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Potential Impacts from a Worst Case Discharge from an United States Offshore Wind Farm

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ABSTRACT 299032:

The main purpose of this research is to explore potential environmental impacts of a worst case discharge (WCD) from an offshore commercial wind farm electric service platform (ESP) in the Northeast United States. Wind farms in the continental United States are a growing industry as an energy alternative to traditional oil, coal, and natural gas energy sources. While many offshore wind farms already exist in Europe and around the world, the Cape Wind Project in New England received the first federally approved lease for an offshore wind energy production facility in the United States. While offshore wind energy is a green source of energy, wind driven energy has its own set of environmental risks, including the risks of an oil spill. A systematic review of scholarly journals, federal government websites and other academic resources was conducted to identify previous spills in the Northeast with the closest match in volume and location to the Cape Wind Project. The oil spills from the barge *North Cape* in 1996 near Point Judith, Rhode Island and from the barge *Florida* in Buzzards Bay, Massachusetts, in 1996, had the most similarities to a potential WCD spill from the Cape Wind Project. Both of these spills adversely impacted the environment, and provide useful information that can be used for the planning efforts surrounding a WCD event from the Cape Wind Project.

INTRODUCTION:

This research paper is focused on understanding the potential environmental impacts from an oil spill following a worst case discharge (WCD) from an offshore wind farm in the northeast United States. The Cape Wind Project, located off the coast of Massachusetts, will be the first offshore wind turbine farm in the United States (figure 1). Wind energy production is a growing and seemingly green technology used to produce electricity; however, risks of environmental impacts from wind energy are still a reality. Current designs of offshore wind farms depend on a type of central connection installation, known as an electrical service platform (ESP), to move the electricity from offshore to inshore (figure 2). The ESP utilizes four transformers each of which use several types of dielectric oil. Minerals Management Service (2009) estimates a total spill of 40,000 gallons of transformer oil is possible from the Cape Wind Project ESP, which could have adverse environmental impacts on birds, fish, and benthic species.

Even though wind energy has been a focal point for alternative energy technologies, very few wind farms exist offshore anywhere around the world. After a systematic literature review, no studies of oil spill releases from wind turbine farms could be located. In addition, the transformer oil types referenced in the Cape Wind Environmental Impact Statement (EIS), including Shell Diala Oil Ax, Diekan 400 and Diekan 410, lack information regarding their toxicity and environmental fate once released into the marine environment. As a result, this paper utilized information from other oil spills in the same geographic area to enhance the analysis. Information from these spills was used to extrapolate the potential impacts of a WCD from the ESP at the Cape Wind Project site. A WCD of transformer oil from the ESP, under the right adverse weather conditions, could have significant environmental impacts to marine and coastal habitats and species. This paper highlights the fact that more research is needed to better understand the potential impacts of a large discharge of transformer oil into the marine environment, and more planning is needed to develop effective spill response mitigation strategies specific to the risks associated with discharges from wind farms.

OIL SPILL POTENTIAL:

The Cape Wind Project is the first wind farm in the United States that places wind turbines offshore. The Cape Wind Energy project developer, Cape Wind Associates LLC, plans to construct and operate 130 wind turbine generators arranged in a grid pattern in the Horseshoe Shoal region of the Nantucket Sound off the coast of Massachusetts (Etkin, 2008). The ESP will have four power transformers, each containing 10,000 gallons of dielectric cooling oil, creating the potential for a spill of 40,000 gallons (Minerals Management Service, 2009). Additionally each of the 130 wind turbine generators (WTG) will have 214 gallons of various oils during operation (Minerals Management Service, 2009).

The specific components and majority of the oil in each WTG are listed in the Final Environmental Impact Statement (FEIS): …"The expected oil storage components are the drive train main bearing containing 19 gallons (81 liters) of Mobile SCH 632, the drive train main gear box containing 140 gallons (530 liters) of optimal synthetic A320; the drive train cooling system which holds 21 gallons (79.5 liters) of optimal synthetic A320" (Minerals Management Service, 2009, p. 5-24). The specific environmental impacts of each type of oil were not analyzed as part of this study; however, the key element is that most of the oil product contained in the WTG is synthetic A320.

