

Electromagnetic Field Effects on Marine Fishes in the Mid-Atlantic

Wind Farms and Electromagnetic Fields

Many countries around the world, including the United States, are looking for ways to increase the amount of electricity generated through renewable energy sources. For coastal states, Virginia included, this has led to an exploration into offshore wind energy. As offshore wind farms develop, it is important to investigate potential impacts to the ocean ecosystem. This document summarizes the current state of knowledge regarding interactions between marine fish species and the Electromagnetic Field (EMF) emitted from transmission cables.

Along the east coast, several offshore wind farms are in development and one is already operational. The Block Island Wind Farm off of Rhode Island was the first commercial offshore wind farm in the United States. Similar projects in Maryland, New Jersey, and Virginia are in various stages of development.

Twenty-seven miles off the coast, Virginia is moving forward on the mid-Atlantic's first offshore wind project in a federal lease area. Virginia is working with Dominion Energy and Ørsted Energy of Denmark, a global leader in offshore wind development, to build two 6-megawatt turbines in the Coastal Virginia Offshore Wind (CVOW) research lease area.

Individual turbines in offshore wind farms typically connect to one or more main transmission power cables leading back to the mainland. These high voltage underground cables

What are Electromagnetic Fields?

Electromagnetic fields, otherwise known as EMF, include fields emitted from both electric and magnetic sources. EMFs are generated naturally as well as by human activities. Magnetic fields are used for orientation and migration by some fish and animals. Electric fields allow fish to detect prey and predators which assists with feeding and predator avoidance.

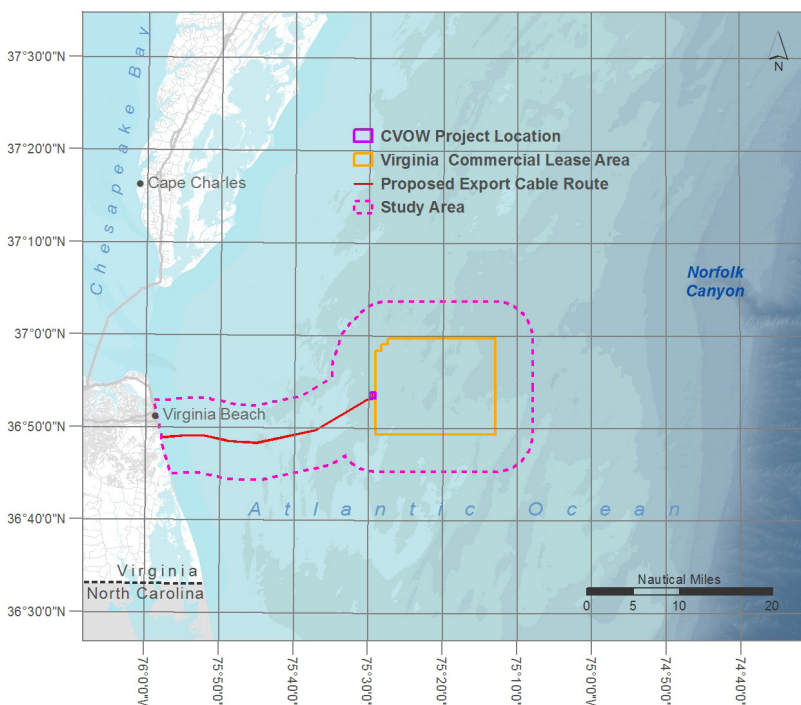
emit a measurable EMF (although the field emitted has been shown to be less than that of typical household appliances¹). An EMF can be measured in terms of the intensity of both the magnetic and electric fields, as well as its frequency.²

Because some fish use the Earth's magnetic fields for navigation and other fish detect electric fields as part of their search for prey, EMF associated with transmission cables has been studied for its impacts on fish behavior. Research to understand how EMF affects fish has focused on the most sensitive species to determine whether significant negative or positive impacts are associated with exposure to these introduced sources of EMF.

What do we know about cables and burial?

Two types of cables may be used in transferring wind generated electricity in coastal waters in the United States: alternating current (AC) and direct current (DC). AC power transmission cables are used extensively in Europe for offshore energy facilities, and many of the offshore wind projects proposed in the US.³ Smaller interarray cables are used to connect the turbines and a larger export cable takes the electricity to shore.

Cables are covered in sheathing to protect the cable and minimize the electric field from affecting the external environment. This sheathing usually includes steel wires or tape around the cables to enhance the mechanical strength of the cable, and the thicker the sheathing materials the weaker the strength of the EMF outside the cable.⁴ The cables are generally buried by ocean currents or trenched at a depth of about 6 feet, so benthic and demersal (bottom and near bottom) fish and shellfish are more exposed to EMF than species living elsewhere in the water column. Burying the cables is a way to mitigate EMF exposure, and the EMF measured above buried cables becomes equal to natural background EMF within a few meters of the cable.²



Coastal Virginia Offshore Wind (CVOW) area off the coast of Virginia Beach, VA.



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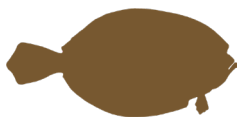
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What do we know about how marine species are impacted by EMF?

