbine noise; (3) entanglement; (4) collisions with service vessel traffic; (5) exposure to releases of liquid wastes, hazardous materials, solid debris, or fuel; and (6) onshore operations.

5.4.12.4.1 Rotor Collisions. As discussed under technology testing (Section 5.4.8.1), turbine tip speeds may reach up to 48 km/h (30 mph) (Fraenkel 2006), and a sea turtle being struck by a turbine tip traveling at that speed could incur significant injury or death. Because they are relatively slow swimmers, sea turtles that inadvertently swim into operating turbines may not be able to evade an oncoming rotor blade and thus risk being struck. Current energy facilities located between nesting beaches and offshore turtle staging areas may have the greatest potential for rotor-turtle collisions, especially large facilities that can have 100 or more generating units and are located offshore of nesting or congregation areas (Elcock 2006). Thus, potential population-level impacts to sea turtles may be minor to moderate.

5.4.12.4.2 Turbine Noise. While no information is available regarding underwater noise levels of operating turbines, noise levels may be similar to those associated with ship traffic. If affected, sea turtles may exhibit behavioral modifications such as changes in foraging or avoidance.

In contrast to the relatively short time period during which construction noise would be generated, noise generated during normal operations would be continuous or near continuous and be produced over the area of the current energy facility (up to 3 km^2 [1 mi^2]. Such noise generation could result in the long-term avoidance of the current energy facility and surrounding area. This could lead to abandonment of feeding habitats or staging areas offshore of nesting beaches. Such disruptions could result in long-term population-level effects to affected species. While it is not known if sea turtles would be affected, normal operational noise may result in minor to moderate impacts, especially if the facility is located in or near an important feeding or staging area.

5.4.12.4.3 Entanglement. Current energy facilities may utilize mooring lines to secure the turbines to the ocean floor, and sea turtles swimming through a current energy facility may strike and become entangled in these lines, becoming injured or drowning. Because they are relatively slow swimming, sea turtles may be expected to detect and avoid mooring cables. Thus, population-level impacts to sea turtles from entanglement with mooring cables may be expected to be negligible.

5.4.12.4.4 Vessel Traffic. During normal operations, there would be at least one vessel trip to and from the current facility each day to perform maintenance duties, and sea turtles may be injured or killed by collisions with these ships. Because of the low level of vessel traffic that could occur under during normal operations, potential impacts to sea turtles from this traffic would likely be limited to no more than a few juveniles or adults. However, a greater number of turtles may be affected by ships traveling through waters where hatchling sea turtles may have passively aggregated. Collisions with any of the threatened or endangered species of sea turtles may result in minor to moderate population-level impacts.

5.4.12.4.5 Releases of Liquid Wastes, Solid Debris, Hazardous Materials, or Fuel. Operational discharges from service vessels, when allowed, would be released into the open ocean where they would be rapidly diluted and dispersed, or collected and taken to shore for treatment and disposal. Operational discharges, as well as accidental releases of wastes, would be quickly diluted and dispersed by local currents and thus may have a negligible impact on sea turtles. Because of the small amount of fuels or other potentially hazardous materials (such as hydraulic fluids) that may be present or used at any given time during normal operations, accidental releases or spills, if they occurred, would likely be small (<50 bbl). These materials would be diluted and dispersed by local currents and thus not be expected to pose a threat to juvenile or adult sea turtles. In addition, juvenile and adult turtles may be able to leave the immediate vicinity of an accidental spill and thus limit their level of exposure. Thus, potential impacts to these individuals are expected to be negligible. Because hatchlings are passively aggregated and may be considered incapable of actively leaving the immediate area of an accidental spill, they may incur greater exposure to an accidental release. While there is limited information regarding the levels of some contaminants in sea turtle tissues, little is known about what concentrations are within normal ranges of a particular species or what tissue levels may result in acute or chronic effects (Pugh and Becker 2001; NOAA 2003).

The discharge or disposal of solid debris into offshore waters from OCS structures and vessels is prohibited by the MMS (30 CFR 250.300) and the USCG (MARPOL, Annex V, Public

Law 100–220 [101 Statute 1458]). Thus, entanglement in or ingestion of OCS-related trash and debris by sea turtles would not be expected during normal operations.

5.4.12.4.6 Onshore Operations. Lighting from onshore infrastructure such as cable landfalls and substations may affect hatchlings emerging from nearby nests. Disorientation by nearby lights could increase exposure to predators, cause entanglement in vegetation, or lead hatchlings away from the surf (National Research Council 1990). Onshore lighting may also draw hatchlings back out of the surf. Population-level impacts to nearby nests may be moderate to major.

5.4.12.5 Decommissioning

Decommissioning of a current energy facility (whether of demonstration- or commercial-scale) would involve the dismantling and removal of infrastructure from each current energy device, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). During decommissioning, sea turtles may be affected by (1) noise generated by removal of mooring structures (especially pilings); (2) decommissioning vessel traffic; and (3) accidental releases of liquid wastes, solid debris, hazardous materials, or fuel.

Potential impacts from these factors would be similar to the potential impacts identified from the construction of current energy projects, although largely in reverse and at lower levels. Explosives may be used for the removal of some mooring piles, and sea turtles in close proximity of the detonations could be injured from pressure- and noise-related effects.

With the possible exception of explosive mooring removal, population-level impacts to sea turtles from decommissioning are expected to be negligible to minor.

5.4.12.6 Mitigation Measures

The principal impacting factors that could affect sea turtles are rotor strikes, seismic noise from geological or geophysical surveys, explosive platform demolition, vessel strikes, onshore lighting, trenching, and placement of onshore facilities near nesting beaches. Since all sea turtle species are either endangered or threatened, mitigation measures would be developed during site-specific consultations with the NMFS and USFWS. General measures that might reduce the likelihood of adverse effects to sea turtles from these impacting factors include:

- Avoid locating facilities in areas where hatchlings are known to be passively aggregated by currents.

- Avoid locating cable landfalls and onshore facilities near known, important nesting beaches.

- Avoid locating offshore facilities in the vicinity of known, important nesting beaches, or in known, important coastal foraging areas and developmental habitats.

- Evaluate applicability of turtle exclusion devices or other measures that could discourage sea turtles from approaching operating turbines or reduce or eliminate turtle-rotor collisions.

- Platform removal should employ cutting rather than explosives. If explosives are used, platform removal should be conducted in a manner similar to that identified in the MMS guidelines for the explosive removal of oil and gas platforms in the Gulf (NTL No. 2004-G06) and to the conservation recommendations identified in the NMFS biological opinion on the removal of offshore structures in the Gulf of Mexico (NOAA 2006g). In particular, visual surveys and physical removal of sea turtles from the blast zone should be conducted, and structure removal should be immediately delayed until the observed turtle leaves the area or is captured and moved.

- The potential for affecting sea turtle nests and emerging hatchlings by onshore construction would be greatly reduced through compliance with applicable Federal and State statutes, regulations, and stipulations (such as specific lighting requirements or restrictions). The implementation of all mitigation measures required by these statutes and regulations would greatly limit the potential for impacts to nests and emerging hatchlings.

- Conduct onshore preconstruction surveys for nest sites and delay construction activities until hatchlings have emerged and moved into open water.

- To minimize potential vessel impacts to sea turtles, project-related vessels should follow NMFS Regional Viewing Guidelines while in transit, and vessel operators should undergo training on applicable vessel guidelines.

- Use appropriate procedures for pile-driving to minimize potential impacts to sea turtles associated with underwater sound levels created by pile-driving activities.

5.4.13 Coastal Habitats

Although many of the activities associated with ocean current energy facilities would occur in offshore waters, coastal habitats could be directly or indirectly impacted by a number of factors associated with ocean current energy development. These factors include vessel traffic, construction and operation of onshore facilities, installation and operation of electric transmission cables, expansion of ports and docks, and operation of offshore ocean current energy components. The potential for impacts would be largely influenced by site-specific factors, such as the habitat types and distribution in the vicinity of an ocean current energy project.

5.4.13.1 Technology Testing

The placement of structures offshore during construction of an ocean current energy demonstration project would include the shipping of components by barge or other vessels. Although waves generated by vessel traffic can affect some habitats, such as barrier beaches, impacts to coastal habitats from the small number of vessel trips would be expected to be negligible. Vessel traffic may result in long-term scarring of seagrass beds if vessels travel outside of established traffic routes. Seagrass beds may require considerable periods of time to recover, particularly in areas of low-density seagrass vegetation. Turbidity resulting from vessel traffic or maintenance dredging of traffic routes may also adversely affect seagrass beds. Impacts to seagrass beds from vessel traffic and maintenance dredging would likely range from negligible to moderate.

Fuel spills could occur as a result of vessel accidents or leaks. Spilled fuel oil that reached coastal beaches or wetlands could result in impacts to associated organisms (Hayes et al. 1992; Hoff 1995; NOAA 1998, 2000; Hensel et al. 2002; Mendelssohn and Lin 2003; Proffitt 1998). The toxicity of lighter hydrocarbons such as diesel fuel is generally greater than that of crude oil. Contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of wetland vegetation or wildlife, or biota associated with sand or gravel beaches or rocky shores. Loss of tidal marsh vegetation could result in erosion of marsh substrates, with subsequent conversion of marsh habitat to open water. Spilled fuels could penetrate into beach substrates or could persist in protected areas such as lagoons. Cleanup operations may also result in long-term impacts to beaches or wetlands, such as from trampling of vegetation, incorporation of petroleum deeper into substrates, increased erosion, or removal of substrates. Fuel spills would likely be relatively small and spill response would likely minimize impacts, allowing for habitat recovery. Therefore, impacts to coastal habitats from fuel spills could range from negligible to moderate. The degree of impact from fuel spills and length of recovery time would depend on the amount and type spilled, degree of weathering prior to contact with coastal habitats, time of year, the site-specific characteristics of the affected habitat, and the clean-up response.

5.4.13.2 Site Characterization

Direct impacts to coastal habitats would not be expected during site characterization for an ocean current energy facility. Required components for site characterization would be installed offshore. The potential impacts from vessels used for the installation of required components would be similar to those for technology testing.

5.4.13.3 Construction

Impacts to coastal habitats may result from activities associated with construction of a commercial-scale ocean current energy facility. Facility construction would be expected to require the installation of an electric transmission cable, the establishment of component assembly areas onshore, and construction of onshore facilities, such as housing for monitors or a substation and transmission lines, although existing facilities would likely be used. Additional generation devices would be shipped to the offshore location for the commercial-scale project. Potential impacts associated with vessel traffic would be similar to those for technology testing.

The potential effects on coastal habitats from construction of onshore facilities would be associated with direct impacts from ground-disturbing activities as well as indirect impacts from decreased water quality or altered hydrology. Coastal habitat, such as estuaries, wetlands, beaches, or dune communities, may be lost during land clearing or from the placement of fill material during construction. Indirect impacts associated with construction may include habitat fragmentation, or altered hydrology in nearby wetlands due to changes in surface drainage patterns. Hydrologic changes may include isolation of wetlands from water sources, reduced infiltration and increased runoff due to soil compaction, and runoff from impervious surfaces, and may result in the conversion of wetlands to upland areas or open water. The increased volume and velocity of runoff from impervious surfaces can increase water-level fluctuations in wetlands and may result in scouring of stream channels and bank erosion. Streams, wetlands, and seagrass beds may also be affected by increased sedimentation and turbidity during construction by disturbance of substrates or erosion of disturbed upland soils. Contaminants may be introduced in stormwater runoff or in discharges from vessels. The deposition of fugitive dust generated by soil disturbance may adversely affect vegetation and other biota in coastal terrestrial or wetland habitats. The impacts of soil disturbance, or changes to hydrology or water quality, may also include changes in biotic community structure, reduction in biodiversity, or establishment of invasive species.