Etkin (2003) defines a WCD as follows: "In the United States, WCD scenarios are defined under the Oil Pollution Act of 1990 (OPA 90) as 'the discharge in adverse weather conditions of the entire cargo' for tank vessels, and 'largest foreseeable discharge in adverse weather conditions' for facilities" (p. 1). In the case of a wind turbine farm, destruction of the ESP could result in the release of 40,000 gallons of electric insulating oil and 2,000 gallons of diesel and other oils, totaling 42,000 gallons of oil product (Etkin, 2003). Additionally, if all of the 130 WTGs suffered catastrophic failure from a natural disaster, then up to 200 gallons of turbine and other lubricating oils from the gearboxes of each WTGs could be released, totaling 26,000 gallons (Etkin, 2003). If the ESP and several, if not all, of the WTG's were completely destroyed in a catastrophic storm or seismic event, it is possible that 68,000 gallons of various oils could be released. Etkin (2003) describes the potential for a WCD as "extremely unlikely".

The ESP and WTGs are being designed to meet the criteria of a 100 year storm event and Category 3 hurricane on the Saffir-Simpson Scale (Etkin, 2008).

Etkin (2003) speculates human error is more likely to result in a discharge than a single catastrophic event. She estimates there will be 500 vessel trips per year between the ESP and the WTGs for routine maintenance, increasing the probability of a collision with a structure. Sharples (2010) maintains that wind turbine failures stem primarily from maintenance issues: "The industry had a number of serial failures in gearboxes. There have been a substantial number of gearboxes that had to be changed out within a shorter period of time than expected" (p. 5). No information could be found on any specific oil spills from gearbox malfunctions. According to the Oil Spill Probability Analysis (Report No. 3.3.5-1 and Report No. 5.2.1-1), "the estimated number of spills from both the ESP and WTGs over five, ten, and thirty years of operation are 0.31, 0.62, and 1.862, respectively" (Minerals Management Service, 2009, p. 5-24). As a result, the data indicates that the probability of a spill from the Cape Wind Farm is very low.

TRANSFORMER OIL PROPERTIES:

The three types of transformer oils referenced in the Cape Wind Environmental Impact Statement include Shell Diala Oil Ax, Diekan 400 and Diekan 410. The first transformer oil listed is Shell Diala Oil Ax. According to the Cape Wind Environmental Impact Statement (Minerals Management Service, 2009), "There is no ecological data available for this product. However, this product is an oil. It is persistent and does not readily biodegrade. However, it does not bioaccumulate" (p.4-5). The second and third transformer oils listed are Diekan 400 and Diekan 410. Diekan 400 transformer oil is an uninhibited naphthenic mineral oil that meets important electric industry standards (Minerals Management Service, 2009). The Marine Safety Data Sheets for Diekan 400 and 410 recommends seeking technical advice in case of a transformer oil spill (Minerals Management Service, 2009). As far as environmental fate, the Marine Safety Data in the Environmental Impact Statement recommends, "An environmental fate analysis has not been conducted on this specific product. However, plants and animals may experience harmful or fatal effects when coated with petroleum products. In stagnant or slow-flowing waterways, an oil layer can cover a large surface area. As a result, this oil layer might limit or eliminate natural atmospheric oxygen transported into water. With time, if not removed, oxygen depletion in the waterway can result in a loss of marine life or create an anaerobic environment" (p.3). Ecological effects testing as stated above would provide more conclusive information for potential impacts in the Cape Wind Area.

SHORELINE IMPACTS:

The draft Cape Wind Oil Spill Response Plan (Minerals Management Service, 2009), provides an optimistic assessment for the potential cleanup of an ESP WCD: "Because of the type of oil used at the off-shore site, spilled materials are expected to float and will be easily recoverable via mechanical methods. Response times are expected to be quick and will ensure that oils do not reach sensitive areas. The oils used at Cape Wind are lighter than water and exhibit less harmful characteristics than crude oils that are typically transported on passing sea vessels. Due to short response times, spill oil is expected to be easily collected." (p.21) The

Cape Wind Project Environmental Impact Statement (EIS) indicates a 90% chance or more that the shorelines could be impacted if there was an oil spill at the Cape Wind site (Minerals Management Service, 2009). The areas with the greatest potential for impact include Cape Cod, Martha's Vineyard, and Nantucket (Minerals Management Service, 2009). Cape Cod had the highest risk of potential shoreline impacts from spring to summer based on normal prevailing winds from the south and west (Minerals Management Service, 2009).

WILDLIFE IMPACTS:

Oil trajectories of a WCD from an ESP show the potential for adverse shoreline impacts. The Cape Wind Project utilized a program called OIL MAP to produce oil spill trajectories (Knee et al., 2006), when combined with local area contingency planning information, to produce projections for potential wildlife impact. These impacts are described as the following by Knee et al. (2006), **"**Depending on the location and the size of the spill, shorebirds and wading birds may be impacted. If the feathers of the birds become coated with oil, birds lose their ability to repel water and to insulate, and in some instances, lose the ability to fly. Potential impacts include mortality from heat loss, starvation, or drowning. Mortality can result if toxins are ingested through water or during preening" (p. 5). The key elements in determining the threat to wildlife, as with most oil spills, are the size of the spill, time of year, and location.

