Offshore Wind Energy in Michigan

Implications for the Great Lakes Environment

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Credit: NOAA

Offshore Wind Energy Outreach Project

Web site: *www.gvsu.edu/marec/offshore-wind-info-83*

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Introduction

Michigan's Great Lakes ecosystems have supported human activities for centuries. The lakes provide clean drinking water, opportunities for fishing and recreation, and a means of transporting raw materials and manufactured goods. The waters of the Great Lakes basin are also used for electricity production. Hydroelectric dams on Great Lakes connecting channels and tributaries, pumped storage facilities, and thermal coal and nuclear plants currently use water and affect Great Lakes environments while producing electricity. In the future, offshore wind may be added to the list.

Michigan's Great Lakes offer world-class wind energy resources, but offshore wind technology presents its own set of environmental challenges. No offshore wind farms have been constructed in North America, so most of the science on its environmental effects come from offshore wind farms in European saltwater seas. This factsheet explores the potential positive and negative effects of traditional electricity production and offshore wind energy development in Michigan's Great Lakes, including the potential impacts on water use, pollution, fish, birds and bats.

Water Consumption and Pollutants

While an offshore wind farm, if constructed, would by located in the Great Lakes, it does not use Great Lakes water in the same way as thermo-electric power plants. Almost all coal and nuclear and most natural gas power plants are thermo-electric, meaning fuel is used to heat water, producing steam that spins a turbine and drives an electrical generator. Producing the steam and cooling the components requires water, and in Michigan, this water primarily comes from the Great Lakes. Thermo-electric generation is the largest user of Great Lakes water, accounting for 79 percent of total water withdrawals in Michigan [1]. These facilities withdraw more Great Lakes water than all other uses combined, including public drinking water, irrigation for farming, and industrial uses. Most of this water is returned (often warm) to the lakes, but the total consumptive use (water lost to the system) for thermo-electric power is still greater than that used for the public water supply [1].

Offshore wind farm construction will create underwater noise and disrupt sediments, but the turbines aren't expected to change fish populations over the long-run.

Michigan's Great Lakes ecosystems are also impaired by mercury pollution from, among other sources, coal-fired power plants. Mercury pollution is one of the leading causes of fish consumption advisories in the Great Lakes, and coal-fired power plants are the largest human-caused source of mercury within the Great Lakes basin [2]. Over the long term, reducing mercury pollution in the Great Lakes could reduce the need for fish consumption advisories due to mercury contamination.

The National Renewable Energy Laboratory estimates that a nationwide electricity portfolio that includes 20 percent wind generation would replace 18 percent of coal consumption by 2030 [3]. The State of Michigan has a 10% renewable energy target, but it is unclear precisely how much coal-fired electricity generation could be replaced by wind energy and other renewable electricity sources. This is an area of active research.

Offshore wind energy offers the potential to generate electricity without consuming Great Lakes water and without emitting pollutants that harm the Great Lakes ecosystems, human health and the global climate.

Great Lakes Fish Populations

Fishing, both commercial and recreational, contributes substantially to the economies of Michigan's coastal communities. In 2006, more than 1.4 million recreational anglers fished Michigan's waters, including the Great Lakes, and contributed over $1 billion to Michigan's economy [4] (Figure 1). Michigan citizens who attended Great Lakes Offshore Wind Council meetings held widely varying opinions regarding the pros and cons of wind energy development on Great Lakes fishing [5]. Many anglers, conservationists and coastal tourism industry representatives have raised concerns about potential negative effects of noise, habitat alteration and electromagnetic fields on fish populations, while others anticipate some benefit to fish populations.

Figure 1. Fishing is an important recreational activity in Michigan's Great Lakes.
Credit: Michigan Sea Grant

Short-term and Long-term Effects of Turbines

The available science suggests that the detrimental effects on fish are mostly local and confined to the construction phase. Many fish species avoid areas of construction activity, especially during pile-driving. In one case, pile-driving noise during construction reduced herring numbers, which in turn affected reproduction of a sea bird that relied on the herring for prey [6]. In addition, sediments will be disturbed and associated contaminants may be released when submarine electric cables are buried beneath the lakebed [7].

During normal turbine operation, some noise will be transmitted through the tower and into the water, producing sound vibrations at levels similar to a small boat engine [8]. Off the coast of Cape Cod where there are plans to construct turbines 2,000 feet apart, underwater noise is expected to decline to background levels 328 feet from each turbine base [9]. Most studies conclude that turbine noise will not cause any physiological damage to fish, but potential impacts on fish behavior and communication are poorly understood. The hearing capability of fish species varies widely — for example carp are much more sensitive to noise that salmon — and some fish are expected to avoid the area within 13 feet of an operating turbine [9]. However, certain fish, such as cod and gobies, seem to congregate around existing turbine foundations in saltwater environments [9,11].

