



Offshore Wind Energy Development In North Carolina

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I. Executive Summary

The Bureau of Ocean Energy Management has identified three areas off the coast of North Carolina that are favorable for wind energy facilities: Wilmington-West Wind Energy Area, Wilmington-East Wind Energy Area, and Kitty Hawk Wind Energy Area. The goal of this analysis is to determine whether offshore wind energy should be encouraged off the coast of North Carolina. The legislative and regulatory processes involved are discussed as well as the steps required for implementation. The analysis will cover the environmental impacts, economic feasibility, and political feasibility of the proposed projects. Overcoming these barriers, or providing evidence that they are not barriers, is important in determining whether offshore wind energy is beneficial to North Carolina.

The environmental impacts of this project is most severe during site assessment and construction phases. Impacts will be mitigated as much as possible. Careful site selection and thorough assessment of the area prior to construction are necessary to ensure minimal impacts. The operational phase is most dangerous to birds, though they have been shown to avoid the area. For the most part the operation phase is low impact and may provide more benefits in the form of habitat for marine organisms, fish, and birds.

The economic analysis is a combination of a Cost Benefit Analysis and a Cost Effectiveness analysis. The results from the CBAs indicate that the project has a positive outcome over the 30 year period when no disaster and the social discount rate (3%) is used. However, with any type of disaster, or the use of the U.S. ACE 7% discount rate, this project is not economically viable. Wind has the highest levelized cost amongst the evaluated energy sources and it has a significantly lower capacity factor resulting in less energy generated than traditional fuels like coal and natural gas. Although wind has a relatively high capacity factor amongst the renewable energy sources, it is still less than half that of coal or natural gas. The high levelized cost of wind power does not make it an attractive renewable energy source outright, despite the lack of fuel and low maintenance costs. Both the results of the CBA and the CEA will be taken into account for the economic recommendation of this report.

The political feasibility study attempted to synthesize public and political attitudes toward offshore wind energy projects. The majority of elected officials were unsure in their of support offshore wind energy for North Carolina or have not provided a stance on the issue. Those who are unsure, are mainly concerned with viability, any potential negative effects to the tourism industry, and the costs of implementing the project. Many officials feel that more extensive analysis needs to be conducted. The majority of the public in the Wilmington, Kitty Hawk, and Carolina Shores areas support offshore wind energy. Few people have outright opposed the project, but simply want to express concerns about possible environmental damage during the construction and development of the offshore wind facilities. Supporters in these coastal communities say the latest developments in the process are a step in the right direction by cutting carbon emissions and providing power with a renewable energy source. However, others are concerned about the impacts offshore wind could have on the

environment and the economies of the affected beach communities. The main concerns are aesthetics, potential negative effects to tourism, expense and long-term maintenance. There is broad agreement that tourism is a major driver of North Carolina's coastal economies and it needs to be protected.

With regard to the original survey distributed for this analysis, the majority of survey takers expressed support for offshore wind energy in North Carolina. However, results differ slightly when filtering results to only include answers of respondents who own a house at the beach in North Carolina. These respondents show less support than the other respondents and are much more concerned with the associated aesthetic issues. All respondents placed importance on fact that this renewable energy source would be better for the coastal environments of North Carolina.

II. Title Page

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1. Introduction

In August 2014, BOEM three identified wind energy areas (WEAs) off the coast of North Carolina, totaling approximately 307,590 acres. While the concept of wind being used as a source of energy is far from revolutionary, the construction of large offshore wind facilities is a more recent technological development, especially in the United States. Foreign nations have already embraced offshore wind to various extents. China is currently in the process of constructing over 5000 megawatts of turbines (Dechert, S., 2014) and Denmark has been utilizing the resource since 1991 (SBOWER, n.d.). Despite the many advances in the implications of offshore wind energy for North Carolina reach well beyond the identification of potential leasing areas.

However, the United States is still waiting for its first operational offshore wind facility. With recent projects in Massachusetts and New Jersey running into conflicts, BOEM and the nation are instead looking now to North Carolina as a potential opportunity for offshore wind. Why should North Carolina consider supporting and investing in the development of offshore wind energy? Beyond the benefits of having a clean, renewable energy source off the coast, is this project something North Carolinians should support?

The goal of this analysis is to determine whether offshore wind energy would be a viable renewable energy source for North Carolina's renewable energy portfolio. Session Law 2007-397, Senate Bill 3 was signed into action on August 20, 2007 making North Carolina the first of the southeast states to adopt a Renewable Energy and Energy Efficiency Portfolio Standard (REPS) (North Carolina Utilities commission, n.d.). The North Carolina Utilities commission REPS goal is to have all "investor-owned utilities in North Carolina [meet] up to 12.5% of their energy needs through renewable energy resources or energy efficiency measures." This standard requires NC to begin investing heavily in renewable energies and more efficient energy technologies, especially solar. Wind energy is one of the acceptable energy resources with which these electric utility companies and suppliers can utilize to meet the REPS. BOEM's proposed project has the ability to place nearly 1,000 five megawatt (MW) turbines at North Carolina's disposal, provided all the WEAs are utilized to their maximum capacity.

To better grasp the concept of offshore wind in North Carolina, it is important to first understand the legislative and regulatory processes involved as well as the steps required for implementation. Once its implementation has been discussed, the analysis will move on to cover the environmental impacts, economic feasibility, and political feasibility of the proposed projects. These types of analyses are important factors because they outline different barriers for development. Overcoming these barriers, or providing evidence that they are not barriers, is important in determining whether offshore wind energy is beneficial to North Carolina. Through these three analyses, this study hopes to demonstrate whether offshore wind facilities are a viable option for North Carolina.

1.1 Background

Studies show that wind blows faster and more consistently over the ocean. Both the west and east coast have substantial wind resources (Figure 1.1), but North Carolina boasts a slowly sloping coastal shelf, also known as the Outer Continental Shelf (OCS). As a result North Carolina hosts a very unique coastal environment, one that has great potential for wind energy development. These relatively shallower depths (Figure 1.2) are favorable for construction of an offshore facility.

Figure 1.1: Annual Average Wind Speed (NREL, n.d.).

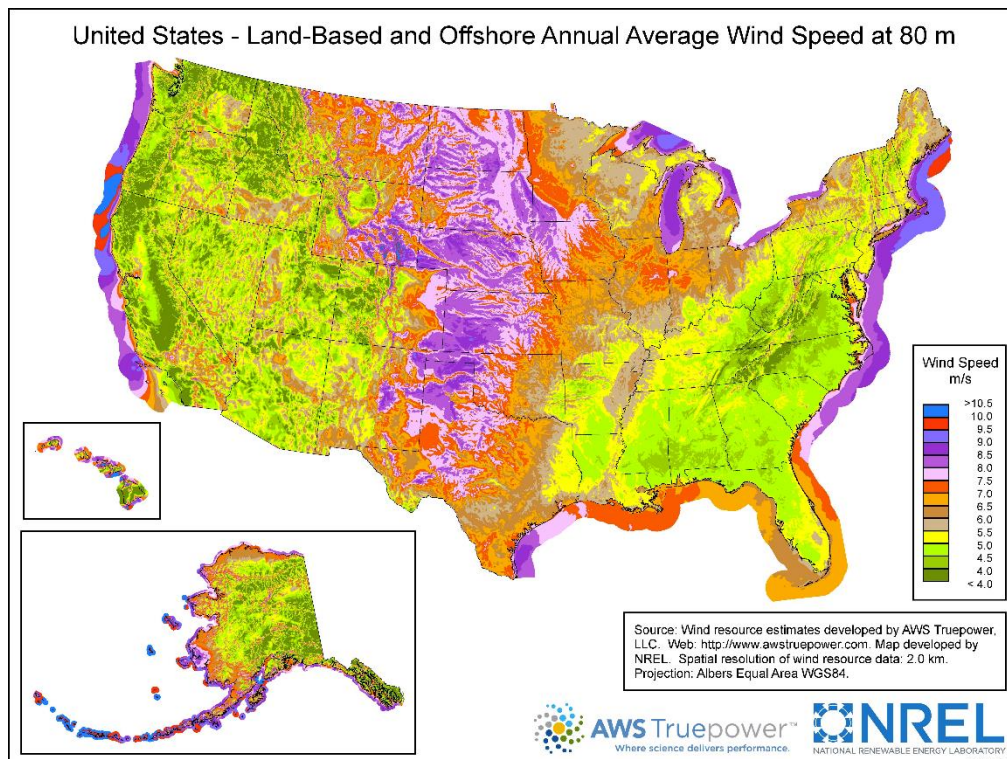
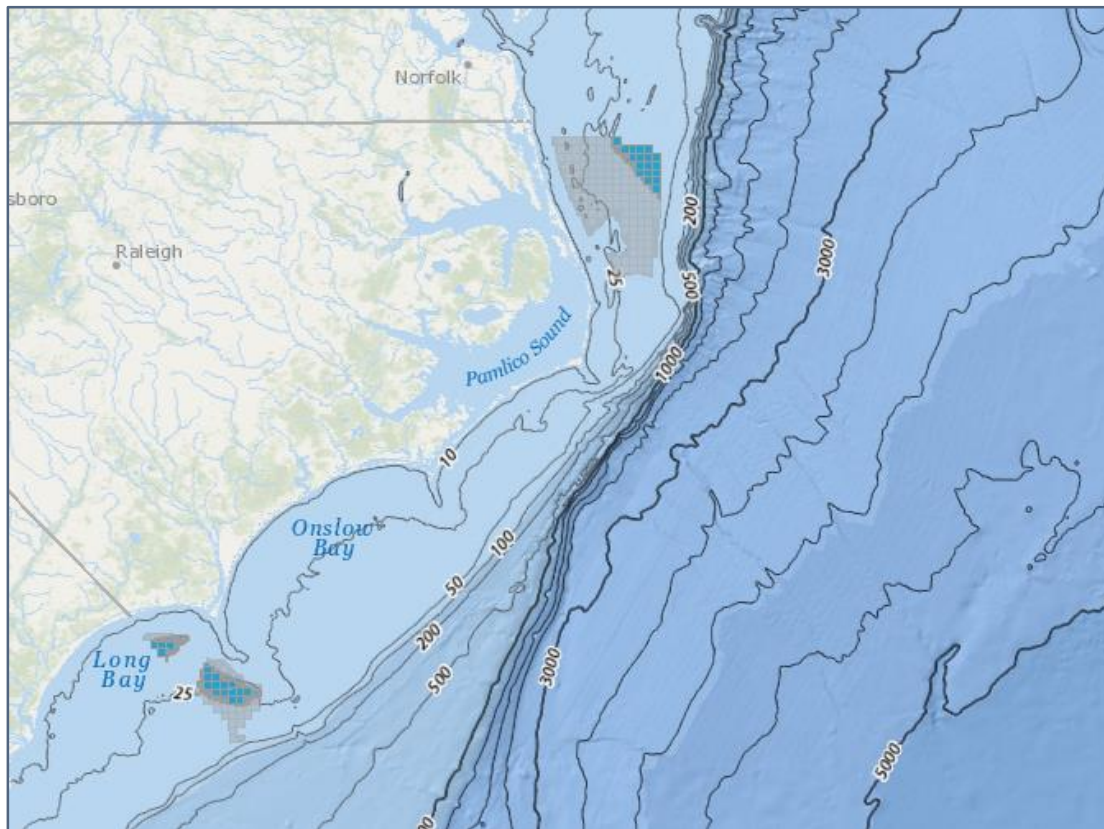
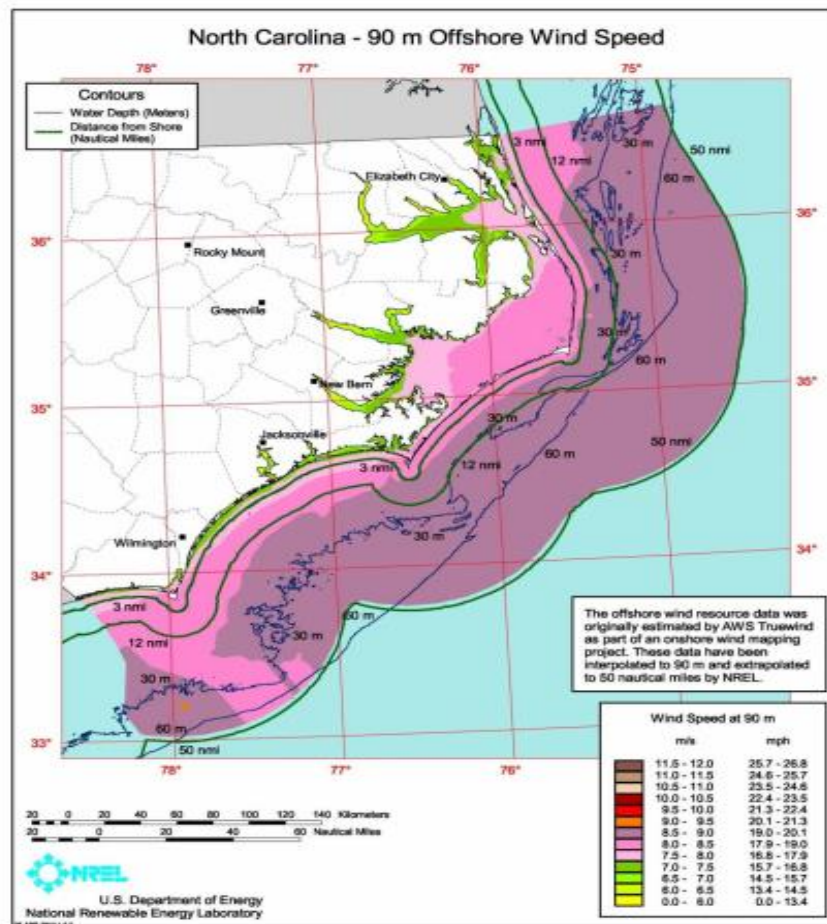


Figure 1.2: Outer Continental Shelf Water Depth

The National Renewable Energy Laboratory has mapped out the wind resource potential for the areas off the coast of the United States, including North Carolina, showing the predicted mean annual wind speeds at 90-m height presented at a spatial resolution of 200 m [Figure 1.3]. The areas with annual average wind speeds of 7 meters per second (m/s) and greater at 90-m height are commonly considered to have a wind resource sufficient for offshore development (DOE, December 2, 2014). The NREL identified 9,237 MW at the 7.0-7.5 m/s interval, 20,491 MW at 7.5-8.0, 68,274 MW at 8.0-8.5, 199,374 MW at 8.5-9.0, and 80 MW at the 9.0-9.5 m/s interval for a combined total of 297,456 MW.

In 2005, before the state became a significant player in the renewable energy market with the implementation of the REPS, the Energy Policy Act (EPAAct) was established and jumpstarted renewable energy development on the Outer Continental Shelf (OCS). This act, while providing loans and tax incentives for energy production, also authorized BOEM (previously the Minerals Management Service) to lease areas of the OCS for renewable energy development while also providing easements and rights-of-way. It was not until 2009 that President Obama finalized BOEM's authority to regulate the OCS Renewable Energy Program under the EPAAct. Under EPAAct, BOEM is required to coordinate with any state and local government affected by offshore development as well as any federal agency that has jurisdiction or interest that offshore activity may impact (30 CFR 585).

Figure 1.3: Offshore Wind Speed for North Carolina (NREL, n.d.)