The Bureau of Ocean Energy Management (BOEM) has evaluated published research to summarize the potential effects of EMF on both demersal (bottom species) and pelagic (open water) fish and shellfish species. Reported information on actual sensitivity to EMF exists only for a handful of the most sensitive species, as this research is still developing.³ Research findings are summarized below and effects are noted by the following legend:

B Behavior **M** Migration & movement **V** Vital Signs

Bony Fishes



B **M** **V**

Different species of bony fishes respond differently to EMF exposure.

- Atlantic cod do exhibit some sensitivity toward emitted EMF.⁵
- European flounder exhibited no response to EMF.⁶
- Potential orientation and navigation effects were documented on Atlantic, King, and Spanish mackerel species.³
- Salmon and trout species detect magnetic fields to help determine their migratory patterns and EMF could disrupt migration behavior.³
- Some behavioral and anatomical responses by Yellowfin tuna have been reported.³
- Salmon have elevated heart rates in some EMF ranges.⁷
- Chinook salmon and green sturgeon migration was not impeded by an HVDC cable.⁸
- EMFs can slow embryonic development of brown trout and rainbow trout in freshwater environments.⁹
- EMF can change blood circulation in embryos and larvae of pike, carp, and brown trout.⁹
- There are conflicting reports on whether or not EMF affects predator and prey detection and navigation in sturgeon species.^{3,10}

Eels



M **V**

- European eels decrease their swimming speed as they pass over cables; the effect is short-lived and determined to be of minor significance.¹¹
- Eels have elevated heart-rates when exposed to certain levels of EMF.⁷

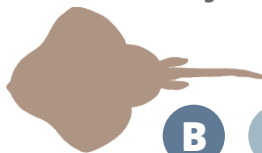
Sharks



B **M**

- Sharks and rays are 14,000 times more sensitive to EMF than bony fish.¹²
- Scientists have found evidence of EMF effects on multiple species of sharks and rays including prey and predator detection and navigation issues.³
- Attraction to cables varies by species and the intensity of the emitted EMF; some species are attracted to the cables while others are repelled.^{13, 14}
- Some species of sharks can detect buried cables up to 20 meters away.⁴
- Some species have been shown to attack exposed electrodes emitting EMF in some instances.¹⁵
- Sandy dogfish, *Scyliorhinus canicula*, were found to non-randomly associate nearer to the cables when energized.¹⁶

Skates & Rays



B **M**

Skate species differ in their responses to EMF exposure including:

- Little Skates (*Leucoraja erinacea*) traveled farther but more slowly which could mean higher energetic costs.²
- *L. erinacea* make larger turns, which could be attributed to increased exploratory activity and/or area restricted foraging behavior.²
- Thornback skates (*Raja clavata*) exhibited a response to the EMF from an energized cable; the response was variable and not predictable.¹⁶

Shellfish



B **M**

The American lobster had small behavioral responses to EMF exposure including:

- Lobsters were observed making larger turns while foraging.²
- Small behavior effects on the lobsters that did not act as a barrier to movement.²



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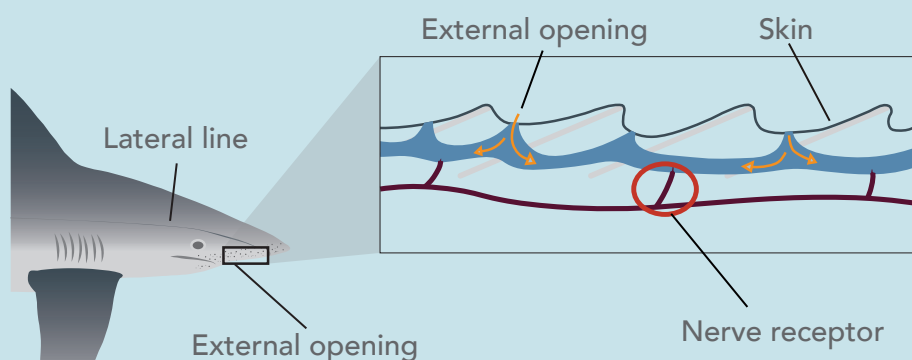
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How do fish detect EMF?

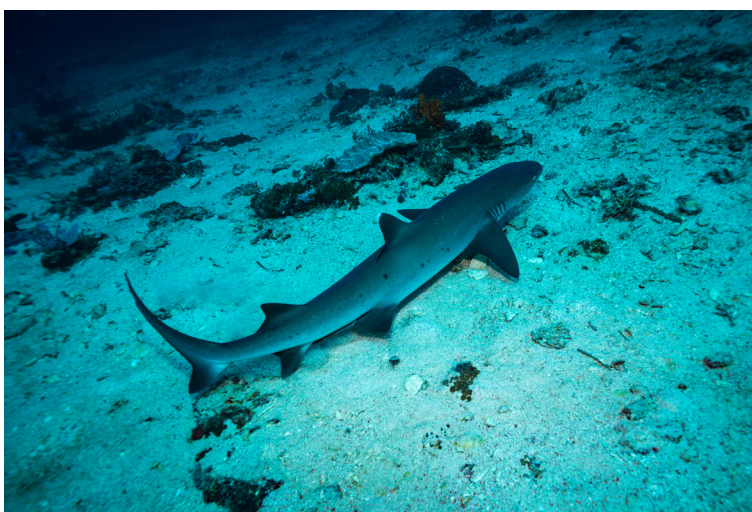
Many marine fish have electrosensory systems that help them sense stimuli and detect objects, including food and predators. Sharks, rays, ratfishes, lampreys, sturgeons, and a few bony fishes have these specialized electrosensory organs. EMF has been shown to impact these species in a variety of ways, as summarized in the table on the previous page.