Figure 2: Scour protection, like this example from a bridge support column, is used to minimize erosion around the turbine foundation
Credit: U.S. Dept. of Transportation

Submarine cables, like those connecting offshore wind farms to the land, can cause induced electro-magnetic fields in the areas immediately around the cable. These fields are not dangerous, but can affect how some species navigate [12]. Freshwater species like perch, pike, American eel, lake sturgeon and Chinook salmon may be sensitive to induced electro-magnetic fields, but it is unclear whether the induced fields from submarine cables actually affect the behaviors of these species [7,12]. Additional research is needed to understand the potential impact of electrical cables on fish.

The footprint of a wind turbine foundation would result in the alteration of about 500 square yards of lakebed habitat for each turbine in the wind farm [13]. The wind turbine foundation is typically covered with rocks, called scour protection (Figure 2). In the saltwater offshore wind farms of Europe, the scour protection has been shown to act as an artificial reef. The boulder-style scour protection that was used increased surface area, crevices and hiding places for small creatures, especially in areas where such three-dimensional structure was lacking. For example, at the Nysted and Horns Rev offshore wind farms in Denmark , the abundance and biomass of mussels and other bottom-dwelling organisms increased substantially compared to reference sites [14]. The presence of the offshore turbines increased fish abundance and biomass in Sweden [11].

Though there are no wind turbines in the Great Lakes, there are underwater structures and artificial reefs from which we can make some comparisons. A variety of game fish species are known to use artificial structures in the Great Lakes (Figure 3) [15]. The crevices of a turbine foundation's scour protection would also provide ideal habitat for invasive species like zebra and quagga mussels and the round goby [7]. It is unclear whether these structures would actually increase the overall abundance of game fish, rather than just attracting them to a particular location. In many Great Lakes environments, water temperature fluctuates widely, and important game fish are likely to use artificial habitats only when temperature is ideal.

Figure 3: Scour protection would likely attract a variety of game fish, including lake trout and yellow perch (above).
Credit: Michigan Sea Grant

Most of the studies reviewed for this fact sheet conclude that fish will actively avoid the area around a wind farm during construction due to significant underwater noise; However, if sited away from sensitive spawning grounds, normal turbine operations are likely to have minimal negative impacts on fish. There is no evidence of long-term declines in fish abundance around offshore wind farms, and there is limited evidence that abundance of certain fish and mussel species in salt water environments, both desirable and undesirable, may increase. Potential negative effects of construction noise, sediment disturbance and electrical cables should be carefully considered on a site-specific basis.

Impacts of Traditional Power on Fish

The effect of existing energy sources upon fish populations is also an important consideration when evaluating alternative energy impacts. Coal and nuclear power require large amounts of water for cooling, and older plants with once-through cooling systems are particularly destructive to fish that are sucked into plant intake pipes or caught on screens [16]. New power and manufacturing plants are required to use better technologies to reduce fish kills under Section 316(b) of the Clean Water Act. Older plants that take in more than 2 million gallons per day may be required to adopt similar technologies in the future, but these existing plants now kill an estimated 86 billion fish per year [17]. This figure includes the death of fish at intake pipes and the loss of fish eggs and larvae that will not grow to adulthood and benefit fisheries.

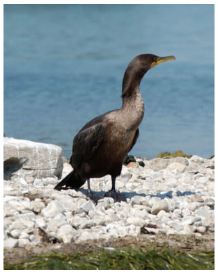

Figure 4: Water-birds, like this cormorant, may fly through or around offshore wind farms in the Great Lakes.
Credit : Michigan Sea Grant

During 2005-2006, a single power plant on Lake Erie was found to trap and kill 46 million fish per year and pull in in an additional 2.2 billion fish larvae annually [17]. Scientists estimate that 349,648 adult game fish are lost and commercial harvests are reduced by 346,000 pounds annually due to older Great Lakes power and manufacturing intakes [17].

Researchers have reported that each megawatt (MW) of wind energy capacity can reduce the need for 0.7 -2.1 million gallons of cooling water [18]. Based on these estimates, a hypothetical 450 MW offshore wind farm could reduce the need for 315 to 945 million gallons of Great Lakes water each year. If less water is withdrawn for thermo-electric generation, fewer fish may be killed.

Birds and Bats

The effect of land-based turbines on birds, and to a lesser extent bats, has been studied for decades, but the effect from offshore wind turbines is less clear. The primary risks to birds from offshore wind turbines are death from collisions; habitat loss and displacement; and habitat fragmentation and barrier effects [19].

Michigan citizens who attended Great Lakes Offshore Wind Council meetings were very concerned about potential impacts on birds and bats; 45 percent of 470 respondents indicated that they expected offshore wind energy development to harm bird and/or bat populations [5].

Bird-turbine collisions are highly variable by location, species and season [20]. While most land-based North American wind farms that have been studied kill fewer than 4 birds per turbine annually, rates as high as 14 birds per turbine annually have been recorded [21].