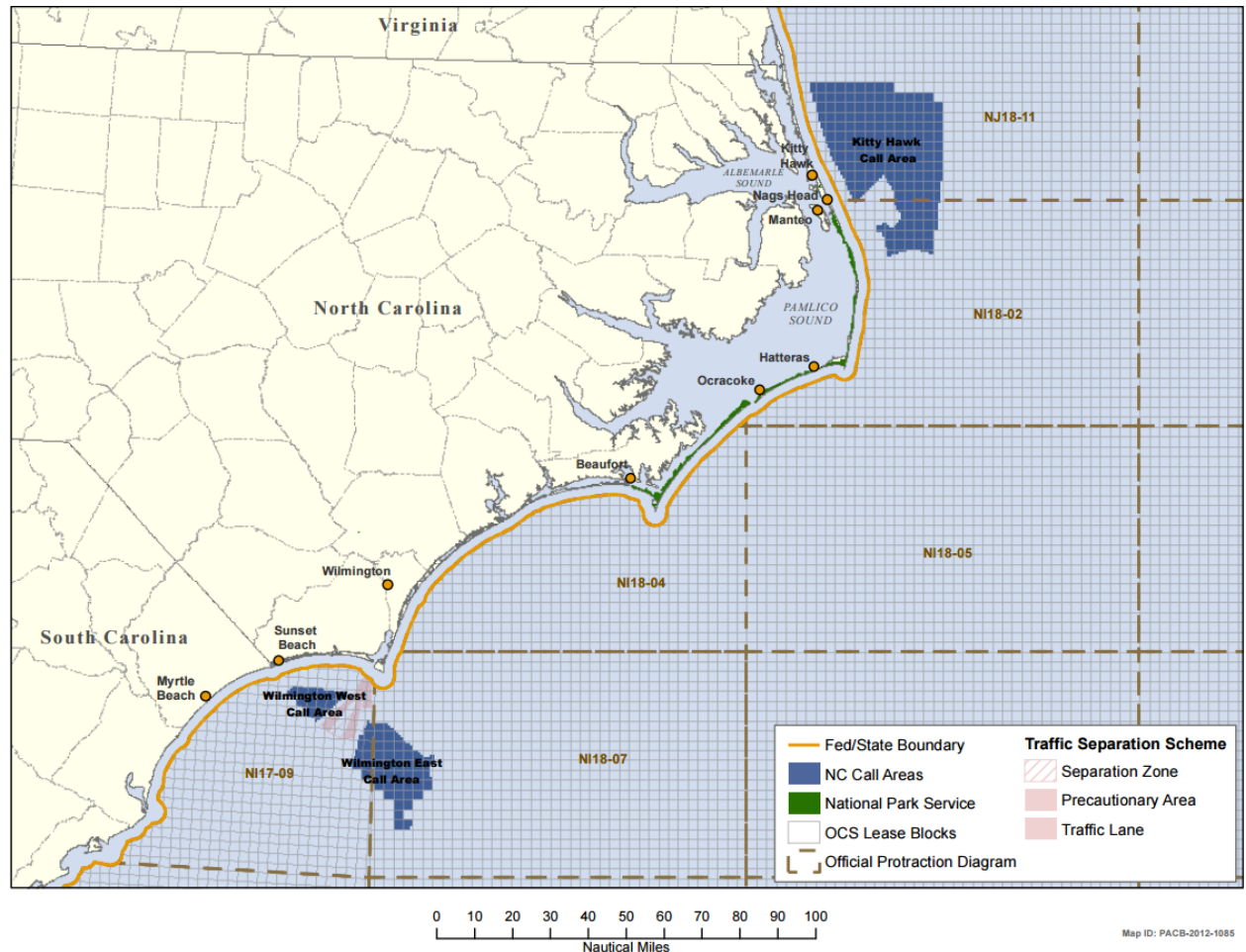


As states began to plan for offshore wind facilities in 2010, the Secretary of the Department of the Interior, Ken Salazar, announced the “Smart from the Start” wind energy initiative with the purpose of creating a streamlined approach to offshore wind development. The process first identifies “wind energy areas” (WEAs) on the OCS that have high potential for development. Information is then gathered about each WEA to determine environmental and geophysical characteristics of the areas that will then be made available to the public. Investors and other applicants for lease sales will be able to access that information. In January 2011, BOEM established the North Carolina Renewable Energy Intergovernmental Task Force to coordinate actions and decisions between federal agencies and state and local governments (77 FR 74204).

BOEM identified 3 areas off the coast of North Carolina that are favorable for wind energy facilities. The Call Areas are delineated as Kitty Hawk, Wilmington-West, and Wilmington-East (77 FR 74204). Figure 1.4 shows the three call areas. A call for information was requested for these lease blocks to indicate if there exist any further conflicts. The Kitty Hawk Call Area overlaps with shipping corridors and the Town of Kitty Hawk requested that

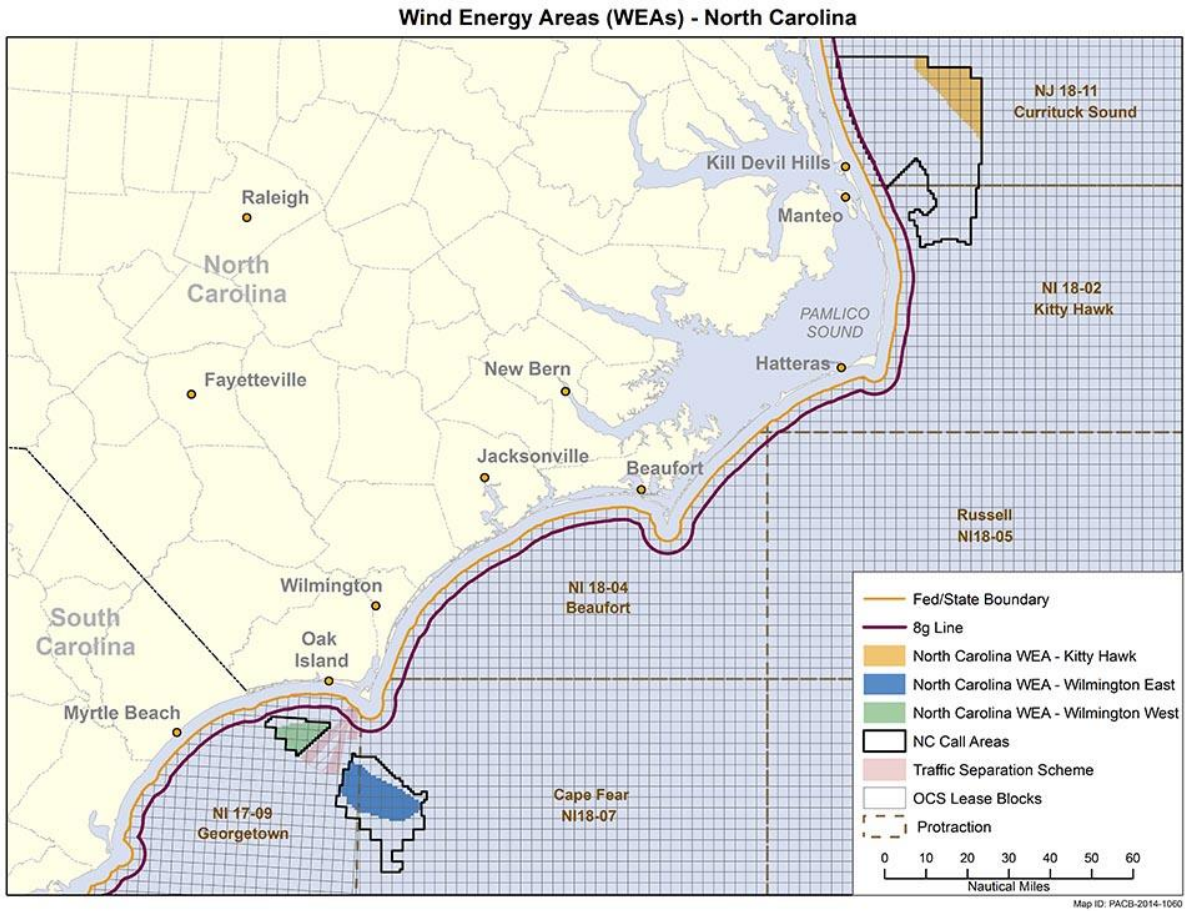
development be limited to areas greater than 20 nautical miles offshore. The Wilmington East Call Area had a similar issue with shipping routes but also showed areas of hard bottom habitat with high fish densities, limiting certain blocks for development. The Wilmington West Call Area was limited to areas more than 10 nm offshore due to issues with aesthetics (Call, 2012).

Figure 1.4: BOEM Call Areas



In August 2014, the US Bureau of Ocean and Energy Management (BOEM) identified three Wind Energy Areas (WEAs) offshore North Carolina, see Figure 1.5. The Kitty Hawk WEA begins about 24 nautical miles (nm) from shore and extends approximately 25.7 nm in a general southeast direction at its widest point. Its seaward extent ranges from 13.5 nm in the north to .6 nm in the south. It contains approximately 21.5 OCS blocks (122,405 acres). The Wilmington West WEA begins about 10 nm from shore and extends approximately 12.3 nm in an east-west direction at its widest point. It contains just over 9 OCS blocks (approximately 51,595 acres). The Wilmington East WEA begins about 15 nm from Bald Head Island at its closest point and extends approximately 18 nm in the southeast direction at its widest point. It contains approximately 25 OCS blocks (133,590 acres).

Figure 1.5: BOEM WEAs



2. Legislative Framework

Any offshore wind project not within three miles of the shoreline is located in federal waters. Despite this, these public trust waters will require permitting from both the state and the federal government, from many varying agencies. Offshore wind turbines require many components to operate and many of these components require separate permitting. Construction of the turbine and the platform or foundation on which it stands, as well as substations that serve to transfer energy produced to shore, must be approved. Transmission cables route energy from turbines to substation and from substation to shore, impacting the onshore environment and the seafloor. Only since the Cape Wind project began has policy been created to handle offshore wind development. Discussed below is a brief overview of many federal laws that will impact offshore development.

2.1 Outer Continental Shelf Lands Act

The Bureau of Ocean Energy Management (BOEM), under the Department of the Interior is the federal agency in control of offshore energy development. In 1953, in order to regulate mineral exploration and development on the Outer Continental Shelf (OCS), the Outer Continental Shelf Lands Act was created under the Department of the Interior and is promulgated by the Secretary of Interior. Originally, this act was intended to ensure competitive bids and provide regulatory framework for offshore oil and gas programs while preventing waste and allocating natural resource efficiently. The OCSLA defines the OCS as “all submerged lands lying seaward [of State coastal waters], and of which the subsoil and seabed appertain to the United States and are subject to its jurisdiction and control” (OCSLA, 1953).

The Energy Policy Act (EPAAct) of 2005 made an addition to OCSLA that allows BOEM to allocate leases, easements, and rights-of-way for renewable energy on the OCS (BOEM, 2014b). Renewable energy regulations requires wind energy development offshore to occur in four phases: planning and analysis, lease issuance, approval of a Site Assessment Plan (SAP), and approval of a Construction and Operation Plan (COP) (BOEM, 2015).

The Outer Continental Shelf Lands Act requires BOEM offer the energy leases competitively. Also, due to this act, on December 13, 2012 BOEM held a 45-day public comment period. BOEM also published in the Federal Register a “Notice of Intent” to prepare an Environmental Assessment on Dec. 13, 2012 (under Docket ID: BOEM-2012-0090).

The phases of the energy programs, such as planning, leasing, site assessment, and construction, are regulated by the Renewable Energy Program Regulations (30 CFR 585). BOEM must then prepare an environmental assessment to have the renewable energy activities

authorized. While preparing this assessment BOEM will need to work with important statutes such as the Endangered Species Act, Magnuson Fishery Conservation and Management Act, Coastal Zone Management Act, and the National Historic Preservation Act. Environmental compliance for the leasing process takes place under the National Environmental Policy Act.

Federal agencies that are major stakeholders in this political process of offshore wind farms include the U.S Coast Guard, National Oceanic and Atmospheric Administration, Environmental Protection Agency, U.S. Fish and wildlife Service, National Marine Fisheries Service, U.S. Army Corps of Engineers, Federal Aviation Administration, U.S. Geological Survey, and Department of Defense.

2.2 Other Associated Acts

2.2.1 Endangered Species Act:

Endangered Species Act (ESA) was passed in 1973. This act provides framework to acknowledge that “our rich natural heritage is of esthetic, ecological, educational, recreational, and scientific value to our Nation and its people” and is in place to ensure protection for all species that are federally listed. Takes are defined in the ESA as actions that would “harm, harass, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct.” As such, “take” is a vague term to describe a potentially harmful interaction with any animal, which may be noise pollution, too close contact, or physical harm. The word “harm” is defined an action that kills or injures a listed animal, though this includes “habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioural pattern, including breeding, feeding, or sheltering.” (Endangered Species Act, 1973). Violations of the ESA can lead to civil and criminal penalties resulting in \$25,000 or \$50,000 fines respectively (McKinsey, 2007)

2.2.2 Marine Mammal Protection Act

The Marine Mammal Protection Act (MMPA) regulates how the public and industry interacts with marine mammals. There are two levels of harassment, “Level A” and “Level B”. The definition of Level A harassment is, “any act of pursuit, torment, or annoyance, which has the potential to injure a marine mammal or marine mammal stock in the wild.” Level B harassment is defined by, “any act pursuit, torment or annoyance, which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, feeding or sheltering. “

Both Level A and Level B harassment would be considered a take of a marine mammal. The North Atlantic right whale is federally listed endangered species, under the ESA and listed

depleted under the MMPA. These whales have the highest level of protection associated with them and therefore actions need to be taken so that there is minimal damage to them during all phases of implementing offshore wind.

2.2.3 Migratory Bird Treaty Act:

Migratory Bird Treaty Act (MBTA) of 1918 outlines protections allowed for migratory birds, originally to protect them from hunting and selling for meat internationally. Though in 1976, Public Law 955-616 was signed and ratified of the United States to take precautions to “protect ecosystems of special importance to migratory birds against pollution, detrimental alterations, and other environmental degradations.” The USFWS has authority to enforce the MBTA, but there has been a history of selective enforcement amongst certain industry (McKinsey, 2007). This act is far reaching and the enforcement for it is nearly impossible for all violations.

If offshore wind turbines are shown to cause a significant amount of bird deaths of species listed in the migratory bird act, then mitigation actions may need to be taken. This will most likely be in the form of a Migratory Bird Impact Assessment.

2.2.4 Magnuson Stevens Act

The Magnuson-Stevens Fishery Conservation and Management Act (MFCMA) is a national program established originally in 1976 that works “to prevent overfishing, to rebuilding overfished stocks, to insure conservation, to facilitate long-term protection of essential fish habitats (EFH), and to realize the full potential of the Nation’s fishery resources” (MFCMA, 2007). Enforced and regulated by the National Oceanic and Atmospheric Administration (NOAA) and the National Marine Fisheries Service, the MFCMA was amended in 1996 to include the Sustainable Fisheries Act, making habitat protection a primary goal. Habitat protection directly impacts the fisheries, which are important for “food supply, economy, and health of the Nation” (MFCMA, 2007) Fishery Management Plans (FMP) are established for each of the eight Regional Fishery Management Councils and they identify areas of essential fish habitat (Rolleri, 2011). EFH are those areas that are “necessary to fish for spawning, breeding, feeding, or growth to maturity” (MFCMA, 2007). To prevent offshore energy projects from impacting these areas of EFH as identified by the MFCMA in the fishery management plan, BOEM and any potential lessee must avoid sites that would negatively affect fish habitat.

