Wind turbines and offshore energy development

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National Fisherman has been covering the first baby steps being taken by offshore energy producers and their allies/supporters in government and the environmental industry to turn our offshore waters into obstacle courses made up of wind turbines that, in their first stage of development, will rival the Eifel Tower in height, with blades that sweep almost half a million square feet of air per revolution and with blade tip velocities of up to 200 miles per hour (see Kirk Moore's **Fisheries science needs to catch up with offshore wind power** at https://tinyurl.com/ybvw6xwr). Whether they are mounted on massive "foundations" on the sea floor or floated in place and moored to the bottom, their construction and their operation is going to have more of an impact on our continental shelf – and on our fisheries – than most of us could imagine just a few years ago.

> From Moore's article *"construction could begin on East Coast offshore wind energy projects in the next couple of years, but the state of science to monitor their environmental effects is lagging badly, experts said at the annual American Fisheries Society meeting. 'We're talking about building projects in a few years…yet we lack a built, on-the-ground monitoring program,' said Andrew Lipsky, a planning officer who leads research into offshore wind energy with the NMFS Northeast Fisheries Science Center"*

According to Governor Phil Murphy, New Jersey is committed *"to quickly generate 1,100 megawatts annually of offshore wind energy, and 3,500 megawatts of generation by the year 2030 — enough to power 1.5 million homes…. Thirty-five hundred megawatts would make us, I think, the number one aspirational wind field in the world," Murphy said. Scale, reliability and predictability will make it possible to attract manufacturing, the governor said. Environment New Jersey Director Doug O'Malley said New York and Massachusetts have goals of 2,400 and 1,600 megawatts, respectively."* (M. Post, **Murphy restarts big offshore wind plan for New Jersey**, Atlantic City Press, 01/31/'18, https://tinyurl.com/yb9ubqb9). That's 7,500 megawatts of wind-generating capacity – five hundred 15 megawatt wind turbines – plus hundreds of miles of transmission cables (and their attendant electromagnetic fields) planned for the rich fishing grounds of the mid-Atlantic and southern New England. The assumption is that these so-called wind farms will be mostly compatible with fishing operations.

But, borrowing from the legendary broadcaster Paul Harvey, what's the rest of the story?

As us terrestrial dwellers are well aware, making electricity is only part of the saga that ends up with flipping a switch and having a light bulb or air conditioner turn on. The rest of it is transmission towers, transformers, substations, hundreds of thousands of miles of transmission cables and very expensive rights of way – all there to get electricity from a generating station to your desk lamp or air conditioner in a useable – and consumer-friendly - form.

What about the electromagnetic fields that will be generated

As defined by Merriam-Webster, an electromagnetic field (EMF) is *"a field (as around a working computer or a transmitting high-voltage power line) that is made up of associated electric and magnetic components, that results from the motion of an electric charge, and that possesses a definite amount of electromagnetic energy."*

Very little research has been done on the effects of EMFs on people or on other terrestrial organisms, and – as in the case of EMFs generated by cell phones – that research often yields conflicting and/or confusing results.

On land the EMFs from electrical transmission lines are controlled by shielding, burial or distance (hence high capacity transmission lines are placed under the ground or up in the air and are heavily shielded). Our terrestrial habitats being fairly stable, this usually suffices for minimizing EMF exposure to terrestrial critters – including *Homo sapiens*.

But what of the marine organisms that regularly migrate through inshore and/or offshore waters as juveniles or adults?

When, thanks to government encouragement (and government subsidies?) our EEZ is going to be cluttered with a multitude of multi-megawatt wind, wave (see https://tinyurl.com/ybznvyb4) or tidal (see https://tinyurl.com/y9pmhztj) powered behemoths, those megawatts are going to have to get to shore. That's supposed to be via transmission lines buried in the bottom.

The transmission lines from the individual offshore wind turbines, and the higher capacity lines connecting to the onshore electric grids, will be in the much more inhospitable and unpredictable offshore environment. The equipment and the maintenance required to keep them operational (and buried in the bottom sediments) will have to be much more robust.

One doesn't need an advanced degree in meteorology or physical oceanography to predict that tropical storms, nor'easters or other examples of extreme weather or day to day geologic or biological processes could expose once buried transmission cables. This would in part or in whole negate the effects of burial, exposing marine organisms to stronger EMFs.