The adjacent graphic provides an overview of a shark's electrosensory system. A shark's nose is covered in tiny pores that act as electroreceptors, detecting electrical fields. Seawater enters through these pores and then passes over nerve receptors. The nerve receptors detect electrical fields and pressure changes around the shark. Sharks and many other fish species have additional sensory systems, called lateral lines, that run along their bodies, detecting movement and vibrations. Studies to date indicate that fish with lateral lines are potentially more vulnerable to increased levels of EMF in the marine environment. While laboratory and field studies have demonstrated that fish respond to EMF, there is no evidence that any species is significantly impacted such as preventing migration at measured exposure levels.



What are the research gaps?

Research to date has focused on select species that are expected to be sensitive to either electric or magnetic fields. While species are observed to sense the fields, no detrimental harm has been observed, such as disruption to migration. An evaluation should be conducted for each new facility based on species known to exist in the area and that may respond to the cables. Measures to reduce or eliminate EMF should be undertaken such as shielding of the cable, burial where possible, and choice of engineering designs and deployment.



Mitigation

Although it is difficult to make specific recommendations, scientists recommend that regulatory agencies require energy companies to provide the details of cable design, burial depth, layout, sheathing, and loading (amperes) early in the permitting process so the effects of cables can be evaluated before cables are installed.³ Placing cables close together could allow field vectors from each cable to cancel each other out, minimizing magnetic fields, and burial of the cable can reduce both the electric and magnetic fields.¹⁷ Using sheathing with high conductivity and permeability can also help reduce the magnetic field.³ More research is needed to fully understand how these cables will affect marine fishes over longer time periods.

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Virginia Commonwealth University - www.vcu.edu

Virginia Coastal Zone Management Program - www.deq.virginia.gov/Programs/CoastalZoneManagement.aspx



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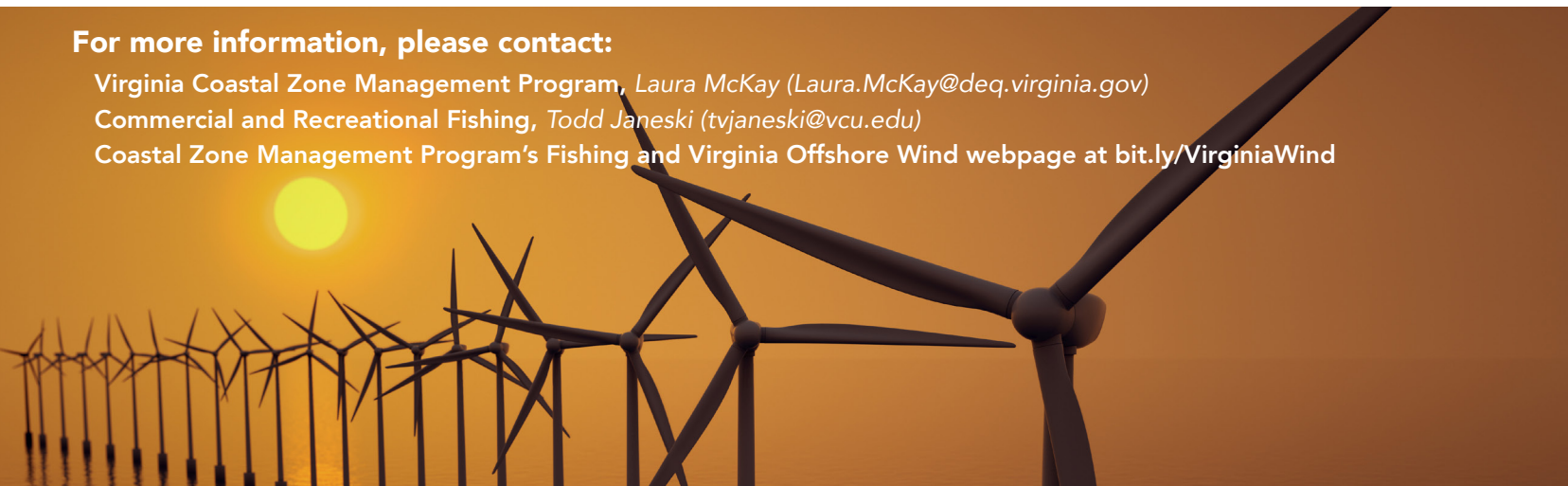
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Coastal Zone Management Program's Fishing and Virginia Offshore Wind webpage at bit.ly/VirginiaWind



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