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SUMMARY

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Offshore wind energy is one alternative to energy derived from the combustion of fossil fuels. The United States' ability to harness wind energy from the outer continental shelf (OCS) is at an initial stage compared with European countries and some Asian countries. As interest in the potential benefits of offshore wind grows in the United States, some stakeholders have expressed concerns about offshore wind projects' potential impacts on the marine ecosystem.

Offshore wind projects may affect the marine ecosystem and associated species in ways both adverse and beneficial. Stakeholders commonly cite effects such as changes to the ocean environment; habitat alterations; risks that living marine resources may collide with construction vessels and offshore wind structures; altered behaviors and disturbance of migration paths of certain fish, marine mammals, and birds; and water pollution. Some observers emphasize that, although individual offshore wind energy projects may have local, immediate impacts to certain species, the global ocean and the wildlife it supports are threatened by the long-term consequences of climate change. Many scientists concur that renewable power is important for addressing climate change and reducing its longer term environmental impacts. Some stakeholders have encouraged decisionmakers to include climate change risks facing the ocean and certain marine animals in analyses of offshore wind projects.

The National Environmental Policy Act (NEPA; 42 U.S.C. §§4321 et seq.) requires federal agencies to evaluate the impacts of major federal actions significantly affecting the human environment, such as issuing permits for offshore wind projects on the U.S. OCS. The Department of the Interior's (DOI's) Bureau of Ocean Energy Management (BOEM) is the lead agency for the preparation of environmental impact statements (EISs) in the context of approving developers' construction and operations plans for offshore wind energy projects. BOEM's responsibilities also include coordinating interagency review and permitting timelines in accordance with provisions of the Fixing America's Surface Transportation Act (42 U.S.C. §§4370m–4370m12). Certain federal agencies have further been tasked with administering specific statutes that aim to protect particular aspects of the environment or certain natural resources. The National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NMFS) cooperates in the EIS processes pursuant to its responsibilities under the Endangered Species Act (ESA; 16 U.S.C. §§1531-1544) and the Marine Mammal Protection Act (16 U.S.C. §§1361-1423h). DOI's U.S. Fish and Wildlife Service considers the ESA and the Migratory Bird Treaty Act of 1918 (16 U.S.C. §703) when participating in EIS processes. Other agencies may also have responsibilities related to permitting and environmental review of offshore wind projects.

The U.S. Department of Energy lists 59 offshore wind projects in federal and state waters at various stages of development, ranging from conception to construction to fully commissioned. In federal waters, BOEM has issued more than 30 leases for offshore wind development (some covering multiple projects) and anticipates completing review of at least 16 construction and operations plans by 2025. Several projects are currently operating in state and federal waters in the Atlantic region. Two commercial-scale projects in federal waters off Massachusetts and Rhode Island—Vineyard Wind 1 and South Fork Wind—have begun delivering power. A two-turbine pilot project operated by Dominion Energy is generating electricity in waters off Virginia. The five-turbine Block Island project is operating in state waters off Rhode Island.

In the 118th Congress, some Members have called for additional research into the potential harm offshore wind projects may cause to marine wildlife or expressed concern about the impacts that offshore wind activities might have on other ocean uses (e.g., H.R. 1). The full impacts of offshore wind activities on the U.S. OCS remain unclear, in part because the development of U.S. offshore wind projects is relatively recent. Issues for Congress may include potential impacts of offshore wind development on the marine ecosystem and potential long-term benefits of climate change mitigation derived from offshore renewable energy versus the immediate, local impacts of offshore wind to the marine ecosystem and associated species. Other concerns may include the potential loss of fishing grounds, interruptions to NMFS surveys, incidental take (or unintentional killing) of birds, and increased vessel activity that may be associated with offshore wind projects.

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Introduction

Development of renewable energy, such as offshore wind energy, is one approach to reducing anthropogenic carbon dioxide (CO_2) emissions by providing alternatives to the combustion of fossil fuels. Many scientists concur that renewable power is important for addressing climate change and reducing its longer term environmental impacts (see text box "Effects of Climate Change on the Ocean").[1] As interest in the potential benefits of harnessing offshore wind for energy grows in the United States, some stakeholders have expressed concerns about the impacts that offshore wind energy development may have on the marine ecosystem and associated species. Environmental impact statements (EISs) for proposed offshore wind projects have found a range of impacts—both adverse and beneficial—on various resources; these impacts are mostly projected to be minor to moderate, while in some cases they are negligible or major.[2]

As the federal government pursues policies for the development of offshore wind energy projects on the U.S. outer continental shelf (OCS),[3] Congress may continue to deliberate actions to mitigate the potential effects of offshore wind energy projects (across several developmental stages) on the marine ecosystem and associated species. For example, the James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 (Division J, Title CXIII, Subtitle C, §11319, of P.L. 117-263) directed a study of the impacts on certain marine living resources from the development of renewable energy on the West Coast. In the 118th Congress, House-passed legislation would direct the Government Accountability Office (GAO) to "assess the sufficiency of the environmental review processes for offshore wind projects," including offshore wind impacts on finfish, invertebrates, whales, and other marine mammals.[4]

This report discusses various aspects of how offshore wind projects may impact the marine ecosystem and associated species. First, the report discusses impacts that may be associated with different offshore wind project activities (e.g., site assessment and construction). Second, the report discusses how offshore wind projects may alter the local ocean environment and the ways in which certain species may be directly or indirectly impacted by offshore wind projects. The report in part draws on observational studies of ecological impacts surrounding offshore wind farms (OWFs) in the North Sea, since this area of the world provides the longest record of modern OWFs (see "U.S. Offshore Wind Energy in a Global Context," below). Other potential species impacts are informed by observational studies of land-based wind farms (e.g., collision risk to birds) or laboratory studies mimicking conditions (e.g., noise levels) often associated with offshore wind construction or operation. Third, the report discusses the responsibilities of federal agencies under various laws to consider and potentially mitigate these impacts. The broader role

[1] Intergovernmental Panel on Climate Change, "Summary for Policymakers," in *Climate Change 2023: Synthesis Report*, eds. Core Writing Team, Hoesung Lee, and José Romero, 2023, p. 21.

[2] For example, see Bureau of Ocean Energy Management (BOEM), "Vineyard Wind 1 Offshore Wind Energy Project Final Environmental Impact Statement Volume 1," March 2021, pp. ES-13-ES-14, https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Vineyard-Wind-1-FEIS-Volume-1.pdf. Environmental impact statements (EISs) are discussed in greater detail in the "Relevant Statutes for Federal Agency Actions Related to Offshore Wind Projects" section of this report.

[3] The U.S. outer continental shelf (OCS) is the seabed and subsoil beneath the U.S. exclusive economic zone located generally between 3 and 200 nautical miles from the shoreline. White House, "Proclamation 5030: Exclusive Economic Zone of the United States of America," 48 *Federal Register* 10605, March 10, 1983.

[4] Division B, Title 1, §20119, of H.R. 1. In June 2023, Rep. Chris Smith announced that the U.S. Government Accountability Office (GAO) had agreed to undertake such a study in response to Member requests (Rep. Chris Smith, "GAO Agrees to Smith's Request for Independent Investigation into the Impacts of New Jersey's Unprecedented Offshore Wind Industrialization," press release, June 15, 2023, https://chrissmith.house.gov/news/documentsingle.aspx?DocumentID=411511).

of federal agencies in the development of offshore wind (beyond environmental review) is outside the scope of this report.[5] Finally, the report discusses some issues for possible congressional consideration, such as additional research on potential impacts associated with offshore wind on the U.S. OCS and competing ocean uses.

U.S. Offshore Wind Energy in a Global Context

Compared with some European and Asian countries, the United States' deployment of offshore wind energy on the U.S. OCS is at an initial stage.[6] Some countries began exploring the development and deployment of modern OWFs as early as the 1990s, when Denmark, the United Kingdom, Sweden, and the Netherlands built OWFs as demonstration projects in the North Sea.[7] In 2022, Europe accounted for 51.0% of global offshore wind capacity, followed by Asia (48.9%).[8] China's offshore wind experienced substantial growth in 2021 and 2022; by the end of 2022, China accounted for nearly 44% of the world's offshore wind capacity.[9]

According to the Department of Energy, the United States has 59 offshore wind projects in federal and state waters at various stages of development, ranging from conception to construction to fully commissioned.[10] In federal waters, the Department of the Interior's (DOI's) Bureau of Ocean Energy Management (BOEM) has issued more than 30 leases for offshore wind development (some covering multiple projects) and anticipates completing review of at least 16 construction and operations plans (COPs) by 2025.[11] Several projects are currently operating in state and federal waters in the Atlantic region.[12]

[5] For information about the role of federal agencies in the development of offshore renewable energy, see CRS Report R46970, *U.S. Offshore Wind Energy Development: Overview and Issues for the 118th Congress*, by Laura B. Comay and Corrie E. Clark; CRS Report R40175, *Offshore Wind Energy Development: Legal Framework*, by Adam Vann.

[6] Department of Energy (DOE), "Grand Challenges to Close the Gaps in Offshore Wind Energy Research," October 2022, https://www.energy.gov/eere/wind/articles/grand-challenges-close-gaps-offshore-wind-energy-research.

[7] Ørsted, "Making Green Energy Affordable," June 2019, https://orsted.com/-/media/WWW/Docs/Corp/COM/explore/Making-green-energy-affordable-June-2019.pdf.

[8] North America makes up the remaining offshore wind capacity at 0.1%. DOE, *Offshore Wind Market Report: 2023 Edition*, DOE/GO-102023-6059, August 2023, p. 53 (hereinafter cited as DOE, *2023 Market Report*).

[9] Ibid.

[10] Ibid., p. 15. For most coastal states, state-controlled waters extend to 3 nautical miles off the coast. For more information, see CRS Report R40175, *Offshore Wind Energy Development: Legal Framework*, by Adam Vann, and CRS Report RL33404, *Offshore Oil and Gas Development: Legal Framework*, by Adam Vann. Offshore wind projects also have been considered for the Great Lakes under state jurisdiction.

[11] BOEM, *Budget Justifications and Performance Information, Fiscal Year 2024*, p. 25, https://www.boem.gov/sites/default/files/documents/about-boem/budget/FY-2024-BOEM-Congressional-Justification_0.pdf. BOEM's approval of a construction and operations plan (COP), along with needed permits from other agencies, allows a lessee to initiate project construction and operations. For more information about U.S. offshore wind energy development, see CRS Report R46970, *U.S. Offshore Wind Energy Development: Overview and Issues for the 118th Congress*, by Laura B. Comay and Corrie E. Clark.

[12] As of the date of this CRS report, two commercial-scale projects in federal waters off Massachusetts and Rhode Island—Vineyard Wind 1 and South Fork Wind—had begun delivering power. Additionally, a two-turbine pilot project operated by Dominion Energy is generating electricity in waters off Virginia. The five-turbine Block Island project is operating in state waters off Rhode Island. For more information, see CRS Report R46970, *U.S. Offshore Wind Energy Development: Overview and Issues for the 118th Congress*, by Laura B. Comay and Corrie E. Clark.

U.S. Policies

Several executive branch and congressional actions have set the stage for increased development and deployment of offshore wind energy on the U.S. OCS.[13] For example, Section 388 of the Energy Policy Act of 2005 (P.L. 109-58) amended the Outer Continental Shelf Lands Act (43 U.S.C. §§1331-1356c) to authorize the Secretary of the Interior to offer leases, easements, and rights-of-way for offshore renewable energy activities on the U.S. OCS.[14] BOEM is the lead agency for the U.S. OCS renewable energy leasing program.[15] In the 117th Congress, Section 50251 of the Inflation Reduction Act of 2022 (P.L. 117-196) expanded BOEM's authority to pursue offshore wind leasing in federal waters in the southeastern Atlantic region, in the eastern Gulf of Mexico, and off U.S. territories.[16]

On the executive side, the Biden Administration suggested a doubling of offshore wind by 2030 as one potential approach to address climate change in Executive Order (E.O.) 14008, "Tackling the Climate Crisis at Home and Abroad."[17] In March 2021, the Biden Administration announced a government-wide effort to deploy 30 gigawatts (or 30,000 megawatts) of offshore wind energy by 2030.[18] In September 2022, the Administration announced a related goal to deploy 15 gigawatts (or 15,000 megawatts) of installed floating offshore wind (i.e., structures that are not set into the ocean floor) by 2035.[19] As of December 2023, BOEM has conducted 12 competitive wind energy lease sales for areas on the OCS, representing more than 2.5 million acres of commercial wind energy lease areas offshore of Delaware, Louisiana, Maryland, Massachusetts, New Jersey, New York, North Carolina, Rhode Island, South Carolina, Virginia, and California.[20]

Background on Offshore Wind Energy Project Development

Stakeholders have expressed concerns regarding potential impacts to the marine ecosystem and associated species that pertain to offshore wind project activities associated with site development, construction, operation, and decommissioning.[21] The following sections provide

[13] For more information, see CRS Report R46970, *U.S. Offshore Wind Energy Development: Overview and Issues for the 118th Congress*, by Laura B. Comay and Corrie E. Clark; and CRS Report R40175, *Offshore Wind Energy Development: Legal Framework*, by Adam Vann.

[14] P.L. 109-58, §388 (43 U.S.C. §1337(p)), authorized the Secretary of the Interior to issue leases, easements, and rights-of-way for energy development "from sources other than oil and gas."

[15] BOEM, "Renewable Energy of the Outer Continental Shelf," https://www.boem.gov/renewable-energy/renewable-energy-program-overview.

[16] For more information, see CRS Insight IN11980, *Offshore Wind Provisions in the Inflation Reduction Act*, by Laura B. Comay, Corrie E. Clark, and Molly F. Sherlock.

[17] Executive Order (E.O.) 14008, "Tackling the Climate Crisis at Home and Abroad," 86 *Federal Register* 7619, January 27, 2021.

[18] White House, "Biden Administration Jumpstarts Offshore Wind Energy Projects to Create Jobs," fact sheet, March 29, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/29/fact-sheet-biden-administration-jumpstarts-offshore-wind-energy-projects-to-create-jobs/.

[19] White House, "Biden-Harris Administration Announces New Actions to Expand U.S. Offshore Wind Energy," fact sheet, September 15, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/09/15/fact-sheet-biden-harris-administration-announces-new-actions-to-expand-u-s-offshore-wind-energy/.

[20] BOEM, *FY2024 Budget Justifications and Performance Information*, p. 31.

[21] For example, John Harwood et al., "Understanding the Population Consequences of Acoustic Disturbance for Marine Mammals," in *The Effects of Noise on Aquatic Life II*, eds. Arthur N. Popper and Anthony Hawkins (New York: (continued...)

background on offshore wind energy turbine structures and discuss activities associated with offshore wind projects, including the potential impacts of these activities on the marine ecosystem and species.

Offshore Wind Energy Turbine Structures

OWFs are constructed in bodies of water and use wind to generate electricity in much the same manner as land-based wind farms do. OWFs can be made up of a few to hundreds of turbine structures that are spaced apart to optimize power generation and can require large, open bodies of water.[22] In general, OWFs generate more electricity per turbine structure than land-based wind farms because offshore wind towers and blades are typically taller and larger than land-based wind structures.[23] Local conditions such as wind speed, meteorological patterns, and terrain can influence the quality of a wind resource; typically wind speeds are stronger and more consistent offshore than onshore.[24] **Figure 1** depicts the typical components of an offshore wind turbine structure.

There are two types of offshore wind energy turbine structures: fixed-foundation towers and floating structures. Fixed-bottom foundation support structures are the predominant offshore wind technology, largely because fixed-bottom foundations are well suited for offshore conditions in Europe, where the industry first developed (**Figure 1**).[25] *Foundations* secure the tower with the other components to the seafloor. There are several types of foundation technologies, the most common of which is the *monopile*.[26] Fixed-bottom foundations may not be appropriate for all U.S. offshore sites because of differences such as the profile of the continental shelf, water depth, seabed characteristics, and extreme weather conditions.

The offshore wind industry is beginning to use floating structures, which are not set into the ocean floor (**Figure 1**).[27] These floating structures are affixed to the seabed through cables or legs rather than supported by a foundation. Floating structures are often used for projects sited in deep water (approximately 60 meters, or 200 feet, in depth or deeper), such as areas in the Gulf of Maine and off the Pacific Coast and Hawaii.[28] Most planned floating projects use

Springer Verlag, 2016), pp. 417-423 (hereinafter referred to as Harwood et al., "Acoustic Disturbance for Marine Mammals"); and see H.Res. 239 in the 118th Congress.

[22] DOE, National Renewable Energy Laboratory, "Offshore Wind Energy Facility Characteristics," March 5, 2018, slides 12, 13, and 15, https://www.boem.gov/sites/default/files/renewable-energy-program/What-Does-an-Offshore-Wind-Energy-Facility-Look-Like.pdf.

[23] DOE, "Wind Turbines: The Bigger, the Better," https://www.energy.gov/eere/articles/wind-turbines-bigger-better.

[24] National Grid, "Onshore vs Offshore Wind Energy: What's the Difference?," at https://www.nationalgrid.com/stories/energy-explained/onshore-vs-offshore-wind-energy.

[25] National Offshore Wind Research and Development Consortium, *Research and Development Roadmap Version 2.0*, October 2019, p. 6.

