Offshore Wind Energy
Anthropogenic Activity Background Document

I. Activity Overview

Offshore wind projects leverage strong, steady winds over the ocean to rotate turbine blades, driving attached generators to create electricity. Turbines can be mounted on fixed piles or floating devices, and the resulting structures can stand several hundred feet above the surface of the water. Each turbine, whether fixed or floating, must be connected to an electric service platform that collects and relays the electricity to shore, and serves as a base for maintenance activities. Together, the collection of wind turbines and a service platform form a “wind farm,” which can consist of just a few or many dozen turbines with a very large project footprint. Specialized, high voltage cables are used to transmit the generated electricity from the service platform to an onshore substation that connects to the existing power grid. While generally termed “offshore wind energy,” projects can be sited in both nearshore and offshore waters. The U.S. Department of the Interior’s Bureau of Ocean Energy Management (BOEM) leases areas to be considered for siting wind energy projects, and the U.S. Army Corps of Engineers (Corps) permits offshore wind projects in state waters. The U.S. Coast Guard oversees lighting and traffic patterns at wind farms to reduce potential navigation hazards.

<u>Construction and Operation</u>

There are several considerations that inform siting of offshore wind farms including wind speed, size of turbines, distance from shore, and depth of water. Larger turbines are more efficient at harnessing energy at a given wind speed; however, they require larger, sturdier piles to support their span. Floating turbines, which employ turbines mounted on floating devices and anchored to the seafloor with cables, can allow wind farms to be sited further from shore and in deep water. However, given current technological limitations with floating turbines and driving piles in deep water, wind farms are most likely to be comprised of fixed turbines and sited in shallow waters less than one-hundred and fifty feet deep.

To construct fixed turbines, construction barges equipped with percussive or gravity hammers drive piles up to 100 feet into the seabed in mostly sandy habitats. Crushed rock or concrete mattresses are placed on the seafloor at the base of the piles to stabilize them against the forces of waves, high winds and ice floes, and to prevent currents from scouring sediment. Cranes onboard the barges are used to mount turbines and a service platform onto the piles. The piles, turbines, and electric service platforms are all assembled onshore and moved to the project site on construction barges for installation.

<u>Electricity Transmission</u>

To collect and distribute the electricity generated at a wind farm, a network of expensive transmission cables must be laid to connect each turbine to the service platform, and the service platform to an onshore power substation. The cables are laid in trenches on the seafloor that are excavated by jetting, trenching, or plowing tools and then buried to protect them from damage or disturbance. The amount of cable required to network a wind farm is related to the spacing between turbines, distance from shore, and the number and type of seafloor obstacles that the cables must be routed around or through. In instances where re-routing cables is impractical, they may be placed on the substrate and buried with concrete mattresses; explosives can also be used to remove benthic obstacles, though this is less common. Throughout the life cycle of a wind farm, transmission cables must occasionally be unearthed and inspected for damage and eventually removed during decommissioning.

Activity in the Mid-Atlantic Region

The Mid-Atlantic region is densely populated with extensive development along the shoreline. High energy demand and lack of space for onshore coastal wind farms make it an attractive area to develop offshore wind projects. While there are currently no operational wind farms in Mid-Atlantic waters, BOEM has worked with states and stakeholders to identify offshore leasing areas for wind development under a program called “Smart from the Start.” Under this program, National Oceanic and Atmospheric Administration (NOAA) Fisheries Habitat Conservation Division staff are actively involved in the pre-consultation phase to help identify potential concerns and impacts to Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC). These insights can prompt states and BOEM to modify the areas identified for potential wind energy development. Offshore wind energy sites have been identified off of Virginia, Maryland, New Jersey, Delaware, and New York, and there are several proposals to develop wind farms in both nearshore and offshore waters. Given technological limitations and the abundance of shallow sandy areas suitable for installing fixed turbines, there are currently no proposals for building floating turbines in the Mid-Atlantic.

II. Habitat Impacts from Offshore Wind by Habitat Type

Development of offshore wind farms has the potential to impact all marine habitat types. Impacts from construction activities are likely to be temporary, while impacts from operation and transmission may occur over longer timeframes. Specific impacts to habitat types are described below, organized by distribution and depth.