2.2.5 Coastal Zone Management Act

The Coastal Zone Management Act (CZMA) was established in 1972 to “preserve, protect, develop, and where possible, to restore or enhance the resources of the nation’s coastal zone” (CZMA, 1976). This act establishes a voluntary partnership between the federal

government and the states through NOAA. States that wish to participate must develop a comprehensive coastal management plan which then allows them to use both state and federal funds to implement the plan. The CZMA requires certain key elements be addressed including habitat protection, public access, water quality, coastal development, coastal hazard, ocean planning and governance, siting of energy facilities, and climate change (CZMA, 1976).

In compliance with the Coastal Zone Area Management Act of 1972, North Carolina passed the Coastal Area Management Act (CAMA) in 1974, establishing rules and regulations for coastal development. Under CAMA, the Division of Coastal Management was created in the Department of Environment and natural resources to enforce coastal regulations, and also the Coastal Resources Commission (CRC), an appointed board, to act as the governing entity. CAMA requires that each coastal community submit a land use plan outlining land classifications and development plans to the CRC to be approved. Communities may establish zoning ordinances, unified development codes (UDOs), comprehensive land use plans or comparable development standards in addition to the CAMA plans. The development plans of the communities in the counties closest proximity to the onshore staging areas Currituck County, Dare County, New Hanover County, and Brunswick County were examined to determine if the community allowed development of energy facilities [Table xx].

Several communities have specific language in their plans or ordinances that oppose any energy development, posing a challenge to establishment of offshore wind energy development. Many of the plans were not specifically clear on the community's position on energy development. Wrightsville Beach, Sunset Beach and Caswell Beach have statements opposing energy development in their plans. The ordinances for Brunswick County, New Hanover County and Currituck County would require a special use permit approved by elected county officials before any energy construction or operation would be allowed. The City of Southport, NC's ordinance is the only ordinance that clear language about the allowance of energy development, likely due to the current presence of Duke Energy's Nuclear Plant.

Growth on the coast prompted the development of the CZMA. Within the CZMA is the idea of "Federal Consistency" which requires all federal action that will affect the coastal zone be consistent with the state's coastal management plan. If an activity "directly, indirectly, or cumulatively" affects the coastal zones natural resources, land uses, or water uses, that activity is then subject to Federal consistency. Before any activity can occur on the Outer Continental Shelf (OCS), BOEM must allow the state to conduct a Federal consistency review. If the state agrees that the activity is consistent "to the maximum extent practicable," then the activity can move forward (BOEM, 2014c).

2.2.6 National Historic Preservation Act

Signed into law in 1966, the National Historic Preservation Act (NHPA) was established to preserve important historical and archaeological landmarks for present and future

generations. As part of the environmental review process, the NHPA requires federal agencies to fully understand the implications of an activity. Section 106 of the NHPA states that federal agencies must determine if a federal activity will affect any site that is listed in the National Register as a historic site. North Carolina is known as the “graveyard of the Atlantic” and many of the shipwreck sites on the OCS are listed as historic sites. The proposed wind energy areas have been chosen to minimize impact on the important historical and cultural sites that lie off the coast.

2.2.7 International Convention for the Prevention of Pollution from Ships

The main international agreement that discusses marine pollution is the International Convention for the Prevention of Pollution from Ships (MARPOL). This convention was adopted in 1973 by the International Maritime Organization. The MARPOL convention is intended for pollution by vessels. Annex V of the MARPOL convention specifically identifies practices for the prevention of garbage pollution from ships. MARPOL prohibits all plastics, domestic wastes, cooking oil, incinerator ashes, operational wastes, and fishing gear being dumped in the ocean regardless of location. It also outlines other types of waste such as animal carcasses (not including fish), cleaning agents, cargo residue, and food wastes.

Any impacts that ships may have on the marine environment during all phases of the wind turbine installation would be covered and enforced under MARPOL. *Annex V has helped reduce the number of entanglements of marine mammals since its inception (Henderson, 2001).*

There are measures in order to mitigate impacts for most of these protected species, such as applying for an Incidental Take Permit. Incidental take permits allow a party a certain number of takes on marine mammals or other endangered species. (McKinsey, 2007)

2.2.8 Clean Water Act and Clean Air Act

The Clean Water Act was established in 1972 as the framework for regulation pollution into our waterways. The only way to legally discharge into navigable waters is through a permit. Additionally, the Clean Water Act sets standards for pollutants and toxins in the water. In the open ocean, however, there is a lot of dilution of pollutants. For the offshore wind turbines, the main concerns would be chemical and oil spills from vessel traffic building and maintaining the farms.

The Clean Air Act (CAA) was established as a tool to control air pollution at the national level. The 1970 amendments to this legislation allowed the CAA to regulate both stationary and mobile sources of pollution and established the National Ambient Air Quality Standards (NAAQS) which identifies six “criteria” pollutants that have the potential to endanger public health and welfare: carbon monoxide, nitrogen dioxide, lead, ozone, sulfur dioxide, and particulate matter (CAA, 1970). The Outer Continental Shelf Lands Act (OCSLA) requires that

activity on the OCS adhere to the NAAQS set by the CAA for a particular area. Within 25 nm, State and Federal requirements for onshore pollution levels are applicable. The North Carolina Division of Air Quality monitors ambient air pollution to ensure that concentration limits remain within the standards. Areas greater than 25 nm offshore must comply with the CAA Prevention of Significant Deterioration, which applies to areas that are unclassifiable with the NAAQS (BOEM, 2014b).

2.3 Implementation Challenges

To research the implementation challenges for offshore wind in North Carolina, a literary review was conducted of international, domestic, onshore, and offshore wind energy projects. Research was also conducted for the project's technical feasibility. Primary data on the installation and performance of offshore wind energy facilities was not available for this evaluation, as there are currently no offshore wind energy facilities operating domestically. Instead, data was utilized from international offshore wind facilities in order to report on the implementation challenges for North Carolina. In the United States, onshore facilities are more common than offshore. While they have similar issues for implementation, the use of public trust land and harsh marine conditions are unique to offshore facilities..

The most significant report utilized in the research is perhaps *A Study of the Feasibility of Wind Turbines in the Pamlico and Albemarle Sounds and in Ocean Waters off the North Carolina Coast*, which was created by UNC-Chapel Hill in 2009. It provided important background information for the evaluation, including an extensive GIS-based site suitability analysis.

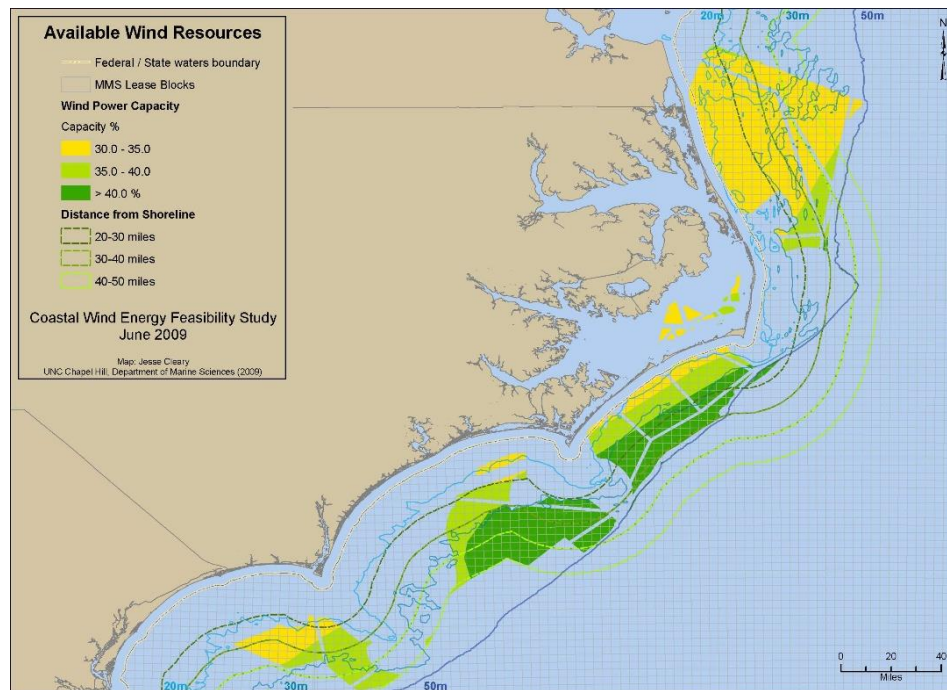
2.3.1 Turbine Siting

One of the most important steps of developing an offshore wind facility is determining its location. Numerous site characteristics must be considered before a final location is determined for leasing and development. A turbine siting analysis produced by University of North Carolina at Chapel Hill in 2009 found several areas that satisfied characteristics necessary to support an offshore wind facility. The most significant characteristics for determining an offshore wind energy facility location are wind speed, environmental impacts, seafloor geology and bathymetry, military user conflicts, onshore utility infrastructure, and maritime corridors.

Perhaps the most important factor is the presence of consistent high speed wind patterns. Wind speed generally increase with the distance from shore. See Figure 2.1. Higher average wind speeds provide more consistent wind energy for the turbine to harness and generate electricity. The two primary wind directions are from the northeast and southwest. These local wind patterns are created by pressure differences along the coast and ocean. Wind

speeds also tend to be more consistent at higher altitudes, as friction against the Earth's surface produces turbulence and wind speed variability (University of North Carolina at Chapel Hill, 2009). Areas with the greatest wind capacity are regions along the continental shelf with water depths of 30 M or more. Figure 2.1 shows wind speeds at 30 M above sea level, which is the height of a typical 3.0 – 3.6 MW size wind turbine. If an area does not have high enough wind speeds to generate energy a wind energy facilities would not be successful.

Figure 2.1: Best Available Wind Resources (UNC, 2009).

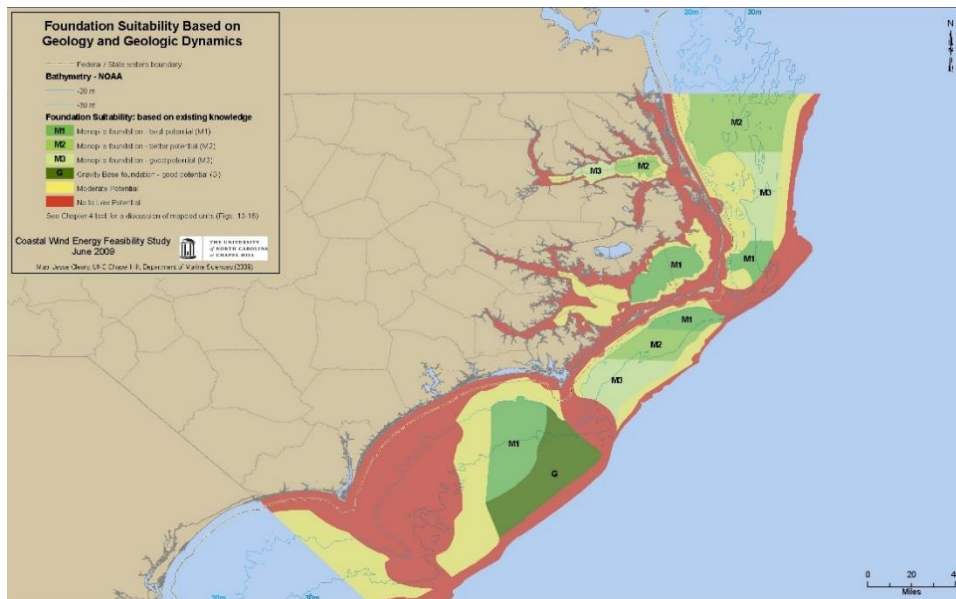


Connectivity could become problematic though, as the long distances from the shore that would allow the greatest wind energy potential also produce higher cost and variability of dependability for the operation as a whole. Transformer stations assemble cables from turbines on their way to shore (Figure 2.1). These platforms require close proximity to the turbines, but vary in distance to the onshore substation via buried transmission lines (University of North Carolina at Chapel Hill, 2009).

Seafloor geology and bathymetry is important for site selection. The continental shelf off of North Carolina is relatively shallow, facilitating monopile foundation construction for most sites. Monopiles are simplest and lowest cost foundation for wind turbines. Areas too deep for monopiles may require tower assemblies for their foundation, but a majority of the proposed areas are suitable for mobiles. Due to differing seafloor geological composition, ocean currents, and sediment patterns, certain areas may more or less suitable for turbine foundations, as shown in Figure 2.2. While upcoming technology suggests that seafloor geology

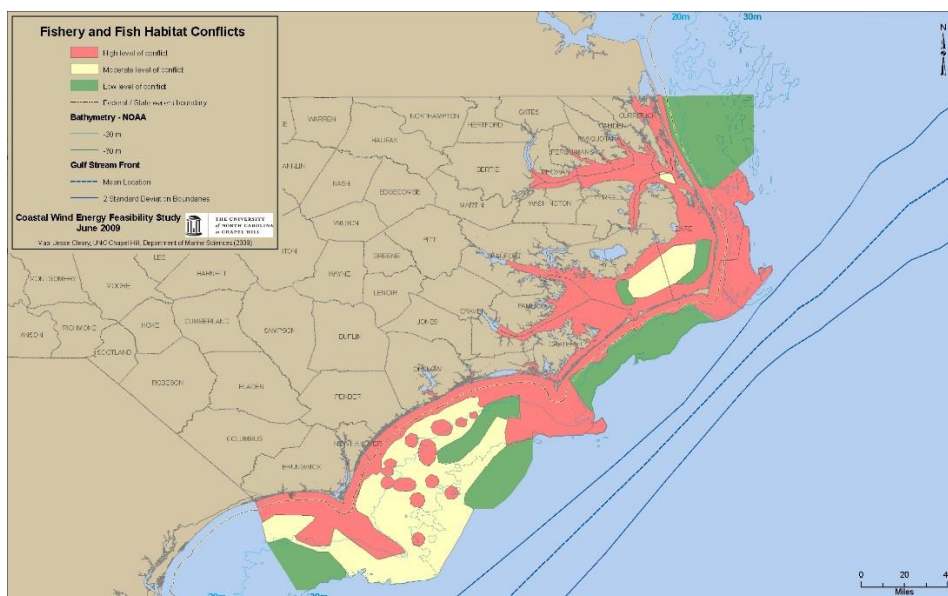
will not be major issue in the future. Less suitable areas may be able to support a wind facility, but could potentially incur extra costs for construction.

Figure 2.2: Ideal Construction Geology Areas (UNC, 2009).



Several airborne and aquatic animals would be potentially influenced or impaired by the presence of offshore wind energy facilities. These animals include, but are not limited to: birds, bats, butterflies, sea turtles, fishes, marine mammals, and invertebrates. The red areas in Figure 8 show areas of high conflict for birds and their habitats. Fisheries and fish habitats are easier to account for than birds and bird habitats, as there are greater areas with moderate to low levels of conflict, seen in Figure 2.3 for fish and Figure 2.4 for birds.

Figure 2.3: Fishery and Fish Habitat Locations (UNC, 2009).



Areas with fewer ecological risks are ideal, but there are inevitably some conflicts with any area. The installation of offshore wind turbines in some areas would assist to increase ecosystem biodiversity and production, however, as the rock escarpment around the foundation would provide a suitable habitat for aquatic organisms (UNC, 2009).

Figure 2.4: Bird and Bird Habitat Locations (UNC, 2009).