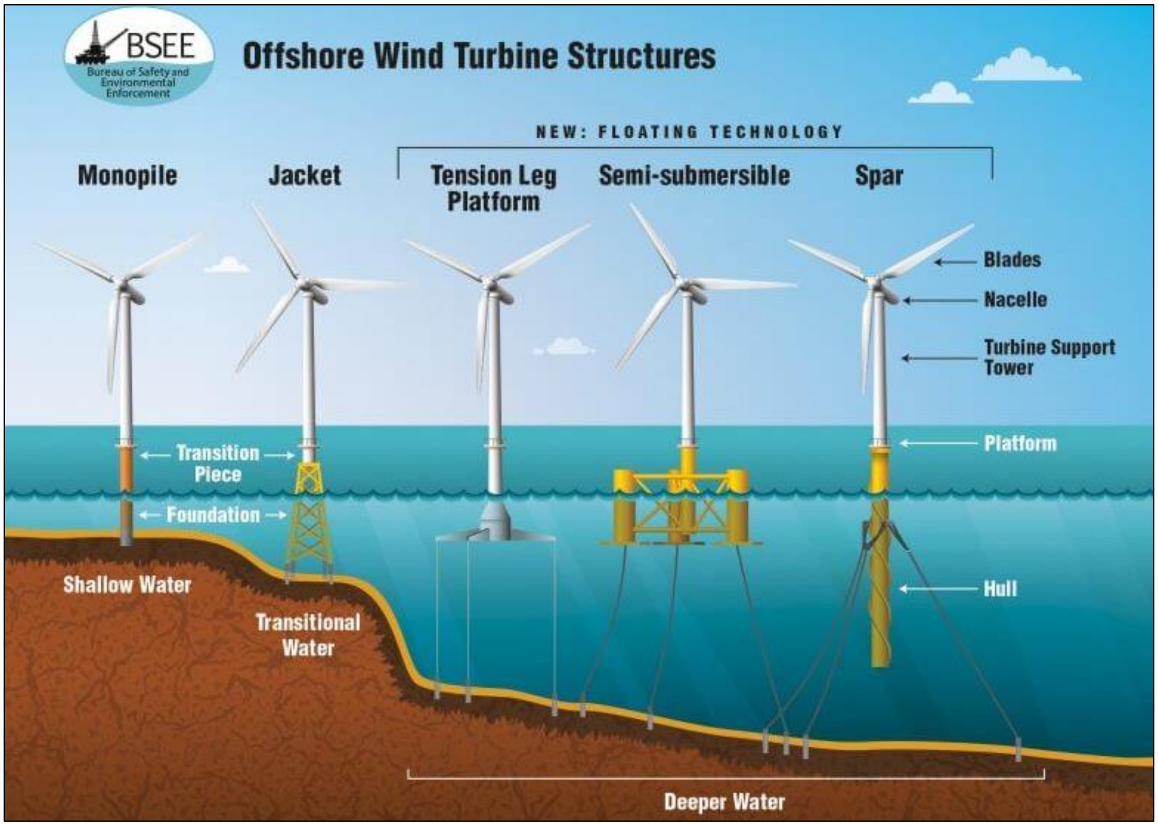
[26] *Monopiles*, which accounted for approximately 64% of the global operating offshore wind capacity in 2021, are cylindrical structures driven or drilled into the seafloor and attached to the bottom of the turbine tower. Other foundation technologies include jackets and gravity-based foundations. Jacket structures typically consist of four legs that are connected by braces and attached via anchors or drilled piles into the seafloor. Gravity-based foundations are placed on the seafloor and rely on the structure's weight to resist overturning. DOE, *2022 Market Report*, p. 67.

[27] BOEM's December 2022 lease sale for the Pacific region included areas expected to be developed with floating wind projects. According to DOI, "the lease sale included a 20-percent credit for bidders who committed to a monetary contribution to programs or initiatives that support workforce training programs for the floating offshore wind industry, the development of a U.S. domestic supply chain for the floating offshore wind energy industry, or both. This credit will result in over $117 million in investments for these critical programs or initiatives." DOI, "Biden-Harris Administration Announces Winners of California Offshore Wind Energy Auction," press release, December 7, 2022, https://doi.gov/pressreleases/biden-harris-administration-announces-winners-california-offshore-wind-energy-auction.

[28] DOE, *2023 Market Report*, p. 54.

semisubmersible structures.[29] **Figure 1** depicts several types of fixed-bottom and floating structures.

Figure 1. Offshore Wind Turbine Components and Foundation Structures



Source: Bureau of Safety and Environmental Enforcement, "Renewable Energy Policy Statement," https://web.archive.org/web/20200728214215/https:/www.bsee.gov/what-we-do/renewable-energy/renewable-energy-policy-statement.

Notes: Rotating blades capture and convert wind energy into mechanical energy. Nacelle contains the electric generator and equipment to convert the mechanical energy to electrical energy. Turbine support tower supports the mass of the other wind turbine system elements. For fixed foundations, transition pieces provide connections between the foundation and the wind turbine tower and can serve as an access platform for workers; foundations secure the wind turbine towers to the seafloor. For floating technologies, platforms can provide access for workers; hulls are the watertight body of floating vessels. Undersea cables transmitting electric power from turbines to shore are not shown.

The rotating blades of the wind turbine capture and convert wind energy into mechanical energy. The nacelle sits at the top of the offshore wind turbine structure, and it contains the electric generator and other equipment to convert the mechanical energy to electrical energy.[30] The electricity produced by offshore wind turbines typically travels to an onshore substation through

[29] Ibid., p. 69. Other floating structure designs can include barges, tension leg platforms, and spar technologies.

[30] DOE, "How a Wind Turbine Works – Text Version," https://www.energy.gov/eere/wind/how-wind-turbine-works-text-version.

undersea power transmission cables.[31] In addition to the onshore substation, some OWFs also may have offshore platform substations.[32]

Different components of the offshore wind structure may affect certain marine species in different ways or not at all. For example, foundations may pose a collision risk for disoriented large fish or marine mammals, or foundations may serve as a new habitat for certain marine invertebrates (e.g., mussels). These possibilities and others are discussed in greater detail in "Potential Impacts of Offshore Wind Energy on the Marine Ecosystem and Associated Species," below.

Selected Activities Associated with Offshore Wind Projects

The life span of an offshore wind project can be characterized by four broad phases: planning and analysis prior to a lease sale, leasing, site assessment, and construction and operations.[33] With respect to impacts on marine ecosystems and wildlife, stakeholders may particularly consider the effects of certain activities associated with the site assessment and the construction and operations phases. In general, activities related to offshore wind site assessment include environmental planning and site design (including site characterization studies), evaluation of wind potential, technology review, and component selection.[34] Construction activities include the installation of offshore substations and wind turbine structures, as well as their connection to the electrical grid (i.e., laying of undersea power transmission cables), which may take 7 to 11 years to complete.[35] During operation, turbine blades (which collect wind energy to generate electricity that is transmitted to the electrical grid) and other structural components may require maintenance, repair, and rehabilitation. In addition to focusing on the broad phases characterized by BOEM, some stakeholders also consider potential impacts from the decommissioning phase, which marks the end of an offshore wind turbine's useful life and the dismantling or repurposing of the existing infrastructure. The typical life span of an offshore wind turbine is about 20 to 25 years, although a number of factors could shorten or extend the useful life.[36]

The risks that offshore wind projects pose to the marine ecosystem and associated species vary depending on the project phase and associated activities. Activities associated with site assessment and construction of offshore wind projects may pose greater risks to marine wildlife than when the OWF is in operation, for example, whereas rotating turbine blades during operation may pose the greatest risks to birds and bats. Other examples include the following:

- During **site characterization and assessment**, a lessee uses geological and geophysical (G&G) surveys to identify sites for offshore renewable energy

[31] For information about undersea cables and relevant U.S. policies, see CRS Report R47648, *Protection of Undersea Telecommunication Cables: Issues for Congress*, coordinated by Jill C. Gallagher and Nicole T. Carter.

[32] Pamela Middleton and Bethany Barnhart, Supporting National Environmental Policy Act Documentation for Offshore Wind Energy Development Related to Heat from Buried Transmission Cables, U.S. Department of the Interior, Bureau of Ocean Energy Management, OCS Study BOEM 2023-006, Washington, DC, January 2023, pp. 2-3, https://www.boem.gov/sites/default/files/documents/renewable-energy/studies/Transmission_Cable_Heat_WhitePaper.pdf.

[33] See, for example, BOEM, "Wind Energy Commercial Leasing Process," fact sheet, May 2021, https://www.boem.gov/sites/default/files/documents/about-boem/Wind-Energy-Comm-Leasing-Process-FS-01242017Text-052121Branding.pdf.

[34] Iberdrola, "Construction of an Offshore Wind Plant," https://www.iberdrola.com/about-us/our-activity/offshore-wind-energy/offshore-wind-park-construction (hereinafter referred to as Iberdrola, Construction of OWF).

[35] Ibid.

[36] A. M. Jadali et al., "Decommissioning vs. repowering of offshore wind farms—a techno-economic assessment," *International Journal of Advanced Manufacturing Technology*, vol. 112, (2021), pp. 2519–2532.

structures, among other purposes.[37] G&G surveys use sound waves that are reflected off seafloor structures to collect data on conditions at and beneath the seafloor.[38] The noise generated from these surveys may cause injury, hearing loss, or behavior changes, among other impacts, to certain marine species.[39]

- During **construction**, increased numbers of construction vessels may transit between the shore and the offshore project site.[40] Heightened vessel activity may increase collision risks for some marine species (e.g., whales). Construction also entails driving piles as anchor points to support the foundations of wind turbines.[41] Pile-driving creates high levels of underwater noise as well as sound pressure that travels through the water column; the noise and pressure can impact certain marine species, both in the construction area and up to tens of kilometers away.[42]
- During **operation**, rotating turbine blades may alter the ocean environment in the immediate area of the OWF and may produce underwater noise that may impact some marine species. In addition, turbine blades pose a collision risk for birds and bats.
- During the **decommissioning** of an offshore wind project, the equipment and components of the offshore wind infrastructure may be reused, recycled, or disposed of. The potential impacts associated with these activities remain largely unknown, since many offshore wind turbines have yet to reach the end of their useful lives.

Federal permits and approvals require that project developers take mitigation steps that have the potential to reduce impacts associated with many of these activities.

Potential Impacts of Offshore Wind Energy on the Marine Ecosystem and Associated Species

Offshore wind projects may affect the marine ecosystem and associated species. Not all impacts may be adverse; some may be beneficial (e.g., the artificial reef effect, discussed below). In general, OWF activities can impact wildlife through

[37] BOEM, "Geological and Geophysical (G&G) Surveys," fact sheet, November 2018, https://www.boem.gov/sites/default/files/about-boem/BOEM-Regions/Atlantic-Region/GandG-Overview.pdf (hereinafter referred to as BOEM, G&G Fact Sheet).

[38] Ibid.

[39] BOEM, "The Science Behind the Decision," https://www.boem.gov/sites/default/files/about-boem/BOEM-Regions/Atlantic-Region/FAQ-Atlantic-GandG-Activities.pdf.

[40] American Clean Power, "Offshore Wind Vessel Needs," https://cleanpower.org/wp-content/uploads/2021/09/Offshore-Wind-Vessel-Needs.FINAL_.2021.pdf.

[41] Iberdrola, Construction of OWF.

[42] One kilometer is approximately 0.621 miles (or 0.54 nautical miles). Frank Thomsen et al., *Effects of Offshore Wind Farm Noise on Marine Mammals and Fish*, COWRIE, Ltd., Hamburg, Germany, 2006 (hereinafter referred to as Thomsen et al., *Effects of Offshore Wind Farm Noise*); P. T. Madsen et al., "Wind Turbine Underwater Noise and Marine Mammals: Implications of Current Knowledge and Data Needs," *Marine Ecology Progress Series*, vol. 309 (2006), pp. 279-295 (hereinafter referred to as Madsen et al., "Wind Turbine Underwater Noise"); Anita Gilles et al., "Seasonal Distribution of Harbour Porpoises and Possible Interference of Offshore Wind Farms in the German North Sea," *Marine Ecology Progress Series*, vol. 383 (2009), pp. 295-307; Michael Dähne et al., "Effects of Pile-Driving on Harbour Porpoises (*Phocoena phocoena*) at the First Offshore Wind Farm in Germany," *Environmental Research Letters*, vol. 8, no. 2 (2013), 025002, pp. 1-16.

- atmospheric and oceanic change,[43]
- marine habitat alteration,
- collision risk,
- electromagnetic field (EMF) effects associated with power cables,[44]
- noise effects, and
- water quality (e.g., pollution).[45]

The scientific literature analyzes the short-term adverse impacts and benefits of offshore wind development to marine mammals, invertebrates, fish, sea turtles, birds, bats, and other components of the marine ecosystem (**Table 1**).[46] Modeling and observational studies (mostly derived from the North Sea) show that most impacts (e.g., habitat alteration) occur within the immediate vicinity of the wind turbine array, with other impacts (e.g., noise effects) extending up to tens of kilometers outside the array.[47] Some of these analyses use land-based wind energy observations to model potential offshore wind scenarios, and other analyses extrapolate observations from existing OWFs (again, mostly in the North Sea) to planned offshore wind energy projects. Other potential impacts are informed by laboratory studies mimicking conditions (e.g., noise levels) often associated with offshore wind projects. The sections below discuss the potential OWF impacts (both adverse and beneficial) to the ocean environment and selected wildlife.

Table 1. Potential Impacts Associated with Offshore Wind Energy Projects

(as documented in federal agency reports and the scientific literature)

Animal Type	Oceanic Change	Habitat Alteration	Collision Risk	EMF Effects	Noise Effects	Water Quality
Marine Mammals	—	Y	Y	—	Y	Y
Invertebrates	Y	Y	—	Y	Y	Y
Fish	—	Y	Y	Y	Y	Y
Sea Turtles	—	Y	Y	—	Y	Y
Birds	Y	Y	Y	—	—	Y

[43] Offshore wind structures may disrupt natural atmospheric and oceanic processes, such as the frequency of ocean mixing or wind patterns.

[44] Electric power cables, such as those used in OWFs, are sources of electromagnetic fields, which are made up of induced electric and magnetic fields. Some animals (e.g., whales, bats, sea turtles) can detect electric and/or magnetic fields and use naturally occurring fields to support essential life functions, such as navigating and searching for prey. Essential life functions of certain animals may be disrupted by human-induced fields. DOE, *U.S. Offshore Wind Synthesis of Environmental Effects Research: Electromagnetic Field Effects on Marine Life*, June 30, 2022.

[45] See Haylet Farr et al., "Potential Environmental Effects of Deepwater Floating Offshore Wind Energy Facilities," *Ocean and Coastal Management*, vol. 207 (2021), p. 3 (hereinafter referred to as Farr et al., "Potential Environmental Effects"); and Johan van der Molen et al., "Predicting the Large-Scale Consequences of Offshore Wind Turbine Array Development on a North Sea Ecosystem," *Continental Shelf Research*, vol. 85, no. 1 (June 2014), p. 61 (hereinafter referred to as Van der Molen et al., "Predicting the Large-Scale Consequences").

[46] Ibon Galparsoro et al., "Reviewing the Ecological Impacts of Offshore Wind Farms," *npj Ocean Sustainability*, vol. 1, no. 1 (August 2022), p. 2 (hereinafter referred to as Galparsoro et al., "Reviewing the Ecological Impacts"); Fiona Hogan et al., *Fisheries and Offshore Wind Interactions: Synthesis of Science*, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), NOAA Technical Memorandum NMFS-NE-291, March 2023, pp. 1-383 (hereinafter referred to as Hogan et al., *Fisheries and Offshore Wind Interactions*).

[47] Van der Molen et al., "Predicting the Large-Scale Consequences," p. 60.

Animal Type	Oceanic Change	Habitat Alteration	Collision Risk	EMF Effects	Noise Effects	Water Quality
Bats	—	—	Y	Y	Y	—

Source: CRS, using various sources, including Fiona Hogan et al., *Fisheries and Offshore Wind Interactions: Synthesis of Science*, National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS), NOAA Technical Memorandum NMFS-NE-291, March 2023.

Notes: EMF = electromagnetic field; Y = documented impact; — = undocumented in federal reports or the scientific literature or not observed. The table provides a general summary of the potential impacts from offshore wind farm projects on marine animals, species dependent on marine resources, or species that travel over the ocean. The table does not indicate the direction (i.e., adverse or beneficial) or magnitude of change, risk, or impact.

Ocean Environment

OWF operation may affect aspects of the local ocean environment. Regional hydrodynamic processes (e.g., ocean mixing and distribution of ocean nutrients) may be influenced by wind wakes produced by aerodynamic drag from wind turbine blades; *wind wakes* are disturbances in the atmosphere that form behind a structure through which air passes.[48] In general, the effects of a wind wake produced by an offshore wind structure depend on atmospheric stability, wind speed, wind direction, and oceanographic conditions.[49]

Changes in wind speeds associated with OWFs can influence ocean *stratification*—the vertical distribution of heat (or another ocean property) that produces horizontal water layers of different densities. Some marine species require a specific temperature range for their habitat and will track the vertical movement of thermal layers.[50] In addition, stratification can affect the distribution of salinity and primary productivity in the water column.[51] *Primary productivity* is the process by which marine phytoplankton use solar energy and atmospheric CO_2 to form organic matter, which makes up the base of the marine food chain.

Some modeling studies show a reduction in average ocean current velocities near OWFs.[52] Reduced surface current velocities may increase the amount of carbon buried in seabed sediments because sediments are not being disturbed as much by water movement as they would be if surface current velocities were faster.[53] One potential consequence of increased carbon burial in seabed sediments is a drop in oxygen levels at the water-seafloor interface, which could affect seafloor-dwelling marine life.[54] Certain areas of the North Sea exhibit an estimated 10% increase of carbon burial at OWF locations.[55]

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[48] Nils Christiansen et al., "Tidal Mitigation of Offshore Wind Wake Effects in Coastal Seas," *Frontiers in Marine Science*, vol. 9 (October 2022), p. 1 (hereinafter referred to Christiansen et al., "Tidal Mitigation").