Distribution (Nearshore (Including Estuarine)/Offshore)

a) Nearshore

Each construction and transmission-related activity associated with developing wind farms has the potential to impact nearshore habitats. The percussive or gravity hammers used to drive piles into the seabed can directly damage benthic habitats by crushing, removing, converting, or suspending substrates. These hammers vibrate and emit sound waves, which can travel great distances and alter fish and marine mammal behavior, damage hearing and communication organs, and decrease survival near the project site (see Indirect Impacts). Placing crushed rock or concrete mattresses at the base of piles can also directly destroy, convert, or bury substrates. These scour-preventing defenses, along with the vertical structure of the piles themselves, can introduce artificial habitat and also alter species behavior (see Indirect Impacts). Construction barges used to install piles, turbines, service platforms, and transmission cables may drag their anchors along the seafloor, which can directly destroy or damage benthic habitats and suspend sediment. Strong cables and anchors placed on the seafloor to keep floating piles in place could also cause similar benthic habitat impacts.

Regardless of where wind farms are sited, cables connecting service platforms to onshore substations must pass through nearshore habitats. After trenches are excavated, cables are positioned and laid inside the trenches by construction barges and covered with the displaced sediment. These activities can directly destroy, damage, bury, or convert benthic substrate. The resulting suspended sediments can increase sedimentation, siltation and turbidity. When cables are unearthed for inspection and eventual decommissioning, these impacts may occur again. Electricity-bearing transmission cables also create electromagnetic fields around cables, which can alter species behavior (see Indirect Impacts).

Estuarine
In addition to the impacts described above, piles in confined water bodies like estuaries can disrupt tidal patterns and alter the flow of currents, sediments, and nutrients. This disruption can impact the distribution of eggs, larvae, and juveniles of many species that rely on these areas as nurseries. These impacts vary with the size, number and configuration of piles. Laying cables in shallow estuaries can disrupt littoral sediment and freshwater inflow, cause faster draining at low tide, and increase saltwater intrusion at high tide; these changes can lead to net loss of salt-intolerant plants and organic matter and cause soil erosion and siltation. In addition, these activities can resuspend contaminated sediments, which cannot easily disperse in shallow waters and may alter the behavior and survival of eggs, larvae, and juvenile fish and shellfish.

b) Offshore
For wind projects sited in offshore waters, the construction and transmission-related impacts described above can also be expected in offshore habitats. As fixed deepwater pile and floating turbine technologies continue to evolve, wind farms may increasingly be sited in deeper offshore waters.

<u>Depth (Pelagic/Demersal/Benthic)</u>

a) Pelagic
Spilled chemicals such as lubricants have the potential to reduce water quality and increase toxicity throughout the water column. Reduced water quality can lead to direct mortality and have sublethal effects on fish and other species by altering behaviors such as feeding, growth, migration, and reproduction. The physical presence of piles and turbines may also impact species behavior throughout the water column (see Indirect Impacts).

b) Demersal
Construction of wind farms and laying transmission cables can suspend sediments, including contaminated sediments, which increases turbidity and causes sedimentation in demersal waters. Suspended particles and contaminants may temporarily degrade the habitability of surrounding waters, decrease long-term survival, and alter the behavior of demersal species.

c) Benthic
Benthic habitats will likely be subject to the most damaging impacts from the construction and operation of wind farms. Installing piles and laying networks of transmission cables can destroy, damage, convert, and disturb all benthic habitat types. The anchors of construction barges and floating turbines may also cause similar impacts by sliding along the seafloor. A considerable amount of cable is required to connect turbines to service platforms and platforms to onshore substations, resulting in a large footprint on benthic impact. The presence of piles themselves are likely to cause currents to speed up as they move around them, leading to scouring of sediment around their bases. Scour unearths and removes benthic sediment in plumes, leaving holes on the seafloor that can alter community dynamics through habitat and species removal. Resuspended contaminated sediments eventually settle to the seafloor and can persist over long timeframes, degrading the habitability of benthic substrates and exposing organisms that live on or feed near the seafloor to toxins. In addition, the presence of transmission cables in benthic substrates can alter or inhibit benthic species' migrations, especially for invertebrates living in sediments.