COMPARISONS WITH OTHER SPILLS IN THE CAPE WIND PROJECT AREA:

Given the lack of information on oil spills from other offshore wind farms, a systematic review of past oil spills was completed from other sources in the Cape Cod area. The objective was to identify potential similarities in the types of environmental impacts that might occur from an oil spill at the Cape Wind offshore energy facility. Research was conducted utilizing a variety of academic research tools including papers from previous International Oil Spill Conference (IOSC) Proceedings, Education Resources Information Center (ERIC), Science Direct, and numerous other public information sources worldwide. The search efforts revealed two oil spills of refined products. Both of these spills originated from tank barges, in the general vicinity of the Cape Wind project area. While there are obvious differences between these spills and a WCD from the Cape Wind project, there are also some similarities that may make these incidents useful surrogates for response planning.

In 1969, the barge *Florida* ran aground resulting in a large oil spill in Wild Harbor in Buzzards Bay, MA, north of Nantucket Sound (Culbertson et al., 2007). Over 185,000 gallons of No. 2 fuel oil spilled resulting in the death of fish, crustaceans, worms, mollusks and other invertebrates. Culbertson et al. (2007) discusses the long-term effects on the salt marsh fiddler crab: "Today the above ground environment appears to be unaffected, but a substantial amount of moderately degraded petroleum still remains 8-20 cm below the surface. Salt marsh fiddler crabs, *Uca pugnax*, burrow into the sediment at depths of 5-25 cm, and as a result, are chronically being exposed to oil" (p.956).

On January 19, 1996, the tank barge *North Cape* was forced aground near Point Judith, Rhode Island due to a tug fire. This resulted in the spill of 828,000 gallons of home heating oil in storm force onshore winds of 60 miles per hour with 15-20 feet sea conditions (Michel,

French, Csulak, & Sperduto, 1997). The discharge in shallow water with heavy onshore winds significantly increased the acute toxicity impacts to the marine environment and over 9 million lobsters, 364,000 kilograms of shellfish, and 111,000 kilograms of benthic macro fauna were killed (Michel, French, Csulak, & Sperduto, 1997). Reddy and Quinn (2001) reported, …"High winds and rough seas drove the oil into the water column, and the oil spread throughout Block Island Sound and into several coastal salt ponds" (p. 445). The location of the spill and high winds were a key factor in the spreading and penetration of the oil into the water column and sensitive coastal habitats.

While the *North Cape* spill demonstrates the potential for significant acute impacts of refined oils spilled in adverse conditions, the *Florida* spill highlights the possible chronic impacts to benthic and other species in marsh areas. While the Cape Wind ESP only contains 42,000 gallons or 158,978 liters of oil, which is significantly less than the releases from either the *North Cape* or *Florida* spills, these spills suggest that the potential still remains, based on the Cape Wind project studies completed thus far, for smaller scale damage of a similar nature under the right set of adverse conditions.

A hurricane or powerful northeaster has the potential for causing structural failure and environmental damage if the ESP was blown off its moorings and either sank or grounded in a sensitive area. While this may seem like an extreme case, during Hurricane Katrina in 2005, a mobile offshore drilling unit, the *Ocean Warwick* (Figure 3), broke from its moorings, drifted 66 miles, before running aground near Dauphin Island, AL (Business Wire, 2005). While the probability of a hurricane impacting the Northeast is less likely than in the Gulf of Mexico, Super storm Sandy similarly caused significant damage across New Jersey and New York in 2012. All of these factors should be considered in the WCD planning process for an oil spill from an offshore wind turbine farm.

CONCLUSION:

The Cape Wind Project in Nantucket Sound is the first offshore wind energy platform in the United States. While wind energy production is a relatively green resource, offshore wind turbine farms, and their ESPs have the potential for adverse environmental impacts from a WCD of their transformer oil. Current research on the ecological impacts of the primary transformer oil types proposed for the Cape Wind project have limited ecological effects testing and environmental fate analysis. Further, studies are needed to provide a clearer picture of potential environmental impacts that would afford better planning and response to an oil spill. The oil spill response plan resources, in the vicinity of the ESP site must be exercised to ensure their proficiency with the recovery of discharged transformer oils. Local area committee members must be involved with industry in the development of effective prevention, spill mitigation and protection strategies. Careful planning must accompany the implementation of offshore wind farms, as other spills of refined oils in the Cape Wind area have shown that there is a significant potential for both acute and chronic impacts to the environment if the right conditions are present.