The installation of an electric transmission cable from the demonstration facility would likely include the use of cable-laying vessels for subsea installation. The cable may be installed by horizontal directional drilling or may be buried in a continuous trench with the use of a jet-plow technique. Intertidal habitats, such as tidal marsh, mudflats, beaches, or rocky shores, or shallow subtidal habitats such as submerged aquatic vegetation would be directly impacted by trenching activities, and excavated sediments may cover adjacent substrates, resulting in the disturbance of at least 0.3 m^2 (3 ft^2) for each linear foot of cable. Infauna and epifauna of beach, mudflat or wetland substrates, as well as adjacent wetland or seagrass vegetation, could be indirectly impacted by sedimentation and turbidity during trench excavation and backfilling. Recovery of some invertebrates, such as some species of mussels, following a large disturbance may be slow (NOAA 1998). Restoration of organic coastal marsh soils to preproject elevations may be difficult because of compaction and oxidation, and re-establishment of the vegetation community may be inhibited. The continued erosion of tidal marsh substrates adjacent to the cable route could result in a widening of the affected area over time and additional marsh losses as marsh becomes converted to open water. Portions of the cable route lacking vegetation reestablishment could promote hydrologic alterations to tidal marsh, affecting the pathway of water flow, increasing the flushing and draining of interior marsh areas, and allowing saltwater intrusion into brackish and freshwater wetlands. Onshore, a transmission cable would connect the undersea cable with a substation, and would also be buried. Disturbance of beaches, dunes, or other coastal habitats would result in direct habitat losses from excavation, as well as indirect impacts. Beach or dune substrates may be difficult to stabilize, and erosion may occur adjacent to the cable route. Establishment of vegetation cover might be slow, possibly resulting in prolonged losses of dune habitat. If directional drilling were used for cable installation, indirect impacts could result from accidental losses of bentonite drilling fluid.

Federal, State, and many local regulations are designed to protect sensitive ecological resources, such as wetlands or coastal dunes. The installation of an electric transmission cable and construction of facilities for offshore alternative energy projects would typically be located to avoid or minimize impacts to sensitive resources, where location alternatives exist, as is done for oil and gas projects, both for regulatory as well as, in many instances, engineering concerns. As a result, it is very unlikely that trench excavation or onshore facilities would be located where a sensitive resource occurs. Potential indirect impacts of construction would be reviewed during project-specific environmental analyses. Impacts would generally require permitting from Federal, State, or local regulatory agencies. Therefore, impacts from construction of facilities and installation of power cables would likely result in negligible to moderate impacts to coastal habitats.

Intertidal and shallow subtidal coastal habitats, including seagrass beds, wetlands, mudflats, and beaches, may be directly impacted by the expansion of existing docks and ports to accommodate the number and size of vessels needed for construction of ocean current energy conversion facilities. Port expansion may include dredging, potentially resulting in habitat losses.

5.4.13.4 Operation

Activities associated with the operation of ocean current energy conversion facilities would include monitoring and maintenance. While monitoring would likely be conducted remotely from shore, maintenance of generation facilities would require periodic visits to the offshore locations. Generation devices may be periodically transported to port for maintenance or repair. Impacts of vessel traffic associated with facility maintenance would be similar to those described for technology testing and would include effects of increased wave action on barrier beaches and risk of fuel spills from accidents. Spills of hydraulic fluids or lubrication oils from generation devices may also occur. Spills at offshore mooring locations would not be expected to impact coastal habitats. However, spills from devices being shipped to or from port facilities may be transported by currents or tides to coastal wetlands or beaches. Because of the small amount of fluids that would be present, impacts would likely be negligible to moderate.

The placement of ocean current energy facilities in coastal waters would generally result in negligible impacts to coastal sedimentary processes (Section 5.4.1). Subsequent effects on coastal sediment deposition and erosion processes would result in a negligible impact to coastal beaches. Where facilities are constructed in nearshore waters, potentially greater impacts could occur and would need to be assessed on a project-specific basis. Operation of a current energy facility could result in a potential reduction in wave height in the vicinity of the structures. The effects of reductions in current energy and velocity would depend on system design (Section 5.4.3) and would be quantified in project-specific analyses. Impacts on currents could affect water temperature, aquatic organisms, interactions with estuaries, inlets, bays, and other near-shore waters, and weather patterns.

The electric transmission cable connecting an ocean current facility to a shore-based substation would be buried 1 to 3 m (3 to 10 ft) below coastal habitats. The electromagnetic fields produced by submarine transmission lines may be detected by some fish and invertebrate species (see Section 5.2.11.4). Although individual organisms in coastal habitats could be attracted to or avoid buried cables, the potential for population-level effects on fish or invertebrates from such electromagnetic fields is largely unknown.

5.4.13.5 Decommissioning

The decommissioning of ocean current energy conversion facilities would require the removal of all facility components and transportation to shore. The removal of the electric generation cable would be expected to result in impacts similar to construction, with direct and indirect disturbance of subtidal and intertidal substrates and terrestrial habitats. Following the restoration of soil elevations and re-establishment of plant communities, these habitats would be expected to fully recover. Decommissioning would also entail the use of vessels for transportation of workers and materials, with subsequent effects of increased wave action on barrier beaches and risk of fuel spills from accidents or spills of hydraulic fluids or lubrication oils. See Section 5.4.13.1 for a discussion of these types of impacts. Impacts from decommissioning activities would likely result in negligible to moderate impacts on coastal habitats.

5.4.13.6 Mitigation Measures

The primary impacting factors associated with ocean current energy development include habitat loss or degradation from construction activities, erosion, and contamination from spills. General measures that could reduce impacts to coastal habitats include:

- Wave activity could be minimized by maintaining reduced vessel speeds in the vicinity of barrier islands to reduce the effects of vessel traffic.

- The effects of fuel spills and spill cleanup activities could be reduced by the use of low-impact response technologies. Effective low-impact cleanup actions could include bioremediation, low-pressure flushing, or use of chemical cleaners (Mendelssohn and Lin 2003; Hoff 1995; Proffitt 1998).

- The use of water-based hydraulic fluids or nontoxic, environmentally benign fluids that are rapidly biodegradable would reduce potential effects to coastal organisms from spills near shore.

- The use of greaseless bearings in gearboxes would reduce the use and potential loss of lubrication oils.

- Avoidance of seagrass communities and implementation of turbidity reduction measures would minimize impacts to seagrasses from construction activities. Scarring of seagrass beds could be minimized by the restriction of vessel traffic to established traffic routes.

- Impacts to wetlands from construction could be minimized by maintaining buffers around wetlands, by the use of best management practices for erosion and sedimentation control, and by maintaining natural surface drainage patterns.

- Marsh losses could be reduced by the application of dredged material onto marsh surfaces in areas of high subsidence, such as the northern Gulf of Mexico.

- Impacts to wetlands could also be minimized by the implementation of practices to minimize air quality and water quality impacts.

- Direct impacts to barrier habitats or wetlands may be avoided during installation of transmission cables by the use of nonintrusive construction techniques, such as horizontal directional drilling under barrier islands or other sensitive coastal habitats.

- Coastal habitat losses could be minimized by monitoring the impacts of construction activities, monitoring habitat restoration/creation activities, and applying corrective actions through an adaptive management process.

5.4.14 Seafloor Habitats

This section evaluates potential impacts to seafloor habitats that could occur during the testing, site characterization, construction, operation, and decommissioning phases of OCS current energy developments. While the activities that would occur during each phase of development and types of direct and indirect impacts that could occur to seafloor habitats from those activities are identified, the potential for impacts can be influenced by site-specific conditions, including physical conditions (e.g., water depth, currents, and topography) and the types of seafloor habitats and associated species present in the vicinity of a particular project. As a consequence, more-detailed analyses of potential impacts to seafloor habitats would be conducted as part of site-specific evaluations for proposed projects.

5.4.14.1 Technology Testing

As described in Sections 3.4 and 3.5.1, prototypes of horizontal axis current turbines have been built and tested, and it is anticipated that proposals to test and demonstrate offshore current energy technologies on the OCS will likely occur within the next 5 to 7 years. These demonstration-scale tests would likely involve deployment of one or two devices per test within an offshore testing area, with or without the construction of an undersea transmission connection to shore. Depending on the technology being tested, test units could use fixed foundations (e.g., monopiles), could use anchors in various mooring arrangements, or could be deployed from a floating structure such as a moored barge.

Construction or placement of support and mooring structures and placement of transmission lines on the seafloor could affect seafloor habitats and organisms in those habitats by disturbing sediment, increasing turbidity due to suspension of sediments, crushing benthic organisms, and causing changes in the fish communities associated with alteration of the availability of various habitat types. Larger mobile invertebrates would likely move temporarily from affected areas, but could return after construction had been completed and after the suspended sediments had settled. Sediment disturbance would be episodic and not occur continuously during the technology testing period.

Although some benthic organisms could be smothered and killed by sediment deposition, mobile species would move before smothering could occur. Sediment deposition could locally affect sessile benthic organisms for a few years in some portions of the project area, but current energy structures for a particular project would be dispersed within the project area and the total area affected by sediment disturbance and deposition should be small compared to the availability of similar seafloor habitat in surrounding areas.

Many species that live in association with seafloor habitats as adults have larval or juvenile stages in the pelagic zone. Depending on the design of the current energy units, there could be a potential for fish within various life stages to become impinged on screens, entrained through concentrators or shrouds designed to increase the flow through the turbines, or trapped within components. In addition, some fish could be struck and harmed by the rotors of the turbine. It is unknown how many individuals could be affected or whether there is a potential for population-level effects.

Fuel spills that could occur as a result of vessel accidents or leaks during the technology testing phase would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected by such spills.

5.4.14.2 Site Characterization

Likely activities that could affect seafloor habitats and biota during site characterization for current energy projects include the presence of survey vessels, the performance of geological and geophysical surveys, and drilling and core sampling to evaluate the underlying geological conditions. One or more buoys would likely be installed in the area of the proposed facility to monitor oceanographic conditions and collect other relevant data to determine whether a site is suitable for a current energy facility.

Depending upon the anchoring system to be implemented, it could be necessary to collect relatively detailed information pertaining to bottom topography and geology. The potential area to be covered by such a survey and, therefore, the potential impacts to biota, would be project-specific and would depend, in part on the number of current energy units to be deployed and the anchoring systems to be implemented. Studies have indicated that geological and geophysical surveys can affect at least some fish and invertebrate species in various ways. High-energy seismic techniques would not generally be needed for site characterization.

In addition to noise from geological and geophysical surveys, there would also be noise generated by other activities during the site characterization phase. Sound sources could include noise associated with geological characterization (e.g., core sampling), noise from vessels associated with surveys or movement of materials and personnel, and noise from deployment of characterization buoys. Noises associated with these activities would be short-lived and localized, but could temporarily disturb or displace some mobile benthic organisms. Overall, noise associated with these activities would have no detectable or persistent effects on seafloor habitats or populations of seafloor organisms.

Core samplers and similar devices would disturb seafloor habitat and would kill sessile organisms within the sample footprint. However, the area affected by such samplers is small (generally no more than a few square meters), and the overall effect on seafloor habitats and associated organisms within the project area would be negligible.