Following are excerpts from three recent publications dealing with the impacts of EMFs on marine organisms. Note that the federal BOEM (Bureau of Ocean Energy Management) report seems to take the possible effects of EMFs on marine organisms much less "seriously" than the other two. BOEM is the agency that has the largest role in siting and permitting energy (and related) projects in U.S. waters. The BOEM website (https://www.boem.gov/About-BOEM/) states *"The Mission of the Bureau of Ocean Energy Management is to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way."*

> *In recent research,* (researcher Kevin) *Scott and his colleagues at the St. Abbs Marine Station on the Scottish coast obtained dozens of crabs from local fishermen and exposed them to electromagnetic fields in the lab. The fields didn't directly harm the animals; physiological responses such as respiration rate remained normal, for instance. However, the fields had a distinct effect on the crabs' behavior.*
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> *Upon being exposed to electromagnetic fields, the crabs stopped what they were doing and were attracted to the plastic containers housing the equipment that generated the electromagnetic field, replicating what a power cable would do in the ocean. This distracting effect occurred roughly 70 percent of the time, while the crabs mostly ignored similar containers without electromagnetic fields.*
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> R. Skibba**, Brown crabs are attracted to undersea power cables**, 7/30/18, Hakai Magazine, https://tinyurl.com/y77eys99 referring to a paper in a recent Marine Pollution Bulletin (Scott, Harsanyi & Lyndon; **Understanding the effects of electromagnetic field emissions from Marine Renewable Energy Devices – MREDs - on the commercially important edible crab, Cancer pagurus**; June 2018; pgs 580-88).

> *Varying reactions were observed at an embryo development, depending on species. Research has shown that B-fields delay embryonic development in sea urchins and fish, while several studies have found EM fields alter the development of cells; influence circulation, gas exchange, and development of embryos; and alter orientation.*
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> *Some aquatic species, including spiny lobster and loggerhead turtle, utilize the Earth's geomagnetic field for navigation and positioning. In addition, benthic species such as skates, rays, and dogfish use electroreception as their principal sense for locating food.*
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> *For B-fields, certain teleost fish species, including salmonids and eels, are understood to use the Earth's B-field to provide orientation during migrations. If they perceive a different B-field to the Earth's field, there is potential for them to become disorientated. However, experimental evidence is inconclusive regarding whether or*

not migrating salmon are affected by anthropogenic B-field levels similar in strength to the Earth's geomagnetic field.

There is a significant lack of research into the potential impacts of EMF to sea turtles and marine mammals. Sea turtles do not appear to be as sensitive to EMF as marine mammals. Statistical evidence suggests that marine mammals are susceptible to stranding as a result of increased levels of EMF.
(C. Fisher, **Effects of electromagnetic fields on marine species: A literature review**, 2010, https://tinyurl.com/yaltubu8)

A new report from the Bureau of Ocean Energy Management (BOEM) addresses four questions about the impact of submerged power cables on fish and invertebrates, the principal one being whether electromagnetic fields (EMF) from submerged power cables attract or repulse fish or invertebrates.

During the three-year study, researchers conducted 38 days of fish surveys, 30 days of invertebrate studies and 38 days of plant studies–in February for the nearshore areas and October for the offshore areas. Over all habitats, they observed 4,671 individuals of a minimum of 44 species of fishes. They also observed a total of 30,523 invertebrates from at least 43 invertebrate species.

Findings:

1.The differences among fish and invertebrate communities associated with three different habitats–energized and unenergized cable habitat and those communities in soft seafloor habitats lacking cables.

Finding: Researchers did not observe any significant differences in the fish communities living around energized and unenergized cables and natural habitats. Overall species diversity and the densities of the most important fish species (defined as comprising at least 1 percent of all fishes observed) were higher at the cables than at the natural habitats. This is likely due to the more complex habitats afforded by the cables than the primarily soft substrata natural habitats. Similar to the fish communities, the invertebrate assemblages living around energized and unenergized cables and natural habitats were similar to one another and the variability between these communities was driven primarily by sea floor depth.

2.Whether electro-sensitive species that are regionally important, such as sharks and rays, respond (by either attraction or repulsion) to the EMFs of an in situ (in place) power transmission cable.