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FIGURES

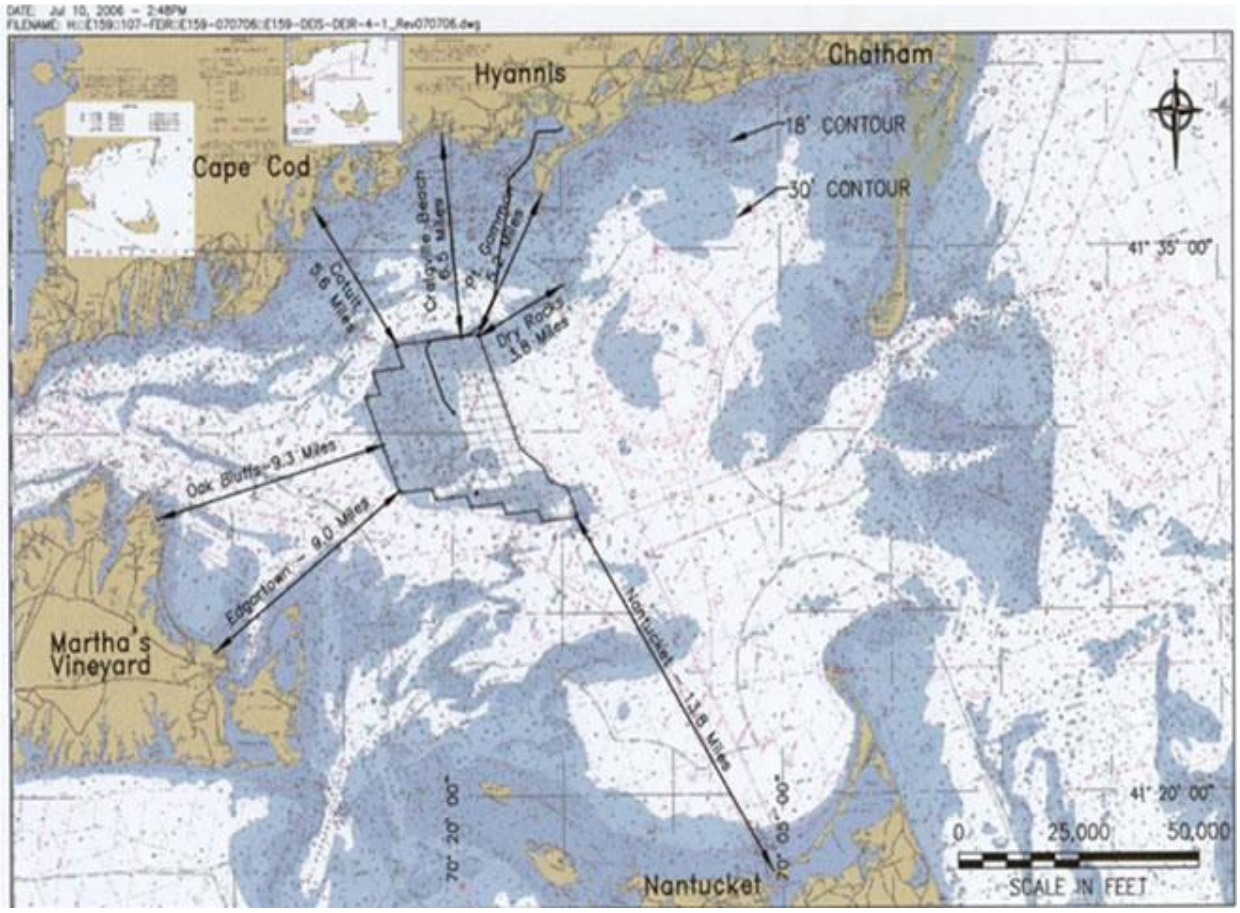

Figure 1. Cape Wind Farm Proposed Project Site

Retrieved from http://buildaroo.com/wp-content/uploads/2010/01/Cape-Cod-wind-farm-proposed-site-plan-450x295.jpg

Figure 2. Electric Service Platform Example

Retrieved from http://buildaroo.com/wp-content/uploads/2010/01/Cape-Cod-wind-farm-proposed-site-plan-450x295.jpg

Figure 3. Mobile Offshore Drilling Unit *Ocean Warwick*, October 2005

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