Depending on the technology to be tested, there may be a possibility for small amounts of hydraulic fluids or oils to be released if the containment system in a unit were to fail. However, the quantity of substances that could be released by such an event would be small and resulting environmental concentrations would be unlikely to substantially affect water quality (see Section 5.3.4). Antifouling coatings could be utilized on some components but would not be expected to substantially affect water quality (see Section 5.3.4). Although fuel or oil spills could occur as a result of vessel accidents or leaks, such contaminants would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected.

5.4.14.3 Construction

Placement of supports or anchors for current energy units and placement of transmission lines on the seafloor to transmit electricity to shore could affect seafloor habitats by disturbing sediments, crushing benthic organisms, increasing turbidity due to suspension of sediments, and by altering of the availability of various habitat types. Ecological function of sediments within disturbed areas could be altered for many years depending upon the amount of disturbance, the size of affected areas, and the types of communities present. Depending on water depth, turbidity caused by placement of transmission lines could result in temporary localized decreases in photosynthesis by phytoplankton. However, because of the short-term and localized nature of such activities, impacts on primary productivity and the availability of other planktonic organisms that serve as a base of the food chain for some benthic organisms would be negligible. Larger mobile invertebrates would likely move temporarily from affected areas, but could return after construction had been completed and after the suspended sediments had settled. Construction time would depend on the number of current energy units included in an individual project.

Some benthic organisms could be smothered and killed by sediment deposition, although many mobile species would move before smothering could occur. Impacts to benthic invertebrate communities could indirectly affect demersal fishes and shellfishes that utilize benthic invertebrates for food. These demersal organisms would likely relocate to nearby areas until food resources within an affected area recover. Sediment deposition could locally affect benthic organisms for a few years in some portions of the project area. However, current energy units and the associated anchoring structures for a particular project would be dispersed over the project area, and the total area affected by seafloor disturbance would likely be quite small compared to the availability of similar seafloor habitat in surrounding areas.

If pilings are required to anchor the current energy units, it is likely that a pile driver would be used to place the pilings. The number of pilings that would be required to anchor current energy structures would be determined by the number of units to be utilized, and potential impacts of noise and vibrations from pile-driving on benthic fish and invertebrates would be similar to those described in Section 5.2.11.3. Some fish and invertebrates associated with seafloor habitats would temporarily move away from noise sources until work had been completed, although some individuals could be harmed or killed. Immediate or delayed mortality of fish from pile-driving activities has been observed at 10 to 30 m (33 to 98 ft) from the source (depending on the size of the hammer used), and it is has been estimated that delayed mortality could occur up to 150 to 1,000 m (492 to 3,280 ft) from the source, although this remains somewhat speculative (Thomsen et al. 2006). The potential for impacts to populations of seafloor organisms from such losses of individuals is unclear, although it is unlikely that measurable proportions of populations would be affected as long as unique habitat areas are identified and avoided.

Construction activities would not result in hazardous emissions to water and would not result in the release of sanitary or hazardous wastes. Although fuel or oil spills could occur as a result of vessel accidents or leaks during construction activities, it is expected that such contaminants would remain at or near the surface until weathering and dilution reduced toxicity. Consequently, seafloor habitats on the OCS would not be affected by such events.

5.4.14.4 Operation

Once construction of an offshore current energy project had been completed and operation had commenced, seafloor habitats and seafloor biota could be affected by the presence of the structures themselves, traffic and noise from vessels used to maintain the structures, and noise associated with turbine operation. Depending on the design of the current energy units, entrainment, impingement, or entrapment of fish or invertebrates could occur. Hazardous chemical substances could be introduced into the water column from the units themselves or as a result of accidental releases or leaks from service vessels. In addition, the presence of electromagnetic fields associated with transmission cables has a potential to affect some benthic species.

Sedentary benthic organisms within the immediate footprint of pilings or beneath anchors or anchoring lines used for individual current energy units could be killed or harmed, and recolonization of the underlying sediments would be precluded by the presence of the pilings or anchors throughout the life of the project. However, construction or placement of structures, such as pilings, on the OCS would introduce an artificial hard substrate that opportunistic benthic species that prefer such substrate could colonize. Minor changes in species associated with softer sediments could also occur due to scouring around pilings (Hiscock et al. 2002). Fishes and invertebrates would likely be attracted to the newly formed habitat complex, and the abundance of seafloor organisms in the immediate vicinity of pilings are likely to be higher than in surrounding areas away from the structures. The overall change in habitat could result in changes in local community assemblages. Although the anchors or pilings needed to install an individual current energy unit would represent only a small amount of artificial habitat and would likely have little effect on overall populations of seafloor biota, there is a possibility that major projects that cover large areas could result in substantial changes in the abundance of individual organisms and in the number of species within the project area. There is also a potential for invasive species to colonize such structures. Effects on diversity and abundance would be project-specific since they would be largely dependent on the prevalence of various types of habitats within surrounding areas.

Noise and vibrations associated with the operation of the turbines would be transmitted to the water column and, depending upon the method for anchoring, could be transmitted to sediments. Depending on the intensity, such noises could disturb or displace some biota within surrounding areas or could mask sounds used by some fish species for communicating and detecting prey.

As identified in Section 5.4.14.1, there could be a potential for some life stages of seafloor organisms to become impinged on screens, entrained through concentrators or shrouds designed to increase the flow through the turbines, or trapped within components, depending on the design of a current energy unit. Turbines for current energy units are likely to turn considerably more slowly than ship props (Section 3.4). However, the tip of the rotor is likely to be traveling at a high rate of speed (10–12 m/s [22–27 mph]) (Fraenkel 2006). Consequently, organisms struck by the rotor could be harmed or killed. However, only a very small proportion of any given population would be subject to impingement, entrainment, entrapment, or turbine strikes regardless of the unit design, and there would be no detectable changes in population levels. Therefore, potential impacts to populations of seafloor organisms are expected to be negligible.

Electrical cabling to interconnect all of the current energy units, plus the high-voltage (115 kV or greater) cable that delivers the electricity to the existing transmission system on land, would likely be trenched into the seabed. The cables would generally be buried 1 to 3 m (3 to 10 ft) into the seafloor. A potential concern associated with underwater electric transmission cables is the generation of electromagnetic fields that could affect some fish species that use such fields for orientation or prey location. There is evidence that electric fields from submarine cables are detectable by some demersal fish species (e.g., rays and sharks) and that this could result in attraction or avoidance (Gill et al. 2005). However, the cable system likely to be used by OCS current energy projects would be shielded and buried to reduce the electric field produced by the conductors. In addition, some fish and invertebrates are sensitive to magnetic fields that could be generated by electricity passing through underwater cables (Gill et al. 2005). Although individual seafloor organisms could be attracted to or avoid cables, the potential for population-level effects on fishes or invertebrates from such electromagnetic fields is largely unknown.

Investigations of the potential effects of the electromagnetic field associated with the cable lines for the Nysted offshore wind facility in Denmark indicated that the migration behavior of some fish species (Baltic herring, common eel, Atlantic cod, and flounder) was altered, but not completely blocked, in the vicinity of the cables (Dong Energy et al. 2006). As long as sufficient numbers of individuals pass over cables to maintain genetic diversity, population-level effects on aquatic organisms would be unlikely to occur. Thus, while it is expected that the impacts of EMF on populations of aquatic species would be negligible to minor, uncertainties remain and additional studies are needed on the potential effects on species that inhabit the U.S. coasts in the vicinity of proposed projects.

During facility operation, hazardous emissions or sanitary or hazardous wastes would not be released to the water. Antifouling coatings could be utilized on some components but would not substantially affect water quality (see Section 5.3.4). Although fuel or oil spills could occur as a result of vessel accidents or leaks during maintenance activities, such contaminants would remain at or near the surface. As a consequence, seafloor habitats on the OCS would not be affected by such events.

5.4.14.5 Decommissioning

Decommissioning of a current energy generation facility would involve the dismantling and removal of the units and the associated infrastructure (including anchoring structures), the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Pilings would be removed by cutting at a depth of at least 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, seafloor organisms could be affected by noise generated during dismantling, and there could be alteration and loss of habitat provided by the existing structures.

While pile driving would not occur during decommissioning, explosives could be used for the removal of some pilings. If explosives were used, organisms close to detonation areas could be injured from pressure- and noise-related effects as discussed in Section 5.4.11.2. Use of explosives would not be necessary to remove units anchored without the use of pilings.

As identified in Section 5.4.14.4, some of the structures associated with anchoring current energy facilities could result in the creation of new hard substrate that would essentially perform as an artificial reef, supplying habitat and supporting the biota. Removal of structures from the project area would remove this artificial habitat. The overall result would be to return the project area to conditions, both physical and biological, similar to those that existed before construction of current energy facilities.

There may be a possibility for small amounts of potentially hazardous materials (e.g., hydraulic fluids, transformer fluids, or lubricating oils) to be released if containment systems in components were to fail. However, the quantity of substances that could be released by such an event would be small (<50 bbl) and would be diluted and dispersed by local currents. The resulting environmental concentrations would not be expected to substantially affect water quality (see Section 5.3.4) or seafloor habitats.

Spills of fuel and oils could also occur as a result of vessel accidents or leaks. Overall, the likelihood of such spills is relatively low because of the small number of trips that would be required to maintain the current energy facility and the volume of fuel that could be spilled by vessels associated with maintenance activities would likely be relatively small (<50 bbl). Fuels and oils spilled on the OCS would be expected to remain at or near the surface until they were dispersed or diluted by wave activity and local currents. As a consequence, contact with deeper seafloor habitats on the OCS is unlikely and impacts to such areas would be negligible; spilled fuels that reach shallower nearshore areas with sensitive seafloor habitats such as seagrass beds or oyster bars could result in greater impacts. In those areas, contact with petroleum products, such as fuel oil or diesel fuels, could result in injury or mortality of seafloor biota or their prey, but it is expected that only small areas could be affected by the volumes of fuels anticipated. Consequently, impacts to seafloor habitats from such spills would be negligible.

Notwithstanding the reversion of the biological conditions to those that existed before installation of current energy facilities, impacts to seafloor habitats from decommissioning are expected to be negligible to minor.

5.4.14.6 Mitigation Measures

The principal impacting factors that could affect seafloor habitats as a result of offshore current energy facility development and construction include the introduction of noise, habitat alterations, and the potential for spills of fuel or other hazardous materials. The measures identified in Section 5.3.5 to mitigate noise generated during site characterization and during construction, operation, and decommissioning of a current energy facility would also provide at least partial mitigation of noise impacts to organisms on the seafloor. Other general measures that could reduce the likelihood of adverse effects on seafloor habitats include these:

- Conduct surveys during siting studies to identify and characterize potentially sensitive seafloor habitats.

- Avoid locating current energy facilities near known sensitive seafloor habitats, such as coral reefs and hard-bottom areas.

- Ensure that anchor chains and cables will not drag across sensitive seafloor habitats where sessile organisms could be harmed.

- Minimize seafloor disturbance during anchoring of units and during installation of underwater cables.

- Consider the potential for impingement, entrainment, entrapment, or turbine strikes of organisms during design of current energy generation units, and incorporate features to reduce the potential where feasible.

- Utilize appropriate shielding for underwater cables to control the intensity of electromagnetic fields, especially in areas where more sensitive shark or ray species are likely to be present.