Finding: Researchers observed very few individuals of electro-sensitive species on the energized or unenergized cables or on the natural habitats. They found no compelling evidence that the EMF produced by the energized power cables in this study were either attracting or repelling fish or macro invertebrates.

3.The strength, spatial extent (distance), and variability of EMFs along both energized and unenergized cables.

Finding: The EMFs produced by the energized cables were similar both over the three years of the study and along the cables. EMF strength dissipated relatively quickly with distance from the cable and approached background levels at about one meter from the cable. The EMF at unenergized cables was similar to that found at the natural habitats.

4.The potential effectiveness of the commonly proposed mitigation method—burying the cable.

Finding: Given the rapidity with which the EMF produced by the energized cables diminishes and the lack of response to that EMF by the fishes and invertebrates in this study, cable burial would not appear necessary strictly for biological reasons. In this and similar cases, cable burial at one to two meters depth below the seafloor would be an adequate mitigation tool to further decrease potential exposure to EMF.
New BOEM Report Presents Findings from Power Cable Observations of EMF and Marine Organisms, Ocean news and Technology, October 24, 2016, https://tinyurl.com/y8ms9d5m.

As illustrated by the above, our knowledge of the impacts of EMFs on marine organisms is often contradictory and generally at a fairly dismal level.

Quoting again from BOEM, this time from the Executive Summary of the Bureau's final report on **Effects Of EMFs From Undersea Power Cables On Elasmobranchs And Other Marine Species** (BOEMRE 2011-09) *Anthropogenic electromagnetic fields (EMFs) have been introduced into the marine environment around the world and from a wide variety of sources for well over a century. Despite this, little is known about potential ecological impacts from EMFs. For decades, power transmission cables have been installed across bays and river mouths, and connecting near-shore islands to the mainland, with little consideration of possible effects to marine species from EMFs. At a time of greater environmental awareness, the US now faces the possibility of a new source of EMFs over a much greater extent of the seabed from offshore renewable energy facilities in coastal waters. This literature review synthesizes information on the types of power cables and models the expected EMFs from representative cables. Available information on electro- and magnetosensitivity of marine organisms, including elasmobranchs (sharks and rays) and other fish species, marine mammals, sea turtles, and invertebrates is summarized and used in conjunction with the power cable modeling results to evaluate the level of confidence the existing state of knowledge provides for impact assessment. Gaps in our knowledge of power cable characteristics and the biology needed to understand and predict impacts are summarized and form the basis of recommendations for future research priorities. Potential mitigation opportunities are described with a discussion of their potential secondary impacts as well as suggested methods for monitoring mitigation effectiveness. Finally, because interest in offshore renewable energy has increased throughout US coastal waters, there is a concern that organisms could be exposed to multiple seabed power cables. Cumulative effects of this exposure are discussed* (https://tinyurl.com/y7f6d84m).

The following chart, from this BOEM report, shows the number of groups of marine and aquatic animals that were found to have been mentioned in EMF sensitivity in 2011 in the scientific literature.

> ***3.2 MAGNETOSENSITIVE AND ELECTROSENSITIVE MARINE SPECIES A total of 441 references in the database cover biological topics including magnetosensitive and electrosensitive marine species, and ecological effects of EMFs from undersea power cables.***

Table 3.2-2

Number of references selected for each group of marine organisms by subject and reference type.

	Subject			Reference Type				
Marine Taxa	Electroreception	Magnetoreception	Natural History	Journal article	Technical report	Book	Other (e.g., thesis, web page, etc.)	Total references[1]
Elasmobranchs	141	27	22	136	11	15	13	175
Other fishes	53	50	15	88	5	7	9	109
Mammals	1	13	22	19	4	7	6	36
Turtles	0	39	8	37	3	4	2	46
Invertebrates	3	31	6	32	1	0	4	37
Microorganisms	0	10	na	10	0	0	0	10

[1] Although the sum across reference types equals total references, the sum across subjects may exceed the total since some references cover multiple categories

So in 2011 we knew at least something about the effects of EMFs on 441 species of marine and aquatic organisms. The **Ocean Biographic Information System** (OBIS) *"a web-based access point to information about the distribution and abundance of living species in the ocean"* currently lists 20,355 species (www.iobis.org/). Many of these species have more than one distinct life stage, many inhabit different niches during different stages and many are migratory during at least one of those stages. So we have somewhat of an idea of the effects of EMFs on perhaps 1% of known marine species/life stages.