[49] Travis Miles et al., "Interactions of Offshore Wind on Oceanographic Processes," in *Fisheries and Offshore Wind Interactions: Synthesis of Science*, NOAA NMFS, NOAA Technical Memorandum NMFS-NE-291, March 2023, p. 51, https://repository.library.noaa.gov/view/noaa/49151 (hereinafter referred to as Miles et al., "Interactions of Offshore Wind").

[50] Ibid., p. 52.

[51] Christiansen et al., "Tidal Mitigation," p. 2.

[52] For example, Ute Daewel et al., "Offshore Wind Farms Are Projected to Impact Primary Production and Bottom Water Deoxygenation in the North Sea," *Communications Earth & Environment*, vol. 3, no. 292 (November 2022), p. 4 (hereinafter referred to as Daewel et al., 2022).

[53] Ibid., p. 5.

[54] Ibid.

[55] Ibid.

Some researchers highlight the challenge of separating natural oceanographic variability or oceanographic change associated with climate change from the impacts of OWFs in observational studies.[56]

Effects of Climate Change on the Ocean

Scientific data show that the combustion of fossil fuels accounts for the majority of global anthropogenic carbon dioxide (CO_2) emissions.[1] Renewable energies (e.g., offshore wind energy) provide one approach to reduce emissions from the energy sector while continuing to meet society's demand for energy services.[2] The construction of renewable energy infrastructure and operation of these technologies may have immediate impacts on the local environment, which stakeholders may weigh against the potential of these energies to help offset the effects of climate change. In addition, some stakeholders have encouraged decisionmakers and federal agencies to include climate change risks facing the ocean and certain marine animals (e.g., whales) in their analyses of offshore energy projects in environmental impact statements.[3]

The ocean absorbs atmospheric CO_2. Since the 1980s, the ocean has likely absorbed between 20% and 30% of total anthropogenic CO_2 emissions, resulting in ocean acidification.[4] Ocean acidification and other consequences of increasing anthropogenic CO_2 emissions have affected marine fisheries, the marine tourism and recreation sector, and global food security. Climate change has impacted the global ocean in the following ways (the list below is not exhaustive).[5]

- Over the 20th century and continuing today, global sea surface temperatures have increased as the ocean absorbs more heat.[6]
- The global average sea level has been slowly rising because of melting continental ice and the thermal expansion of ocean water due to its warming.[7]
- Glacial and sea-ice melt, as well as increased precipitation associated with climate change, are freshening near-surface ocean waters, thereby contributing to weaker ocean circulation.[8]
- Because warm water holds less dissolved gas than cold water, the ocean is holding less dissolved oxygen as a result of global ocean warming.[9]
- As the surface of the ocean absorbs more CO_2, the pH of seawater decreases in a process referred to as *ocean acidification*.[10]

Sources:

1. Intergovernmental Panel on Climate Change (IPCC), "Summary for Policymakers," in *Climate Change 2023: Synthesis Report*, eds. Core Writing Team, Hoesung Lee, and José Romero, 2023, p. 4.
2. Ibid., p. 21 and Figure SPM.7.
3. Letter from University of Columbia, Sabin Center for Climate Change Law, to Karen Baker, Program Chief, Office of Renewable Energy, Bureau of Ocean Energy Management, January 15, 2023, https://climate.law.columbia.edu/sites/default/files/content/Attachment%201%20Sabin%20Center%20Comments%20on%20Empire%20Wind%20DEIS.pdf.
4. IPCC, "Summary for Policymakers," in *The Ocean and Cryosphere in a Changing Climate: A Special Report of the Intergovernmental Panel on Climate Change*, eds. Hans-Otto Pörtner et al., 2019, p. 9.
5. National Oceanic and Atmospheric Administration, "Understanding Our Changing Climate," https://www.fisheries.noaa.gov/insight/understanding-our-changing-climate.
6. Environmental Protection Agency, "Climate Change Indicators: Sea Surface Temperature," https://www.epa.gov/climate-indicators/climate-change-indicators-sea-surface-temperature.
7. IPCC, "Summary for Policymakers," in *Changing Climate 2021: The Physical Science Basis*, eds. Valerie Masson-Delmotte et al., 2021, p. SPM-14.
8. Ibid., p. SPM-6.
9. T. L. Frölicher et al., "Contrasting Upper and Deep Ocean Oxygen Responses to Protracted Global Warming," *Global Biogeochemical Cycles*, vol. 34, no. 8 (August 2020), p. 1.
10. For more information on ocean acidification, see CRS Report R47300, *Ocean Acidification: Frequently Asked Questions*, by Caitlin Keating-Bitonti and Eva Lipiec.

[56] For example, Miles et al., "Interactions of Offshore Wind," p. 52.

Marine Mammals

Certain activities associated with offshore wind development may affect marine mammals. The scientific literature generally has not found long-term impacts from offshore wind development on marine mammals, although short-term interference effects associated with site assessment activities and construction have led to some concerns from scientists and stakeholders.[57] OWF construction involves numerous activities that can generate high sound pressure levels, with pile-driving in particular producing intense impulses that may induce marine mammal hearing impairment or loss at close range and may disrupt marine mammal behavior at ranges up to tens of kilometers.[58] Marine mammals, including pinnipeds and cetaceans,[59] use sound for foraging, orientation, and communication. As a result, underwater sound resulting from site characterization (i.e., G&G surveys)[60] and construction may disturb marine mammals and disrupt their behavioral patterns.[61]

Auditory and displacement effects from pile-driving have been observed or may occur in porpoises, harbor seals, bottlenose dolphins, and other marine mammals.[62] A May 2023 National Oceanic and Atmospheric Administration (NOAA) biological opinion (BiOp) for the Atlantic Shores South Offshore Wind Project off New Jersey noted that the behavior of endangered North Atlantic right whales, fin whales, and sei whales could be adversely disrupted by—but would not be injured by—noise and activities around the OWFs.[63] As an example of a behavioral change, studies suggest that noise from pile-driving activities may negatively affect foraging in some harbor porpoises by decreasing their fish catch success rates and increasing their termination of fish catching attempts.[64]

Some stakeholders have expressed concerns about human-induced noise sources (e.g., underwater noise associated with offshore wind surveys or pile-driving) displacing marine mammal mothers from calves, which may have implications for future reproduction and survival.[65] Technological

[57] Siddharth S. Kulkarni and David J. Edwards, "A Bibliometric Review on the Implications of Renewable Offshore Marine Energy Development on Marine Species," *Aquaculture and Fisheries*, vol. 7, no. 2 (2022), pp. 211-222 (hereinafter referred to as Kulkarni and Edwards, "Bibliometric Review").

[58] See footnote 42.

[59] Pinnipeds include species of the order Pinnipedia (e.g., seals and sea lions). Cetaceans include species of the infraorder Cetacea (e.g., dolphins and whales).

[60] BOEM, G&G Fact Sheet.

[61] Madsen et al., "Wind Turbine Underwater Noise"; NOAA, "Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to Marine Site Characterization Surveys in the New York Bight," 88 *Federal Register* 42322-42341, 2023.

[62] Helen Bailey et al., "Assessing Underwater Noise Levels During Pile-Driving at an Offshore Windfarm and Its Potential Effects on Marine Mammals," *Marine Pollution Bulletin*, vol. 60, no. 6 (2010), pp. 888-897; Paul M. Thompson et al., "Framework for Assessing Impacts of Pile-Driving Noise from Offshore Wind Farm Construction on a Harbour Seal Population," *Environmental Impact Assessment Review*, vol. 43 (2013), pp. 73-85; Debbie J. F. Russell et al., "Avoidance of Wind Farms by Harbour Seals Is Limited to Pile Driving Activities," *Journal of Applied Ecology*, vol. 53, no. 6 (2016), pp. 1642-1652; Thomsen et al., *Effects of Offshore Wind Farm Noise*; Madsen et al., "Wind Turbine Underwater Noise."

[63] BOEM, Office of Renewable Energy Programs, *Atlantic Shores Offshore Wind Atlantic Shores South Project Biological Assessment for National Marine Fisheries Service*, May 2023, p. 105, https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Atlantic%20Shores%20South%20NMFS%20BA.pdf.

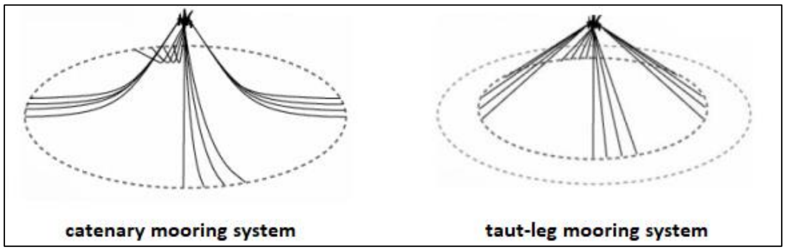
[64] Foraging responses of porpoises may vary among individuals. Ronald A. Kastelein et al., "Effect of Pile-Driving Playback Sound Level on Fish-Catching Efficiency in Harbor Porpoises (*Phocoena phocoena*)," *Aquatic Mammals*, vol. 45, no. 4 (2019), pp. 398-410.

[65] Harwood et al., "Acoustic Disturbance for Marine Mammals."

modifications to OWFs may reduce both sound levels and distances at which observed behavioral responses may occur in marine mammals.[66]

Some stakeholders also have raised concerns about collision risks with offshore wind energy structures and potential effects associated with underwater power transmission cables.[67] Large cetaceans could collide with structures or become entangled in mooring cables, power transmission cables, or anchor lines.[68] Baleen whales have been identified as having the greatest risk of entanglement, particularly on *catenary moorings* where the lines are not taut but rely on gravity to create tension (**Figure 2**).[69] Marine mammals that are disoriented from loud noise or poor water clarity (i.e., increased turbidity) may have an increased risk of collision. In addition, investigators have raised concerns that EMFs generated by OWF power transmission cables may adversely affect some marine animals.[70] However, according to various studies, no impacts of EMFs on marine mammals have been documented.[71]

Figure 2. Examples of Floating Wind Mooring Systems



Sources: ABC Moorings, "Mooring Systems," http://abc-moorings.weebly.com/mooring-systems.html; S. Benjamins et al., *Understanding the Potential for Marine Megafauna Entanglement Risk from Renewable Marine Energy Developments*, Scottish Natural Heritage, Scottish Natural Heritage Commissioned Report No. 791, 2014, https://ore.exeter.ac.uk/repository/bitstream/handle/10871/21616/Understanding?sequence=1.

Notes: Basic floating platform types—such as spar, semisubmersible, and tension-leg platforms—require mooring systems to tether or anchor the platform to the seafloor. In a *catenary mooring system*, the most common mooring system in shallow waters, the mooring lines hang freely between the floating unit and the seabed, relying on gravity to create tension. In a *taut-leg mooring system*, the pretensioned mooring lines intersect at an angle (typically 30-40 degrees) at the seabed, for which there is less entanglement risk but which can

[66] For example, the use of direct drive technology instead of a gear box may reduce sound levels. Direct drive technology powers a generator directly by the rotor, whereas a gear box is placed between a low-speed rotor and an electrical generator to increase rotor speed before feeding to the generator. Frank Thomsen and Uwe Stöber, "Operational Underwater Sound from Future Offshore Wind Turbines Can Affect the Behavior of Marine Mammals," *Journal of the Acoustical Society of America*, vol. 151, no. 4 (2022), pp. A239-A239; Edis Osmanbasic, "The Future of Wind Turbines: Comparing Direct Drive and Gearbox," April 7, 2020, https://www.engineering.com/story/the-future-of-wind-turbines-comparing-direct-drive-and-gearbox.

[67] Amy E. Davis, *Potential Impacts of Ocean Energy Development on Marine Mammals in Oregon*," 2010, pp. 1-25, https://ir.library.oregonstate.edu/concern/technical_reports/jh343z21h.

[68] Ibid.

[69] S. Benjamins et al., *Understanding the Potential for Marine Megafauna Entanglement Risk from Renewable Marine Energy Developments*, Scottish Natural Heritage, Scottish Natural Heritage Commissioned Report No. 791, 2014, https://ore.exeter.ac.uk/repository/bitstream/handle/10871/21616/Understanding?sequence=1; Farr et al., "Potential Environmental Effects."

[70] Klaus Lucke et al., "Literature Review of Offshore Wind Farms with Regard to Marine Mammals," in *Ecological Research on Offshore Wind Farms: International Exchange of Experiences, Project No.: 804 46 001, Part B: Literature Review of the Ecological Impacts of Offshore Wind Farms*, eds. Catherine Zucco et al. (Bonn, Germany: Bundesamt für Naturschutz, 2006), pp. 199-284; Andrea E. Copping et al., "Potential Environmental Effects of Marine Renewable Energy Development—The State of the Science," *Journal of Marine Science and Engineering*, vol. 8, no. 11 (2020), Article 879.

[71] Farr et al., "Potential Environmental Effects"; Kulkarni and Edwards, "Bibliometric Review."

require vertical load anchors and add design complexities. A mooring system with attributes of both catenary and taut leg is referred to as a *semi-taut mooring system* (not pictured), which can reduce the anchor distance from the turbine without changing anchor types or substructure design.

To minimize short-term disruptions to marine mammals, developers could take mitigation actions. Such actions could include

- establishing monitored safety zones that lead to shut-down or low-power operations if certain animals enter these zones;
- using noise reduction gear such as bubble curtains or hydro-sound dampeners around pile-driving; and/or
- implementing noise source modifications or operational parameters, such as soft starts.[72]

Less-targeted mitigation actions also have been proposed, including adopting best management practices for construction and adhering to seasonal work restrictions to protect marine wildlife at sensitive life stages. For example, some experts have proposed limiting pile-driving activities during spawning and other biologically sensitive periods to reduce potential noise impacts.[73] In some studies, mitigation actions were correlated with reduced harm for certain species. Research into strategies for reducing the impacts of offshore wind projects on marine mammals is ongoing. Some stakeholders, including Members of Congress, have expressed concern that projects nonetheless would cause unacceptable harm to marine wildlife and have sought further actions, such as a GAO study of offshore wind's environmental impacts.[74]

Marine mammals are protected by the Marine Mammal Protection Act (MMPA).[75] In addition, certain marine mammal species may be listed under the Endangered Species Act (ESA);[76] actions that affect these species may trigger the prohibitions and requirements imposed by that act. For more information on these statutory regimes, see "Marine Mammal Protection Act" and "Endangered Species Act," below.

Whales

Some stakeholders and public officials, including some Members of Congress,[77] have raised concerns about potential connections between offshore wind development and whale mortality. In particular, reports of whale deaths off the northeast Atlantic coast, especially off New Jersey, in early 2023 raised questions about whether increased mortality could be due to offshore wind

[72] Ursula K. Verfuss et al., "Review of Offshore Wind Farm Impact Monitoring and Mitigation with Regard to Marine Mammals," in *The Effects of Noise on Aquatic Life II*, eds. Arthur N. Popper and Anthony Hawkins (New York, NY: Springer, 2016), pp. 1175-1182; Christine Erbe, Rebecca Dunlop, and Sarah Dolman, "Effects of Noise on Marine Mammals," in *Effects of Anthropogenic Noise on Animals*, eds. Hans Slabbekoorn et al. (New York, NY: Springer, 2018), pp. 277-309. The term *soft start* is applied to the gradual, or incremental, increase in hammer blow energy from the initiation of piling activity until required blow energy is reached for installation of each pile. Maximum hammer blow energy may not be required to complete pile installation. Ørsted, *Hornsea Project Four: Preliminary Environmental Information Report (PEIR)*, F2.5: Outline Marine Mammal Mitigation Protocol, Version A, July 2019, p. 4, https://orstedcdn.azureedge.net/-/media/www/docs/corp/uk/hornsea-project-four/01-formal-consultation/additional-application-information/hornsea-four-peir-outline-marine-mammal-mitigation-protocol.pdf.

[73] Linus Hammar, Andreas Wikström, and Sverker Molander, "Assessing Ecological Risks of Offshore Wind Power on Kattegat Cod," *Renewable Energy*, vol. 66 (2014), pp. 414-424 (hereinafter referred to as Hammar, Wikström, and Molander, "Assessing Ecological Risks").

[74] For example, H.R. 1, §20118.

[75] 16 U.S.C. §§1361-1423h.

[76] 16 U.S.C. §§1531 et seq.

[77] See H.Res. 239 in the 118th Congress.

G&G surveys.[78] Eight humpback whale strandings occurred in New Jersey between January and November 2023, compared with four strandings in 2022 and none in 2021.[79] Since 2016, elevated humpback whale mortalities have occurred along the U.S. Atlantic coast from Maine to Florida. In April 2017, NOAA's National Marine Fisheries Service (NMFS) declared an *unusual mortality event*—unexpected strandings involving significant die-offs of any marine mammal that demand an immediate response—involving humpback whales.[80] Humpback whale strandings have continued along the Atlantic coast; between January and November 2023, 37 humpback whale strandings occurred.[81] In May 2023, some Members of Congress wrote a letter to GAO requesting that the agency look into the potential impacts of offshore wind energy development and associated infrastructure in the North Atlantic.[82] In June 2023, GAO announced it would study the environmental impacts of OWFs and any connections to whale mortalities, along with other potential impacts.[83]

Neither BOEM nor NOAA has found evidence that offshore wind development-related site characterization surveys caused recent whale mortalities.[84] Assessments by NOAA scientists have not found any connections between G&G surveys for offshore wind energy projects and marine mammal deaths along the U.S. Atlantic coast.[85] On the basis of roughly 90 necropsy investigations of whales from 2016 to 2023, NOAA found 40% of documented whale mortalities and serious injuries resulted from vessel strikes or fishing gear entanglements.[86] A 2021 BOEM risk assessment of OWF development on the Atlantic OCS suggested a positive relationship between vessel speed and potential strike risk for vessel types that operate in support of OWFs both in transit and in wind farm areas (i.e., increased strike risk for OWF service vessels traveling at higher vessel speeds).[87]

In response to increased public concern, New Jersey's Department of Environmental Protection issued a statement clarifying that "as of August 2023, no offshore wind-related construction activities have taken place in waters off the New Jersey coast."[88] In addition, marine mammal

[78] Amanda Oglesby and Dan Radel, "Whale Deaths Along East Coast Prompt 12 NJ Mayors' Call for Offshore Wind Farm Moratorium," *Cape Cod Times*, January 31, 2023; Krik Moore, "Poll Finds Whale Strandings Drive Down New Jersey Support for Offshore Wind," *National Fisherman*, May 13, 2023.