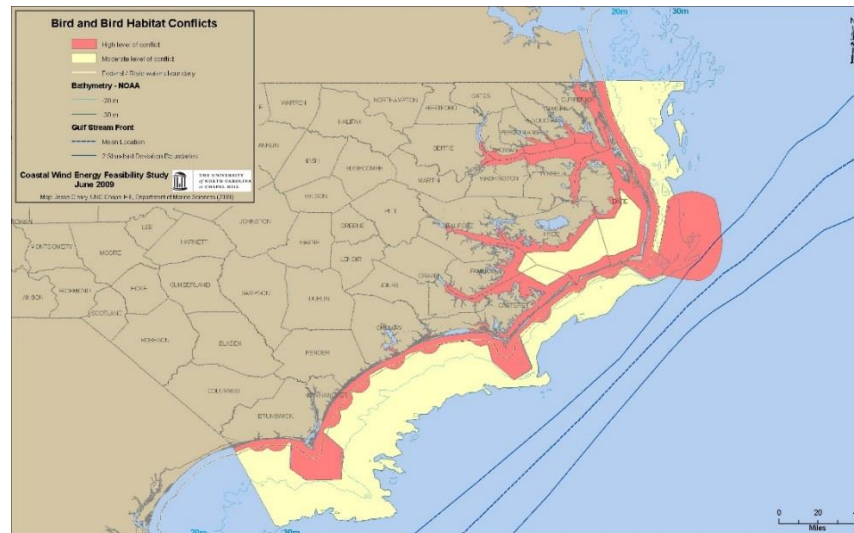
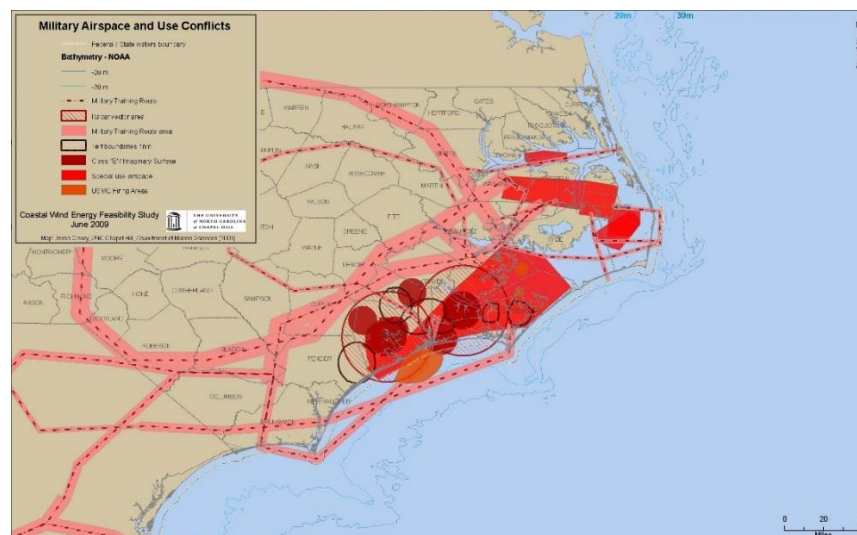


Figure 2.5 displays conflicts with Military uses along coastal areas. These conflicts are clustered around Marine Base Camp Lejeune in Onslow and Carteret County. Conflict areas in red include radar vector areas, military aircraft corridors, and firing ranges. While these are immediate issues, these incompatible areas mostly exist on land and inshore where turbines wouldn't likely be located. The issue with this is that the connectivity potential is significantly lowered in the central coast where many of the training areas and firing ranges are located (UNC, 2009).

Figure 2.5: Military Airspace (UNC, 2009).



As seen in Figure 2.6, the continental shelf has numerous small obstruction sites of historic shipwrecks, oyster sanctuaries, artificial reefs, and live bottom habitats. These areas are important to the ecology and economy of North Carolina. These ecological habitats are areas with high biodiversity. The fish and other marine animals that live and around shipwrecks, live bottoms, and artificial reefs provide many economic benefits for tourism. Diving and fishing in these areas are both important to local and state economies. Interaction with these locations are not ideal for a wind turbine facility, as it would negatively affect several ecological and tourism based markets (University of North Carolina at Chapel Hill, 2009).

Figure 2.6: Vessel Transportation Corridors, Cultural Resources, and Reef Habitats (UNC, 2009)

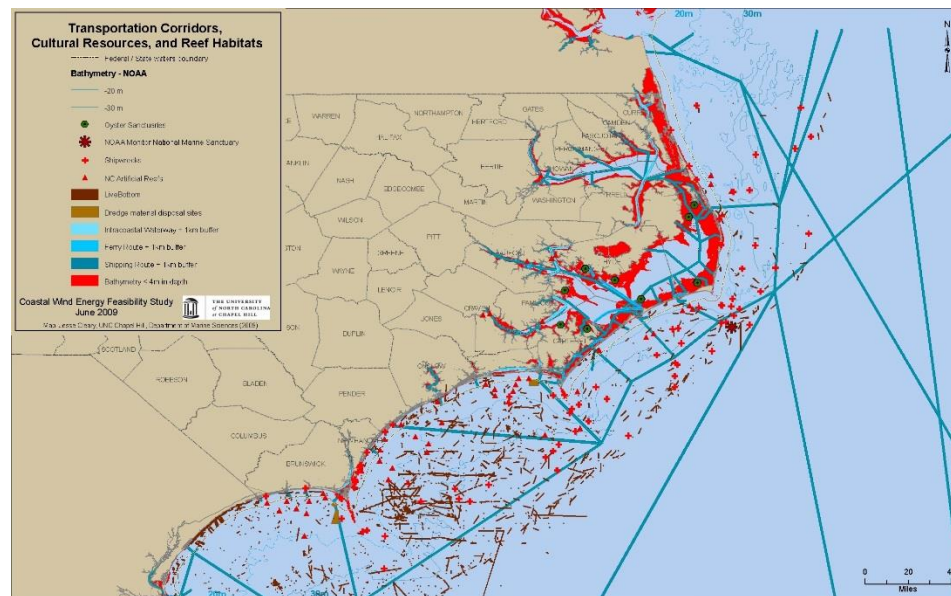
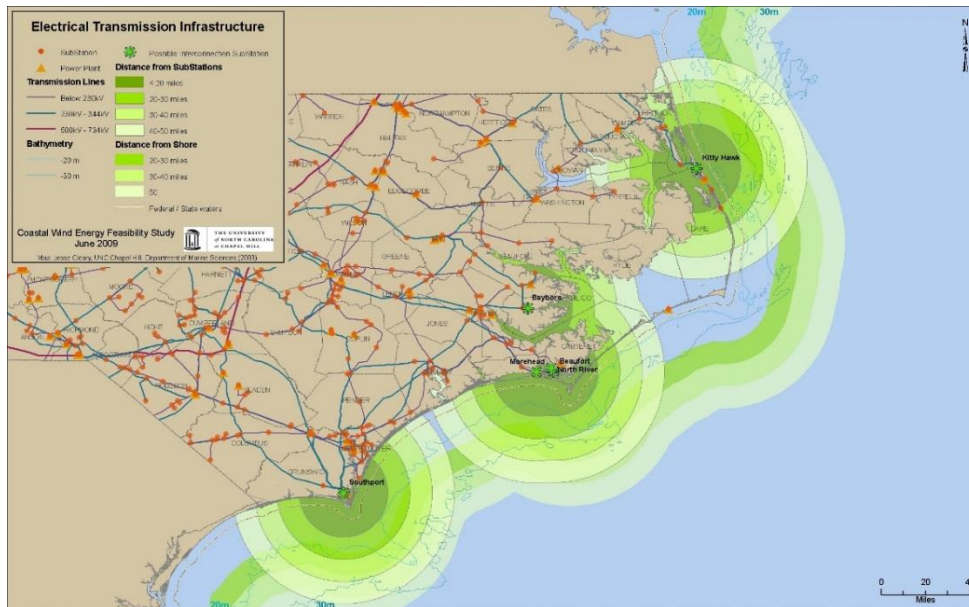


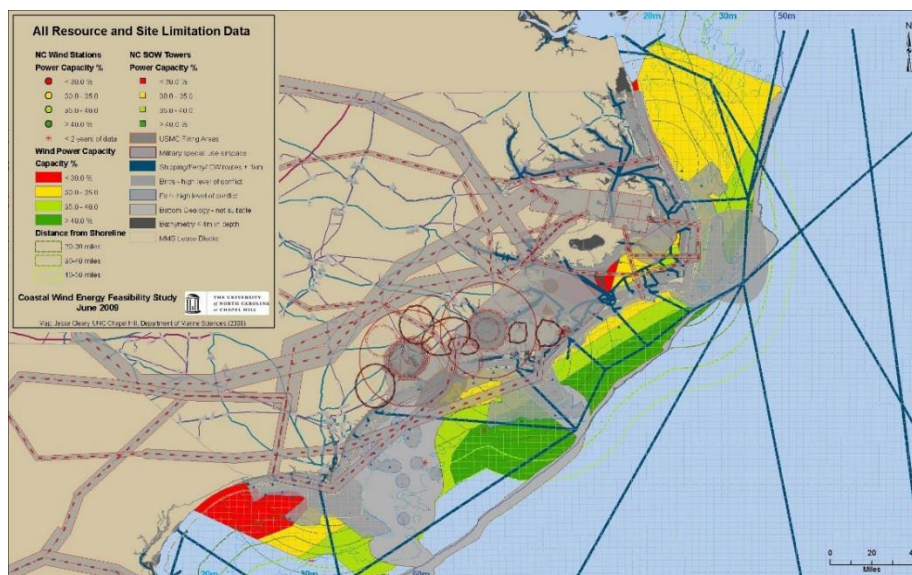
Figure 2.7 displays areas with large electrical substations which are needed to connect an offshore facility to North Carolina's inland electrical grid. A substation connection is needed to disseminate electricity inland to the rest of North Carolina. There are three major substation areas, Wilmington, Kitty Hawk, and the Morehead City Region. The figure also indicates 30, 40, and 50 mile buffers to substations and the shoreline (University of North Carolina at Chapel Hill, 2009). A greater distance from the substation a facility would incur more costs for transmission onshore.

Figure 2.7: Existing Onshore Electrical Transmission Infrastructure (UNC, 2009).



This map shows all major user conflicts overlaid together. Areas in gray are excluded due to significant user conflicts. The remaining areas colored in red, yellow, and green are available offshore regions with appropriate wind conditions. These lease blocks are the areas that could potentially be leased for production of offshore wind energy facilities. The most significant user conflict is with Military Operations. The offshore wind areas east of Carteret and Onslow County have the highest wind speeds, however they were not considered for leasing due their close proximity and to Camp Lejeune’s Military Operations (University of North Carolina at Chapel Hill, 2009).

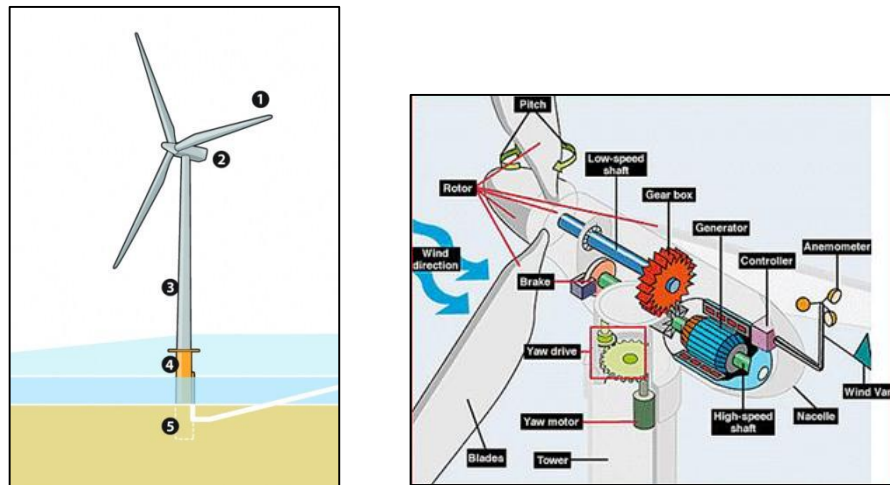
Figure 2.8: All Use Conflicts (UNC, 2009).



2.3.2 Turbine Technology

The current technology of wind turbines, shown in Figure 2.9, favors the design of three vertical blades (1), connected at a horizontal hub, or rotor (2), at the top of a tall tower, (3) (Schroeder, 2010). For offshore turbines, the tower is fitted into a monopile jacket, (4), which is driven into the seafloor and connected by cables (5). The inherent structural rigidity of turbines is strained under the dynamic and harsh offshore conditions, which was taken into account during design of turbines used in or near the ocean (Wood et al., 2010). The modular design is common, to facilitate easy maintenance and operation.

Figure 2.9 & 2.10: Turbine Design Parts & Interior Components



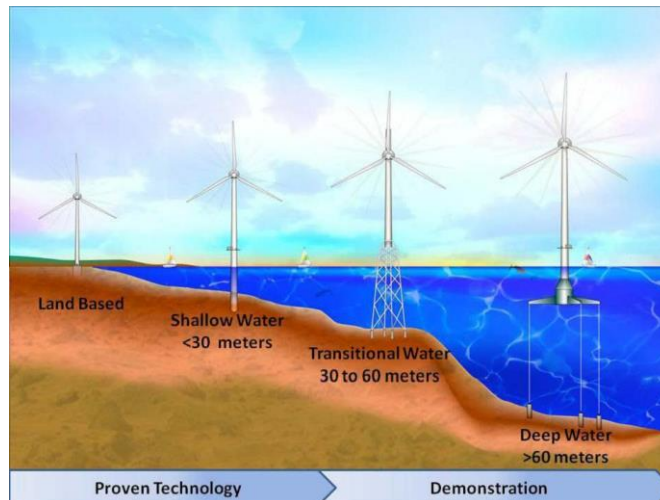
The blades tend to host the majority of external issues for turbines offshore. The blades are angled, or “pitched”, with the prevailing wind direction. The blade can also be adjusted to accommodate the current wind speed to gain the most efficient torque and revolution speed for energy generation in the hub (Leithead, 2007; Kotzalas & Doll, 2010). This creates mechanical power for the generator inside the nacelle, as seen depicted in the diagram Figure 2.10. The nacelle contains the drivetrain and electronics. The rotor is connected to the gear box inside the nacelle, which generates electricity by rotating magnets within the generator (Kotzalas & Doll, 2010; Schroeder, 2010).

Energy is generated about 75% of the time. The prevailing wind patterns are considered for blade angle to utilize the most wind energy. The lowest wind speed at which the turbine will function is referred to as the ‘cut-in’ speed. The highest wind speed at which the turbine will function is referred to as the ‘cut-out’ speed. Below the ‘cut-in’ wind speed, the energy generated by wind is less than the turbine uses to turn the rotor. At this speed more energy is used in the rotation of the rotor than is generated by the generator, resulting in no electricity generated. Above the ‘cut-out’ speed, the risk of potential damage to the internal or external components of the turbine is too high to continue operation. (Leithead, 2007).

2.3.3 Turbine Foundations

Harsh environmental marine conditions are present offshore. Turbines with wider blade diameters are able to harness more energy efficiently. As turbine blades are developed to be wider, more supportive foundations may be required (Byrne & Houlsby, 2003). Monopile foundations, the most common turbine foundation style, are suitable for water depths up to 100 feet. It consists of a steel tube that is driven into the sea floor. The depth the monopile is driven into the seafloor is dependent on the seafloor geology and turbine size. The monopile secures the turbine is stable on the seafloor and rises above the water level to an appropriate high for the local wind conditions. Newer technologies, such as three-pile and jacket foundations, seen in Figure 2.11, have been under development increase the structural integrity in deeper waters common in offshore oil and gas structures (BOEM, 2014).