- Avoid the use of explosives for removing pilings when feasible to minimize impacts to nearby fishes and invertebrates.

5.4.15 Areas of Special Concern

As identified in Section 4.2.15, there are approximately 40 Federally designated marine protected areas located in the southern Atlantic region. While many of these areas, including national parks, national seashores, national wildlife refuges, national estuarine research reserves, and National Estuary Program estuaries are located on or along the coast, there are a number of marine sanctuaries, fishery habitat conservation zones, and fishery management zones located in offshore waters. Section 388 prohibits alternative energy leasing "in any area on the Outer Continental Shelf within the exterior boundaries of and unit of the National Park System, National Wildlife Refuge System, or National Marine Sanctuary System, or any National Monuments" (43 USC 1337 [p] [10]).

Impacts to these areas of special concern could result from activities that disturb lands or waters within the protected area, activities that harm special habitat types or ecological resources (e.g., hard-bottom and coral habitats, fishes, or waterfowl), activities that harm cultural resources, or activities that affect other values for which a particular area of concern was established. Potential impacts of offshore current energy development to values or resources that such areas of special concern are intended to protect are identified and evaluated in the following sections. However, more detailed analyses of potential impacts to areas of special concern would be conducted as part of site-specific evaluations for proposed projects once specific locations and technical specifications are better understood.

In essentially every respect, the potential impacts to areas of special concern from development of current energy projects on the OCS would be similar to those presented for wave energy development in Section 5.3.15, although only areas in the southern Atlantic region are currently being considered for development of offshore current energy technologies.

5.4.15.1 Technology Testing

As described in Section 3.5.1, proposals to test and demonstrate offshore current energy technologies will likely occur within the next 5 to 7 years. These demonstration-scale tests would likely involve deployment of one or two test devices within an offshore testing area, with or without the construction of an undersea transmission connection to shore. Depending upon the technology being tested, test units could utilize fixed foundations (e.g., monopiles), or could use concrete anchors in various mooring arrangements. There is also a potential that current energy units could be deployed from a barge anchored in offshore waters.

Potential impacts to areas of special concern from testing of current energy technologies are anticipated to be essentially the same as those identified for wave energy technologies in Section 5.3.15.

5.4.15.2 Site Characterization

Likely activities during site characterization include the operation of survey and construction vessels, the performance of geological and geophysical surveys, and drilling and core sampling to evaluate the underlying geological conditions. In addition, one or more buoys would be installed in the area of the proposed facility to measure oceanographic conditions and collect other relevant data to determine whether a site is suitable for a current energy project.

Potential impacts to areas of special concern from site characterization for current energy technologies are anticipated to be essentially the same as those identified for wave energy technologies in Section 5.3.15.

5.4.15.3 Construction

Depending on project location, placement of current energy structures and placement of transmission lines to transport electricity to shore could affect areas of special concern. However, as previously identified, OCS current energy projects would not be located in offshore areas of special concern.

Potential impacts to areas of special concern from construction of OCS current energy facilities are anticipated to be essentially the same as those identified for wave energy technologies in Section 5.3.15.

5.4.15.4 Operation

During the operations phase, areas of special concern could be affected by the presence of offshore energy units themselves, disturbances resulting from the use of vessels to maintain the units, and noise associated with operations. In addition, the presence of transmission facilities and the associated maintenance activities have a potential to affect some onshore areas of special concern. Because, as previously identified, OCS current energy projects would generally not be located in offshore areas of special concern, impacts from OCS current energy operation are unlikely.

Potential impacts to areas of special concern from the operation of OCS current energy facilities are anticipated to be essentially the same as those identified for wave energy technologies in Section 5.3.15.

5.4.15.5 Decommissioning

Decommissioning of a current energy project would involve the dismantling and removal of infrastructure associated with each current energy unit, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Pilings used to anchor the energy generation units would be removed by cutting at a depth of approximately 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, areas of special concern could be affected by noise and vessel activity generated during dismantling, the alteration and loss of habitat provided by the existing structures, and accidental releases of hazardous materials and fuel.

Potential impacts to areas of special concern from the decommissioning of OCS current energy facilities are anticipated to be essentially the same as those identified for wave energy technologies in Section 5.3.15.

5.4.15.6 Mitigation Measures

The principal impacting factors that could potentially affect areas of special concern from offshore current energy development include noise, habitat disturbance, and the potential for spills of fuel or other hazardous materials. Some general measures that could reduce the likelihood of adverse effects on fish resources include:

- Avoid locating energy generation units close to or in marine protected areas.
- Utilize practices and follow operating procedures that reduce the likelihood of vessel accidents and fuel spills.
- If facilities are located near areas of special concern, avoid the use of explosives for removing pilings when feasible to minimize impacts to fishes and marine mammals.
- Implement and require compliance with measures to reduce the potential for trash and debris to enter the water during the various phases of development.

5.4.16 Military Use Areas

5.4.16.1 Technology Testing and Site Characterization

There are two principal types of current energy facilities undergoing testing and development. Most interest in this technology is currently centered along the east coast of Florida but is potentially applicable to other areas. All testing and site characterization activities would be relatively small and unobtrusive but could be an obstruction to surface and subsurface use by military subsurface units depending upon their location. There does not appear to be any potential for conflict with airborne units. Potential impacts would be negligible.

5.4.16.2 Construction, Operation, and Decommissioning

Developments employing current energy conversion devices are expected largely to remain at the demonstration-scale level during the analysis period. Some commercial-scale installations are possible. Proposals have been made for installations along the eastern Florida coast that may proceed. During the analysis period, it appears that systems likely to be deployed could require 3 km^2 (1 mi^2) of surface area per 50 MW of capacity (Elcock 2006) but would pose a very small likelihood of affecting overall military use of the OCS. The eventual size of current energy developments could be very large but are unknown at this time. Large current energy installations would effectively bar military uses. Overall impact on military uses during the analysis period is expected to be negligible.

5.4.16.3 Mitigation Measures

The MMS would need to ensure effective coordination with the USDOD regarding future alternative energy leases, new areas of industry interest, and current or proposed areas of military operations. As part of this coordination, stipulations would be routinely evaluated and applied, as necessary, to minimize or eliminate conflicts.

5.4.17 Transportation

The Coast Guard has issued a Navigation and Vessel Inspection Circular (USCG 2007), which provides guidance on information and factors the Coast Guard will consider when reviewing applications for permits to build and operate an Offshore Renewable Energy Installation (OREI) in the navigable waters of the United States. The circular identifies information that the Coast Guard will consider when evaluating the potential impacts of an OREI in the areas of navigational safety and the traditional uses of waterways and on Coast Guard missions. Applicants planning to build an OREI are encouraged to refer to this circular to better understand the Coast Guard review process and how to provide information to assist the Coast Guard and expedite this process. The circular also offers guidance on addressing the necessary marine safety and security issues when preparing an application for submission to the MMS. The

Coast Guard will provide the MMS with an evaluation of the potential impacts of the proposed facility on the safety of navigation and the traditional uses of the particular waterway and other Coast Guard missions to help the MMS to prepare its NEPA documentation. The Coast Guard will help develop appropriate terms and conditions that provide for navigational safety and minimize potential impacts on other Coast Guard missions in and around the proposed facility and recommend them to the MMS for consideration.

5.4.17.1 Technology Testing

Potential ocean current energy devices can be barged or towed to a test site. The number of vessels required for installation of a given device is expected to be about one or two. For example, the Seaflow prototype requires the use of a large jack-up barge for installation (Elcock 2006). Thus, the addition of one to several vessels with devices in tow in a region's vessel traffic is not significant and would result in negligible to minor impacts. All technologies would be designed for remote monitoring from onshore locations, but daily trips to a unit may initially occur as installed equipment is tested at startup. As testing proceeds, an occasional visit to the test site may be required to monitor the technology's performance and interaction with the marine environment, as well as to make repairs.

Onshore support would be limited to truck, rail, or barge delivery of a power device and limited support equipment such as cabling and monitoring devices. Devices may be delivered intact to the onshore support location, as in the case of turbine designs that are moored to the seafloor and drift in the ocean current, or in sections that may be readily assembled at the installation location.

5.4.17.2 Site Characterization

Negligible to minor transportation impacts are expected during site characterization. One or two survey vessels may be deployed to the area at any one time to investigate the marine environment. Local studies would be performed so that potential current energy generation site locations would minimize environmental impacts (e.g., to aquatic species and ocean-floor habitats) and provide suitable ocean-floor characteristics for submarine cable installation and monopile installation or device mooring.

5.4.17.3 Construction

As discussed in Section 5.4.17.1, each device may be transported to the power generation site with a small number of support vessels. With the deployment of multiple power generation devices, devices are expected to be installed in sequence, in part because of the anticipated need for the use of purpose-built vessels (e.g., a large jack-up barge used for the Seaflow technology). Such a schedule would also allow for an orderly installation, resulting in negligible to minor transportation impacts. One or two vessels may also be employed in the laying of submarine cable and the electrical connection of each device to an electrical grid. However, onshore staging areas near the supporting dock facilities may be necessary if large numbers of devices are to be installed.

Onshore impacts could also include the construction of an electrical substation, if not already present, for connection to the onshore electrical network. This activity would involve several construction workers and related heavy equipment for land preparation and building construction. Construction materials would be readily delivered by truck with little impact on the local transportation system unless the substation was situated in an undeveloped location away from a major transportation route. In this latter case, additional road upgrades or construction may be necessary. If the power cable from the offshore facility were to traverse local roads or railroad rights-of-way to connect with the onshore power grid, temporary interruptions in local traffic may be required.

5.4.17.4 Operation

Negligible transportation impacts are expected. Little vessel traffic is anticipated during operation of any offshore current generation facility. However, support vessel access to port facilities could be limited by vessel traffic at the busier ports and/or by navigational hazards. Monitoring of the facility would be conducted remotely from an onshore location. Visual inspection of the devices and their moorings may be conducted, but such inspections are expected to require the use of a single vessel and occur weekly or monthly. Maintenance or repairs of some devices may be accomplished in place while others may require returning them to a dock facility.

5.4.17.5 Decommissioning

Removal of an ocean current generation facility would entail transporting each energy device or its major parts back to port with negligible to minor impacts. The same low number of vessels required for construction (see Sections 5.4.17.1 and 5.4.17.3) would be used for decommissioning. A vessel to support removal of monopiles or mooring lines and anchors would also be needed. Once onshore, the ocean current generation devices could be refurbished for use in another location or dismantled for scrap, and/or disposed of at an appropriate facility. An onshore staging facility may be required depending on the rate of recovery of devices, the rate of device processing, and the availability of land transportation.

5.4.17.6 Mitigation Measures

Vessel traffic in support of the testing, construction, operation, and the decommissioning of an offshore ocean current generation facility is expected to be low as discussed above. Thus, most ports and harbors supporting commercial operations and traffic would be able to accommodate the needs of such a facility without significant modifications or upgrades that might affect current operations and the environment.

The Coast Guard requires the performance of a traffic study for all uses of the area affected by a proposed offshore facility (USCG 2007) as part of a detailed risk assessment focusing on navigational safety, traditional uses of the area, and impacts on other Coast Guard missions. Because some ocean current energy facilities may have equipment protruding above the water surface, they pose a potential hazard to marine navigation. As is also the case with offshore wind and wave generation technologies, the location of an ocean current energy facility should be selected so as not to interfere with designated fairways and shipping lanes as well as prime fishing areas. The USCG has statutory authority for promoting the safety of life and property on OCS facilities and adjacent waters (USCG 1989). Therefore, vessels used on waters of the OCS as well as facilities installed on the OCS are subject to USCG licensing and inspection. To mitigate any navigational impacts such as vessels colliding with ocean current generation devices, each supporting platform on the water surface would require appropriate signage and/or lighting as a warning to passing vessels. Also, for those facilities that are well underwater, restrictions on underwater activities, including the use of fishing equipment and mooring (dropping anchor), would be required in those areas.