[79] NOAA NMFS, "2016-2023 Humpback Whale Unusual Mortality Event Along the Atlantic Coast," https://www.fisheries.noaa.gov/national/marine-life-distress/2016-2023-humpback-whale-unusual-mortality-event-along-atlantic-coast (hereinafter NOAA NMFS, "2016-2023 Humpback Whale Unusual Mortality Event").

[80] Ibid.

[81] Ibid.

[82] Representatives Bruce Westerman, Chris Smith, Andy Harris, and Jeff van Drew to Gene L. Dodaro, Comptroller General, U.S. GAO, May 15, 2023, https://chrissmith.house.gov/uploadedfiles/north_atlantic_wind_study_letter_-_gao.pdf.

[83] Wayne Parry, "Congressional Watchdog Agency to Probe Offshore Wind Impacts," *Associated Press News*, June 15, 2023.

[84] NOAA NMFS, "Frequent Questions—Offshore Wind and Whales," https://www.fisheries.noaa.gov/new-england-mid-atlantic/marine-life-distress/frequent-questions-offshore-wind-and-whales (hereinafter NOAA NMFS, "Frequent Questions"); BOEM, "Renewable Energy Fact Sheet: Offshore Wind Activities and Marine Mammal Protection," https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/Offshore%20Wind%20Activities%20and%20Marine%20Mammal%20Protection_1.pdf.

[85] NOAA NMFS, "Frequent Questions."

[86] NOAA NMFS, "2016-2023 Humpback Whale Unusual Mortality Event."

[87] Mary Jo Barkaszi et al., *Risk Assessment to Model Encounter Rates Between Large Whales and Vessel Traffic from Offshore Wind Energy on the Atlantic OCS*, BOEM, OCS Study BOEM 2021-034, 2021, pp. 1-54, https://tethys.pnnl.gov/sites/default/files/publications/BOEM_2021-034.pdf.

[88] State of New Jersey, Department of Environmental Protection, "2016-2023 Humpback Whale Unusual Mortality Event," https://dep.nj.gov/humpback-whale-unusual-mortality-event/.

surveys conducted as part of the New Jersey Department of Environmental Protection ecological baseline study documented few large whales in the vicinity of OWF development areas off New Jersey.[89] However, because whales are difficult to see and spend much of their time submerged, the research techniques used to track them may miss whales that are present and therefore might underestimate whale abundance and density in the study areas.[90] On October 17, 2023, Cape May County, NJ—along with environmental, hotel, and seafood industry groups—filed a lawsuit in U.S. District Court against NOAA and BOEM.[91] The lawsuit claims in part that these agencies did not fully consider the potential harm to the environment and wildlife from offshore wind projects. The lawsuit seeks to reverse BOEM and NOAA's approval of Ocean Wind I, an offshore wind project located about 13 nautical miles southeast of Atlantic City, NJ.[92]

Marine Invertebrates

OWFs may have a mixed effect on invertebrates that live in marine environments (e.g., clams, crabs, squids), with potential positive and negative consequences for such species. In particular, the installation of foundations alters the seafloor habitat but also creates a new habitat in the water column, thereby impacting different species in various ways. In addition, noise and EMF effects associated with OWF activities seem to have neutral to negative effects on invertebrate species.

An offshore wind foundation, after its installation, may act as an *artificial reef* and may be rapidly colonized by various macroalgae (i.e., seaweed) and encrusting invertebrate organisms (e.g., mussels, barnacles) that attach to the submerged foundation (**Figure 3**).[93] In general, mussels and barnacles, which consume organic particles suspended in the water column (i.e., *suspension feeders*), attach to the foundation near the surface of the ocean.[94] The artificial reef created by the foundation may attract more marine life than natural reefs. [95] However, the attraction of suspension feeders to OWF foundations may alter the surrounding water quality by reducing the availability of nutrients in the water column (**Figure 3**).[96]

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[89] Amy D. Whitt et al., "Abundance and Distribution of Marine Mammals in Nearshore Waters off New Jersey, USA," *Journal of Cetacean Research and Management*, vol. 15, no. 1 (2015), pp. 45-59.

[90] Ibid.

[91] County of Cape May v. United States, No. 1:23-cv-21201 (D.N.J. Oct. 17, 2023). See Cape May County, "Cape May County Files Lawsuit Challenging Approval of Ørsted's Ocean Wind 1 Project," October 17, 2023, https://capemaycountynj.gov/CivicAlerts.aspx?AID=1423.

[92] Ørsted has ceased development of Ocean Wind I (and Ocean Wind II) for financial reasons, but the lawsuits over the permitting are ongoing. See Ørsted, "Ørsted Ceases Development of Its U.S. Offshore Wind Projects Ocean Wind 1 and 2, Takes Final Investment Decision on Revolution Wind, and Recognizes DKK 28.4 Billion Impairments," October 31, 2023, https://orsted.com/en/company-announcement-list/2023/10/oersted-ceases-development-of-its-us-offshore-wind-73751.

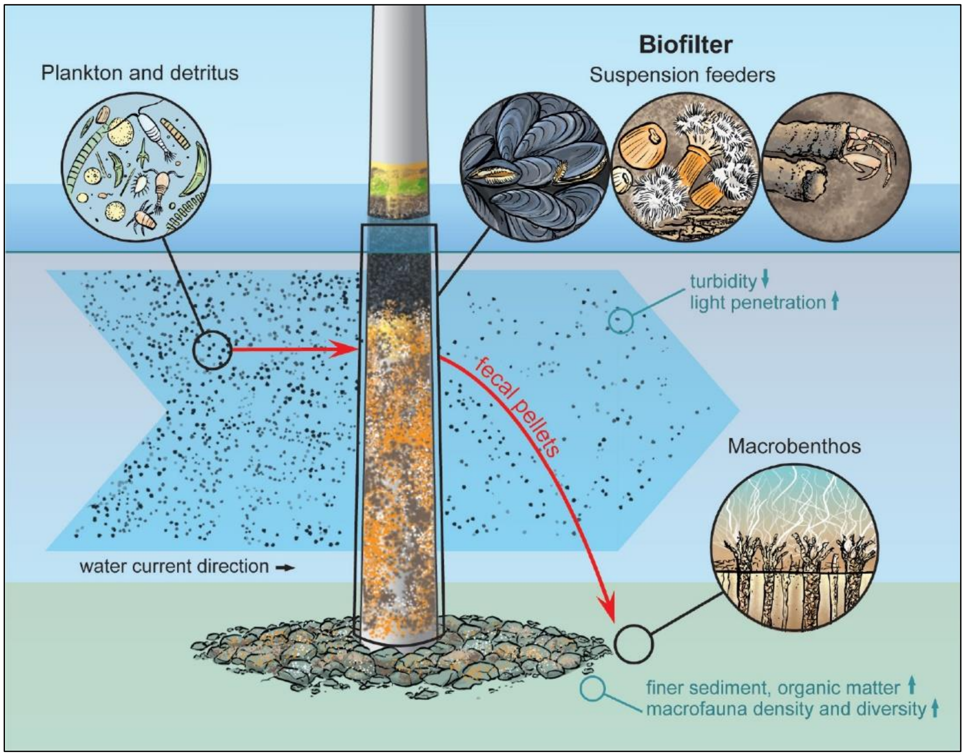
[93] Traditionally, *artificial reefs* are human-made structures deliberately placed in the sea to mimic characteristics of natural reefs to increase local biodiversity. Structures installed on the OCS such as oil and gas platforms, coastal defense constructions, and OWFs also have become artificial reefs, although they were not built for this purpose. Steven Degraer et al., "Offshore Wind Farm Artificial Reefs Affect Ecosystem Structure and Functioning: A Synthesis," *Oceanography*, vol. 33, no. 4 (2020), pp. 49-50 (hereinafter referred to as Degraer et al., "Offshore Wind Farm Artificial Reefs"); and Silvana N. R. Birchenough and Zoë L. Hutchinson, "Shellfish and Crustaceans," in *Fisheries and Offshore Wind Interactions: Synthesis of Science*, NOAA NMFS, NOAA Technical Memorandum NMFS-NE-291, March 2023, https://repository.library.noaa.gov/view/noaa/49151 (hereinafter referred to as Birchenough and Hutchinson, "Shellfish and Crustaceans").

[94] Farr et al., "Potential Environmental Effects," p. 6.

[95] Galparsoro et al., "Reviewing the Ecological Impacts," p. 3.

[96] Degraer et al., "Offshore Wind Farm Artificial Reefs," pp. 52, 55.

Figure 3. Schematic of Artificial Reef on Offshore Wind Foundation



Source: Steven Degraer et al., "Offshore Wind Farm Artificial Reefs Affect Ecosystem Structure and Functioning: A Synthesis," *Oceanography*, vol. 33, no. 4 (2020), pp. 48-57.

Notes: The water current flows from left to right in the schematic. Mussels, sea anemones, and barnacles (in order of left to right in the circular zoomed-in illustrations on the right side of the schematic) are suspension-feeding organisms that commonly attach to the foundation structure. As plankton and detritus suspended in the water (the left-most circular zoomed-in illustration) flow past the foundation, they are consumed by these organisms, resulting in less material suspended in the water column. Less material in the water column (i.e., decreased turbidity) would increase the depth of light penetration. In addition, fecal pellets from the suspension-feeding organisms would accumulate around the base of the foundation, which would increase the amount of organic matter in the seafloor sediment while supporting greater population densities and biodiversity of visible seafloor organisms (i.e., macrobenthos).

Offshore wind foundations typically alter the seafloor habitat at the base of the foundation. In general, the installation of offshore wind foundations replaces soft sediment habitats with hard substrates, leading to a biodiversity loss of species adapted to living on (or in) soft sediment environments.[97] Conversely, one study estimated a 4,000-fold biomass increase when comparing the original seafloor biomass with the new biomass.[98] The study attributed the increase in biomass to the artificial reef.[99] Some studies found that foundations may attract an increased number of crabs and lobsters, suggesting the offshore wind foundations act as aggregation sites and nursery grounds for these crustaceans.[100]

[97] Chen Li et al., "Offshore Wind Energy and Marine Biodiversity in the North Sea: Life Cycle Impact Assessment for Benthic Communities," *Environmental Science & Technology*, vol. 57, no. 16 (2023), pp. 6455-6464.

[98] Degraer et al., "Offshore Wind Farm Artificial Reefs," p. 51.

[99] Ibid., p. 52.

[100] See Birchenough and Hutchinson, "Shellfish and Crustaceans," p. 93.

In addition, OWFs may attract nonindigenous species to the area, because a foundation anchored in the open ocean provides a new site favorable to encrusting marine invertebrates.[101] No threats to indigenous communities from nonindigenous invertebrate species associated with OWFs have been documented.[102]

Some crustaceans (e.g., lobster, crabs) and mollusks (e.g., clams, scallops, and squids) may react to underwater sound associated with offshore wind energy projects. For example, a laboratory study that exposed lobsters and hermit crabs to noise effects similar to that of offshore wind construction found that lobsters exhibited reduced mobility and altered feeding activities.[103] Another laboratory study assessing the responses of squids to OWF noise observed changes in squid behaviors.[104] Squids and other cephalopods likely use underwater sound from the local environment to aid navigation and to detect predators and prey.[105] In addition, prolonged exposure to noise physically damaged the auditory structures of some squid species.[106]

In addition, EMF produced by the electricity transmitted through undersea power transmission cables associated with OWFs may affect some invertebrate species. Some shellfish (e.g., spiny lobster) use geomagnetic fields for navigation. The potential impacts of EMF on mollusks and crustaceans are not well studied.

Certain marine invertebrate species may be listed under the ESA and are subject to the prohibitions and requirements imposed by that act. For more information on those protections, see "Endangered Species Act," below.

Fishes[107]

Offshore wind installations may affect fish and fisheries in multiple ways and at different scales.[108] Perceptions of whether certain impacts are positive or negative vary across species and among stakeholders.[109]

As with some marine mammals, offshore wind energy projects may pose collision risks for large fishes, such as sturgeons, especially those that are disoriented because of loud noise or decreased water clarity (i.e., increased turbidity).[110]

Fishes may be attracted to the artificial reef effect created by offshore wind energy foundations. In general, the food and habitat associated with the artificial reef effect attract *demersal* fishes (e.g., cod, flatfishes, whiting) and increase the abundance and diversity of finfish in the OWF

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[101] Degraer et al., "Offshore Wind Farm Artificial Reefs," p. 51.

[102] Degraer et al., "Offshore Wind Farm Artificial Reefs," p. 52.

[103] Birchenough and Hutchinson, "Shellfish and Crustaceans," p. 94.

[104] Ibid., p. 95.

[105] Ibid., p. 94.

[106] Ibid., p. 95.

[107] *Fish* refers to one species of fish; *fishes* refer to more than one species of fish.

[108] 16 U.S.C. §1802(13) defines a *fishery* as "one or more stocks of fish which can be treated as a unit for purposes of conservation and management and which are identified on the basis of geographical, scientific, technical, recreational, and economic characteristics; and any fishing for such stocks."

[109] Andrew B. Gill et al., "Setting the Context for Offshore Wind Development Effects on Fish and Fisheries," *Oceanography*, vol. 33, no. 4 (2020), pp. 118-127 (hereinafter referred to as Gill et al., "Setting the Context").

[110] BOEM, *Ocean Wind: An Ørsted & PSEG Project, Appendix I – Atlantic Sturgeon Supplemental Material*, April 2023, p.4, https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/OCW01_COP_Volume%20III_Appendix%20I_20230518.pdf.

area.[111] In addition, OWFs may increase the local abundance of economically important highly migratory finfishes (e.g., sharks, tunas).[112]

Behavioral reactions to underwater sound have been observed in fish at distances up to tens of kilometers from sites of offshore wind construction and operation.[113] For example, juvenile seabass exhibited disrupted schooling behaviors during playbacks of pile-driving noise.[114] No direct fish mortality from offshore wind pile-driving activity has been observed, but some individuals of cod experienced *barotrauma*, an injury of a body part or organ as a result of changes in pressure, to their swim bladders,[115] as well as internal bleeding and a high degree of abnormal swimming behavior.[116] During power production, noise generated by wind turbines can be detected by fish sensitive to sound pressure (e.g., herring, salmon, cod) at distances up to several kilometers; other fish species may detect the turbine noises only within a 10-meter distance.[117] These acoustic impacts from turbines appear to be restricted to masking communication and orientation signals rather than causing physiological damage.[118]

EMFs associated with OWFs, including their undersea power transmission cables, also may impact fishes. EMFs may cause behavioral change in some fish, such as altered navigation, migratory, or homing behaviors.[119] For example, experimental studies show that small sharks, such as dogfish, are attracted to EMFs from wind power installations that are comparable in

[111] NOAA defines *demersal* as "living in close relation with the bottom and depending on it. Cods, groupers, crabs, and lobsters are demersal resources. The term usually refers to the living mode of the adult, i.e., demersal fish" (NOAA, *NOAA Fisheries Glossary*, June 2006, p. 10). Elizabeth T. Methratta et al., "Offshore Wind Development in the Northeast U.S. Shelf Large Marine Ecosystem," *Oceanography*, vol. 33, no. 4 (2020), pp. 16-27 (hereinafter referred to as Methratta et al., "Offshore Wind Development in the Northeast U.S. Shelf"); Ralf van Hal, Arie Benjamin Griffioen, and O. A. van Keeken, "Changes in Fish Communities on a Small Scale, an Effect of Increased Habitat Complexity by an Offshore Wind Farm," *Marine Environmental Research*, vol. 126 (2017), pp. 26-36; and Hogan et al., *Fisheries and Offshore Wind Interactions*, pp. 66-91. Claus J. G. Stenberg et al., "Long-Term Effects of an Offshore Wind Farm in the North Sea on Fish Communities," *Marine Ecology Progress Series*, vol. 528 (2015), pp. 257-265; Elizabeth T. Methratta and William R. Dardick, "Meta-Analysis of Finfish Abundance at Offshore Wind Farms," *Reviews in Fisheries Science and Aquaculture*, vol. 27, no. 2 (2019), pp. 242-260; Hogan et al., *Fisheries and Offshore Wind Interactions*, pp. 66-75.

[112] Methratta et al., "Offshore Wind Development in the Northeast U.S. Shelf."

[113] Mathias H. Andersson, "Offshore Wind Farms: Ecological Effects of Noise and Habitat Alteration on Fish," Doctoral Dissertation, Stockholm University, 2011, pp. 28-34.

[114] James E. Herbert-Read et al., "Anthropogenic Noise Pollution from Pile-Driving Disrupts the Structure and Dynamics of Fish Shoals," *Proceedings of the Royal Society B: Biological Sciences*, vol. 284, no. 1863 (2017), 20171627, pp. 1-9.

[115] Thomas J. Carlson, "Barotrauma in Fish and Barotrauma Metrics," in *The Effects of Noise on Aquatic Life*, eds. Arthur N. Popper and Anthony Hawkins (New York, NY: Springer, 2012), pp. 229-234.