Figure 2.11: Turbine Foundations



Electricity generated by offshore wind turbines is transmitted via undersea cables to a common electronic service platform (ESP), shown in Figure 2.12. The electricity is then transmitted to shore and integrated into the grid (BOEM, 2014). These stations house emergency equipment and system backup, which includes generators that are able to supply power in the event of loss of electrical supply (Leithead, 2007). The construction and presence of both the ESPs and the offshore turbine foundations are similar aesthetically to other infrastructure platforms in oil and gas facilities.

Figure 2.12: Electrical Transmission Hub



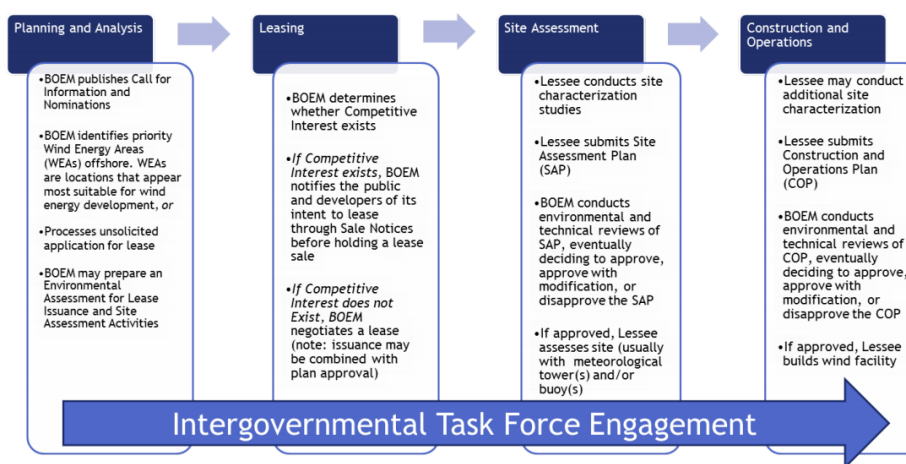
3. Leasing, Permitting, and Development Phases

BOEM is authorized to issue leases, easements and rights of way to allow for renewable energy development on the Outer Continental Shelf (OCS) under the general framework provided by the Energy Policy Act of 2005. BOEM's Outer Continental Shelf Renewable Energy Program provides a comprehensive guideline for governing how BOEM manages its Renewable Energy Program, ensuring that BOEM meets its statutory obligations, and providing both certainty and flexibility for overseeing the nascent offshore renewable energy industry.

BOEM's renewable energy program occurs in four distinct phases: planning and analysis, leasing, site assessment, and construction and operations. The planning and leasing phases are carried out by BOEM and, the site assessment and the construction and operations phases are conducted by the lessee.

During the first phase BOEM identifies suitable areas to be considered for offshore wind energy using collaborative input from a wide range of stakeholders. Next, lessees are given the rights to seek approval from BOEM for lease blocks. The third phase requires the lessee to develop a Site Assessment Plan (SAP) outlining installation and operation plans, subject to approval by BOEM. If approved, the project may move to the next phase, submittal of a Construction and Operation Plan (COP) by the lessee, detailing the construction, operation, and term limit of the wind energy facility, also subject to approval by BOEM.

Figure 3.1: BOEM Planning, Leasing, and Development Phases



A final Programmatic Environmental Impact Statement (PEIS) was prepared by BOEM to examine the potential environmental effects of the program on the OCS, identify policies and best management practices that may be adopted for the program, and support establishing its program for authorizing renewable energy and alternate use activities on the OCS.

3.1 Site Characterization and Assessment Activities

In January 2015, BOEM unveiled the environmental assessment of leasing and site assessment on the OCS. It identified three locations that are being examined for possible wind energy development. Those Wind Energy Areas (WEAs) are referred to as Kitty Hawk, Wilmington West, and Wilmington East.

The site characterization process includes surveying of offshore resources. Site assessment involves installation, operation, and decommission of meteorological survey tools (towers or buoys). By using a “reasonably foreseeable scenario,” the EA maximizes the survey activities for each WEA in each alternative in order to evaluate possible impacts. Note that all of the following techniques may not be employed by the leasing party but all are possible scenarios (BOEM, 2015, pg 3-1).

BOEM assumes that for each Wind Energy Area, zero to one meteorological tower, one to two buoy(s), or a combination, would be constructed or deployed for assessment. A total of up to 3 meteorological towers and 6 meteorological buoys may be used. The site assessment is expected to take 1 to 3 years with meteorological tower installation, site assessment, and decommission activities occurring during the months of April through August. The time window of April through August is selected to reduce disruptions to whale migration. “The entire WEAs would be surveyed once to collect required information for both site assessment and siting the meteorological tower or buoy. The surveys [must] be completed in phases with the meteorological tower areas performed first.” (BOEM, 2015)

3.1.1 Site Characterization

Site characterization activities, also known as geological and geophysical surveys, are important for determining ocean bottom geology. Understanding geological formations is critical to determining appropriate sites for meteorological towers and, later, turbines. BOEM requires submission of the results of five different types of site characterization activities: shallow hazards survey, geological survey, geotechnical survey, archaeological resource survey, and biological survey (BOEM, 2015) in the form of Archaeological Resource Survey Reports and Site Characterization Survey Reports (BOEM, 2012). Surveying can be completed using several different methods or a combination of many. Discussed below are different surveying techniques specific to the NC WEAs and their possible environmental effects. “Because the same vessel (or group of vessels) following the smallest line spacing could conduct all of the surveys necessary to acquire all of the relevant data in a single trip, the smallest line spacing, which is 98 feet (30 meters) for the archaeological resource survey, is assumed for all survey types” (BOEM, 2015). Additional requirements for these surveys can be found in 30 CFR 585 (BOEM, 2015).

3.1.1A High-Resolution Geophysical Survey

High-resolution geophysical (HRG) surveys are used for three purposes: to obtain geophysical shallow hazards data, to determine if there are archaeological resources present, and to create bathymetric charts. A combination of bathymetry/depth sounder, magnetometers, seafloor imagery/side-scan sonar, and shallow and medium (seismic) penetration sub-bottom profilers will be used for the HRG surveys.

HRG surveys for cable transmission routes to interconnection points onshore will be conducted with a minimum 984-foot (300-meter) wide corridor in anticipation of disturbances or site location changes. Locations of power substations have not been established, making this corridor width necessary. BOEM assumes that there will be “one cable route for each individual lease, a 300-meter-wide survey corridor to shore, and 5nm of survey line per mile of cable corridor equals 1 hour of survey per mile of cable” (BOEM, 2015). Figures 12.5.1 – 12.5.3 in the Appendix show potential cable routes for each lease location.

3.1.1B Geotechnical/Sub-bottom Sampling

Geotechnical sampling is used to determine sediment characteristics and suitability for proposed structures and transmission cables. A combination of bottom-sampling devices, vibracores, deep borings, and cone penetration tests will be used to complete the geotechnical and sub-bottom sampling (BOEM, 2015).

3.1.1C Biological Surveys

The proposed project has the potential to affect biological resources. BOEM regulations require that these biological resources be surveyed and included in the lessee’s SAP, COP, and General Activities Plans. Specifically, benthic habitats, avian resources, and marine fauna must be characterized in the lease area (BOEM, 2015).

The benthic environment refers to the ocean floor and the organisms that make their habitat on or near this layer of the water column. Geotechnical sampling and geophysical (G&G) surveys can assist in locating sensitive benthic habitats such as exposed hard bottoms with algae beds or thin, ephemeral sand layers. If G&G surveying identifies sensitive habitat, BOEM has established Benthic Habitat Survey Guidelines which require the completion of two additional surveys. The first, Sediment Scour or Deposition Survey, requires either an analysis of particle size or sediment-profile imaging (SPI) along with a multibeam/interferometric bathymetry (with backscatter data). The second, Benthic Community Composition Survey, requires video or still images of the soft and hard bottom and physical sampling with a Hamon

grab for hard bottom, a Van Veen grab for soft sediment, and/or the use of a Benthic sled (BOEM, 2015).

Avian Resource Surveys involve documenting the distribution and abundance of bird species in the proposed development areas. These survey can be completed by visual observers from boats and planes, but can also be completed using aerial digital imaging surveys, which have shown to have higher statistical and scientific validity (BOEM, 2015). Bat distribution and abundance can be surveyed using ultrasonic detectors which locate and identify bats by their species-specific echolocation calls that they use for communication. These detectors are portable and can be installed on survey vessels. Fall and spring migration are the best times to survey for bats in the development area (BOEM, 2015).

Marine fauna includes marine mammals, sea turtles, and fish that exist or could be impacted by development in the proposed WEAs. Lessees are required to identify fauna within the lease areas. BOEM, the U.S. Department of Energy, and state governments are currently conducting marine fauna surveys in the Atlantic WEA's. The results of these surveys may indicate the need for additional data acquisition before lessees can get plans approved (BOEM, 2015). Table 3.1 describes survey methods and timing for biological resources.

Biological Survey Type	Survey Method	Timing
Benthic Habitat	Bottom sediment/fauna sampling (sampling methods described under geotechnical surveys)	See Geotechnical Sampling
Avian	Visual surveys from a boat	10 OCS blocks per day; monthly for 2 to 3 years
Avian	Plane-based aerial surveys	Two days per WEA or monthly for 2 to 3 years
Bats	Ultrasonic detectors installed on survey vessels being used for other biological surveys	Two annual cycles in area of potential effect
Marine Fauna (marine mammals, fish, and sea turtles)	Place-based and vessel surveys – may be concurrent with other biological surveys	Two annual cycles in area of potential effect

Table 3.1: Biological Survey Types and Methods (BOEM, 2015).

3.1.2 Site Assessment

Before any site assessment activities can take place, the lessee must submit a site assessment plan to BOEM and it must be approved. Over the next five years, site assessment can occur. BOEM assumes that this would include a meteorological tower or buoy to collect data on wind resources and ocean conditions within the proposed development area. Multiple scenarios have been assessed that include construction, operation, and decommission of data collection devices (BOEM, 2015).

Meteorological data collection will occur via towers or buoys using measurement technology such as anemometers, vanes, barometers, and temperature transmitters. Other measurement tools that may be utilized include light detection and ranging (LiDAR), sonic detection and ranging (SODAR), and coastal ocean dynamics applications radar (CODAR). Aside from meteorological data, ocean current data will be collected using Acoustic Doppler Current Profilers (ADCPs). ADCPs measure the speed and direction of ocean currents. It is also possible that a tower or buoy could incorporate monitoring equipment for birds, marine mammals, bats, water temperature, and salinity.

3.1.2A Meteorological Towers and Buoys

The meteorological tower is one of the more common methods of collect data on wind and ocean conditions. A tower is made up of a mast, platform, and foundation. Masts hold all the data collection devices. Platforms can be fixed or floating. Fixed platforms are anchored using a tripod, monopole, or steel jacket foundation.

Once an SAP has been approved, installation will begin and is expected to take between 8 days to 10 weeks depending on the type of structure, the weather, and the ocean conditions. The tower will be fabricated onshore before being transported to the installation location. Installation requires a 1,500 foot radius for support vessels. Piles for the foundation will be drilled between 25 and 100 feet into the seafloor to support the platform and instrumentation is mounted using a crane. This process can take anywhere from a few days to 6 weeks depending on conditions (BOEM, 2015, 3-19). Scour control systems are used to prevent scouring of the seafloor and will be installed around each pile, affecting no more than 16,000 square feet around each pile.

BOEM assumes that any data collection tower installed will be operational for 5 years, which includes the two years that BOEM will be reviewing the lessees COP. Weekly maintenance and refueling (if diesel generators are used) of the meteorological tower is expected(BOEM, 2015, 3-21). Under USCG regulations, all meteorological towers must have lighting and marking to assist in navigation. All data will be transmitted wirelessly.

Once a lease is terminated or expired, the lessee must submit to BOEM a decommissioning application and then has two years to return the lease area to its original

state. Removal of a meteorological tower is expected to take no more than one week. Foundation piles must be removed to, at minimum, 16 feet below the seafloor as well as scour control systems. Disposal of material will occur onshore unless parts of the structure are approved for use as artificial reefs by the U.S. Army Corps of Engineers (USACE).

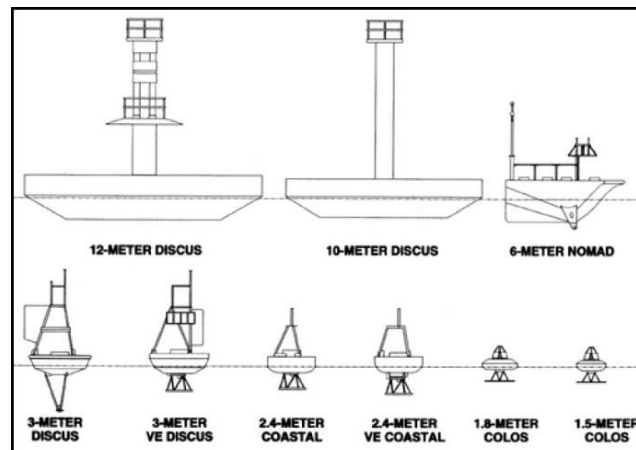
Figure 3.2 and 3.3: Lattice-mast meteorological tower with monopole foundation and monopole-mast meteorological tower (BOEM, 2015).



As an alternative to a meteorological tower, lessees have the option to install a buoy and anchor system. No more than two buoys are permitted in a single lease area and those buoys will be in fixed locations via anchors. Hull shape (as seen in Figure 3.4) is chosen based off anchoring location. Mooring design is determined based on hull type, intended location for the buoy, and water depth at that location. The most likely mooring type will consist of a combination of nylon, chain, and polypropylene materials.

Buoy construction takes place at port. Then, in about a day's time, the buoy is towed or carried on a vessel to the anchoring location, installed, and configured. Buoys will most likely be powered by solar or wind energy, limiting the need for frequent refuel visits to the site. Maintenance of the devices will occur monthly and all data will be transmitted wirelessly. Decommissioning of buoys will take less than a day with all materials being fully recovered (BOEM, 2015).

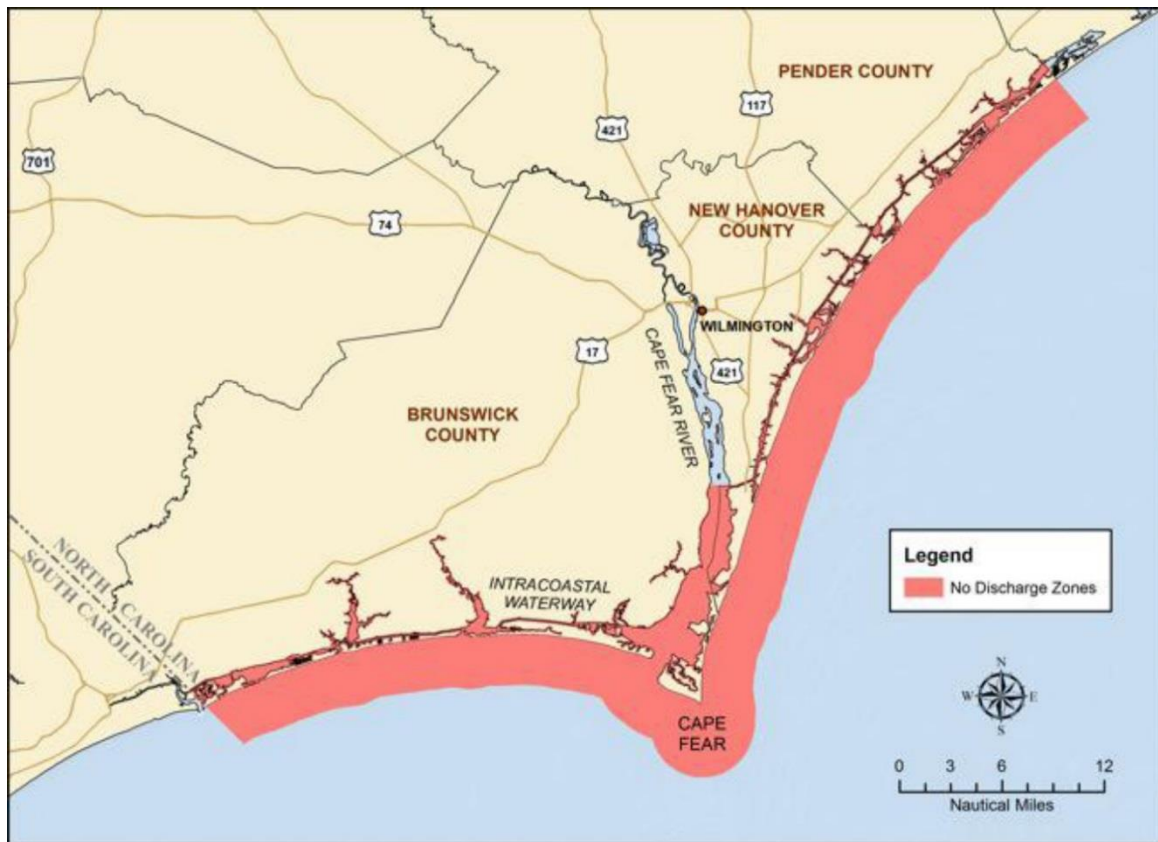
Figure 3.4: Schematic showing different buoy designs (BOEM, 2015).