5.4.18 Socioeconomic Resources

A short description of the coastal economies (metropolitan, small urban, single industry small urban, coastal residential, rural industrial, and rural agriculture) and sociocultural systems (large urban, small urban, single-industry small urban, rural diverse, and rural) used in this analysis can be found at the beginning of Section 5.2.18.

As detailed in the sections below, for each phase of OCS current energy development, impacts to socioeconomic resources are expected to be minor. For each phase of current energy development, potential impacts to population, employment, and regional income; sociocultural systems; and environmental justice require consideration.

5.4.18.1 Technology Testing and Site Characterization

Activities associated with the testing of OCS current energy technologies would include the deployment of a small number of current energy devices with the use of barges, and the associated shore-based activities; during site characterization, survey ships or barges would be deployed. Although the number of workers required for testing and site characterization is not known (Elcock 2006), these activities would not employ many workers, would be temporary in nature, and would have low impacts on regional income and population. They would have similarly low impacts on sociocultural systems. Potential environmental justice impacts would be site-specific and would be evaluated in future environmental evaluations for individual projects. Any impacts that would occur would be qualitatively similar to those occurring during the construction, operation, and decommissioning phases, but the magnitude of the impacts would be less.

5.4.18.2 Construction, Operation, and Decommissioning

Activities associated with the construction of OCS current energy technologies would include the onshore manufacturing of components, their transportation to offshore sites, the preparation of port facilities, and the installation of components, transformers, and cables. Activities associated with operation would include monitoring and maintenance of offshore facilities with the use of small boats and cranes. During decommissioning, the dismantling and removal of offshore facilities, devices, and cables would occur, and the components would be transported to shore with the use of special vessels.

Population, Employment, and Regional Income. The impact of employee and contractor wage and salary spending and project procurement expenditures associated with these activities would likely be small. However, because there are a number of contrasting types of economic areas in each region, there would likely be some variation in the magnitude of the impact of OCS energy technologies depending on the type of economy in which specific projects were to be located.

The impacts of energy technology construction activities in metropolitan and small urban areas would likely be small, with sufficiently diverse local economic infrastructure and labor markets to provide the required labor force, equipment, materials, and services. Single-industry small urban and coastal residential economies are likely to experience more significant impacts, with wage and salary spending and procurement expenditures larger compared to the local economic base, and with higher demands on local occupational groups. OCS activities would likely have a larger impact in rural industrial and rural agricultural areas than in other types of economies, requiring a relatively large share of labor in key occupational categories and of available local production capacity for the required material and services.

The economic impacts of the construction, operation, and decommissioning of current energy facilities are not known (Elcock 2006). However, it is likely that current technologies would create only small direct employment, income, and population growth in the Atlantic coastal region, and that impacts would be localized in the communities located near each development. The relevant job skills for device fabrication, installation, and maintenance could be present in most coastal communities (Elcock 2006), while some components may be manufactured elsewhere.

Sociocultural Systems. Activities associated with the construction, operation, and decommissioning of OCS current energy technologies would likely require only a small labor force in each location in which the technology would be developed, with few, if any, workers required to relocate into the communities hosting OCS developments. However, because there are a number of contrasting types of sociocultural areas in each region, there is the potential for some variation in the magnitude of the impact of OCS energy technologies depending on the type of sociocultural environment in which specific projects were to be located.

Aggregate regional effects can be expected to be small. Although it is not likely that in-migration of any workers would be required to fill positions, sociocultural impacts may vary by community, with the social organization of some communities leaving them vulnerable to fluctuations in industry activity. In other communities, local sociocultural structures buffer them from any rapid industrial change. In communities where impacts would occur, effects might include alterations in ethnic composition, self-identity, and cultural persistence and overall changes in social institutions, notably family, government, politics, education, and religion.

The impacts of current energy technology activities in large urban areas would likely be small, with a wide diversity of population groups and cultural systems present and, therefore, little likely contrast with any in-migrating population. Sociocultural impacts are likely to be larger in small urban and single-industry small urban areas than in large urban areas, with more homogeneity in local cultural systems and more likely contrast with any in-migrating population. Similar impacts might be expected in rural diverse communities, depending on the cultural origin of any in-migrating population.

Environmental Justice. The majority of potential impacts to low-income and minority populations would come as a result of the construction and operation of onshore infrastructure and support facilities. As it is likely that onshore facilities would be located close to industrial port facilities, it is possible that onshore current facility infrastructure could be located near minority and/or low-income populations. Infrastructure that would be constructed in support of OCS developments might include the addition of new landfalls, administration and waste facilities, and switchyard and transmission facilities. Construction of new facilities could produce noise and visual impacts, increased traffic, air and water pollution, impacts to residential property values, and land-use changes.

Varying degrees of hazard could be associated with the construction of the onshore components of OCS current energy facilities, producing potentially harmful impacts to the environment, subsistence, health, and physical safety. The effect of air emissions from OCS development on coastal air quality may also create environmental justice issues. The effect of air emissions associated with current energy facilities (e.g., emissions from onshore construction machinery and from construction and operation vessels and helicopters) on coastal air quality may also create environmental justice issues. Such emissions would result in NO_2, SO_2, PM_{10}, and CO levels that are well within the NAAQS. Air emissions from the proposed program are not expected to result in air quality impacts to minority or low-income populations.

Although construction, operation, and decommissioning of OCS current energy facilities and their associated coastal infrastructure support facilities might result in environmental justice issues in a number of counties along the coast, in the absence of specific locations for these developments at the programmatic level, it is not possible to identify any specific disproportionately high and adverse impacts on minority and low-income populations. Impacts of offshore energy projects on specific population groups in specific coastal communities and neighborhoods would be part of site-specific analyses undertaken at the individual project level. These analyses would be based on population data at the census block group level for up to 50 mi from a project location, to fully reflect the impact of a particular energy development project on environmental justice given the regional distribution of minority and low-income population groups.

5.4.18.3 Mitigation Measures

Mitigation of economic, sociocultural, and environmental justice impacts associated with the development of OCS current technologies may be required, depending on the location, scale, and impact of specific projects. However, the magnitude of the economic and sociocultural impacts of ocean current technologies is likely to be small, with little employment and population in-migration required during each stage of a project. With onshore facilities likely to be located in existing ports, environmental justice issues may arise, depending on the location and nature of impacts of these facilities.

5.4.19 Cultural Resources

Impacts to cultural resources can occur during all construction-related phases of offshore current energy development where there is the potential for seafloor disturbance in previously undisturbed areas. Seafloor disturbance can be either the direct or indirect result of construction activities, such as securing or anchoring the devices to the ocean floor or offshore cable placement. Direct impacts are the result of direct destruction or removal of cultural resources from their primary context. Indirect visual effects could occur to historic resources on the coast if visual factors are important for maintaining the integrity of the resources (see Section 5.2.19.3). Although the specific types of cultural resources and their potential locations may vary regionally, the types of impacts that could occur to cultural resources are similar across the three regions.

5.4.19.1 Technology Testing and Site Characterization

Impacts to cultural resources could occur during technology testing and site characterization; however, specific impacts would need to be addressed at a site-specific project level. Impacts are expected to be minor to negligible assuming testing and characterization activities are at a very small scale and related construction activities can be moved to avoid cultural resources. Cultural resources identified in small testing areas can be just as significant as cultural resources in larger, full-scale development areas and require the same level of protection. Because some seafloor disturbance occurs during this phase, the same protection measures for cultural resources must be implemented during this phase as with the larger-scale construction phase to meet the requirements of Section 106 of the National Historic Preservation Act (NHPA) (see Section 5.4.19.2).

5.4.19.2 Construction

Impacts to cultural resources are most likely to occur during construction of a current energy development project; however, specific impacts would need to be addressed at a site-specific project level. Most impacts would result from some form of seafloor disturbance (trenching, dredging, facility, or component placement or installation), which could disrupt shipwrecks and buried prehistoric archaeological sites offshore. The level of impact could range from negligible to moderate depending on the location of the project; the level of seafloor disturbance that has previously occurred in that location; the number and significance of the sites present in that location if it has been previously undisturbed; the feasibility of moving portions of the development project to avoid important resources; and the expected efficacy of mitigation/data recovery should impacts to some significant sites be unavoidable.

Indirect visual impacts could also result from disruption of a historical setting that is important to the integrity of a historic structure, such as a lighthouse or residential or community building. Visual impacts during construction are anticipated to be negligible to minor since the impacts of construction are temporary.

5.4.19.3 Operation

There are few activities during operations that would have the potential to impact cultural resources; impacts would need to be determined on a site-specific basis. Maintenance and inspection activities involve mostly transportation activities for workers and equipment and would not likely affect cultural resources. The exception to this would be the replacement or removal of system components. These impacts would be similar to those described in Section 5.4.19.4, under decommissioning. The level of impact would be considered negligible to minor as impacts would have already occurred during construction. However, if new areas were disturbed as a result of these activities, the potential for impact would increase and surveys could be necessary if not already completed in the area of new disturbance. Indirect visual impacts to historic structures are not expected with this technology.

5.4.19.4 Decommissioning

Decommissioning activities are similar to construction activities, although in reverse order. Impacts to cultural resources are expected to be negligible to minor, as most impacts would have likely occurred during construction. Impacts are possible if new areas of the seafloor are disturbed during decommissioning. If new areas are disturbed as a result of these activities, the potential for impact would increase, and surveys could be necessary if not already completed in the area of new disturbance.

5.4.19.5 Mitigation Measures

Cultural resources are nonrenewable and are, therefore, irretrievably lost once they have been impacted. Avoidance of a significant resource is the preferred mitigation option and the MMS's preferred policy. Currently, the MMS has regulations in place for addressing cultural resources prior to oil and gas development (e.g., 30 CFR 250.194); similar regulations are currently being drafted for the development of alternative energy as similar types of impacts could occur. The MMS meets its responsibilities under the NHPA for projects over which it has permitting authority on the OCS through the following procedures: the MMS begins the Section 106 process by initiating consultation with the appropriate States, affected tribes, and other interested parties. Consultation begins with the MMS informing the parties of the project's details and the steps the MMS undertakes to identify and consider cultural resources that may be affected by the proposed project. Consultation is ongoing throughout the project.

The MMS policy requires the performance of marine remote sensing surveys within all areas where MMS archaeological baseline studies indicate a potential for cultural resources (historic and prehistoric) to exist. If the results of these surveys indicate the presence of a potential cultural resource within the project area, the MMS requires that the project either be modified to avoid the location of the potential cultural resource or that further investigations be conducted to conclusively determine the identity of the potential resource. If further investigations indicate that a significant cultural resource exists and cannot be avoided by the proposed project, the MMS would continue Section 106 consultation with the State, affected tribes, and other interested parties to determine the appropriate mitigation. Potential mitigation strategies include, but are not limited to, full data recovery, partial data recovery, monitoring, sampling strategies, remote sensing, mapping, and photography. Confining maintenance and decommissioning activities to areas previously disturbed during project construction activities would be encouraged to minimize additional potential impacts to cultural resources.