[116] Annelies De Backer et al., "Swim Bladder Barotrauma in Atlantic Cod When in Situ Exposed to Pile Driving," in *Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: A Continued Move Towards Integration and Quantification*, eds. Steven Degraer et al. (Brussels, Belgium: Royal Belgian Institute of Natural Sciences, OD, Natural Environment, Marine Ecology and Management Section, 2017), pp. 25-37.

[117] Ibid.

[118] T. Aran Mooney, Mathias H. Andersson, and Jenni Stanley, "Acoustic Impacts of Offshore Wind Energy on Fisheries Resources," *Oceanography*, vol. 33, no. 4 (2020), pp. 82-95; Magnus Wahlberg and Håkan Westerberg, "Hearing in Fish and Their Reactions to Sounds from Offshore Wind Farms," *Marine Ecology Progress Series*, vol. 288 (2005), pp. 295-309.

[119] Zoë L. Hutchinson, David H. Secor, and Andrew B. Gill, "The Interaction Between Resource Species and Electromagnetic Fields Associated with Electricity Production by Offshore Wind Farms," *Oceanography*, vol. 33, no. 4 (2020), pp. 96-107; Methratta et al., "Offshore Wind Development in the Northeast U.S. Shelf."

magnitude to fields produced by dogfish prey. As another example, experimental studies of skates show increased exploratory and foraging behaviors in response to EMFs.[120]

Grease, lubricant, and oil emissions from operational OWFs may have local effects to fishes and other marine wildlife.[121] Potential risks associated with lubricant spills from major turbine breakdowns include exposure to toxic substances among early fish recruits, including cods.[122] To mitigate the potential for an exposure event, investigators recommend precautionary approaches such as using less toxic or biodegradable lubricants to minimize effects to marine life.[123]

The Magnuson-Stevens Fishery Conservation and Management Act is the primary statute for management of harvested marine fish populations and their habitats.[124] Certain marine fish species may be listed under the ESA and are subject to the prohibitions and requirements imposed by that act. For more information on those protections, see "Endangered Species Act," below.

Fisheries[125]

The marine ecosystem includes all associated living species, environmental elements, and human components, such as marine fisheries (including fishing communities).[126] Experts consider marine fisheries as part of the marine ecosystem, given their direct influences on ecosystem functioning, living marine resource populations, and human socioeconomics.[127] OWFs may influence localized fish aggregating dynamics (i.e., the gathering of a single fish species or multiple species of fishes during a particular period of time), which may influence marine fisheries.[128] Local increases in fish abundance may increase commercial and recreational *fishing effort* at OWFs

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[120] Zoë L. Hutchinson et al., "Anthropogenic Electromagnetic Fields (EMF) Influence the Behaviour of Bottom-Dwelling Marine Species," *Scientific Reports*, vol. 10, no. 1 (2020), 4219, pp. 1-15.

[121] Rickard Arvidsson and Sverker Molander, *Screening Environmental Risk Assessment of Grease and Oil Emissions from Off-Shore Wind Power Plants*, Chalmers University of Technology, Report No. 2012:7, 2010, pp. 1-39, https://core.ac.uk/download/pdf/70593839.pdf.

[122] Hammar, Wikström, and Molander, "Assessing Ecological Risks"; O. Mauricio Hernandez C. et al., "Environmental Impacts of Offshore Wind Installation, Operation and Maintenance, and Decommissioning Activities: A Case Study of Brazil," *Renewable and Sustainable Energy Reviews*, vol. 144 (2021), 110994, pp. 1-18. Most lubricant components have low water solubility, and fish eggs and larvae generally drift below the surface, which may reduce exposure to potentially harmful substances adhered to the surface.

[123] Hammar, Wikström, and Molander, "Assessing Ecological Risks."

[124] 16 U.S.C. §§1801-1891d.

[125] The Magnuson-Stevens Fishery Conservation and Management Act, under 16 U.S.C. §1802(13), defines a *fishery* as "one or more stocks of fish which can be treated as a unit for purposes of conservation and management and which are identified on the basis of geographical, scientific, technical, recreational, and economic characteristics; and any fishing for such stocks."

[126] J. S. Link et al., "Keeping Humans in the Ecosystem," *ICES Journal of Marine Science*, vol. 74, no. 7 (2017), pp. 1947-1956.

[127] Ibid; M. Sinclair et al., "Responsible Fisheries in the Marine Ecosystem," *Fisheries Research*, vol. 58, no. 3 (2002), pp. 255-265; J. S. Link and A. R. Marshak, "Characterizing and Comparing Marine Fisheries Ecosystems in the United States: Determinants of Success in Moving Toward Ecosystem-Based Fisheries Management," *Reviews in Fish Biology and Fisheries*, vol. 29 (2019), pp. 23-70.

[128] Kevin D. Friedland et al., "Forage Fish Species Prefer Habitat Within Designated Offshore Wind Energy Areas in the U.S. Northeast Shelf Ecosystem," *Marine and Coastal Fisheries*, vol. 15, no. 2 (2023), e10230, pp. 1-20; G. van Hoey et al., *Overview of the Effects of Offshore Wind Farms on Fisheries and Aquaculture*, Publications Office of the European Union, 2021, pp. 1-99, https://op.europa.eu/en/publication-detail/-/publication/3f2134f9-b84f-11eb-8aca-01aa75ed71a1/language-en (hereinafter referred to as Van Hoey et al., 2021).

(i.e., the amount of time and fishing power used to harvest fish),[129] particularly for rod and reel or trap/pot fisheries.[130]

Fishing and other activities may need to avoid certain zones during the construction of OWFs.[131] Certain vessels towing fishing gear may need to avoid the OWF area during its operation.[132] Federal agencies may prohibit certain fishing practices, such as bottom trawling, near OWFs for safety reasons.[133] The prohibition of certain fishing activities may reduce disturbances to benthic fish habitats (i.e., species living on or in seafloor sediments) from fishing activities.[134] The displacement of fishing effort may affect fish species in other locations and may increase local competition for space among fishing vessels.[135] Studies of the North Sea suggest that any potential *refugium effects* (i.e., protection from fishery harvest) to fishes do not become apparent until nearly a decade after the establishment of an OWF.[136]

Sea Turtles

Although the potential effects of OWFs on sea turtles remain unclear,[137] researchers and stakeholders suspect sea turtles may experience effects similar to those experienced by marine mammals (e.g., collision risks, acoustic effects on hearing and behavior).[138]

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[129] NOAA, *NOAA Fisheries Glossary*, June 2006, p. 12.

[130] Ibid.

[131] Maximilian Felix Schupp et al., "Fishing Within Offshore Wind Farms in the North Sea: Stakeholder Perspectives for Multi-Use from Scotland and Germany," *Journal of Environmental Management*, vol. 279 (2021), p. 2.

[132] Ibid.

[133] Kaitlynn Webster and Read Porter, "Legal Limits on Recreational Fishing near Offshore Wind Facilities," *Sea Grant Law Fellow Publications*, 2020, https://docs.rwu.edu/law_ma_seagrant/98.

[134] Van Hoey et al., *Overview of the Effects of Offshore Wind Farms*; Galparsoro et al., "Reviewing the Ecological Impacts," p. 3.

[135] Gill et al., "Setting the Context"; Methratta et al., "Offshore Wind Development in the Northeast U.S. Shelf."

[136] Some experts consider *refugium effects* for species in offshore wind farm areas as being related to a combination of fisheries exclusion and increased food availability. Annelies De Backer, Jolien Buyse, and Kris Hostens, "A Decade of Soft Sediment Epibenthos and Fish Monitoring at the Belgian Offshore Wind Farm Area," in *Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Empirical Evidence Inspiring Priority Monitoring, Research, and Management, Memoirs on the Marine Environment*, eds. Steven Degraer et al. (Brussels, Belgium: Royal Belgian Institute of Natural Sciences, OD Natural Environment, 2020), pp. 79-113; Annelies de Backer, Liam Wyns, and Kris Hostens, "Continued Expansion of the Artificial Reef Effect in Soft-Sediment Epibenthos and Demersal Fish Assemblages in Two Established (10 Years) Belgian Offshore Wind Farms," in *Environmental Impacts of Offshore Wind Farms in the Belgian Part of the North Sea: Attraction, Avoidance and Habitat Use at Various Spatial Scales. Memoirs on the Marine Environment*, eds. Steven Degraer et al. (Brussels, Belgium: Royal Belgian Institute of Natural Sciences, OD Natural Environment, 2021), pp. 60-68.

[137] CSA Ocean Sciences, Inc., *Technical Report: Assessment of Impacts to Marine Mammals, Sea Turtles, and ESA-Listed Fish Species, Revolution Offshore Wind Farm*, Prepared for Revolution Wind, LLC, February 2023, pp. 98-104, https://www.boem.gov/sites/default/files/documents/renewable-energy/state-activities/App_Z1_MarineMammalSeaTurtleandFishTechnicalReport_CSA_V15_27Feb2023.pdf (hereinafter referred to as CSA Ocean Sciences,, *Technical Report*); Morgan Wing Goodale and Anita Milman, "Cumulative Adverse Effects of Offshore Wind Energy Development on Wildlife," *Journal of Environmental Planning and Management*, vol. 59, no. 1 (2016), pp. 1-21 (hereinafter referred to as Goodale and Milman, "Cumulative Adverse Effects").

[138] Sarah K. Henkel, Robert M. Suryan, and Barbara A. Lagerquist, "Marine Renewable Energy and Environmental Interactions: Baseline Assessments of Seabirds, Marine Mammals, Sea Turtles and Benthic Communities on the Oregon Shelf," in *Marine Renewable Energy Technology and Environmental Interactions*, eds. Mark A. Shields, Andrew I. L. Payne (London: Dordrecht, 2014), pp. 93-110 (hereinafter referred to as Henkel, Suryan, and Lagerquist, "Marine Renewable Energy and Environmental Interactions"); CSA Ocean Sciences, *Technical Report*.

Sea turtles may be attracted to offshore wind structures because of beneficial foraging and shelter opportunities.[139] At the same time, increased vessel traffic associated with offshore wind energy development may result in higher collision risks for sea turtles.[140] Displacement of sea turtles from natural habitats in response to OWF noise, or potentially from alteration of sea turtles' migration patterns due to EMFs, may increase their susceptibility to vessel collisions.[141] Lights used on offshore wind turbines and construction vessels also may disrupt movements of sea turtles and their hatchlings, which tend to move toward the brightest light.[142] In addition, researchers have raised concerns about impacts from OWF development on sea turtle nesting and breeding grounds, including habitat fragmentation, among other potential effects.[143]

Certain sea turtle species are listed under the ESA and are subject to the protections and requirements of that act. For more information on those protections, see "Endangered Species Act."

Birds

Bird collisions with rotating turbine blades are one of the most high-profile and debated potential impacts of land-based wind farms and OWFs. Researchers view migratory bird species as more vulnerable to OWF collisions than other birds.[144] Bird species that congregate during breeding periods or pre-migration "staging" periods might be vulnerable if congregations are located near OWFs.[145] For any individual bird, collision risk at land-based or offshore wind farms depends on flight path, flight height, and avoidance or attractance behaviors.[146] Each of these behaviors is described in more detail below.

- **Flight Path:** Many bird species have migratory pathways that they follow during spring and fall migration periods. These pathways, which are essentially migratory bird highways, may overlap with the locations of OWFs.
- **Flight Height:** Bird flight height can depend on species-specific factors, as well as variables such as the distance of the flight, whether it is day or night, air pressure, and prevailing wind direction.

[139] CSA Ocean Sciences, *Technical Report*, p. 102.

[140] Goodale and Milman, "Cumulative Adverse Effects.

[141] Ibid.; Henkel, Suryan, and Lagerquist, "Marine Renewable Energy and Environmental Interactions."

[142] Josep Lloret et al., "Unraveling the Ecological Impacts of Large-Scale Offshore Wind Farms in the Mediterranean Sea," *Science of the Total Environment*, vol. 824 (2022), 153803, pp. 1-12.

[143] Helen Bailey, Kate L. Brookes, and Paul M. Thompson, "Assessing Environmental Impacts of Offshore Wind Farms: Lessons Learned and Recommendations for the Future," *Aquatic Biosystems*, vol. 10, no. 1 (2014), pp. 1-13; CSA Ocean Sciences, *Technical Report*.

[144] Chris B. Thaxter et al., "Bird and Bat Species' Global Vulnerability to Collision Mortality at Wind Farms Revealed Through a Trait-Based Assessment," *Proceedings of the Royal Society B: Biological Sciences*, vol. 284, no. 1862 (2017), p. 7 (hereinafter referred to as Thaxter et al., "Bird and Bat Species' Global Vulnerability to Collision").

[145] For example, Joris Everaert and Eric W. M. Stienen, "Impact of Wind Turbines on Birds in Zeebrugge (Belgium)," *Biodiversity and Conservation*, vol. 16, no. 12 (2007), pp. 3345-3359 (hereinafter referred to as Everaert and Stienen, "Impact of Wind Turbines on Birds").

[146] Robert W. Furness et al., "Assessing Vulnerability of Marine Bird Populations to Offshore Wind Farms," *Journal of Environmental Management*, vol. 119 (2013), pp. 56-66 (hereinafter referred to as Furness et al., "Assessing Vulnerability of Marine Bird Populations").

- **Avoidance or Attractance**: Certain species can avoid or be attracted to OWFs for various reasons, such as changes in food availability near turbines, or can avoid or be attracted to individual turbine structures or blades.[147]

How bird species exhibit these behaviors can determine collision risk, as can the environment (e.g., wind, visibility).[148] Behavioral and environmental interactions (e.g., strong winds causing migratory birds to fly closer to blades) also affect collision risk.[149]

There is little monitoring of bird collisions with OWFs in the United States, in part because U.S. OWFs are relatively recent. Information about the potential scale of bird collisions with U.S. OWFs may be derived from studies of European OWFs and land-based wind farms.[150] Some research estimates that hundreds of thousands of individual birds are killed at land-based turbines annually.[151] Many of the factors that influence collision risk for land-based wind farms also influence risk for OWFs. However, land-based wind energy turbine structures are typically smaller than offshore turbine structures and require more turbine structures per megawatt at lower hub heights compared with offshore wind turbine structures.[152] As a result, many experts anticipate fewer collision risks with offshore wind structures than with land-based ones. The U.S. Fish and Wildlife Service (FWS) reports that mortality rates vary among wind energy facilities and across regions. FWS also notes that most birds killed at land-based wind farms are songbirds, which occupy offshore areas only during migration.[153]

Several bird species that occupy areas in and near OWFs during some part of their life cycle can be found in both the United States and Europe.[154] A study of European OWFs suggests that displacement of some bird species from OWFs is more common than mortality events.[155] Some studies have noted the need to distinguish temporary versus permanent avoidance of an area, which can cause population declines.[156]

BOEM and cooperating agencies have required offshore wind developers to undertake mitigation activities, monitoring, and reporting to reduce potential harm to wildlife from collisions with

[147] For example, Shanshan Zhao et al., "Effect of Wind Farms on Wintering Ducks at an Important Wintering Ground in China Along the East Asian–Australasian Flyway," *Ecology and Evolution*, vol. 10, no. 17 (2020), pp. 9567-9580; Carlos D. Santos et al., "Factors Influencing Wind Turbine Avoidance Behaviour of a Migrating Soaring Bird," *Scientific Reports*, vol. 12, no. 1 (2022), Article 6441.

[148] Furness et al., "Assessing Vulnerability of Marine Bird Populations."

[149] Ommo Hüppop et al., "Bird Migration Studies and Potential Collision Risk with Offshore Wind Turbines," *Ibis*, vol. 148, no. s1 (March 2006), pp. 90-109.

[150] For example, Jonne C. Kleyheeg-Hartman et al., "Predicting Bird Collisions with Wind Turbines: Comparison of the New Empirical Flux Collision Model with the SOSS Band Model," *Ecological Modelling*, vol. 387, no. 8 (2018), pp. 144-153.

[151] Scott R. Loss et al., "Estimates of Bird Collision Mortality at Wind Facilities in the Contiguous United States," *Biological Conservation*, vol. 168 (2013), pp. 201-209.

[152] According to DOE's 2023 Land-Based Market Report, U.S. cumulative wind capacity was 144.2 gigawatts in 2022, including 0.042 gigawatts of offshore wind (DOE, *Land-Based Wind Market Report: 2023 Edition*, DOE/GO-102023-6055, August 2023, p. 4). According to the U.S. Geological Survey's (USGS's) U.S. Wind Turbine Database, as of May 2023, 72,731 turbines are located in 43 states plus Guam and Puerto Rico (USGS, "The U.S. Wind Turbine Database," https://eerscmap.usgs.gov/uswtdb/).

[153] U.S. Fish and Wildlife Service (FWS), "Wind Energy," https://www.fws.gov/node/266177.

[154] Bird species that occur both in the United States and in Europe include the northern gannet; several species of tern (*Sterna* spp.); and seabird species with large geographic ranges, such as shearwaters, petrels, and other species in the family *Procellariidae*.

[155] Stefan Garthe et al., "Large-Scale Effects of Offshore Wind Farms on Seabirds of High Conservation Concern," *Scientific Reports*, vol. 13 (2023), 4779.

[156] For example, Everaert and Stienen, "Impact of Wind Turbines on Birds."

OWFs.[157] For instance, to reduce collision risk for birds, offshore wind developers' mitigation actions may include the following:

- Deploying taller turbine models with turbine blades that are largely above typical flight heights[158]
- Painting turbine blades black[159]
- Installing lights near turbines
- Automating rotors to stop rotating turbine blades during times of high bird passage rates
- Causing the installations to make additional noise to scare birds from an area[160]

Although most concerns about impacts to birds focus on collisions during the operational stage of an OWF, some birds may be impacted in other ways. For example, bird species that feed underwater, such as diving ducks or species that plunge dive, may be affected by changes in food availability in or near OWFs.[161] For some species, OWFs may serve as a barrier to reaching feeding, breeding, or resting areas.[162] **Table 2** describes selected bird species that may be vulnerable to impacts from OWFs because of small population sizes, geographic range, species-specific behaviors, or some combination of these factors.