3.1.2B Site Assessment and Site Characterization Waste

Operational wastes are generated from vessels associated with the proposed plan. Such waste generally includes bilge and ballast water, trash, and domestic wastes. Discharge of bilge water is regulated by the U.S. Environmental Protection Agency. Ballast water may be subject to the U.S. Coast Guard Ballast Water Management Program which regulates nuisance marine species (BOEM, 2012a).

Figure 3.5: No Discharge Zones for Southeastern NC (BOEM, 2015).



3.1.2C Ports and Vessel Traffic

Site assessment and characterization activities require the presence and use of major ports and minor ports close to the proposed development sites. In order to transport meteorological towers and buoys, ports with deep-water access and staging areas are required. These “major ports” must have depths greater than 15 feet (4.6 meters) to allow deployment vessels to dock and load. Five major ports in relatively close proximity to the three WEA’s have been identified: Port of Virginia in Norfolk, Wilmington Port, Charleston Port, Port of Georgetown in South Carolina, and Port of Morehead City in North Carolina.

Minor ports can be used to accommodate traffic from survey vessels, which involves staging and loading of supplies and crew. These vessels are predicted to be 65-100 feet (20-30 meters) long and have the ability to dock in shallow ports. To that point, three minor ports have also been identified in North Carolina: Wanchese Port, Southport Marina, and Hatteras Harbor Marina. These ports are used primarily for commercial and recreational fishing, but are also suitable for BOEM's purposes.

BOEM assumes that vessel traffic for site assessment activities will tend toward larger ports and vessel traffic for site characterization activities will use whatever port is most convenient, evenly distributing vessel traffic between SC, NC, and VA. It is also anticipated that vessel traffic will occur between April and August over roughly five years, or the amount of time required for the lessee to create and submit a COP to BOEM for approval (BOEM, 2015).

3.2 Construction

The construction phase of the wind turbines may potentially hold the most environmental impact of all the phases. This phase involves five steps: onshore manufacturing, transportation to port, assembly and loading onto marine vessels, offshore installation, and onshore installation. Onshore construction would include staging areas for assembly and transport, and cable hookup locations and existing substations (MMS, 2007). Onshore facilities are responsible for the manufacturing of major components of the project which includes turbines and rotors, foundation and anchoring structures, transformers, and transmission cables. Following the manufacturing phase, all components must be transported to the port of choice for the project, which will likely occur via truck or train depending on the port location. The port will utilize large cranes to load the components onto the marine vessels to be transported to the OCS project area. Helicopters may also be used to transport technicians and other personnel to the site (MMS, 2007).

3.2.1 Offshore Installation:

Offshore installation involves many steps. Wind Turbine Generators (WTG) are expected to be anchored using monopile foundations made of steel which would be driven into the seafloor. Pile-driving will be completed using a barge with a vibratory hammer or impact driver. Water depth and geotechnical resources will dictate the length of the monopile, the distance inserted into the seafloor and the final elevation. Scour protection mats or rock armor will likely be used to prevent impact to the seabed and erosion around WTGs due to underwater currents (DOE, 2012). Energy conversion devices within the turbine structure are likely to be assembled onshore and transported to the site for installation using a barge. Medium-voltage cables will be used for electricity transport from the turbine to the transformer on site, or the Electric

Service Platform (ESP). High-voltage cables will transport the energy to shore using high voltage AC. Cables may be buried depending on other marine uses. Cable-laying vessels will use a jet-plow technique that buries the cable one to three meters into the seafloor (MMS, 2007).

3.3 Operation

WTGs are designed to require no on-site personnel. All monitoring of the offshore arrays are done using a supervisory control and data acquisition (SCADA) system from an onshore location. Remote monitoring will acquire information related to electrical systems (power, voltage, frequency), climate (wind speeds, temperature, humidity, wind direction), and the turbine itself (acoustics, temperatures, particulates, transformer gases) (DOE, 2012).

Maintenance and service activities require technicians to visit the site two to five times per year for each WTG. These activities can be classified into two categories: work that requires only personnel to be present and work that requires to use of large marine vessels. The important differentiation is that large marine vessels require the use of ports that can accommodate larger drafts. General maintenance technicians will be transported by small vessel or helicopter, depending on weather conditions. These small vessels can in most harbors (DOE, 2012).

Service of the WTGs will occur predominantly in the summer months when wave heights are lower. Some planned maintenance activities include testing fog horns, changing carbon brushes, replacing defective instruments, cleaning lenses, torqueing bolts, replacing hazard warning lights, and changing filters. Major repairs involve replacement of large parts of the WTG such as turbine blades, the hub unit, the main drive shaft, the gearbox, or the entire nacelle (DOE, 2012)

Periodic inspections are required by BOEM in order to ensure structural, worker, engineering, and environmental safety. Scour protection around the monopile foundations must be visually inspected to ensure that no erosion or other deterioration is occurring, especially in the first year (DOE, 2012).

3.4 Decommission

After the wind facility has reached the end of its life, BOEM requires the structures be removed. Removal requires that all structures and devices be dismantled, transported back to shore, and properly disposed of or recycled. The first major components of concern are the inner-array cables that connect the WTGs. They must be disconnected and removed from the seabed. The WTGs would then be drained of lubricating fluids per operations and maintenance

procedure before being dismantled and recycled onshore. All foundations would then be removed to a depth of 15 ft. (4.6 m). Scour protection mats are also removed via crane and recycled onshore (DOE, 2012).

3.5 Port Staging and Transportation

Since there are currently no existing offshore wind energy facilities in the United States, staging construction requirements are based on the experience of European offshore wind facilities and offshore petroleum facilities in the U.S. Gulf of Mexico.

Most turbine components are manufactured and shipped separately of each other, although there may be some overlap. Most rail and truck delivery options are limited to the aggregate used for scour protection or sectional pieces. Fully assembled foundations are too large in size and unable to be transported by rail or truck (Tetrattech, et.al. 2010).

The wind turbine construction staging sites do not necessarily have to be staged from the same facility where offshore foundation deployment will occur. While it may be more convenient to keep the staging areas in close proximity of one another, it is important to determining the most cost effective method for logistics, assembly, storage space and handling needs. In certain circumstances, one way to minimize handling needs is to store fully assembled foundation on barges and tug the barges to the installation sites (Tetrattech, et.al. 2010).

There is a range of options for turbine transport from the staging port and installation site, and the turbines can be at various stages of assembly. Turbines can be fully assembled at the staging port, considered a more controlled environment, and transported in an upright position to the wind farm site for installation. Another option less risky than transporting fully assembled turbines is to assemble the turbines at the installation site. This method does have risks associated with the nature of the marine environment (Tetrattech, et.al. 2010).

Port and support needs for offshore wind energy operation and maintenance are generally smaller scale than the needs of commercial shipping. Port requirements and vessel requirements for operation and maintenance of offshore wind energy facilities are comparable to those existing for commercial fishing operations, offshore LNG ports, and petroleum platforms (Tetrattech, et.al,2010).

3.5.1 Vessel Constraints and Requirements

A port and infrastructure analysis prepared for the Massachusetts Clean Energy Center (MCEC) identified basic characteristics, capabilities, limitations, and general availability of vessels that are currently available for use in the construction and maintenance of offshore wind farms. Turbines are generally shipped aboard open hatch cargo vessels in pieces (tower

sections, nacelle, hub, individual blades) from their manufacturing facility directly to the project staging site. Jack-up crane vessels or floating derrick barges can be used for delivery and installation of foundations. Leg-stabilized jack-up crane ships, jack-up crane barges, and jack-up crane ships have all been used in wind turbine installations in Europe. All three vessels are limited by 15 to 20 knot winds speeds. Leg-stabilized jack-up crane ships are additionally limited by 1.7-foot seas, and the jack-up barges and cranes are limited to 5-foot seas with the cranes able to operate under higher sea states once the vessel has been jacked-up. Maintenance access to wind farms is usually done via crew boat or helicopter (Tetrattech, et.al., 2010).

Physical conditions in which vessels must operate at offshore wind farm sites, size and weight of the wind turbines being installed, and methodology for transport and installation of turbines all factor into the overall suitability of the port for use as a staging facility (Tetrattech, et.al., 2010)..

Installation vessels are subject to the Jones Act, requiring vessels engaged in the transport of passengers or cargo between U.S. places to be built and flagged in the United States, and owned and crewed by U.S. citizens.

Turbine installation and transport vessels must consider beam, length, draft, and vertical clearance dimensions. The beam of installation and transport vessels is largely dictated by stability requirements of the vessel during transit and, the stability requirements and structural strength while jacked up elevations. The vessel's length is dependent on functional and cargo requirements and structural considerations. Hull form and total weight, including cargo help determine the vessel's required draft, or the required clearance between the waterline and sea bed. Vertical clearance requirement is dictated by three factors: length of legs for a jack-up barge or vessel, the methodology chosen for assembly, and crane height in the stowed position (Tetrattech, et.al., 2010).

One developer report used for the MCEC report describes the ideal staging port facility to support offshore wind as a port with a 1000-ton crane on rolling tracks, with the ability to carry components from a delivery vessel to a storage location; sufficient linear footage to efficiently load/unload one vessel at a time, with a preference for multiple deepwater berths to unload several vessels simultaneously; a secondary 80-ft berth; and about 200 acres for assembly and storage (Tetrattech, et.al., 2010).

3.5.2 Physical Conditions for Turbine Staging

Staging of offshore wind farm development requires several physical requirements of port characteristics, including:

- Minimum 24-ft depth of water at low tide;
- Minimum 450-ft berth;
- Minimum horizontal channel clearance to harbor of 130 ft;

- No restriction or air draft limitation on vertical clearance (in anticipation of a future need to transport fully assembled turbines to the installation site); and
- Minimal distance in open water to project site (Tetrattech, et.al., 2010).

Harborside, water depth, horizontal clearance, and vertical clearance requirements will be determined by type of vessel used and assembly methodology. Landside, the port facility must have space to accommodate laydown for delivery, storage and assembly of turbine components (Tetrattech, et.al., 2010).

A complete analysis of port infrastructure at the Port of Wilmington and Port of Norfolk, VA is needed to determine the full capability of staging needs for offshore wind staging. Trends toward production of larger scale components such as increased blade lengths taller towers have the potential to complicate this process.

4. Turbine Output, Organization and Connectivity

Wind turbines are engineered to generate varying capacities of energy. Manufacturers measure the maximum capacity of their wind turbines to produce electric power in megawatts (MW). One MW is equivalent to one million watts. The production of power over time is measured in megawatt-hours (MWh) or kilowatt-hours (kWh) of energy. A kilowatt is one thousand watts. Production of power at the rate of 1 MW for 1 hour equals 1 MWh of energy (wind-watch.org).

4.1 Energy Output Analysis

Turbines used in offshore wind farms typically range from the 1.6MW-3.6MW capacities with recent farm proposals using 5MW turbines, and there have even been tests for turbines as large as 8MW. Offshore wind farms, however, do not operate at one hundred percent capacity all the time due to many different factors that can interfere with the machine's performance. One factor to account for array losses or decreased energy yield is wake effect (Schlez, et.al., 2014) (Figures 4.1-4.2).

Figure 4.1: Wake structure

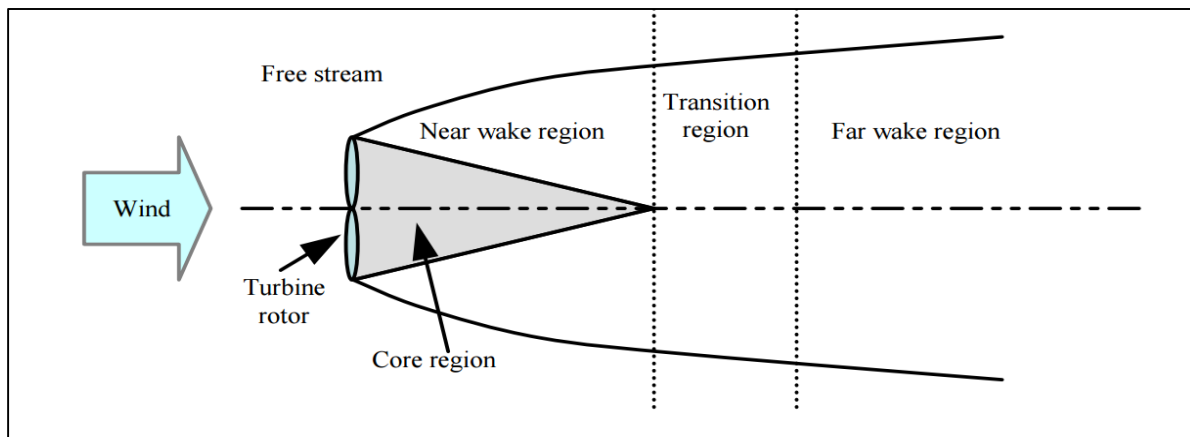


Figure 4.2: Wake effect



<http://www.boggawind.com/vision.html>

The wake effect, or downwind effect, occurs in commercial turbines where upwind turbines create wind wakes that impact the natural wind flow to adjacent downwind turbines. The wake effect causes the downwind turbines to experience diminished energy production. In some cases, the wake effect can also cause increased mechanical loads as well (Diamond & Crivella, 2011).

The term “wake effect” originates from the wake behind a ship. Wind turbine wakes are long trails of turbulent wind exiting the turbine with diminished wind speed. Far upstream from a wind turbine, the air that is traveling at natural velocity and unaffected by wake is the freestream. As wind flows through a turbine, the volume of air downwind of the turbine has lower wind speed and higher turbulence than wind in the freestream. Turbines generate power by converting the kinetic energy in wind into electricity and the wind exiting a turbine contains less kinetic energy than it does before it passes through a turbine. The diminishing kinetic energy from the wake effect in the wind downstream results in a decrease in overall energy output of turbine downwind (Diamond & Crivella, 2011).

There are many complicated factors that have an impact on the size, magnitude and wake rose shape a turbine creates. These factors impact the wind speed, turbulence and

atmospheric stratification above and around the turbine. Atmospheric changes, relative humidity, temperature and wind velocity may impact the size and magnitude of wakes. Design specifics such as blade length, pitch and angle at which the blade is attached to a wind turbine can significantly impact wake formation as well. The pattern a wake forms, or the “wake rose” (Figure 4.3), is in a corkscrew like pattern and is heavily influenced by turbulence (Diamond & Crivella, 2011).