Most of the collision risk for offshore installations occurs during the spring and fall migrations, when large numbers of birds fly across bodies of water. Many birds fly over Michigan's Great Lakes during migrations (Figures 4 and 5).

In a study of the Nysted offshore wind farm in Denmark, thousands of migrating ducks and geese were observed migrating in the vicinity of the wind farm. The researchers used radar to estimate that less then 1% of the seabirds flew close enough to one of the 72 turbines to be at risk of a collision. In this study, the birds kept their distance from the turbines during both day and night, and most flew around the wind farm [22].

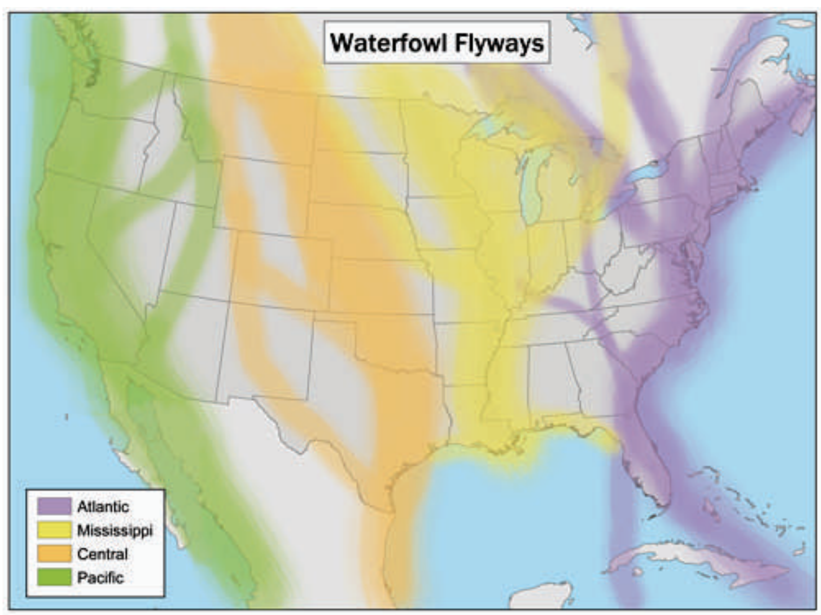

Figure 5 Michigan's Great Lakes occupy parts of the Mississippi and Atlantic flyways for bird migration.
Source: Based on U.S. FWS maps, Wikimedia Commons

German researchers offered the following suggestions for reducing the risk of bird collisions, habitat loss and fragmentation associated with offshore wind turbines:

- Do not build wind farms in specific areas with dense migration patterns.
- Align turbine rows parallel, not perpendicular, to the migration direction.
- Maintain corridors for migration between offshore wind farms.
- Avoid locating wind farms between resting and feeding grounds.
- Turn off turbines during nights with high migration intensities or adverse weather.
- Avoid continuous, large-scale lighting when possible.
- Build turbines that are more recognizable to birds [23].

Bats often incur higher fatality rates than birds at land-based wind farms [20], but the effects of offshore wind farms is uncertain. A study in Sweden found that both resident and migrating bats fly close to offshore wind turbines. Some bats even rested on the turbines. Migrating bats flew at a relatively low altitude (less than 30 feet), below the turbine blades. Foraging bats, however, flew higher to catch insects near vertical structures including lighthouses and turbines [24]. Bat migration in the Great Lakes region is poorly understood and additional research is required [25].

Researchers from Grand Valley State University and the Michigan Natural Features Inventory are deploying a monitoring buoy in Lake Michigan (Figures 6 and 7). In addition to measuring wind speeds, the buoy will also detect the presence of birds and bats in the buoy's vicinity. This information will provide a more complete picture of bird and bat migration over Lake Michigan. The project is funded by the U.S. Department of Energy, We Energies of Wisconsin and the Sierra Club [26].

Conclusions

Much site-specific information needs to be collected to determine the precise effects, both positive and negative, of an offshore wind farm in Michigan's Great Lakes. Experience from Europe suggests offshore wind farms, if properly sited, can generate low-pollution electricity without significantly disrupting local ecosystems. Grand Valley State University's research buoy will enhance understanding of the wind resource and the Lake Michigan ecosystem.

Figure 6. GVSU's wind assessment buoy completed a trial in Muskegon Lake before being deployed in Lake Michigan.
Credit: E. Nordman (Fig 6 and 7)

Figure 7. A close-up of the Vindicator unit which is mounted on the buoy (Fig 6) and measures wind speeds at multiple heights using laser pulses.

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Please visit our project web site for more information about the benefits and challenges of offshore wind energy in Michigan's Great Lakes. Web site: *www.gvsu.edu/marec/offshore-wind-info-83*

Additional information about offshore and land-based wind energy is available through the West Michigan Wind Assessment project web site: *www.gvsu.edu/wind.*

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