Impacts of OWFs on birds may give rise to liability under certain federal statutes. Migratory birds may be protected by the Migratory Bird Treaty Act of 1918 (MBTA).[163] Other bird species may be listed under the ESA and subject to its protections. For more information on the regulatory frameworks governing these species, see "Relevant Statutes for Federal Agency Actions Related to Offshore Wind Projects," below.

157 See, for example, Section 4 and Appendix A of BOEM, *Record of Decision: Vineyard Wind 1 Offshore Wind Energy Project Construction and Operations Plan*, May 10, 2021.

158 Alison Johnston et al., "Modelling Flight Heights of Marine Birds to More Accurately Assess Collision Risk with Offshore Wind Turbines," *Journal of Applied Ecology*, vol. 51, no. 1 (2014), pp. 31-41.

159 One research study found that bird deaths decline by 70% after painting a single turbine blade black (leaving the other blades unpainted). See Roel May et al., "Paint It Black: Efficacy of Increased Wind Turbine Rotor Blade Visibility to Reduce Avian Fatalities," *Ecology and Evolution*, vol. 10, no. 16 (February 2020), pp. 8927-8935.

160 For example, DOE, National Renewable Energy Laboratory, "Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines," subcontractor report, August 2003, https://www.nrel.gov/docs/fy03osti/33249.pdf.

161 For example, a 2012 study found changes in abundance of sandeel, a forage fish for many seabirds (Mikael van Deurs et al., "Short- and Long-Term Effects of an Offshore Wind Farm on Three Species of Sandeel and Their Sand Habitat," *Marine Ecology Progress Series*, vol. 458 (2012), pp. 169-180).

162 Eric W. M. Stienen et al., "Trapped Within the Corridor of the Southern North Sea: The Potential Impact of Offshore Wind Farms on Seabirds," in *Birds and Wind Farms: Risk Assessment and Mitigation*, eds. Manuela de Lucas, Guyonne F. E. Janss, and Miguel Ferrer (Quercus, Madrid, Spain, 2007), pp. 71-80.

163 16 U.S.C. §703.

Table 2. Selected Bird Species That May Be Impacted by Offshore Wind Projects

Common Name (scientific name)	Federal Protections	Characteristics That Cause Vulnerability
Roseate terns *(Sterna dougallii dougallii)*	ESA;[a] MBTA	Individuals make foraging trips between nesting sites on oceanic islands and near-shore environments and migrate long distances over the U.S. OCS.
Northern gannet *(Morus bassanus)*	MBTA	The species' geographic range overlaps the U.S. OCS, and individuals plunge dive at up to 40 miles/hour from heights of up to 100 feet.
Cahow (*Pterodroma cahow*)	ESA; MBTA	The species nests only in Bermuda and makes long foraging flights that intersect the U.S. EEZ. Less than 200 remain globally in 2023.
Blackpoll warbler *(Setophaga striata)*	MBTA	Individuals make nonstop, transoceanic flights that overlap the U.S. OCS during spring and fall migration.
Ashy storm petrel (*Hydrobates homochroa*)	MBTA	Species breeds on offshore islands across a limited geographic range from Central to Southern California. Individuals use a specific feeding behavior that involves flying near the ocean surface.
Brown pelican *(Pelecanus occidentalis)*	MBTA	Individuals feed by plunge diving in coastal areas of the Atlantic and Pacific Oceans. The species' geographic range overlaps the U.S. OCS.

Source: S. M. Billerman et al., eds., *Birds of the World*, Cornell Laboratory of Ornithology (2022), https://birdsoftheworld.org/bow/home; and Emma C. Kelsey et al., "Collision and Displacement Vulnerability to Offshore Wind Energy Infrastructure Among Marine Birds of the Pacific Outer Continental Shelf," *Journal of Environmental Management*, vol. 227 (2018), https://doi.org/10.1016/j.jenvman.2018.08.051.

Notes: EEZ = exclusive economic zone; ESA = Endangered Species Act (16 U.S.C. §§1531 et seq.); OCS = outer continental shelf; MBTA = Migratory Bird Treaty Act of 1918 (16 U.S.C. §703). The U.S. OCS is the area of the seafloor located generally between 3 and 200 nautical miles from the shoreline.

a. The northeast population in the United States is listed as endangered under the ESA.

Bats

Little is known about OWF collision risk for bat species, but some modeling studies suggest higher collision rates for bats than birds.[164] In the United States, several species of bat are migratory. Bats typically migrate over land, but some species (e.g., red bats) have been detected flying over the open ocean.[165] Research suggests that long-distance dispersing bats have the highest collision rates compared with other bats.[166] Some scientists have proposed that bats may be attracted to OWFs because the OWFs emit light (which attracts insects) and are prominent landmarks.[167] Other factors, such as high offshore wind speeds, may discourage bats from flying near OWFs.[168]

Certain bat species are listed under the ESA and are subject to the prohibitions and requirements of that act. For more information on those protections, see "Endangered Species Act."

[164] Thaxter et al., "Bird and Bat Species' Global Vulnerability to Collision," p. 7.

[165] Shaylyn K. Hatch et al., "Offshore Observations of Eastern Red Bats (*Lasiurus borealis*) in the Mid-Atlantic United States Using Multiple Survey Methods," *PLOS One*, vol. 8, no. 12 (2013), e83803.

[166] Thaxter et al., "Bird and Bat Species' Global Vulnerability to Collision," p. 7.

[167] Donald I. Solick and Christian M. Newman, "Oceanic Records of North American Bats and Implications for Offshore Wind Energy Development in the United States," *Ecology and Evolution*, vol. 11, no. 4 (2021), pp. 14433-14447.

[168] Ibid.

Relevant Statutes for Federal Agency Actions Related to Offshore Wind Projects

Several federal agencies have responsibilities relevant to the development, permitting, and environmental oversight of offshore wind development. All federal agencies bear responsibility for assessing certain environmental effects of their actions—including issuing permits—under general statutory frameworks such as the National Environmental Policy Act (NEPA)[169] and the ESA. Certain federal agencies have been further tasked with administering specific statutes that aim to protect particular aspects of the environment or certain natural resources. This section of the report outlines certain statutes that may impose procedural or substantive requirements on federal agencies intended to assess and potentially mitigate the environmental effects of wind projects in federal waters. Separately, state agencies typically must permit and approve portions of federal projects, such as power transmission cables, that cross through state waters.[170] Federal law also authorizes state governments to review federal projects for consistency with coastal protection programs under the Coastal Zone Management Act.[171]

In general, BOEM has primary responsibility for administering offshore renewable energy development on the OCS, with several other agencies playing a role in the permitting and environmental review process. The U.S. Army Corps of Engineers (USACE) has the authority to review and regulate certain activities, such as the installation of structures and laying of power transmission cables.[172] Other agencies that have a permitting, approval, and enforcement role in the development of offshore renewable energy include DOI's Bureau of Safety and Environmental Enforcement (BSEE), the Federal Aviation Administration, the Environmental Protection Agency, NOAA, and the U.S. Coast Guard (USCG).[173] In response to E.O. 14008, "Tackling the Climate Crisis at Home and Abroad," BOEM and USACE entered into a partnership in support of planning and reviewing renewable energy projects on the Atlantic OCS.[174]

National Environmental Policy Act

NEPA requires federal agencies to evaluate the impacts of major federal actions that significantly affect the human environment.[175] NEPA is a procedural statute that requires federal agencies to

[169] 42 U.S.C. §§4321 et seq.

[170] BOEM, "Agency Approval," https://www.boem.gov/renewable-energy/agency-approval.

[171] 16 U.S.C. §§1451-1466.

[172] The U.S. Army Corps of Engineers (USACE) has the authority to regulate (1) activities that affect navigation from the mean high-water line at the shore out to three nautical miles and the seabed of the OCS and (2) dredging and filling impacts of project segments out to three nautical miles of the territorial sea. USACE exercises this authority pursuant to, *inter alia*, Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. §403), which addresses structures and work in or affecting the course, condition, or capacity of navigable waters; these waters extend from the mean high-water line to three nautical miles from the shore. USACE's Section 10 authority extends to the seabed of the OCS for certain activities—artificial islands, installations, and other devices (43 U.S.C. §1333(e)). This extension results in the agency regulating the navigation impacts of installations on the seafloor of the OCS. USACE also has authority pursuant to Section 404 of the Clean Water Act to authorize activities that may discharge dredge or fill material into waters of the United States (33 U.S.C. §1344).

[173] BOEM, "Agency Approval," https://www.boem.gov/renewable-energy/agency-approval.

[174] BOEM, "BOEM and USACE Collaborate to Meet Offshore Wind Goals," press release, June, 14, 2021, https://www.boem.gov/boem-and-usace-collaborate-meet-offshore-wind-goals.

[175] For an overview of the environmental review process under the National Environmental Policy Act (NEPA; 42 U.S.C. §§4321 et seq.), see CRS In Focus IF12417, *Environmental Reviews and the 118th Congress*, by Kristen Hite.

take a "hard look" at the environmental consequences of their proposed actions and consider alternatives to those actions.[176] The statute requires federal agencies undertaking this process to consult with and solicit comments from any other federal agencies with "jurisdiction by law or special expertise" about the environmental impact involved.[177] NEPA also requires federal agencies to make these analyses available to the public.[178]

The level of review and analysis NEPA requires varies based on the anticipated level of impacts of the proposed action. For actions expected to have significant impacts on the human environment, the lead federal agency must prepare an EIS.[179] In its EIS, the lead agency must assess (1) reasonably foreseeable environmental impacts of the proposal, (2) reasonably foreseeable but unavoidable adverse environmental effects, (3) a reasonable range of alternatives to the proposed action, (4) the relationship between the short-term uses of the environment and maintenance of long-term productivity, and (5) any irretrievable resource commitments involved if the proposal is implemented.[180] In general, an EIS should be completed within two years,[181] during which the lead agency releases a draft EIS for comment from other agencies and the public. A final EIS must respond to comments from agencies and the public by modifying the proposal, developing alternatives, or explaining why comments do not merit substantive replies or changes.[182] Once an agency reaches a final decision on the action it wishes to take (i.e., the proposed action or an alternative, including no action), it issues a record of decision (ROD).[183]

As the agency responsible for offshore wind leasing on the OCS,[184] BOEM conducts NEPA evaluations of multiple actions at successive stages of the leasing process, often employing a tiered evaluation to allocate the burden while avoiding redundancies.[185] BOEM generally conducts its most detailed NEPA review when lessees file COPs. A COP details actions the lessee proposes to take to build and operate the wind farm. BOEM serves as the lead agency for the preparation of an EIS analyzing the COP, in cooperation with other agencies (discussed below) that also have responsibilities related to the COP.[186] EISs prepared by BOEM for offshore wind COPs have considered potential marine ecosystem impacts of the proposed wind development, such as potential impacts from animals' collisions with offshore wind energy structures or construction vessels, noise associated with project development, displacement from traditional habitat, and other effects. On the basis of these evaluations, BOEM has often required, as conditions of COP approvals, that developers undertake monitoring, reporting, and mitigation to address anticipated impacts. For instance, a developer's mitigation activities could include

[176] Robertson v. Methow Valley Citizens Council, 490 U.S. 332, 350 (1989).

[177] 42 U.S.C. §4332(C).

[178] 42 U.S.C. §4332; 40 C.F.R. §1503.1.

[179] 42 U.S.C. §4332; 40 C.F.R. Part 1502.

[180] 42 U.S.C. §4332.

[181] 42 U.S.C. §4336a(g)(1)(A).

[182] 40 C.F.R. §1503.4.

[183] 40 C.F.R. §1505.2.

[184] 43 U.S.C. §1337(p).

[185] For more information, see CRS Report R46970, *U.S. Offshore Wind Energy Development: Overview and Issues for the 118th Congress*, by Laura B. Comay and Corrie E. Clark; and CRS Report R40175, *Offshore Wind Energy Development: Legal Framework*, by Adam Vann.

[186] For examples of completed EISs, see BOEM, "National Environmental Policy Act and Offshore Renewable Energy," https://www.boem.gov/renewable-energy/national-environmental-policy-act-and-offshore-renewable-energy. The EIS analyses address impacts from infrastructure construction and operations in the primary project area as well as associated transmission cables connecting to shore.

installing bird deterrent devices on turbines and adhering to seasonal work restrictions to protect marine wildlife at sensitive life stages, among many others.

Several agencies cooperate with BOEM during the NEPA process. BSEE cooperates with BOEM by overseeing implementation, monitoring, and assessment of the mitigation measures developed to avoid potential environmental impacts, among other tasks.[187] NMFS, FWS, USACE, and other agencies have participated in the EISs as cooperating or participating agencies,[188] in connection with these agencies' permitting responsibilities under the MMPA, ESA, Section 10 of the Rivers and Harbors Act of 1899,[189] Section 404 of the Clean Water Act,[190] and other laws. BOEM also consults with state agencies in developing the EIS. Some agencies—in particular, NMFS and USACE—have joined with BOEM and DOI in issuing the RODs for some EISs, so that the RODs authorize not only BOEM's approval of the COP but also the permits required from NMFS and/or USACE.[191]

Fixing America's Surface Transportation Act

BOEM's responsibilities include coordinating interagency review and permitting timelines under provisions of the Fixing America's Surface Transportation (FAST) Act.[192] Title 41 of the FAST Act (known as FAST-41) requires certain types of coordination among federal agencies for environmental review and permitting of specified infrastructure projects. Many federal offshore wind projects are covered under FAST-41.[193]

FAST-41 and its implementing guidance require that the designated lead agency for environmental review of a covered project (i.e., BOEM, in the case of offshore wind projects) coordinate the project's review timetable.[194] The mechanism for coordination is the Federal Infrastructure Permitting Dashboard (FIPD).[195] Cooperating agencies with review and permitting responsibilities (e.g., NMFS, USACE) participate in the BOEM-led EIS and in maintaining the FIPD timetable.[196]

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[187] Bureau of Safety and Environmental Enforcement, "NEPA Compliance," https://www.bsee.gov/what-we-do/environmental-compliance/environmental-programs/nepa-compliance.

[188] A *cooperating agency* "means any Federal agency, other than a lead agency, [that] has jurisdiction by law or special expertise with respect to any environmental impact" involved in a proposed project or project alternative (40 C.F.R. 1508.5). A *participating agency* means any federal agency, other than the lead agency, or any nonfederal agency that may have an interest with respect to the environmental review process in the project (23 U.S.C. §139(d)).

[189] 33 U.S.C. §403.

[190] 33 U.S.C. §1344.

[191] NMFS has co-issued all five records of decision (RODs) completed to date for offshore wind COPs. USACE has signed onto two RODs and, in three cases, has issued its own ROD for the USACE permits, while incorporating by reference the analysis in the BOEM-led EISs.

[192] 42 U.S.C. §§4370m–4370m12.

[193] The definition of *covered projects* includes projects that require "authorization or environmental review by a Federal agency involving construction of infrastructure for renewable or conventional energy production" (42 U.S.C. §4370m(6)).

[194] Office of Management and Budget and Council on Environmental Quality, "Guidance to Federal Agencies Regarding the Environmental Review and Authorization Process for Infrastructure Projects," January 13, 2017, https://www.permits.performance.gov/sites/permits.dot.gov/files/2019-10/Official%20Signed%20FAST-41%20Guidance%20M-17-14%202017-01-13.pdf.

[195] Federal Infrastructure Permitting Dashboard (FIPD), https://www.permits.performance.gov/about.

[196] 42 U.S.C. §4370m-4(a).

FAST-41 sets the goal for coordinated review and permitting of covered projects to generally be completed within two years.[197] Despite this goal, the review and approval process has taken longer than two years for each of the five offshore wind projects covered by FAST-41 that have progressed to the point of COP approval. These projects are Vineyard Wind 1 off Massachusetts, South Fork Wind off Rhode Island and Massachusetts, Ocean Wind 1 off New Jersey, Revolution Wind off Rhode Island and Massachusetts, and the Coastal Virginia Offshore Wind Commercial Project off Virginia.

Some Members of Congress and other stakeholders contend that offshore wind projects would benefit from additional permitting efficiencies beyond the FAST-41 requirements.[198] These advocates contend that a more expedited process would assist states in meeting renewable power commitments, facilitate a transition away from fossil fuel energy, and help build a domestic supply chain. The Fiscal Responsibility Act of 2023 amended aspects of NEPA, including directing agencies to rely on a single document during the environmental review.[199] Other stakeholders have expressed an opposing concern that wind permitting may be proceeding too quickly, with insufficient consideration of potential impacts, including those on the marine environment and ecosystem.[200]

Marine Mammal Protection Act

The MMPA provides for the protection of marine mammals from extinction or depletion due to human activities. Of relevance to offshore wind activities, the MMPA prohibits the take of marine mammals, with certain exceptions, absent authorization from NOAA or FWS. Under the MMPA, to *take* a marine mammal means to "harass, hunt, capture, or kill" the animal or to attempt to do any of those acts.[201] The MMPA further defines *harassment* as

> any act of pursuit, torment, or annoyance which—(i) has the potential to injure a marine mammal or marine mammal stock in the wild; or (ii) has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.[202]

The MMPA and its implementing regulations give NOAA the authority to authorize *incidental takes* (i.e., unintentional, but not unexpected, takes) of small numbers of marine mammals within a specified geographic region during particular activities.[203] Authorization of incidental takes to a given party may be given through

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[197] 42 U.S.C. §4370m-1(c)(1)(C). FAST-41 also establishes a process for resolving disputes that may affect the permitting timetable (42 U.S.C. §4370m-2(c)(2)(C)).