Figure 4.3: Wake Rose



<http://waubrafoundation.org.au/resources/wake-effects-wind-turbines-danish-wind-industry-association/>

Turbine wake can adversely impact individual turbines downwind and the magnitude of the impact depends on the rotor size of the turbines and the spacing between the turbines. The further away a downwind turbine is located from an upwind turbine, the less impact the downwind turbine experiences. The decay in a wake is a function of the distance behind the turbine generating the wake. The downwind wake effect from an individual turbine can continue for a minimum distance of eight to ten times the turbine’s rotor diameter and can persist even longer in offshore settings with low turbulence.

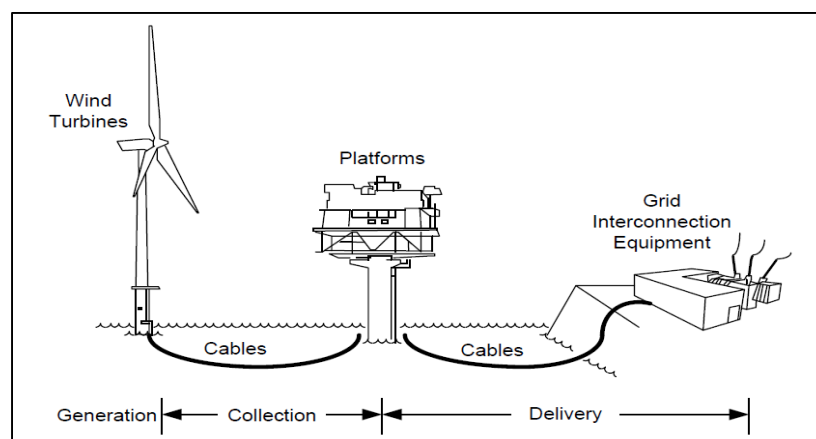
To maximize energy output and decrease array loss due to wake effect, turbine spacing must be carefully considered. The newest large arrays typically use turbines with rotor diameters of about 300 feet, spacing the turbines about seven rotor diameters apart. A report from Johns Hopkins University released a few years ago suggested wind turbines be spaced fifteen rotor diameters apart for more cost-efficient power generation. High-performance computer simulations and wind tunnel experiments revealed the energy generated in a large wind farm has “less to do with horizontal winds and is more dependent on the strong winds that the turbulence created by the tall turbines pulls down from higher up in the atmosphere.” Correct spacing helps to alter the landscape to create turbulence, stirring the air and drawing more kinetic energy from higher altitudes (Science Daily, 2011). Research from the University of Delaware has suggested that the tight grid layouts of existing arrays reduce power generation,

but efficient spacing or staggering turbines can significantly increase their capacity factor (Marcacci, 2013).

4.2 Utilization and Connectivity

To utilize energy produced by offshore wind resources, the energy generated must be introduced into the onshore transmission grid. There are three processes needed to accomplish this: generation, collection, and delivery (Figure 4.4).

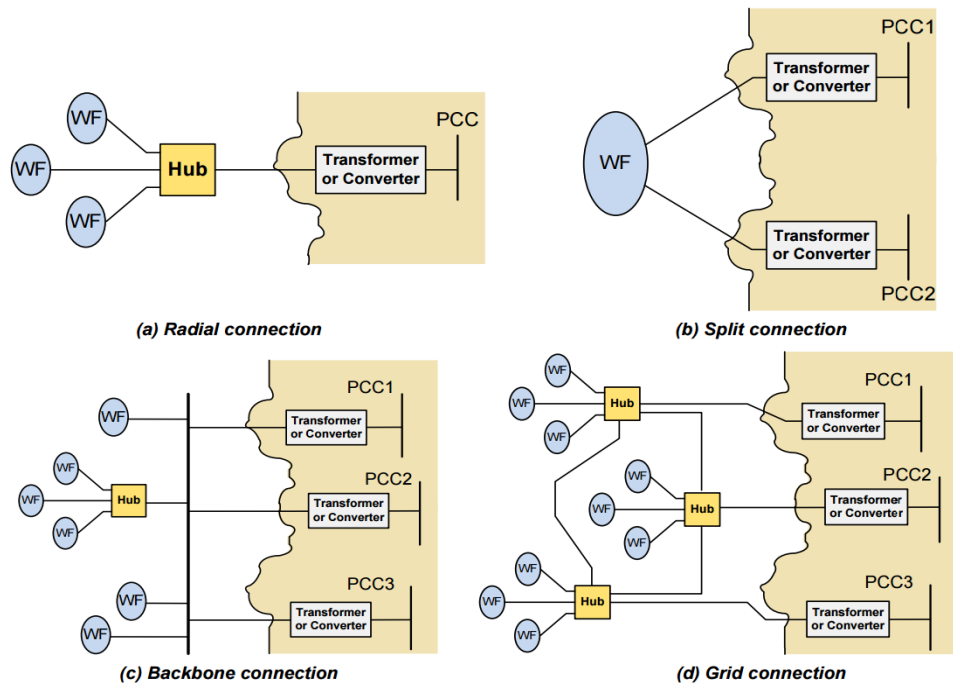
Figure 4.4: Generalized concept for an offshore wind energy system (NOWEGIS).



The wind turbines used today operate using a doubly-fed induction generator (DFIG) or an induction generator behind a full AC-DC-AC converter. Other generators and design alternatives are available, but less commonly used. With each of the three processes of the offshore energy sections, operation of an alternating current (AC) or direct current (DC) must be considered. There are technical options that would allow for the use of a DC network for energy collection, but most energy collection systems are operating using AC (Daniel, et.al., 2014).

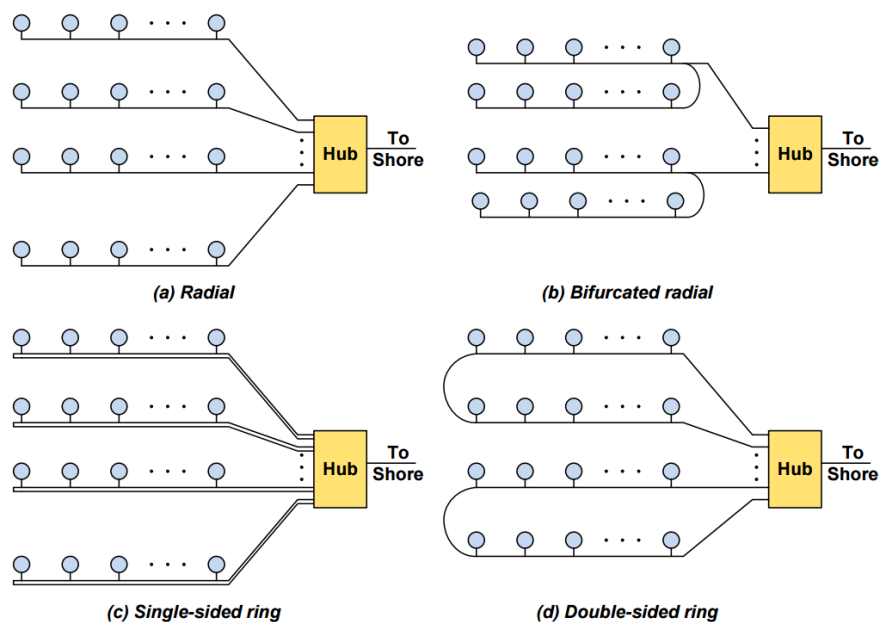
There are four offshore wind farm delivery system options: radial connection, split connection, backbone connection, and grid connection. Offshore wind farms typically use radial feeder collection systems. Radial and split collection systems can be implemented with either high voltage AC (HVAC) or high voltage DC (HVDC) technologies and it is anticipated that backbone and grid delivery systems would be developed based on HVDC technologies (Daniel, et.al., 2014) (Figure 4.5).

Figure 4.5: Offshore wind farm delivery system options (Daniel, et.al., 2014).



There are also four offshore wind farm collector system options: radial, bifurcated radial, single-sided ring, and double-sided ring. Ring topologies have a higher reliability with a 50 percent difference in the estimated expected energy not supplied (Daniel, et.al., 2014) [Figure x].

Figure 4.6: Offshore wind farm collector system options (Daniel, et.al., 2014).



Offshore radial connections are the least expensive to connect to shore, but can be problematic in high wind generation conditions. Backbone structures are more reliable and HVDC backbone systems have greater flexibility than HVAC backbone systems. Grid systems are even more reliable offshore, but when using HVAC with both grid and backbone systems longer connections between platforms increase due to requirement of reactive compensation equipment. HVDC systems show greater flexibility than HVAC systems because of their ability to control the power flow both on and offshore. When determining the best delivery and collector system options long- and short-term costs will drive which system will work best for the WEA (Daniel, et.al., 2014).

The northern coast is in the service territory of Dominion Power would require connecting to the PJM Regional Transmission Organization System and would not be able to accommodate significant offshore wind generation without significant systems upgrades. Capability without upgrades is estimated to be 10 MW. In the southern coast of North Carolina, the service territory of Duke Energy could accommodate up to 250 MW of offshore wind generation without major transmission upgrades (Efland, 2009).

5. Environmental Impact

5.1 Introduction

In order to assess the environmental impacts of offshore wind energy production, the following questions will be answered: How does offshore wind affect the environment off the coast of North Carolina and will there be any onshore environmental impacts due to such energy production? Specifically, how does offshore wind affect each individual sector of the environment?

This chapter will synthesize data accumulated from a variety of sources in order to assess the environmental impacts of four phases of a wind facility project: site assessment, construction, operation, and decommissioning/ abandonment. Due to the current lack of completed offshore wind energy projects in the United States, some of the literature will come from wind projects abroad where successful offshore farms are in operation. Additionally, the Bureau of Ocean Energy Management (BOEM) has compiled numerous studies related to the potential sites for wind energy production off the coast of North Carolina. It is through these projects that we will obtain measured information related to the environmental impacts that offshore wind energy production can create. Additionally, research conducted by local professionals in the field of fishery management, oceanography, marine biology, and ecology were utilized to gain a clearer understanding of the current environmental state off the coasts of North Carolina.

Many of the fauna categories that will be evaluated have legal status, either with organizations such as the International Union for Conservation of Nature and Natural Resources (IUCN) list status. More specifically, fisheries have many stakeholders in North Carolina, including watermen, recreational fishermen, legislature, fish markets, local consumers, and tourists. Birds have also been a source of controversy because of the potential for birds to strike the turbine blades. Many organisms fall under more than one legislation. The National Marine Fisheries Service (NMFS), a department within the National Oceanic and Atmospheric Administration (NOAA), protects species listed under a variety of acts, such as the Marine Mammal Protection Act and the Endangered Species Act. Other relevant legislation include the Magnuson-Stevens Act, the Migratory Bird Treaty, the Coastal Zone Management Act, and the National Historic Preservation Act.

This analysis is not a full EIS or EA, but it does attempt to synthesize existing data to form a clear idea of the short and long-term impacts this project can have on North Carolina and the OCS.

5.2 Environmental Impacts

Preliminary analysis by BOEM identified seventeen resources that will be affected by Atlantic G&G activities: benthic communities, marine mammals, sea turtles, marine and coastal birds, fisheries resource and Essential Fish Habitat (EFH), threatened and endangered fishes, sediments, air and water quality, physical oceanography, and meteorology (BOEM, 2014b). This analysis will focus on the environmental impacts to benthic resources, marine mammals, air and water quality, birds and bats, coastal habitats, sea turtles, and essential fish habitat and finfish.

The environmental impacts of each phase of the project are evaluated on a four-level classification system that is used by BOEM and has been adapted for this analysis. Impacts are described at negligible, minor, moderate, or major (BOEM, 2015).

Negligible	No measurable impacts.
Minor	Most impacts on the affected resource could be avoided with proper mitigation. If impacts occur, the affected resource would recover completely without any mitigation once the impacting agent is eliminated.
Moderate	Impacts on the affected resource are unavoidable. The viability of the affected resource is not threatened although some impacts may be irreversible, or the affected resource would recover completely if proper mitigation is applied during the life of the project or proper remedial action is taken once the impacting agent is eliminated.
Major	Impacts on the affected resource are unavoidable. The viability of the affected resource may be threatened, and the affected resource would not fully recover even if proper mitigation is applied during the life of the project or remedial action is taken once the impacting agent is eliminated.

Table 5.1: BOEM Classification System (BOEM, 2015).

5.2.1 Site Assessment and Characterization Phases:

Site characterization activities include biological surveys and G&G action taken within the lease zones. Site assessment activities include the deployment, construction, operation, and decommissioning of meteorological towers and buoys. The environmental impacts of these two activities will be evaluated. The factors that pose the most impact during this phase are: site surveying, pile driving, and vessel traffic and dumping.

5.2.1A Benthic Resources

The Benthic, or bottom, community is an important part of the marine ecosystem. Often the community is overlooked in environmental impacts due to the small size of many benthic organisms. However, small does not mean insignificant. Many benthic organisms provide a vital role at the bottom of the food chain.

Site characterization activities are anticipated to have **negligible** impacts on benthic communities. Bottom sampling activities could result in localized crushing or burial of benthic fauna. Sensitive benthic communities such as hard/live bottom areas, deep-water corals, and chemosynthetic communities will be avoided. Figures 12.5.4 – 12.5.6 in the Appendix show hard bottom habitat in the three WEAs. Impacts of trash and debris will have a negligible impact on benthic communities with adequate compliance with USCG and EPA regulations. Accidental deposition of trash is anticipated and may sink to bottom communities. Fuel spills from survey vessels could occur accidentally. USCG statistics anticipate spill volume from survey vessels falling in the range of 1.2 to 7.1 barrels. A small spill such as this is expected to disperse on the surface, never reaching the seafloor. Accidental fuel spills would cause negligible impacts on benthic communities (BOEM, 2014b).

Site assessment activities are expected to be **negligible to minor**. Contact with anchors, driven piles, and scour protection has potential to crush or smother benthic resources at a maximum radius of 1,500 feet around structures. Recovery of communities from adverse effects would take one to three years.

5.2.1B Marine Mammals

During site characterization activities, marine mammals will be most affected by noise generated from vessels, aircrafts, and surveying techniques. HRG surveys typically use electromechanical sources like side-scan sonars and sub-bottom profiling. These survey methods are only detectable at close range and produce sounds that exceed the hearing range of marine mammals. Under NMFS criteria for Level A and Level B harassment, little to no Level A harassment would occur. Level B harassment, or impacts to behavior, are the most likely. NAWRs migrate past North Carolina during the winter and summer months. By limiting impact activities to occur between April 30th and November 1st, impacts on NARW and other marine mammals will be avoided. Overall, impacts to marine mammals from site characterization surveys will be **negligible to minor** (BOEM, 2014b).