<u>Benthic Substrate (Submerged Aquatic Vegetation/Structured/Soft)</u>

a) Submerged Aquatic Vegetation
In addition to the general benthic impacts described above, sedimentation, siltation and turbidity from construction activities can bury submerged aquatic vegetation (SAV) with fine particles and decrease sunlight penetration, which results in decreased productivity of SAV habitats. SAV is particularly sensitive to reduced water quality from pollutants and resuspended contaminated sediments, which can poison existing SAV and prevent future growth in the surrounding substrate. If cables are sited through SAV, these habitats could be directly destroyed by excavation and burial, and contribute to increased turbidity and sedimentation.

b) Structured
Offshore wind farms are unlikely to be sited on structured habitats such as gravel, shell beds, or cobble; however, destruction and damage from excavation and cable burial may result if transmission cables need to be routed through these habitats. Where cables are unable to be buried to standard depths, concrete mattresses may be used to cover cables passing through hard bottom habitats, resulting in similar impacts. In some cases, explosives may be used to permanently remove large hard bottom obstacles. The force of explosives can directly destroy and permanently remove hard structured habitat, alter nearby habitats, and increase sedimentation and turbidity as the result of suspended sediments. Structured habitats may also be crushed, removed or disturbed by driving piles in adjacent habitats or dragging construction barge anchors.

c) Soft
Soft bottom habitats such as sand, silt, and clay are particularly vulnerable to sediment impacts due to the small, relatively light particles that typify them. Construction activities near the seafloor may create small disturbances that can remove sediment altogether or cause plumes of sediment to be resuspended, leading to sedimentation and burial of existing benthic habitat.

Trenching and burying transmission cables can alter habitat complexity and quality by removing or exposing sediment, smoothing out existing seafloor depressions, and creating new contours through the effects of scour.

III. Potential Impacts of Offshore Wind to MAFMC Managed Stocks

Considering the full potential of wind farm configurations and siting options, all habitats utilized by Mid-Atlantic Fishery Management Council (MAFMC) species could potentially be impacted to some extent by offshore wind development. Given technological limitations and the structure of current proposals, offshore wind developments in the near term are likely to be sited close to shore and utilize fixed turbine technology. Thus, impacts from construction and transmission activities will occur in nearshore, shallow water, and will be mostly benthic or demersal in nature. Offshore wind development activities are most likely to occur in soft bottom habitat given the ease of construction in this substrate. SAV and estuarine habitats are particularly vulnerable to transmission-related construction, and may incur significant impacts if activities occur in those areas. If wind farms are sited in deeper offshore water in the future, the impacts described above will likely extend to benthic and demersal habitats offshore.

The following table lists the habitat types designated as EFH and HAPC for the different life stages of MAFMC managed stocks *(*see *Impacts to Fish Habitat from Anthropogenic Activities: Introduction and Methods)*. Cells highlighted in orange indicate an overlay between the habitat type used and the potential for the habitat type to be adversely impacted by offshore wind activities; cells highlighted in yellow indicate a lower potential for adverse impacts.

MAFMC species that depend on nearshore, benthic habitats during at least one life stage have the most potential to be impacted by wind development projects. In the Mid-Atlantic, soft, sandy substrate is the dominant benthic habitat type. Given that wind farms tend to be sited in soft substrates, there are very large areas of the Mid-Atlantic region where wind development could potentially take place. Of the six species that utilize nearshore, benthic habitat, soft bottom substrate is an essential habitat for at least one life stage. The overlap between potential areas of development and the common use of soft bottom habitat may increase the likelihood of impacts to some of these species. With their strong dependence on soft bottom substrates, ocean quahogs and Atlantic surfclams may be particularly vulnerable to impacts from offshore wind development. If transmission cables are routed through estuarine habitats, additional species may be impacted considering the sensitivity and importance of that habitat to early life stages of many stocks. Golden tilefish are the only MAFMC managed species not likely to be impacted directly by wind development activities due to their reliance on very deep, offshore habitats.