[198] For example, the joint explanatory statement for FY2021 BOEM appropriations in P.L. 116-260 stated, "The Committees on Appropriations remain concerned that unreliable schedules for permit processing and environmental reviews have created uncertainty for the long-term viability of offshore wind development." U.S. Congress, Joint Explanatory Statement of the Committee of Conference on H.R. 133: Committee on Appropriations, House of Representatives, 116th Cong., 2nd Sess., *Congressional Record*, December 21, 2020, p. H8534.

[199] 42 U.S.C. §4336a(b).

[200] For further discussion, see CRS Report R46970, *U.S. Offshore Wind Energy Development: Overview and Issues for the 118th Congress*, by Laura B. Comay and Corrie E. Clark, section on "Permitting Decisions."

[201] 16 U.S.C. §1362(13).

[202] 16 U.S.C. §1362(18).

[203] 50 C.F.R. §216.

- an Incidental Harassment Authorization (IHA) for small-scale activities or activities expected to result only in harassment of marine mammals (e.g., short-term offshore wind site characterization and construction) or
- a Letter of Authorization (LOA) for larger scale activities or activities that may cause serious injury or mortality to marine mammals.

Under the MMPA, IHAs must prescribe, as applicable, the permissible means of taking the marine mammals by harassment, the measures NOAA determines to be necessary to avoid unmitigable adverse impacts on the species' availability for taking for subsistence purposes, and requirements for monitoring and reporting.[204] To obtain an IHA, the applicant must submit information about the planned activity (including dates, duration, and geographic region), the anticipated impacts on species or stocks of marine mammals and their habitats, the feasibility of conducting the activity so as to have the least possible adverse impact on the species, and the manner in which they plan to accomplish the necessary monitoring and reporting.[205] For activities near traditional Arctic subsistence hunting areas or that may affect species or stocks used for those purposes, additional requirements apply.[206] When issuing IHAs, NOAA typically works with applicants to define appropriate monitoring and mitigation measures to minimize adverse effects to marine mammals.[207]

As of November 2023, takes for marine mammals associated with approved offshore wind energy activities (i.e., site characterization and construction) have been authorized by NOAA in IHAs and in two LOAs for five-year construction activities off Rhode Island and New Jersey.[208]

Endangered Species Act

Offshore wind development activities may be subject to requirements under the ESA when those activities may affect species identified under the act as endangered or threatened (i.e., *listed species*) or when they may affect designated critical habitat for such species.[209] The ESA aims to protect threatened and endangered fish, wildlife, and plants from extinction. The act is administered by FWS, which covers terrestrial, freshwater, and *catadromous* species,[210] and NMFS, which covers marine species and *anadromous fish*.[211] FWS and NMFS determine which species qualify as endangered or threatened based on an analysis of threats to the species. When a

[204] 16 U.S.C. §1371(a)(5)(D)(II).

[205] 50 C.F.R. §216.104(a).

[206] 50 C.F.R. §216.104(a)(12).

[207] NOAA NMFS, "Apply for an Incidental Take Authorization," https://www.fisheries.noaa.gov/national/marine-mammal-protection/apply-incidental-take-authorization; A. Michael Macrander et al., "Convergence of Emerging Technologies: Development of a Risk-Based Paradigm for Marine Mammal Monitoring for Offshore Wind Energy Operations," *Integrated Environmental Assessment and Management*, vol. 18, no. 4 (2022), pp. 939-949.

[208] NOAA is in the process of finalizing the proposed rules for Incidental Harassment Authorizations (NOAA NMFS, "Incidental Take Authorizations for Other Energy Activities (Renewable/LNG)," https://www.fisheries.noaa.gov/national/marine-mammal-protection/incidental-take-authorizations-other-energy-activities-renewable). The Marine Mammal Protection Act also authorizes federal agencies to implement mitigation measures related to the taking of marine mammals. For example, 16 U.S.C. §1371(a)(5)(D)(ii) states that an incidental take authorization shall prescribe mitigation measures and requirements for monitoring and reporting of any incidental takes that may affect the availability of that species for subsistence uses.

[209] 16 U.S.C. §1533(a)-(b). An *endangered species* is a species "in danger of extinction throughout all or a significant portion of its range." 16 U.S.C. §1532(6). A *threatened species* is a species "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. §1532(20).

[210] *Catadromous species* spend most of their lives in freshwater but enter the ocean to spawn (e.g., American eel).

[211] *Anadromous species* spend most of their lives in the ocean but enter freshwater to spawn (e.g., salmon).

species is listed under the ESA, certain protections and requirements directed at conserving the species and its ecosystem apply.

Among other things, Section 9 of the ESA prohibits the take of an endangered species, and FWS or NMFS may extend this prohibition to a threatened species.[212] The ESA defines *take* to mean "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" the species, or to attempt to do any of those things.[213] When taking of a particular listed species would be prohibited, by statute or by regulation, a person or other entity expecting to take that species in the course of an otherwise lawful activity (referred to as *incidental take*) generally must obtain authorization from FWS or NMFS.[214] When no federal agency is involved, such authorization is generally given in the form of an *incidental take permit*.[215] When one or more federal agencies are involved in the action, such as the federal permits required for an offshore wind project, the applicant and federal agencies obtain authorization of any anticipated take through the Section 7 consultation process.[216]

Section 7 of the ESA governs review of federal agency actions, such as issuing federal permits, that may affect listed species or critical habitat. For actions that may adversely affect listed species, the Section 7 process also is the means of obtaining authorization for any associated incidental take.[217] Actions subject to Section 7 may include infrastructure projects, such as the installation of offshore wind facilities, undertaken by action agencies or by nonfederal entities with federal authorization (e.g., permits, contracts) or funding. For example, federal agencies may be required to consult with NMFS if the installation of an offshore wind facility that they are carrying out, authorizing, or funding likely would affect listed marine species.

Section 7 requires federal agencies to ensure actions they undertake, authorize, or fund are not likely to jeopardize listed species or adversely modify designated critical habitat for listed species.[218] To satisfy this mandate, Section 7 generally requires federal agencies to consult with FWS or NMFS when their proposed actions may affect listed species or critical habitat. A multistep process, generally referred to as *Section 7 consultation*, is used to evaluate the effects of agency actions on listed species and critical habitat and to consider alternative actions that could minimize those effects.

At the end of a Section 7 consultation, FWS or NMFS issues a BiOp.[219] A BiOp states the agency's opinion as to whether the proposed action is likely to jeopardize listed species or adversely modify their designated critical habitat. If the agency concludes that the action may jeopardize listed species or adversely modify critical habitat, the agency must suggest any reasonable and prudent alternatives (RPAs) that could avoid jeopardizing listed species or adversely modifying critical habitat. If the agency concludes the proposed action (or the action as modified by an RPA) would not jeopardize listed species or adversely modify critical habitat, the agency includes an incidental take statement (ITS) in the BiOp. The ITS describes the anticipated impact of any incidental take (i.e., harassing, harming, killing, or otherwise taking the species, as

[212] 16 U.S.C. §§1538(a)(1), 1533(d).

[213] 16 U.S.C. §1532(19).

[214] 16 U.S.C. §§1536, 1539(a)(1)(B).

[215] 16 U.S.C. §1539(a)(1)(B).

[216] 16 U.S.C. §1536.

[217] 16 U.S.C. §1536(o).

[218] 16 U.S.C. §1536(a)(2).

[219] 16 U.S.C. §1536(b).

defined by the ESA, in the course of the otherwise legal action) and provides reasonable and prudent measures the agency considers necessary to minimize that impact.

BOEM consults with NMFS under Section 7 of the ESA for offshore wind facilities for listed marine species such as the North Atlantic Right Whale, fin and sei whales, sea turtles, Atlantic sturgeon, and giant manta rays. BiOps for offshore wind facilities have been issued under the ESA. For example, on December 18, 2023, NMFS issued a BiOp to BOEM on the effects of the proposed Atlantic Shores South Offshore Energy Project to be built off the coast of New Jersey.[220] The BiOp concluded that the proposed facility is likely to adversely affect, but not jeopardize, the continued existence of certain listed marine species or to adversely modify critical habitat. The project includes some measures aimed at minimizing effects on species and other measures to monitor and report effects of the project on listed species. The ITS also contains measures to conserve and protect listed species.

Migratory Bird Treaty Act

The MBTA prohibits taking, killing, or possessing species that are part of one or more of the bilateral migratory bird treaties between the United States and Canada, Mexico, Japan, and Russia.[221] FWS administers the MBTA. Over 1,000 species are protected under the act.[222]

Violations of the MBTA are subject to criminal penalties.[223] U.S. courts are split on whether the MBTA's prohibition on taking migratory birds includes take that results from, but is not the purpose of, another lawful activity (i.e., incidental take).[224] FWS currently interprets the MBTA to prohibit the incidental take of covered migratory birds.[225]

OWFs may result in the take of migratory birds. For example, a single fatal collision of a covered species with a turbine would be considered a take.[226] To date, no persons or entities have been prosecuted in the United States under the MBTA for takes related to OWFs. However, in 2013, Duke Energy Renewables was prosecuted for incidental take from a land-based wind farm in Wyoming, in part because the company failed to "make all reasonable efforts to build the projects in a way that would avoid the risk of avian deaths" and to follow FWS "guidance about how wind project developers could avoid impacts to wildlife."[227] In 2014, PacifiCorp Energy was prosecuted for incidental take at two land-based wind farms in Wyoming.[228] Both companies pled guilty and were sentenced to pay fines and implement environmental compliance plans.

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[220] NOAA NMFS, "NOAA Issuing Biological Opinion on the Atlantic Shores South Offshore Energy Project," December 18, 2023, https://content.govdelivery.com/bulletins/gd/USNOAAFISHERIES-3802d5d?wgt_ref=USNOAAFISHERIES_WIDGET_1.

[221] 16 U.S.C. §703.

[222] The list of species that receive protections under the Migratory Bird Treaty Act (MBTA: 16 U.S.C. §703) is maintained through the regulatory process (50 C.F.R. §10.13).

[223] 16 U.S.C. §707.

[224] For more information on legal interpretations of the MBTA and incidental take, see CRS Report R44694, *The Migratory Bird Treaty Act (MBTA): Selected Legal Issues*, by Linda Tsang and Erin H. Ward.

[225] In 2021, FWS narrowed its interpretation of "take" under the MBTA to preclude prosecutions for incidental take, see 86 *Federal Register* 1134, but this rule was revoked later that year, see 86 *Federal Register* 54642.

[226] 16 U.S.C. §703.

[227] Department of Justice (DOJ), "Utility Company Sentenced in Wyoming for Killing Protected Birds at Wind Projects," press release, November 22, 2013, https://www.justice.gov/opa/pr/utility-company-sentenced-wyoming-killing-protected-birds-wind-projects.

[228] DOJ, "Utility Company Sentenced in Wyoming for Killing Protected Birds at Wind Projects," press release, (continued...)

FWS is also obligated to consult with federal agencies on the implementation of E.O. 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds."[229] E.O. 13186 directs agencies to develop a memorandum of understanding with FWS for any projects that may impact species protected under the MBTA. In addition, FWS has served as a participating agency in the preparation of final EISs for offshore wind projects.[230]

Issues for Congress

The full extent of impacts of offshore wind activities on the marine ecosystem of the U.S. OCS remains unclear, in part because the development of U.S. offshore wind projects is relatively recent. If interest in the climate mitigation benefits derived from offshore wind energy grows in the United States and BOEM continues to issue leases for offshore wind development, Congress may continue to consider how offshore wind energy development may impact the marine ecosystem and associated species.[231] In the 118th Congress, some Members called for additional research into the potential harm offshore wind projects may cause to marine wildlife or expressed concern about the potential impacts offshore wind activities might have on other ocean uses (e.g., H.R. 1).

Research on the Impacts of Offshore Wind Energy Development and Mitigation Strategies

The magnitude and direction (i.e., positive or negative) of offshore wind impacts on the marine ecosystem have yet to be quantified.[232] In addition, gaps exist in scientific knowledge about the interactions between offshore wind turbines and marine species.[233] According to one literature review of the interactions between OWFs and oceanographic conditions, most studies focus on OWFs in Europe's North Sea.[234] Although these operational OWFs may provide some insight into the potential impacts of offshore wind development on the U.S. OCS, the continental shelves of the United States differ from the offshore characteristics of the North Sea.[235] Offshore wind projects on the U.S. OCS are generally sited for deeper waters where turbines are to be spaced at a greater distance (nearly double) than those in the North Sea. Moreover, the offshore characteristics of the Gulf of Mexico and the U.S. Atlantic and Pacific Coasts also differ. Some believe that additional studies, including modeling studies tailored to specific conditions of the U.S. OCS, are needed to better understand the potential impacts of offshore wind development.[236] Section 20115 of H.R. 1 in the 118th Congress would prohibit the Secretary of the Interior from holding a lease sale for offshore wind energy in certain areas of the U.S. OCS until GAO

December 19, 2014, https://www.justice.gov/opa/pr/utility-company-sentenced-wyoming-killing-protected-birds-wind-projects-0.

[229] E.O. 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds," 66 *Federal Register* 3853, January 17, 2001.

[230] For example, BOEM, "Notice of Availability of the Empire Offshore Wind Final Environmental Impact Statement," 88 *Federal Register* 63615, September 15, 2023.

[231] For additional discussion about issues for Congress related to offshore wind and fisheries, see CRS Report R46970, *U.S. Offshore Wind Energy Development: Overview and Issues for the 118th Congress*, by Laura B. Comay and Corrie E. Clark.

[232] Hogan et al., *Fisheries and Offshore Wind Interactions*; and Galparsoro et al., "Reviewing the Ecological Impacts."

[233] Galparsoro et al., "Reviewing the Ecological Impacts."

[234] Miles et al., "Interactions of Offshore Wind," p. 54.

[235] Refer to the subsection on "Ocean Environment" in this report.

[236] Ibid.

"publishes a report on all the potential adverse effects of wind energy development in such areas." Other potential considerations for Congress are the level of research funding provided to agencies involved in offshore wind projects (e.g., BOEM, Department of Energy, NOAA NMFS) and the locations where these agencies should focus their research (e.g., Gulf of Mexico, east coast OCS, or west coast OCS).[237]

EISs for offshore wind projects on the U.S. OCS may provide some insight into wind development's potential impacts on the marine ecosystem and its associated species, as well as the alternative actions considered. EISs prepared by BOEM, with cooperating agencies, include details about the potential marine ecosystem impacts of wind development. As the agencies develop EISs for more offshore wind projects on the U.S. OCS, Congress may wish to consider whether specific agencies or an interagency working group should use these studies to identify emerging patterns of impacts to marine ecosystems in specific areas of the U.S. OCS.[238] Such assessments may also identify trends in the size of offshore wind development projects or developments in the types of wind turbine foundations, among other patterns. (Also see the text box "Department of Energy Wind Energy Research and Development and Impacts," below).

If assessments identify patterns in offshore wind EISs, such findings could help inform decisionmaking about the level of funding needed to implement mitigation strategies, for example, or for restricting areas of the U.S. OCS that may not be suitable for offshore wind development (e.g., based on water depth, seabed composition, or critical habitat). Alternatively, if an analysis of EISs for offshore wind projects identifies no patterns, it could suggest that generalizations from existing OWFs on the U.S. OCS (or from the North Sea) cannot be applied to newly proposed lease sites for offshore wind.

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[237] For example, in the 118th Congress, H.Rept. 118-126 (accompanying H.R. 4394) includes support for DOE research "related to resource characterization, site planning, aquaculture assessments, community outreach, and planning for long term environmental monitoring for applications of marine energy and floating offshore wind technologies to support sustainable, scalable aquaculture production." S.Rept. 118-72 (accompanying S. 2443) includes support for DOE research "[w]ithin available funds, up to $5,000,000 is recommended to support university-led research projects related to resource characterization, site planning, aquaculture assessments, community outreach, and planning for long-term environmental monitoring for applications of floating offshore wind and marine energy technologies to support sustainable, scalable aquaculture production." The Senate report continues with the following language: "The Committee encourages the Department to continue to support research and development related to siting and environmental permitting issues, which if not properly addressed may lead to unnecessary delays in achieving the National goal to deploy 30 gigawatts of offshore wind generation by 2030. In considering research and development funding related to siting and environmental permitting issues, the Department shall prioritize the development of technologies and capabilities related to minimizing impacts to coastal communities, Federal radar missions, and living marine resources. The Committee encourages the Department to continue focusing efforts with nonprofit and academic partners to conduct coastal atmospheric boundary layer characterization that will help optimize and inform efforts of the Department of Interior's Bureau of Ocean Energy Management and assist the growing domestic coast wind energy industry."

[238] Scientists often conduct literature reviews to identify patterns in the results of similar studies published in peer-reviewed journals (e.g., Galparsoro et al., "Reviewing the Ecological Impacts"; and Fatemeh Rezaei et al., "Towards Understanding Environmental and Cumulative Impacts of Floating Wind Farms: Lessons Learned from the Fixed-Bottom Offshore Wind Farms," *Ocean and Coastal Management*, vol. 243 (2023)).