The MMS also requires, through regulation, and/or lease stipulation that if any unanticipated cultural resource is encountered during project-related activities, all activities within the area of the discovery be immediately halted and the MMS contacted.

The MMS (BLM prior to 1981) and/or the NPS have tested and refined the survey and mitigation strategies for identification, evaluation, and avoidance of offshore cultural resources through numerous studies over the past 30 years. These studies include, among others, CEI 1977; Institute for Conservation Archaeology 1979; SAI 1981; CEI 1982; CEI 1986; PS Associates 1987; Garrison et al. 1989; Espey, Huston & Associates, Inc., 1990; Pearson et al. 2003; and PBS&J 2006. See Sections 4.2.19, 4.3.19, and 4.4.19 for discussions of those OCS areas within the Atlantic, Gulf of Mexico, and Pacific regions where MMS baseline studies indicate a potential for historic properties and where the MMS will implement its survey and mitigation requirements.

For onshore cultural resources, including historic architectural resources, districts, and landscapes that may be subject to adverse visual effects from an OCS project, the MMS will develop appropriate mitigation through consultation with the States, affected tribes, and other interested parties in accordance with the procedures outlined in the ACHP regulations at 36 CFR 800.

5.4.20 Land Use and Existing Infrastructure

5.4.20.1 Technology Testing and Site Characterization

Most interest in ocean current energy technology is centered along the east coast of Florida. All testing and site characterization activities would be relatively small and unobtrusive but would be an obstruction to navigation and could affect some uses, but impacts would be negligible.

5.4.20.2 Construction, Operation, and Decommissioning

Support requirements for current energy development would be similar to those for wave energy developments and would require standard-size port facilities to support construction and placement, so no modification of existing facilities is expected. Vessel types and sizes to handle the equipment would also be typical. Impacts are expected to be negligible.

There are currently no available estimates of the amount of labor that would be required to construct or maintain a current energy facility, but generally it is expected that job skills for installation are present in most coastal communities. Individual components for a facility would likely be constructed elsewhere and shipped to the area by truck. With the expected size of commercial developments during the analysis period, impact on local labor, housing, and infrastructure is expected to be negligible but would need to be reviewed at the site-specific level.

The area occupied by a current energy development could be highly variable depending on both the design capacity and the technology employed. During the analysis period, it appears that systems likely to be deployed would require 2.6 km^2 (1 mi^2) per 50 MW of capacity. Estimates indicate a potential for very large installations in the long term if the technology proves successful. Current energy technology is likely to use pile-driven supports that will emerge from the water and create surface obstructions. For that reason, the area occupied by the facility may be unavailable for other uses. Facilities would exclude commercial shipping, but other possible restrictions would be developed on a project-specific basis. Overall impacts are expected to be negligible to minor.

Onshore construction to deliver electrical production from an offshore facility to the local/regional grid will be required but is expected to have negligible impact on the area. Additional underground and/or overhead transmission lines may be required, as well as some additional electrical substation facilities, depending on the generation capacity of the new project and the capacity of the existing land-based transmission system. For the analysis period, the overall impact is expected to be negligible.

There are many existing uses along coastal areas and in the nearshore areas that are potentially affected by or could affect a current energy development. Examples of existing water uses can include shipping fairways, recreational boating, undersea cable installations, shellfish beds or fishery areas, and marine sanctuaries. Examples of onshore uses that may be affected include wildlife refuges; units of the national, State, and local park systems; and areas of high scenic value. All existing uses of areas proposed for current energy development would need to be identified during site-specific project review to determine the potential effects of any proposed development. Additionally, the Coastal Zone Management Act (CZMA) requires a Federal agency to consult with States regarding consistency with their approved Coastal Zone Management Programs.

Operations activities would require conventional ocean surface transport but no special facilities beyond those likely already available in most coastal areas. Employment associated with project operation is unknown and would need to be defined at the project level.

Activities associated with decommissioning of a current energy facility would likely be the reverse of the construction process, although likely somewhat shorter in duration. Port, transportation, labor, and housing would be required to accomplish the removal. Impacts to land uses would be similar to those in the construction phase and are expected to be temporary and negligible.

5.4.20.3 Mitigation Measures

Public involvement and discussion should be effective in identifying the site-specific concerns associated with any proposed development. Once the concerns and issues were identified, it would be possible to develop effective mitigation measures and/or identify necessary trade-offs in making the decision on requested projects. An important factor is that Federal, State, and local processes would be involved before a final decision could be rendered. Depending on the specific proposal, impacts could range from negligible to moderate; they would be identified in a site-specific National Environmental Policy Act (NEPA) analysis.

5.4.21 Visual Resources

Technology testing, site characterization, construction, operation, and decommissioning of ocean current technologies and associated onshore facilities and activities on the OCS potentially would cause a variety of visual impacts. Ocean current technologies considered likely for commercial development in the time frame of the programmatic EIS would be completely submerged during normal operations, but depending on the type of technology deployed, some might be visible for brief periods during maintenance activities. The types of visual impacts of concern include the potential visibility of offshore and onshore structures; the potential visibility of vessels, helicopters, and other watercraft and aircraft associated with the transport of workers and equipment for construction, maintenance, and facility decommissioning; and the potential visibility of the construction, maintenance, and decommissioning activities themselves.

Because of the subjective and experiential nature of human visual perception and cognition, the assessment of the magnitude and importance of perceived visual impacts is both subjective and site- and time-specific. Visual impacts are highly dependent not only physical factors that affect what the impacts are and how they are perceived, but also on the number and type of viewers, their sensitivity to the visual environment, and cultural factors that concern both the viewer and the affected landscape/seascape (BLM 1984; DTI 2005; USFS 1995); the reader is referred to Section 5.2.21 for a discussion of the these factors. It should be noted that because of the lack of established commercial ocean current energy facilities, little is known about the perception of visual impacts arising from ocean current energy facilities, especially at distances offshore comparable to those on the OCS.

Several visual impact mitigation measures for ocean current energy facilities are presented in Section 5.4.21.6. Although the visual impacts that would be expected to occur from ocean current energy development would be highly site- and viewer specific, application of appropriate mitigation measures might substantially reduce or even eliminate visual impacts for many viewers/locations.

5.4.21.1 Technology Testing

As discussed in Section 3.5.1, a demonstration-scale test for an ocean current facility would most likely involve the deployment of one or two devices per test. The devices would be installed in the offshore environment, and depending on the size of the individual unit, they could be towed to their offshore locations or shipped by barge or special-purpose vessel. Depending on the distance from shore, these activities might be visible from shore, but because the ocean current energy devices would be underwater, they would not contribute to visual impacts after installation. Navigational markers (e.g., buoys) would be located on the water's surface above the devices, but would likely be hidden from onshore viewers by waves or the curvature of the earth (see Table 5.2.21-1). Waves and the presence of fog, rain, or haze would sometimes provide further screening. Onshore viewers thus might see the marine vessels transporting the ocean current energy devices and equipment to the site. Navigation warning lights above the devices might be visible from shore under clear conditions in some cases; however, this would depend on site-specific factors, such as viewer elevation and distance of the facility from shore. Visual impacts would be determined at the site-specific level but would be expected to be negligible for onshore viewers in most cases. Boaters could approach the ocean current facility closely, and thus the markers could become visually prominent, but the view duration would normally be very brief, and the expected impacts negligible.

5.4.21.2 Site Characterization

It is not expected that site characterization activities for ocean current facilities would involve placement of structures or floating devices on or above the water that would be visible from shore. Boaters and onshore viewers with elevated viewpoints might see buoys and equipment as well as marine vessels involved in subsurface characterization, but the duration of these activities would be brief, the extent of the activities would be small in visual terms, and the activity level would likely not be above normal for many locations; thus, the expected visual impact level would be negligible.

5.4.21.3 Construction

Construction activities for an ocean current facility would involve both onshore and offshore activities associated with potential visual impacts. Onshore activities would include the manufacture, transport, and assembly of device components at a facility that likely would be at or near the shore. Offshore construction activities would include transport of the ocean current energy devices and related equipment to the facility site and the assembly and installation of the devices at the site.

Manufacture of ocean current energy device components for use on the OCS is expected to occur at existing facilities, so that no additional impacts are expected beyond those associated with normal activities. In the vicinity of the assembly point (typically a port facility), there would be increased traffic visible from trucks and/or marine vessels delivering components. If the assembly facility required expansion to accommodate the activities associated with device component assembly and storage, construction activities such as dredging and dock expansion might be visible, and while impact levels would depend on site- and situation-specific factors, impacts could range from negligible to moderate for some viewers. A determination of impacts for construction and operation of these facilities would be conducted during a site-specific NEPA analysis. These construction-related visual impacts would cease when construction was completed, but if the facility expansion resulted in visible permanent structures, the related impacts could be permanent for the lifetime of the facilities.

While it is not anticipated that construction of new conduits, substations, and overhead transmission lines would be required within the time frame of the programmatic EIS, if such construction was needed, related visual impacts would be expected to be negligible to moderate, depending on the size and nature of the facilities, as well as the proximity and visibility of the facilities to viewers. A determination of impacts for construction and operation of these facilities would be conducted during a site-specific NEPA analysis. These construction-related visual impacts would cease when construction was completed, but because the facilities would result in visible permanent structures, the related impacts could be permanent for the lifetime of the facilities.

Transport of ocean current energy device components to the offshore facility location would involve marine vessels to carry components and construction equipment to the facility site, and helicopters might be used to transport workers. Nearby onshore and offshore viewers might notice an increase in traffic. Views would typically be of short duration and impacts would be expected to be negligible to minor.

Construction activities at the offshore facility could include mooring installation, assembly of ocean current energy devices, and laying of cable. All of these activities could potentially cause both onshore and offshore visual impacts, depending on the distance from shore- and from water-based viewers. A variety of marine vessels would be used for these tasks, and one or more might be present on site at a given time. Helicopters might also be present at times, and viewers might notice the activity of the vessels and helicopters; however, the visual impacts directly associated with construction would cease upon completion of construction. Impacts are expected to be negligible to minor for onshore viewers, and minor to moderate for boaters in the immediate vicinity of the facility.

5.4.21.4 Operation

Operation of an ocean current facility could potentially cause both onshore and offshore visual impacts. While it is not anticipated that construction of new conduits, substations, and overhead transmission lines would be required within the time frame of the programmatic EIS, onshore impacts would arise if new conduits, substations, and overhead transmission lines were constructed or expanded in association with the new ocean current energy facility. In addition to the presence of the structures associated with the conduits, substations, and overhead transmission lines, periodic maintenance activities would require the temporary presence of workers and vehicles. These impacts would be determined during the conduct of the site-specific NEPA analysis but generally would be expected to be negligible to minor, because the maintenance activities are infrequent and of short duration.

Offshore impacts associated with the development of ocean current energy facilities on the OCS include the presence of navigational lighting and buoys on the ocean surface above the devices, and the presence of marine vessels and/or helicopters for maintenance activities. Potential visual impacts would normally be expected to be different for onshore viewers than for offshore viewers; onshore viewers would see the facility from a distance of at least several miles, but might see onshore facilities from much shorter distances. Depending on their location, offshore viewers might see the facility from a wide range of distances, including very short distances.