In 2016 in the above referenced **New BOEM Report Presents Findings from Power Cable Observations of EMF and Marine Organisms** BOEM generalized from observations in a three-year study compromised of *"38 days of fish surveys, 30 days of invertebrate studies and 38 days of plant studies–in February for the nearshore areas and October for the offshore areas,"* in which "*671 individuals of a minimum of 44 species of fishes" and "30,523 invertebrates from at least 43 invertebrate species."*

From this the federal agency that has responsibility *"to manage development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way"* found that *"given the rapidity with which the EMF produced by the energized cables diminishes and the lack of response to that EMF by the fishes and invertebrates in this study, cable burial would not appear necessary strictly for biological reasons. In this and similar cases, cable burial at one to two meters depth below the seafloor would be an adequate mitigation tool to further decrease potential exposure to EMF."*

When the potential environmental damage that could result, the scope of the research that was done in support of this – and several other – findings by BOEM, it's easy to come to the conclusion that the agency takes its economic responsibility somewhat more seriously than its environmental responsibility.

And we shouldn't forget windfarm generated sediment plumes

Some of you will remember back several years when anti-fishing activist extrordinaire Daniel Pauly at the University of British Columbia used a satellite picture of sediment plumes created by Chinese shrimp boat trawls as further proof that commercial fishing was leading to the ruination of the world's oceans (see **Are you getting the idea that if you're a fisherman Daniel Pauly isn't on your side?** at http://www.fishnet-usa.com/Are_you_getting_the_idea.pdf) .

Below is a satellite photo of the sediment plumes created down-current of wind turbines in operation at the mouth of the Thames River off of the UK coast (https://tinyurl.com/y7926gfk). The sediment plumes that are caused by each of these 100 or so wind turbines stretch for several kilometers.

As the photo indicates, a lot of sediment is going to be suspended and dispersed by a large wind "farm." It seems that Dr. Pauly and the other foundation-funded crepe hangers, however, differentiate between trawl-generated and wind turbine-generated turbidity when it comes to negatively impacting marine critters. Go figure!

I'm sure that anyone who is reading this is familiar with the Precautionary Principle, that supposed irrefutable benchmark of modern conservation science that holds that *"when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically*" (Wingspread Statement on the Precautionary Principle, Jan. 1998, http://sehn.org/wingspread-conference-on-the-precautionary-principle/). Our colleagues in the environmental industry, those folks who are willing to claim this principle when it comes to preventing fishermen from catching fish or whatever else it is that helps their "environmental crisis"

campaign of the week, should be one tenth as zealous (read that "precautionary") when it comes to cheerleading for ocean energy.

The remainder of the above "Wingspread" statement is *"in this context the proponent of an activity, rather than the public, should bear the burden of proof. The process of applying the precautionary principle must be open, informed and democratic and must include potentially affected parties. It must also involve an examination of the full range of alternatives, including no action."* It seems the burden of proof for negative impacts of windfarms and related developments can be met by the potential developers "determining" that those impacts are either non-existent or negligible.

With the threatened proliferation of "clean energy" from the oceans (see Manhattan Institute's Robert Bryce's opinion piece **All-renewable energy in California? Sorry, land-use calculations say it's not going to happen** from the August 22 Los Angeles Times at https://tinyurl.com/yb5j6ur9) – which includes tidal and wave power as well, not to mention Microsoft's submerged server farms – keep in mind that the coming profusion of undersea transmission cables might be barriers to the natural migrations of critters at one life stage or another that the fishing industry depends on. It could be way more than chopped up albatrosses and increased "no netting" zones, though they'll certainly be a part of it.

And as a final (at least for now) note, Some recreational fishing groups and spokespeople with a pronounced anti-commercial bias are now hyping offshore wind turbines as the best thing that's happened since dehydrated chum because of their fish attracting abilities. The jury is still out on this issue but there is a school of thought that holds that any structures placed on the "barren" sea floor – be they surplus weaponry, construction rubble, decommissioned vessels, oil rigs or wind turbine supports – attract fish from the surrounding open bottom, bottom over which netting is currently allowed. How's that for reallocation?