Visual Overlay of Potential Impacts from Offshore Wind and MAFMC Species' EFH/HAPC

Legend	Distribution			Water Column			Benthic Substrate/Structure		
Orange = potential for adverse impacts									
Yellow = low potential for adverse impacts **Green** = no potential for adverse impacts	Estuary	Nearshore (state waters)	Offshore	Pelagic (upper/mid/ entire column)	Demersal (lower water column)	Benthic (seafloor substrate)	SAV	Structured (e.g. shell, manmade)	Soft (sand, silt)
MAFMC Species									
Atlantic Mackerel									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Black Sea Bass									
Eggs	x	x	x	x					
Larvae	x	x	x	x	x	x		x	
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x		x	x
Atlantic Bluefish									
Eggs		x	x	x					
Larvae		x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Butterfish									
Eggs	x	x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x	x					
Adults	x	x	x	x					
Shortfin Squid (*Illex*)									
Eggs			x	x					
Pre-Recruits			x	x					
Recruits		x	x	x					
Longfin Squid (*Loligo*)									
Eggs	x	x	x		x	x	x	x	x
Pre-Recruits	x	x	x	x					
Recruits	x	x	x	x	x	x	x	x	x
Ocean Quahogs									
Juveniles		x	x			x			x
Adults		x	x			x			x
Scup									
Eggs	x	x							
Larvae	x	x							
Juveniles	x	x	x		x	x	x	x	x
Adults	x	x	x		x	x			
Spiny Dogfish									
Juveniles		x	x	x	x				
Sub-Adults		x	x	x	x				
Adults		x	x	x	x				
Summer Flounder									
Eggs		x	x	x					
Larvae	x	x	x	x					
Juveniles	x	x	x		x	x	x		x
Adults	x	x	x		x	x	x		x
HAPC	x						x		
Atlantic Surfclams									
Juveniles		x	x			x			x
Adults		x	x			x			x
Golden Tilefish									
Eggs			x	x					
Larvae			x	x					
Juveniles			x		x	x		x	x
Adults			x		x	x		x	x
HAPC			x			x		x	x

IV. Indirect Impacts

In addition to the habitat impacts described above, offshore wind development may result in indirect impacts, such as potentially excluding fishing vessels and shifting fishing effort away from wind farms, introducing potential hazards to navigation, and increasing mortality of seabirds through collisions with turbines. Offshore wind may also have impacts on the survival and productivity of marine species over various timeframes. Construction activities may cause temporary, site-specific impacts on fish and marine mammal species, depending on the specific number and configuration of turbines and transmission cables. Other impacts from operation and transmission activities are likely to occur over the life of a wind farm, such as:

a) Underwater Sound

Pile driving hammers emit harmful sound waves that create concussive forces and cause pressure changes that can temporarily or permanently damage hearing organs and cause disorientation. These sounds can alter feeding and migration behaviors and reduce hearing, communication and echolocation effectiveness in marine mammals and fish. Persistent sound from spinning turbines over the lifespan of a wind farm can also deter or attract some species. For example, salmon and cod are capable of detecting sound generated by operating wind turbines from several miles away, which could lead to long-term avoidance of those areas.

b) Electromagnetic Fields

Transmission cables bearing high-voltage electricity loads create electromagnetic fields around them. Electromagnetic fields can be detected by anadromous and elasmobranch species such as salmon and sharks, and may potentially alter their distribution, behavior, feeding and migration, potentially changing community dynamics near wind farms.

c) Artificial Habitat Creation

Piles, scour preventing structures, and floating turbines can create artificial habitat or act as Fish Aggregating Devices (FADs) throughout the water column. The introduction of new habitat may be beneficial to fish species, though it is not known if they increase local fish production or simply act as an aggregation point for existing fish. The attraction or avoidance caused by offshore wind infrastructure may also alter predator-prey relationships, disrupt species dominance, and modify local mortality rates by supplying ambush sites for predators and refuge for prey. The presence of this infrastructure can also impede migratory pathways for many species of marine mammals, fish, and invertebrates over a portion of the ocean.

V. References

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