The magnitude of the visual impacts associated with a given ocean current energy facility would depend on site- and project-specific factors, including:

- Distance of the proposed facility from shore;
- The size of the facility (i.e., number of ocean current energy devices);
- The number and type of viewers (e.g., residents, tourists, workers);
- Their location (onshore vs. offshore);
- Their attitudes toward alternative energy and ocean current power;
- The visual quality and sensitivity of the landscape/seascape;
- The existing level of development and activities in the facility area and nearby onshore areas (i.e., scenic integrity and visual absorption capability);

- The presence of sensitive visual and cultural resources;
- Weather conditions;
- Lighting conditions; and
- The arrangement of navigation lights and buoys on the ocean surface above the devices.

The ocean current energy devices considered likely for commercial development in the time frame considered in the programmatic EIS would be completely below the water's surface during normal operations, thus there would be no expected visual impacts from the devices themselves.

Because of their low height above the water surface, aviation warning lights would not be required on ocean current energy devices considered likely for commercial development in the time frame considered in the programmatic EIS. Buoys with navigation lights and markings would be present, but these lights and markings would be relatively inconspicuous to onshore viewers, and at greater distances could be partially or completely concealed below the horizon due to the earth's curvature. Expected visual impacts caused by buoys and navigational lighting/markings would be determined during a site-specific NEPA analysis but would be expected to be negligible in most cases for onshore viewers.

For offshore viewers, potential visual impacts could be greater than for onshore viewers, because boats could closely approach or potentially move through an ocean current energy facility that contained multiple buoys. In a close approach, the individual buoys could be noticeable to boaters. Structural details, such as surface textures, could become apparent, as could strong specular reflections from the buoy surfaces. However, views from passing boats would be brief, and the buoys are relatively small devices and common in most areas. Consequently, visual impacts would be expected to be negligible for most boaters.

For both onshore and offshore viewers, ocean current energy facility maintenance activities could potentially cause visual impacts. Technicians would be transported by relatively small boats to the facility where they would either work directly on the devices underwater, or remove components to the shore for repair and then return them. In poor weather conditions, the technicians might be transported via helicopter to the OCS location. These activities would result in marine vessel traffic and/or helicopter traffic in and around the facility that might be noticed by viewers. Such service-related stops would be of short duration, and associated impacts would be expected to be negligible to minor in most instances.

5.4.21.5 Decommissioning

Decommissioning of an ocean current energy facility would involve the dismantling and removal of infrastructure associated with each unit, foundations or moorings, scour protection devices, and transmission cables, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). In terms of expected visual impacts, decommissioning activities would be similar to construction activities; however, activities would generally proceed in reverse order from construction, and would proceed more quickly than construction, and thus the associated impacts would last for a shorter time. At the completion of decommissioning, no evidence of the facility's presence would remain offshore; however, as noted above, impacts associated with any new or expanded permanent onshore facilities resulting from ocean current energy facility development would remain.

5.4.21.6 Mitigation Measures

Recommended visual impact mitigation measures for ocean current energy development on the OCS include the following:

Project siting. The choice of location for an ocean current facility is the single most important opportunity for visual impact mitigation. Recognizing that resource and economic as well as other drivers must be considered and balanced against aesthetic concerns, consideration should be given to locating developments further offshore or farther away from sensitive visual resource areas and/or areas with limited visual absorption capability or high scenic integrity, in order to reduce perceived visual impacts. Where possible, developments should be sited in seascapes that are already industrialized and developed, with due consideration for visual absorption capacity and possible cumulative effects. The use of headlands to screen views of developments from sensitive landscapes/seascapes should be considered, and ocean current facilities should be sited so that they are not framed by landforms in "keyhole" views from highly sensitive inland scenic vistas or other sensitive areas.

Viewshed mapping, visual impact simulations, and public involvement. Viewshed mapping and visual impact simulations should be used to create accurate depictions of the visibility and appearance of proposed facilities. Simulations should depict proposed project appearance from sensitive/scenic locations as well as more typical viewing locations. These viewshed analyses and visual impact simulations should form key elements of a program to inform and involve the public in evaluation of visual aspects of project design.

Navigational warning lighting. If possible within the lighting requirements of the Coast Guard, lighting should be minimized, and navigation lights with minimal visibility from shore should be considered.

5.4.22 Tourism and Recreation

5.4.22.1 Technology Testing and Site Characterization

Because it is likely that testing activities would be located close to industrial port facilities, it is not expected that construction of a support base for vessels and other onshore infrastructure (if needed), use of existing airfields for helicopter support, and other operations activities would impact tourism and recreation. As there have been no negative impacts on tourism and recreation reported from military, commercial, and recreational water and air vessels that currently traverse coastal areas intermittently, it is unlikely that there would be any detrimental impact on tourism and recreation from vessels supporting technology testing and site characterization activities.

5.4.22.2 Construction, Operation, and Decommissioning

The main recreation and tourism activities on the Atlantic Coast that could be affected by OCS construction, operations and decommissioning would be beach recreation, sightseeing, diving, and recreational fishing. The extent of impacts would depend on the proximity of OCS coastal and offshore activities to recreational use areas.

The location of OCS developments and coastal infrastructure might visually affect visitors, although the extent of the impact of the visibility of offshore OCS on tourism and recreation is uncertain. While some visitors may prefer unobstructed views, for others the opportunity to view alternative energy facilities might be attractive. Regardless of structure location, there would be the potential for a visual impact on tourists traveling on cruise ships; however, there appears to be no detrimental visual impact on the cruise industry in other destinations. There would be a potential visual impact to recreational boaters who might not want any structures offshore, and adverse impacts to offshore wildlife may also affect recreation. The displacement of recreational users from areas in which offshore energy development might occur could adversely affect the overall recreational experience in other coastal areas not likely to host offshore energy facilities, as these might become popular recreation locations. Some tourists and recreational users on coastal beaches could be affected by the sight and sound (helicopter and boat traffic) of OCS facility operations, but few, if any, are expected to forgo their visits because of these routine intermittent operations.

Switchyards and transmission lines could exist near important recreational areas, and transmission line landfalls could cause temporary removal of shoreline recreational land from public use for short periods. Except in extreme circumstances, however, impacts are expected to be minor or temporary.

5.4.22.3 Mitigation Measures

Mitigation of impacts on tourism and recreation associated with the development of OCS current technologies may be required depending on the location, scale, and impact of specific projects. The visibility and audibility of OCS structures from areas where there is significant recreational activity, tourism, or scenic quality would likely exaggerate the magnitude of impacts, while locations in areas where these activities were largely absent would likely minimize the magnitude of such impacts of OCS energy developments.

5.4.23 Fisheries

The southern Atlantic region (Section 4.2.23) supports diverse and valuable commercial and recreational fisheries. Impacts to fisheries could result from OCS alternative energy development activities that (1) cause changes in the distribution or abundance of fishery resources, (2) reduce the catchability of fish or shellfish, (3) preclude fishers from accessing viable fishing areas, (4) cause losses or damage to equipment or vessels, or (5) reduce the market value of a fishery. Although this section evaluates general types of impacts that could result from OCS current energy development, specific impacts to fisheries would depend on various aspects of a particular project, including geographic location, spatial scale, timing of activities, design of energy technology components, and the proximity of that project location to specific fishery resources. Thus, it would be necessary to conduct more detailed analyses of potential impacts to fisheries as part of site-specific evaluations for proposed projects.

As described in Section 5.4.11, there could be localized temporary effects on the distribution or abundance of some fish resources during some phases of OCS current energy development. However, activities are not expected to measurably affect overall populations of fishes or invertebrates that support commercial or recreational fisheries. It is assumed that sensitive seafloor habitats, which sustain production for many important fishery species, would be avoided during development of OCS current energy projects (Section 5.4.14). Thus, although individual organisms or small areas of seafloor habitat could be affected, the populations of organisms that are the targets of commercial fisheries would not be measurably reduced. In addition, it is anticipated that none of the OCS activities would measurably alter the market value of fishery resources. Because of this, the following sections focus on potential effects of OCS current energy development on catchability of targeted organisms, access to fishing areas, and damage or loss of equipment or vessels.

In essentially every respect, the potential impacts to commercial and recreational fisheries from development of current energy projects on the OCS would be similar to those presented for OCS wave energy development in Section 5.3.23. However, only areas in the southern Atlantic region are currently being considered for development of offshore current energy technologies.

5.4.23.1 Technology Testing

As described in Section 3.5.1, proposals to test and demonstrate offshore current energy technologies will occur within the next 5 to 7 years. These demonstration-scale tests would likely involve deployment of one or two test devices within an offshore testing area, with or without the construction of an undersea transmission connection to shore. Depending on the technology being tested, test units could utilize fixed foundations (e.g., monopiles) or could use concrete anchors in various mooring arrangements. As described in Sections 5.4.11 and 5.4.14, impacts on fish resources and seafloor habitats from the small number of vessel trips required for technology testing would be expected to be negligible.

Potential impacts to commercial and recreational fisheries from testing of current energy technologies are anticipated to be essentially the same as those identified for wave energy technologies in Section 5.3.23.

5.4.23.2 Site Characterization

Fisheries could be affected during site characterization by the presence of survey vessels, by geological and geophysical surveys, by drilling and core sampling, and by the installation of one or more oceanographic sampling buoys within the project area.

Potential impacts to commercial and recreational fisheries from site characterization for current energy projects are anticipated to be essentially the same as those identified for wave energy projects in Section 5.3.23.

5.4.23.3 Construction

Construction activities and placement of transmission lines on the seafloor could harm or temporarily displace individual organisms from localized areas. However, population-level changes in abundance or distribution are not anticipated, and impacts to seafloor habitats are expected to be negligible (Sections 5.3.11 and 5.3.14). If pilings are required to anchor the current energy structures, the use of pile-driving equipment would be required for a few hours for each piling needed. It is estimated that pile driving would occur only intermittently during the construction period and that fishery resources would likely return to the disturbed areas between construction sessions. Other anchoring options would likely result in smaller effects.

Potential impacts to commercial and recreational fisheries from construction activities for current energy projects are anticipated to be essentially the same as those identified for wave energy projects in Section 5.3.23.

5.4.23.4 Operation

Once construction of an offshore current energy facility is completed and operation of the facility has commenced, fish resources could be affected by the presence of the structures, by traffic and noise from vessels used to maintain the structures, and by noise associated with operations. In addition, the presence of electromagnetic fields associated with transmission cables has a potential to affect some fish species. As identified in Sections 5.4.11 and 5.4.14, impacts to fish populations and seafloor habitats from these impacting factors are expected to be negligible in most cases.

Potential impacts to commercial and recreational fisheries during operation of current energy projects are anticipated to be essentially the same as those identified for wave energy projects in Section 5.3.23.

5.4.23.5 Decommissioning

Decommissioning activities would include the dismantling and removal of current energy generation units, the removal of offshore transformers, and the shipment of these materials to shore for reuse, recycling, or disposal (Section 3.5.5). Pilings (if needed) would be removed by cutting them at a depth of at least 4.6 m (15 ft) below the surface of the surrounding sediment. During decommissioning, there could be some localized effects on fishery resources (Section 5.4.11), especially if explosives were needed to remove pilings. Removal of structures that act as artificial reefs would result in loss of recreational fishing opportunities that had developed during the operational phase. There is also a small potential for accidental releases of hazardous materials and fuel during decommissioning activities.

Potential impacts to commercial and recreational fisheries from decommissioning of current energy projects are anticipated to be essentially the same as those identified for wave energy projects in Section 5.3.23.

5.4.23.6 Mitigation Measures

- Avoid locating OCS energy generation facilities and cables near known sensitive fish habitats and within known high-use fishing areas.