Department of Energy (DOE)
Wind Energy Research and Development (R&D) and Impacts

Section 30003 of the Energy Act of 2020 (Division Z of the Consolidated Appropriations Act, 2021; P.L. 116-260, 42 U.S.C. §16237) authorized the Secretary of Energy "to establish a program to conduct research, development, demonstration, and commercialization of wind energy technologies." One of the program's purposes is "to reduce and mitigate potential negative impacts of wind energy technologies on human communities, the environment, or commerce." The section identifies several subject areas for research, development, demonstration, and commercialization activities. Subjects relevant to offshore wind include fixed and floating substructure systems, materials, and components; the operation of offshore facilities to (1) conduct research for oceanic, biological, geological, and atmospheric resource characterization and (2) test development, demonstration, and commercialization of large-scale and full-scale offshore wind energy support structure components and systems; and monitoring and analysis of site and environmental considerations unique to offshore sites (including freshwater environments). One subject area, reducing market barriers to the adoption of wind energy technologies, includes impacts or challenges relating to local communities and wildlife and wildlife habitats. Another subject area is technologies or strategies that "avoid, minimize, and offset the potential impacts of wind energy facilities on bird species, bat species, marine wildlife, and other sensitive species and habitats." According to DOE's FY2024 Budget Request, in FY2023, the Offshore Wind Environmental and Siting R&D subprogram was funded at $13,145,000. For FY2024, the Administration requested $38,260,000 for this same subprogram.

Offshore Wind Development and Competing Ocean Uses

Some Members of Congress have expressed concern about how the development of offshore wind energy on the U.S. OCS may compete or conflict with other uses of maritime space and how such competition may affect the marine ecosystem and associated species.[239] A House-passed bill in the 118th Congress would require the GAO to "assess the sufficiency of the environmental review processes for offshore wind projects," with attention to impacts of development on marine wildlife, commercial and recreational fishing, and military use of the ocean, among other factors.[240] Some favor legislation to limit U.S. OCS wind development to facilitate existing ocean uses and reduce local and regional impacts of offshore wind development;[241] others focus on the potential environmental, social, and economic benefits that may result from long-term reduction of CO_2 emissions via renewable offshore energy.[242]

Offshore wind energy development could result in loss of fishing grounds, disruption to NMFS surveys, incidental take of birds, and increased vessel activity.

Loss of Fishing Grounds. One concern of the U.S. fishing industry is that during the construction of offshore wind projects, the USCG proposes to establish a temporary safety zone of 500 meters around OWFs that excludes commercial and recreational fishing vessels.[243] Limitations on fishing gear in and around offshore wind areas also may be considered a "loss of

[239] See H.Res. 239 in the 118th Congress.

[240] H.R. 1, §20118.

[241] For example, see H.R. 4284 in the 118th Congress.

[242] For example, see Galparsoro et al., "Reviewing the Ecological Impacts," p. 5. Also see U.S. Representative Paul D. Tonko, "Tonko Introduces Sweeping Offshore Wind Legislation," press release, December 22, 2022, https://tonko.house.gov/news/documentsingle.aspx?DocumentID=3776; and Center for American Progress, "The Inflation Reduction Act Will Help Boost Offshore Wind Production," https://www.americanprogress.org/article/the-inflation-reduction-act-will-help-boost-offshore-wind-production/.

[243] See U.S. Coast Guard, "Safety Zone; Vineyard Wind 1 Wind Farm Project Area, Outer Continental Shelf, Lease OCS-A 0501, Offshore Massachusetts, Atlantic Ocean," 88 *Federal Register* 27839, May 3, 2023. 33 C.F.R. Part 147 permits the establishment of safety zones for non-mineral energy resource permanent or temporary structures on the OCS.

grounds."[244] Changes in fishing practices and fisheries displacement could increase interactions (e.g., entanglements with fishing gear) between marine mammals and the fishing industry in OWF areas.[245] Scenario modeling suggests additional fisheries management measures (e.g., modified catch quotas, spatial and temporal management areas) may need to occur both inside and outside OWFs to avoid any unintended negative effects from redistributed fishing activities.[246]

Some Members of Congress have suggested establishing a fund to compensate U.S. fishers impacted by offshore wind activities.[247] Such a fund could be similar to the Fishermen's Contingency Fund—a fund that compensates fishers for gear damaged from offshore oil and gas infrastructure—or could address a broader range of potential impacts.[248] In June 2022, BOEM sought feedback on draft guidelines for offshore wind lessees to mitigate impacts of their activities on commercial and recreational fisheries, including through financial compensation.[249] Some offshore wind developers already have pursued financial compensation arrangements with fishers in the development area.[250] BOEM also has included financial compensation for the fishing industry in the sale terms for some lease auctions. For example, in the final sale notice for its August 2023 Gulf of Mexico wind lease sale, BOEM offered a 10% bidding credit to bidders who commit to contribute to a fisheries compensatory mitigation fund "to mitigate potential negative impacts to commercial and for-hire recreational fisheries."[251]

Disruption to NMFS Surveys. One concern for NMFS, as well as for the U.S. fishing industry, is potential interruptions to regular (e.g., seasonal or annual) fishery surveys during the construction of offshore wind projects. NMFS and other researchers regularly operate surveys to track the abundance and distribution of fish stocks over time.[252] Surveys provide information on fishery resources and their environment. The data derived from fishery surveys inform stock assessments and management plans and actions. Delays or modifications to the scope or geographic scale of surveys can impede the ability of NMFS, U.S. regional fishery management

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[244] NOAA, "Offshore Wind Energy: Fishing Community Impacts," https://www.fisheries.noaa.gov/topic/offshore-wind-energy/fishing-community-impacts.

[245] Methratta et al., "Offshore Wind Development in the Northeast U.S. Shelf," pp. 16-27.

[246] Miriam Püts et al., "Trade-Offs Between Fisheries, Offshore Wind Farms and Marine Protected Areas in the Southern North Sea: Winners, Losers and Effective Spatial Management," *Marine Policy*, vol. 152 (2023), 105574, pp. 1-17; Methratta et al., "Offshore Wind Development in the Northeast U.S. Shelf."

[247] See, for example, Senator Ed Markey, "Senator Markey, Rep. Moulton Announce Bicameral Efforts on National Offshore Wind and Fisheries Compensation," press release, December 22, 2022, https://www.markey.senate.gov/news/press-releases/senator-markey-rep-moulton-announce-bicameral-efforts-on-national-offshore-wind-and-fisheries-compensation.

[248] 43 U.S.C. §1842.

[249] BOEM, "Guidelines for Mitigating Impacts to Commercial and Recreational Fisheries on the Outer Continental Shelf Pursuant to 30 C.F.R. Part 585," June 23, 2022, https://www.boem.gov/sites/default/files/documents/renewable-energy/DRAFT%20Fisheries%20Mitigation%20Guidance%2006232022_0.pdf. Also see BOEM, "Reducing or Avoiding Impacts of Offshore Wind Energy on Fisheries," https://www.boem.gov/renewable-energy/reducing-or-avoiding-impacts-offshore-wind-energy-fisheries.

[250] See, for example, Vineyard Wind and Massachusetts Executive Office of Energy and Environmental Affairs, "Agreement Regarding the Establishment and Funding of the Massachusetts Fisheries Innovation Fund," May 21, 2020, https://static1.squarespace.com/static/5a2eae32be42d64ed467f9d1/t/5ee122f4c0502b68b9dc41cf/1591812875587/MA+Fisheries+Compensatory+Mitigation+Plan+-+May+2020.pdf; and Vineyard Wind, "Vineyard Wind 1 Fisheries Compensatory Mitigation Program for the Offshore Export Cable Corridor," https://www.vineyardwind.com/cable-compensation-package.

[251] BOEM, "Final Sale Notice for Commercial Leasing for Wind Power Development on the Outer Continental Shelf in the Gulf of Mexico (GOMW-1)," 88 *Federal Register* 47173, July 21, 2023.

[252] NOAA NMFS, "Research Surveys," https://www.fisheries.noaa.gov/national/science-data/research-surveys.

councils, and others to assess and manage stocks.[253] Some stakeholders, as well as NOAA, have expressed concerns about potential conflicts offshore wind construction and development may pose for NMFS surveys.[254]

Incidental Take of Birds. Some stakeholders have raised concerns about OWFs' impacts on bird populations, especially ESA-listed species or non-listed species with small population sizes.[255] Other stakeholders seek ways to reconcile prohibitions against killing certain birds with continued action to promote renewable energy production.[256] Some further contend that wind energy developers would benefit from more consistent enforcement of the MBTA for unintentional takings.[257]

In September 2021, FWS announced its objective to "create a common-sense approach to regulating the incidental take of migratory birds that works to both conserve birds and provide regulatory certainty to industry and stakeholders."[258] This FWS policy could be a subject of congressional interest, including how it might affect BOEM's anticipated approval of offshore wind leases over the next five years.

FWS can authorize limited incidental or intentional take under the ESA or the MBTA. For example, FWS has authorized industry-wide, programmatic incidental take for ESA-listed species in relation to land-based wind energy development through Section 10 of the ESA.[259] FWS also can authorize take for species protected under the MBTA through permitting under an existing regulatory process (50 C.F.R. §21.41). FWS can issue such permits to individuals or through species-specific programs that grant permission to states or other public entities to issue permits for take in certain contexts.[260] In such cases, FWS balances stakeholder needs with a species' population status as well as obligations under the MBTA and migratory bird treaties. Obligations to these treaties may be of interest to Congress when considering amendments to the MBTA.

[253] For more information on U.S. regional fishery management councils, see CRS Report R47645, *U.S. Regional Fishery Management Councils*, by Anthony R. Marshak.

[254] For example, the Research Offshore Development Alliance and Seafood Harvesters of America has expressed concerns about offshore wind impacts on surveys, including in a letter to members of the House and Senate Commerce, Justice, Science, and Related Agencies subcommittees of the Committees on Appropriations (Anastasia E. Lennon, "Fishing Industry: Millions More Needed to Support NOAA Surveys amid Wind Development," *The New Bedford Light*, March 20, 2023, https://newbedfordlight.org/fishing-industry-millions-more-needed-to-support-noaa-surveys-in-light-of-wind-development/); NOAA, "Efforts to Mitigate Impacts of Offshore Wind," https://www.fisheries.noaa.gov/feature-story/efforts-mitigate-impacts-offshore-wind-energy-development-noaa-fisheries-surveys.

[255] For example, BOEM, "Transparent Modeling of Collision Risk for Three Federally-Listed Bird Species to Offshore Wind Development (AT-21-x07)," August 2023, https://www.boem.gov/sites/default/files/documents/environment/environmental-studies/Transparent%20modeling%20of%20collision%20risk%20for%20three%20federally-listed%20bird%20species%20to%20offshore%20wind%20development_1.pdf.

[256] White & Case, "Environmental Laws and Regulations Affecting U.S. Offshore Wind," https://www.whitecase.com/insight-our-thinking/environmental-laws-and-regulations-affecting-us-offshore-wind.

[257] Erika Bosack, "Incidental Take Under the Migratory Bird Treaty Act and How to Share the Skies," *William & Mary Environmental Law and Policy Review*, vol. 46, no. 3 (2022), pp. 849-853 (hereinafter referred to as Bosack, "Incidental Take Under MBTA").

[258] DOI, "Interior Department Ensures Migratory Bird Treaty Act Works for Birds and People," press release, September 29, 2021, https://www.doi.gov/pressreleases/interior-department-ensures-migratory-bird-treaty-act-works-birds-and-people.

[259] For example, incidental take permits under ESA Section 10 have been issued for activities related to renewable energy development that, while otherwise legal, may result in take of lesser prairie chickens (e.g., 86 *Federal Register* 19634). For more information on lesser prairie chicken incidental take permits, see CRS Report R47632, *Lesser Prairie Chicken Listing Under the Endangered Species Act (ESA)*, by Pervaze A. Sheikh and Benjamin M. Barczewski.

[260] For example, FWS has issued statewide depredation permits to protect commercial livestock producers from black vulture depredation.

FWS has not published permitting guidelines under the MBTA related to incidental take associated with wind development.[261] An option for Congress on this issue could be to direct FWS to create exceptions to protections for certain species.[262]

Increased Vessel Activity. Some stakeholders have expressed concerns about increased vessel activity in the areas of offshore wind development.[263] The development of offshore wind areas has been estimated to rely on at least 27 vessels per project across all the project stages.[264] Increased vessel activity may pose navigation and safety concerns for fishers (and other maritime industries), may displace fishers from their fishing grounds, and may increase the risk of whale strikes both from OWF-associated vessels and potentially displaced vessels from other sectors. An option for Congress on the issue could be to direct the USCG, the primary authority for navigational safety in U.S. waters, to enhance communications and monitoring for vessel traffic (including vessel speed and seasonal speed limits)[265] in offshore lease areas.[266] Another option for Congress could be to provide direction to NMFS on vessel speed regulation potentially considering risk tolerance, existing technology and other vessel strike avoidance measures, and relevant spatial and temporal factors.[267]

The James M. Inhofe National Defense Authorization Act for Fiscal Year 2023 (Division J, Title CXIII, Subtitle A of P.L. 117-263) directed several federal agencies to address the impacts of vessel traffic on marine mammals through federal grant programs and real-time monitoring, among other actions.[268] In addition to these actions, Congress may wish to consider identifying technological opportunities that would allow federal agencies (e.g., BOEM, DOT, NOAA, and USCG) to analyze vessel activity in offshore wind energy areas, including vessel types, speed, and vessel strike incidents with large marine mammals. The boundaries of offshore wind areas could be incorporated into SeaVision, a maritime domain awareness sharing tool for the U.S. government and partner governments developed by DOT (see the text box on "SeaVision," below). In considering proposed offshore wind areas, federal agencies and partners could use SeaVision to analyze the activities of vessel types (e.g., fishing vessels, vessels associated with OWF construction) as well as to identify patterns, if any, in the occurrence of vessel and marine mammal interactions.

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[261] Bosack, "Incidental Take Under MBTA," pp. 850-851.

[262] Ibid.

[263] Consensus Building Institute, *Stakeholder Perspectives on the Development of a North Atlantic Right Whale Vessel Risk Reduction Strategy*, report prepared for BOEM, Office of Renewable Energy Programs, OCS Study, BOEM 2023-004, 2023, https://www.boem.gov/sites/default/files/documents/renewable-energy/studies/Stakeholder%20Perspectives%20of%20Vessel%20Risk%20Reduction%20and%20NARWS_0.pdf.

[264] American Clean Power, "Offshore Wind Vessel Needs," https://cleanpower.org/wp-content/uploads/2021/09/Offshore-Wind-Vessel-Needs.FINAL_.2021.pdf. For additional discussion of OWF deployment and vessel issues, see CRS Report R46970, *U.S. Offshore Wind Energy Development: Overview and Issues for the 118th Congress*, by Laura B. Comay and Corrie E. Clark.

[265] Seasonal vessel speed limits of 10 knots have been in place since 2008 to minimize vessel strike impacts to marine mammals. NOAA NMFS, "Endangered Fish and Wildlife; Final Rule to Implement Speed Restrictions to Reduce the Threat of Ship Collisions with North Atlantic Right Whales," 73 *Federal Register* 60173-60191, October 10, 2008.

[266] For example, some fishers identify safety and navigation concerns within an OWF as factors limiting their decision to fish in the area (Angela Silva et al., "Fisheries Socioeconomics" in *Fisheries and Offshore Wind Interactions: Synthesis of Science*, NOAA NMFS, NOAA Technical Memorandum NMFS-NE-291, March 2023, https://repository.library.noaa.gov/view/noaa/49151).

[267] For example, see NOAA NMFS, "Amendments to the North Atlantic Right Whale Vessel Strike Reduction Rule; Extension of Public Comment Period," 87 *Federal Register* 56925, September 16, 2022; and in the 118th Congress H.Amdt. 566 to H.R. 4821 and S. 2986.

[268] See §§11302-11304 of Division J, Title CXIII, Subtitle A, in P.L. 117-263.

SeaVision

SeaVision is a web-based sharing network of maritime domain awareness information (i.e., the effective understanding of anything associated with the maritime domain that could impact security, safety, the economy, or the marine environment) developed by the U.S. Department of Transportation (DOT) and the U.S. Navy.[1] SeaVision uses nonclassified vessel Automatic Identification System (AIS) data to display current and past vessel movement within the U.S. exclusive economic zone (EEZ), the EEZs of partner countries, and on the *high seas* (international waters) on a live SeaVision map.[2] AIS data include navigation information, such as the identity, flag state, type, course, and speed of the vessel, that is transmitted in real-time via ship-to-ship or ship-to-shore transmissions.[3] In general, information of vessels in EEZs is obtained via radio frequency data and information about vessels on the high seas is obtained by satellite data.

SeaVision may be accessed and used by U.S. federal agencies with a maritime interest or by any partner country.[4] According to DOT, at least 83 foreign governments participate in SeaVision through a partnership with the U.S. government.[5]

SeaVision can be used to analyze individual vessel activity or the activity of vessels within a specific area of the ocean.[6] For example, SeaVision can be used to analyze the tracks of a single cargo vessel or the activity of all fishing vessels in the Gulf of Maine in real time or over a certain time period, among other scenarios. SeaVision data may be analyzed to identify maritime security incidents, illegal fishing activity, vessel interactions (e.g., vessel-to-vessel collision or vessel strike of marine mammal), areas of heavy vessel activity, vessel speed, and more.

Sources:

1. U.S. DOT, Volpe National Transportation Systems Center, "SeaVision," https://info.seavision.volpe.dot.gov/.
2. Ibid.
3. U.S. Coast Guard, "Automatic Identification System (AIS) Overview," https://www.navcen.uscg.gov/automatic-identification-system-overview.
4. U.S. Navy, "SeaVision: Improving Maritime Domain Awareness During Cutlass Express," press release, July 29, 2021, https://www.navy.mil/Press-Office/News-Stories/Article/2712219/seavision-improving-maritime-domain-awareness-during-cutlass-express/.
5. Email communication between CRS and U.S. DOT, Volpe National Transportation Systems Center, January 19, 2024.
6. U.S. Navy, "SeaVision: Improving Maritime Domain Awareness During Cutlass Express," press release, July 29, 2021, https://www.navy.mil/Press-Office/News-Stories/Article/2712219/seavision-improving-maritime-domain-awareness-during-cutlass-express/.

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