- Require lessees to review planned activities with potentially affected fishing organizations and port authorities to prevent unreasonable fishing-gear conflicts.

- When possible, conduct noise-generating activities during closed fishing periods or seasons.

- Consider the addition of lights and/or radar reflectors to increase the ability of vessel captains to detect and avoid OCS energy structures.
- Ensure that locations of energy projects are supplied to regional fishing organizations and are added to navigational charts.

- Utilize practices and follow operating procedures that reduce the likelihood of vessel accidents and fuel spills.

- Where possible, bury cables to prevent conflicts with fishing gear.

5.4.24 Nonroutine Conditions

As discussed for wind and wave energy in Sections 5.2.24 and 5.3.24, there is the potential for nonroutine events that could cause impacts to human health and the environment during all phases of current energy development on the OCS. The primary hazards common to all project phases are: (1) industrial hazards, (2) collisions between marine vessels and either components of the current energy facility or vessels constructing, used in servicing, or maintaining the facility, (3) natural events, such as hurricanes and earthquakes, and (4) sabotage or terrorism events.

For any activity or facility, the *risk* posed by a nonroutine event depends on two factors: the probability (or expected frequency) of the event occurring and the consequences if the event did occur. Event probabilities can range from very rare events, highly unlikely to occur during the lifetime of a facility, to relatively frequent events that might be expected to occur once or more during the lifetime of a facility. In many cases, nonroutine event probabilities can be estimated from historical statistical data for similar activities, facilities, or locations. The consequences of events could range from essentially no measurable or observable impacts to potentially severe impacts to human health or the environment. Quantifying the risk of nonroutine events requires that both factors be taken into account: likely events with relatively minor consequences might present a similar overall risk compared to highly unlikely or incredible events with much higher consequences.

Both the probability of nonroutine events occurring and the potential consequences if they did occur are project- and site-specific. Therefore, the risk posed by such events must be evaluated on a project-specific basis. As discussed in Section 3.4, ocean current energy is at an early stage of development, with only a small number of prototypes and demonstration units having been tested to date. Many of the proposed technologies utilize significantly different generating technologies and mooring systems. Consequently, risks from nonroutine events are discussed in general terms in this section.

Industrial Hazards. The industrial hazards during the testing, characterization, construction, operation, and decommissioning of ocean current energy projects on the OCS are working on, over, or under water. Working on, over, or under water can pose a risk of drowning, and requires the additional consideration of wind and weather and the availability of buoyancy devices and qualified boat and rescue personnel.

A further industrial hazard involves vessel entanglement with undersea gathering or transmission lines. Entanglement or catching undersea cables can occur during trawling and other net fishing, shellfishing on the seabed, or during anchoring. Attempting to lift a cable by a vessel can result in the capsizing of the vessel or in electrocution (Drew and Hopper 1996). Undersea cables are typically buried to minimize risks associated with entanglement as well as potential damage to the cable.

Industrial accidents could result in both worker injuries and fatalities. However, the risks from industrial hazards depend on the magnitude, location, and characteristics of the specific project, health and safety planning and training, and adherence to established regulations and safety and accident prevention and control measures. Under authority established in the Outer Continental Shelf Lands Act (OCSLA) and pursuant to a memorandum of understanding (MOU) between the two agencies, the MMS and USCG regulate safety on fixed OCS facilities. The MMS regulates the structural integrity of fixed OCS facilities, and the USCG regulates marine systems, such as lifesaving, navigation equipment, and workplace safety and health. In February

2002, the USCG issued a final regulation that authorized the MMS to perform inspections on fixed facilities engaged in OCS activities on their behalf, and to enforce USCG regulations applicable to those facilities (67 FR 5911-5916; February 7, 2002 [revising 33 CFR 140.103(c)]). The OCSLA also requires that the MMS and the USCG investigate major accidents, deaths, serious injuries, major fires, and major spillages, as well as lesser accidents.

Collisions. An ocean current energy facility located on the OCS could potentially cause a navigational risk to marine vessels. Applicants for offshore energy facility permits are required to perform an evaluation of all reasonably foreseeable issues related to navigation as set forth in guidelines published by the Coast Guard (USCG 2007). Collisions between marine vessels and current energy facility components that are on the ocean surface could be caused by human error (such as navigation errors), weather, or mechanical failures onboard ships that cause either a steering failure or loss of power (resulting in a drifting collision). Collisions between marine vessels and either components of an ocean current energy facility or vessels constructing, servicing, or maintaining the facility could have economic, safety, and environmental consequences. A collision between a ship and an ocean current energy device could result in production loss from a single device or the entire facility, as well as loss of life and spills of hazardous materials.

As discussed above, the risk posed by collisions depends on the probability of a collision occurring and the consequences if a collision does occur. Both of these factors are project- and site-specific. The probability of collisions between marine vessels and components of an ocean current energy facility depends in part on (1) physical characteristics of the facility itself, such as the type and number of devices and characteristics of components that are located at the ocean surface; (2) the location of the facility in relation to commercial shipping lanes or recreational marine traffic; and (3) environmental conditions at the facility location, such as wind velocities and direction, currents, water depths, ice, and visibility. The consequences of a collision also depend on project-specific characteristics, including the design of the ocean current energy devices as well as the distribution of ship types and sizes in the vicinity of the facility. Therefore, the risk posed by collisions must be evaluated on a project-specific basis.

During a collision, spills to the environment can occur from both the striking marine vessel as well as the object struck. The potential types and quantities of hazardous materials that might be present at an ocean current energy facility are summarized in Table 4.2.6-1. Considering the quantities of hazardous materials reported in Table 4.2.6-1, it is likely that any single spill from an ocean current energy facility would be small. The amount of hazardous material, such as diesel fuel, that could be released by a marine vessel involved in a collision would depend on the type of vessel and severity of the collision. As indicated by the Gulf of Mexico data for collisions with oil and gas platforms (see Section 6.5.2), releases on the order of 10,000 gal are possible.

It should be noted that collisions between marine vessels and ocean current energy devices would be very dependent on the characteristics of facility components located at the ocean surface. For a completely submerged ocean current technology, collision risks would be essentially nonexistent. However, some ocean current technologies might employ rigid monopiles anchored to the seafloor. Collisions with such facilities would be similar to those described for wind facilities in Section 5.2.24.

Natural Events. There is a potential for natural events to cause impacts to human health and the environment during all phases of ocean current energy development on the OCS. Such events include hurricanes, earthquakes, tsunamis, and severe storms. Depending on the severity of the event, components of a wave energy facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. Moreover, marine vessels used in constructing, servicing, or maintaining the facility could also be impacted, potentially resulting in loss of life and the release of hazardous materials (e.g., diesel fuel) to the environment. The potential types and quantities of hazardous materials that would be present at an ocean current energy project site and could be potentially released to the environment during a natural event were discussed above for collisions.

The probability of a natural event occurring is location-specific and differs among the three OCS regions considered in this study. For the Southern Atlantic region, hurricanes are much more likely to occur than earthquakes and the tsunamis that undersea earthquakes can cause. The risks from natural events should be taken into account during project-specific studies and reviews.

Sabotage or Terrorism. In addition to the events described above, there is a potential for intentional destructive acts, such as sabotage or terrorism events, to cause impacts to human health and the environment. As opposed to industrial hazards, collisions, and natural events, where it is possible to estimate event probabilities based on historical statistical data and information, it is not possible to accurately estimate the probability of a malevolent act. Consequently, discussion of the risks from sabotage or terrorist events generally focuses on the consequences of such events.

In general, the consequences of a sabotage or terrorist attack on an ocean current energy facility would be expected to be similar to those discussed above for collisions and natural events. Depending on the severity of the event, components of the facility could be damaged or destroyed, resulting in economic, safety, and environmental consequences. Moreover, marine vessels used in constructing, servicing, or maintaining the facility could also be impacted, potentially resulting in loss of life and the release of hazardous materials (e.g., diesel fuel) to the environment. The potential types and quantities of hazardous materials that would be present at an ocean current energy project site and potentially could be released to the environment were discussed above for collisions. The potential consequences of such events need to be evaluated on a project- and site-specific basis.

5.4.24.1 Technology Testing

As discussed in Section 3.5.1, ocean current technologies are much less advanced than wind technologies, and proposals to test and demonstrate various forms of these technologies on the OCS can be expected in the next 5 to 7 years. A demonstration-scale test for these technologies would most likely involve the deployment of one or two devices per test—with or without an undersea transmission connection to the shore. Although the risks would depend on the specific characteristics of the testing project, the expected limited extent of such activities would likely result in minor to negligible impacts to human health and the environment from nonroutine events.

5.4.24.2 Site Characterization

As discussed in Section 3.5.2, for ocean current energy technologies, acoustic Doppler current profilers (mounted on vessels or the seafloor) would likely be used to characterize currents. Site characterization might also involve geological and geophysical testing of the sea bottom to determine the strength and stability of substrata for the drilling and installation of anchoring devices. As described in Section 3.5.2, most seafloor characterization technologies would either involve the towing of sensors above the seafloor or the sampling of seafloor sediments. Although the risks would depend on the specific characterization project, the expected limited extent of such activities would likely result in minor to negligible impacts to human health and the environment from nonroutine events.

5.4.24.3 Construction

Construction of an ocean current energy facility may require the use of barges or special purpose vessels to install mooring systems and system components. The devices themselves would likely be constructed onshore and towed into place within the facility. The risk to human health and the environment from nonroutine events would depend on the characteristics of the specific construction project. However, given the relatively limited amounts of hazardous materials expected to be present during construction and assuming adherence to applicable occupational health and safety regulations, it is expected that impacts during construction would be negligible to minor.

5.4.24.4 Operation

The primary nonroutine event risk during operation of an ocean current energy facility is related to marine vessel collisions with the devices. As discussed above, the risk and consequences of collisions are site- and project-specific. Consequently, it is not possible to assign a generic level of significance to risks and impacts. However, with proper planning and mitigation, it is expected that risks could be maintained at negligible to minor levels.

5.4.24.5 Decommissioning

Nonroutine event risks during decommissioning are expected to be similar to those discussed for construction in Section 5.4.24.3.

5.4.24.6 Mitigation Measures

A number of mitigation measures are expected to be employed to minimize accident risks during ocean current energy development on the OCS. The primary mitigation measures would be aimed at minimizing the risk of vessel collisions with facility components that are located at or above the ocean surface. Ocean current energy facilities on the OCS likely would be noted on updated navigational charts for mariners. Moreover, surface components of the devices would be outfitted with navigational aids, such as lighting and (potentially) sound signals (e.g., bells or fog horns).

To ensure that mitigation measures are taken into account during OCS alternative energy projects, the developers of specific projects are required to conduct a navigational safety and risk assessment during the application process (USCG 2007). Among other items, the assessment must include a maritime traffic survey and an evaluation of collision risk (including likely frequencies and consequences of collisions). In addition, the developer must identify potential measures that could be implemented to mitigate any increased risks associated with the proposed project. The assessment must be submitted to the Coast Guard. The Coast Guard reviews the assessment to determine potential impacts of the proposed facility on the safety of navigation and other Coast Guard missions, such as marine environmental protection, search and rescue, aids to navigation, and maritime security.

In addition, vessels are generally expected to operate under the International Regulations for Preventing Collisions at Sea 1972. These rules require all vessels to duly regard all dangers of navigation and collision and specify that mariners are responsible for the safe operation of their vessels, regardless of the navigational situation.