Site assessment impacts could include underwater noise from pile driving for meteorological tower foundations, loss of habitat that could affect prey abundance and distribution, and effects from decommissioning of data collection devices. Pile driving can be completed using an impact hammer or a vibratory hammer. The underwater acoustics generated from pile driving is measured as sound pressure levels (SPLs) and is reported as the root-mean-square (RMS) acoustic pressure in micropascals (or dB re 1 μ Pa). Impact hammers

have been shown to create SPLs at a maximum of 200 dB re 1 μ Pa at bandwidths that range from 20Hz to greater than 20 kHz. These types of sounds are pulsed and can have different effects than non-pulsed sounds (Madsen et. at., 2006). The NMFS regulated underwater acoustics at maximum sound pressure levels of 180 dB re 1 μ Pa (RMS) for cetaceans and 190 dB re 1 μ Pa (RMS) for pinnipeds (NMFS 2003), levels at which Level A harassment or behavioral disturbances are likely. Vibratory hammers will vibrate the pile causing movement of sediments which enables the pile to penetrate the seafloor. SPLs for vibratory hammers can be greater than 180 dB but is spread out over time causing levels to be lower than impact hammers by a magnitude of 10 to 20 dB. The underwater acoustics of both impact pile driving and vibratory pile driving can be affected by the pile types, pile sizes, and environmental characteristics. Level A harassment is expected if marine mammals are within 1000 meters of impact pile driving activities or within 10 meters of vibratory pile driving and Level B harassment will occur if the animals are within seven kilometers (four miles). Vibratory pile driving has a much smaller range of effect than impact pile driving (BOEM, 2015).

As such, BOEM requires a 1000 meter exclusion zone around impact pile driving activities and a observation vessel circling at 500 meters to prevent marine mammals from entering the area. Pile driving activities are also prohibited between November 1st and April 30th due to NARW migration. Effects of pile driving activities to marine mammals outside the exclusion zone are expected to be **negligible**. Should an animal come within the noise producing area, impacts would be **moderate** (BOEM, 2015).

In terms of loss of habitat, meteorological towers and buoys would take up water column space that would otherwise be viable habitat. By requiring animals to avoid the structures, a change in behavior occurs. However, marine mammals are extremely mobile and loss of habitat relative to total habitat is small. Impacts of habitat loss are expected to be **negligible** (BOEM, 2015).

The construction, operation, and decommissioning of towers and buoys may cause other impacts, such as suspension of sediments or changes in prey abundance around the foundation of the towers. These additional effects to marine mammals are expected to be **negligible**. Effects of collisions with right whales due to increased vessel traffic will be **minor** to **moderate** depending on the likelihood of injury or mortality. Possible fuels spill from vessels could result in **negligible** to **minor** impacts depending on size and dispersal of the spill (BOEM, 2015).

5.2.1C Air Quality

Under the EPA 1970 Clean Air Act, National Ambient Air Quality Standards (NAAQS) list “criteria” pollutants as air pollutants that are anticipated to be dangerous to public health. Those pollutants are carbon monoxide, nitrogen dioxide, lead, ozone, sulfur dioxide, and particulate matter. Activities that may have an impact on air quality include onshore

vehicle emissions, vessel emissions, and emissions from diesel engines on meteorological towers and buoys. These emissions include the CAA criteria pollutants and greenhouse gas emissions. Site characterization and assessment activities are expected to have **minor** impacts on air quality with no violation of NAAQS (BOEM, 2015).

Activity	CO	NO _x	OC's	M10	M2.5	SO _x
Site Characterization Surveys	3.50	37.99	.46	.07	.07	3.74
Site Assessment: Construction of Meteorological Towers*	0.36	2.11	.43	.14	.14	0.20
Site Assessment: Operation of Meteorological Towers	4.03	22.04	.85	.47	.47	1.64
Site Assessment: Decommissioning of Meteorological Towers*	0.36	2.75	.44	.16	.17	0.27
Sum of emissions from all sources	8.26	64.89	.16	.85	.85	5.86
<p>*Also serves as a conservative (high) estimate for construction, deployment, and decommissioning of meteorological buoys and equipment.</p> <p>CO = carbon monoxide, NO_x = nitrogen oxides, VOCs = volatile organic compounds, PM10 – particulate matter with aerodynamic diameters of 10 microns or less, PM2.5 = particulate matter with aerodynamic diameters of 2.5 microns or less, SO_x = sulfur oxides</p>						

Table 5.2: Air Pollutant Emissions (Tons Per Year) in a Single Year (BOEM, 2015).

5.2.1D Water Quality

Coastal and marine waters that could be affected by site assessment and characterization activities include; ports/harbors and rivers, bays, estuaries, state territory waters within three nautical miles of the coast, and waters inside or near the proposed WEA on the OCS.. Activities that have the potential to affect water quality are: drilling, coring, bottom sampling which increases turbidity, discharge of bilge and ballast water, discharge of sanitary/domestic wastewater, and any accidental fuel or maintenance material spills (BOEM, 2015).

The EPA in the 2012 National Coastal Condition Report IV rated the water quality of the coastal waters of North Carolina based on levels of dissolved oxygen, chlorophyll a, nitrogen, phosphorus, and water clarity. Sediment quality was also evaluated and is graded on sediment toxicity, sediment contaminants, and total organic carbon. Ratings are given on a scale of good, fair, or poor. NC coastlines were given a fair to poor rating for both water quality and sediment quality (EPA, 2012).

Site characterization activities are expected to have **minor** impacts. While increased turbidity is likely, due to bottom sampling, drilling and coring, it would occur locally and would not be long-lasting. Vessel discharges are heavily regulated by the USCG and should not affect water quality. Site assessment activities will also disturb the sea floor but effects will be temporary and local. Fuel spills are unlikely to occur and effects will be **minor** (BOEM, 2015).

5.2.1E Birds and Bats

Seabirds, shorebirds, and waterfowl have the potential to be affected by site assessment and characterization activities. The impact factors for site characterization include acoustic sounds sources from survey activities, noise from vessels activities, accidental fuel spills, trash or debris. Impacts from the overall activity are expected to be negligible. (SEE G&G DOCUMENT).

In addition to the above impacts, site assessment will also create airborne noises from pile-driving that can cause behavior changes in birds, causing them any impact from slight annoyance to exhibiting escape behavior. This activity would only occur between May and October and is limited to the time require to construct the tower, which it estimated to be three days. Migratory behavior is not expected to be influenced by pile-driving. Birds collision with towers are minimal. In good weather, migratory birds fly at altitudes above the tower but other birds such as sea ducks and loons may make contact with the tower. However, due to distance from the shoreline and the total number of towers, collision are unlikely. Overall effects of site assessment will be **negligible to minor** (BOEM, 2015).

Bat species along the NC coast are not well documented, but existing research from the New Jersey Ecological Baseline Survey indicates that normal behavior does not cause bats to travel into ocean areas farther than 10 nautical miles from shore (NJDEP, 2010). If a bat was present, avoidance and attraction responses to noise and lighting could occur. However, overall effects are expected to be **negligible** (BOEM, 2015)..

5.2.1F Coastal Habitats

The three WEAs are located more than 10nm offshore so construction, operation, and decommissioning activities of data collection devices will not have a direct effect

on coastal ecosystems. The use of ports for site characterization and assessment vessel traffic may have impacts on nearby habitats. Existing ports will not need to be expanded for these new uses and additional vessels will produce very little impact. Overall, effects to coastal habitats will be **negligible** (BOEM, 2015).

5.2.1G Sea Turtles

Five species of sea turtle has been identified in the Mid and South Atlantic planning areas: the loggerhead turtle, green turtle, hawksbill turtle, Kemp's ridley turtle, and the leatherback turtle. All five of these species are endangered or threatened under the ESA. Impacts from site assessment and characterization activities may come from underwater acoustics from vessels, equipment, or activities, vessel traffic, trash and debris, disturbance of the seabed, and accidental fuel spills. Many of the same effects to marine mammals are also applicable to sea turtles. Mitigation procedures for marine mammals will also prove to limit effects to sea turtles. As a result, pile driving is expected to have minor to **moderate** effects to sea turtles, while survey activities will have only **minor** effects (BOEM, 2015).

5.2.1H Essential Fish Habitat and Finfish

Essential fish habitat in the Mid and South Atlantic planning areas has been identified for the species list in Table 12.5.1 in the Appendix (BOEM, 2015).

Site characterization activities within the program area are expected to produce active acoustic sound sources, vessel and equipment noise, and seafloor disturbance. All of those are expected to have **negligible** impacts to EFH and finfish (BOEM, 2014b).

Construction, operation, and decommissioning of meteorological towers shows additional impacts. BOEM outlines numerous studies which show the effects of underwater acoustics on marine fish. Fish are able to detect the motion of the sound waves. Bony fish that have air bubbles within the inner ear are also more likely to detect the pressure waves from sound sources. Potential noise impacts on fish are physical damage, generalized stress, and/or changes in behavior (BOEM, 2015).

Normal behaviors of fish could be disturbed should pile driving activities proceed with no mitigation efforts. However, with soft-start pile driving, impacts to fish are expected to be **negligible**. Construction of towers may temporarily suspend some sediments, and operation may involve a local increase of species around the hard surface of the tower. Impacts to habitat and prey abundance/distribution around the sites are negligible. Decommissioning of the meteorological towers may involve noise from removal of pilings, but impacts are predicted to be **negligible** (BOEM, 2015).

The smalltooth sawfish and the Atlantic sturgeon are federally listed species that may exist within the planning areas. As the Atlantic sturgeon is only found in the OCS during the fall and winter when pile driving is prohibited, site assessment activities are not likely to adversely affect this species. Additionally, the smalltooth sawfish has not been sighted offshore of NC recently, though its historical range extends to Long Island. Using mitigation procedures, effects to these listed species are expected to be **negligible** (BOEM, 2015).

5.2.2 Construction Phase

The construction phase poses the most potential for impact. During the construction phase, the impact factors with the most impact to the evaluated sectors are: pile driving, vessel traffic, and vessel dumping. Pile driving, while a factor in site assessment activities, is conducted on a much greater scale during construction. The noise and turbidity it creates in the water column appears to pose the greatest threat to marine organisms and habitat.

5.2.2A Bottom Community

Both infaunal and epifaunal benthic organisms will be impacted by construction operations. Infaunal organisms live in the sand and epifaunal organisms live on top of the sand. During construction, habitat would be lost due to sediment removal. Impacts to the benthic community will vary based on the length and intensity of the disturbance (Gill, 2005 and Warwick & Clark, 1991). However, there is potential for recolonization after the construction operations cease. . Much of this information is based off of benthic disturbance due to trawling, and how the benthic community recovers after fishing has stopped (Gill, 2005). Additionally, the type of substrate being removed would also impact the speed of recovery. In soft sediments, there is more biota, but the recovery time is faster. On hard substrates there are less organisms, however, they take longer to recover. Studies have shown that the fauna composition after construction of the turbines is up to 85 percent similar to reference sites, within only three months (Daan et al, 2009). This indicates that there are low short term impacts of offshore wind construction on benthic communities.

Also, the piles may provide additional hard substrate for many organisms to utilize for habitat or shelter. Studies examining the recruitment of organisms onto the turbines found that 80 to 100 percent of the submerged turbine was covered in sessile animals such as anemones, mussels, and tube worms (Lindeboom et al 2011).

Construction of offshore wind turbines also re-suspend sediments which can settle in another area smothering organisms not directly in the construction area. Some organisms will be able to burrow themselves out of danger, though there will still be an impact. Due to the sedimentation and the smothering of small benthic animals, trophic effects may occur, limiting

food availability for more predatory organisms higher in the food chain. Overall, the impacts on the benthic community would be **negligible**.

5.2.2B Birds

There is limited information regarding how birds will be affected by the construction phase of the wind turbines. It is assumed that the construction phase will have similar impacts to the site assessment phase. Noise generation may deter birds from the area, which could reduce survivability if the area is rich with food resources or causes them to expend excessive energy to avoid the area. Overall, there is a low risk of bird impacts during construction and the impacts would be negligible (BOEM, 2007).

5.2.2C Marine Mammals

Pile driving during construction produces low frequency sounds that are similar to the North Atlantic right whale, blue whale, humpback whale and fin whale acoustics. This could be disorientating for the whales and drown out their communication or impact feeding behaviors (Bailey *et al.*, 2014). Constructing the foundations of the turbines and cable laying produce noises up to 260 dB re: 1uPa and 178 dB re: 1uPa respectively (Gill, 2005). These noises have been found to be at frequencies that may damage marine mammals if they are within 100 meters of the source (Lindeboom *et al.*, 2011 and Gill, 2005). However, there was also area avoidance of at least 40 km by pinnipeds (Lindeboom *et al.*, 2011). Based on that research, avoidance may also happen in other types of marine mammals. Level B impacts are the most likely type of disturbance for the construction phase. Minor amounts of Level A harassment will be incurred if noise levels are high when marine mammals are in the direct vicinity.

Mitigation, such as incidental take permits and utilizing spotters to search the area for marine mammals, will reduce the impacts. Additionally, utilizing acoustic devices as deterrents for marine mammals can significantly reduce damaging impacts on their hearing during pile driving (Edren *et al.*, 2009).

5.2.2D Fishes

Some fishes have been found to be impacted by certain frequency sounds underwater (Gill, 2005). These impacts are at greater than 150 dB and generally result in the fish being startled (Blaxter *et al.*, 1981). Some fishes may be able to hear construction noises from up to 80 km away from the site. Generally speaking, fish species should respond with an avoidance behavior that should not impact them in the long term (Thomsen *et al.* 2008).

5.2.3 Operation Phase

During the operation phase, the impact factors with the most impact to the evaluated sectors include: collisions with the structures, electric and magnetic fields created by underwater cables, and WTG noise generation.

5.2.3A Benthic Resources

After the piles are installed, the bottom fauna should recover somewhere between months and years after the disturbance, depending on the system (Gill, 2005). Once the fauna has reestablished, the operational phase should actually provide benefits for the benthic community and other fouling organisms. The matrix of offshore wind turbines provides structure that sessile organisms can attach to (Wilhelmsson and Malm, 2008). Studies have shown that within three months of construction of the turbines, the fauna composition is up to 85 percent similar to the undisturbed reference sites (Daan et al, 2009). However, the assemblages are not exactly the same to natural structures in the water (Wilhelmsson and Malm, 2008).

5.2.3B Birds and Bats

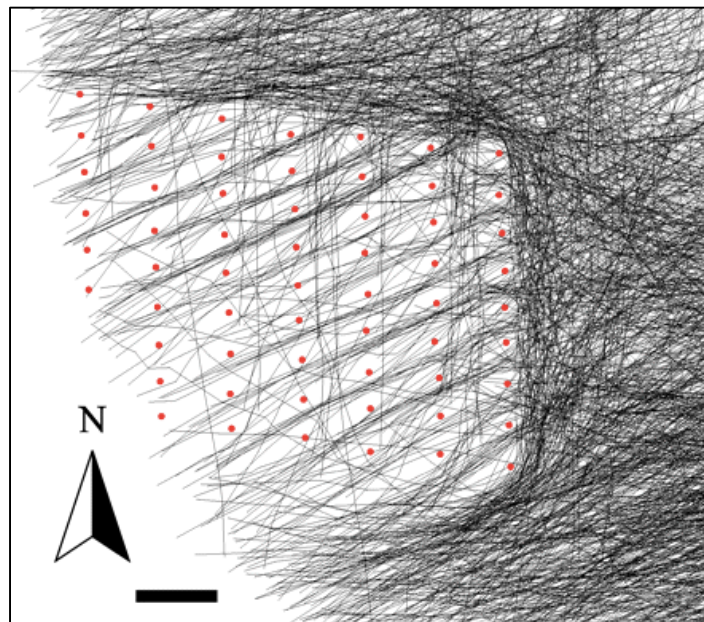
Historically, birds and bats have been impacted by onshore wind turbines. Seabirds could be impacted by collisions with moving turbine blades. Shorebirds, pelagics, and waders are at risk of collision with the wind turbines. The 5 MW turbines stand at approximately 100-125 meters tall with a blade length of approximately 75 meters. There is only about 22-40 meters of clearance between the bottom of the turbine blade at its lowest point and the water level. Most bird species fly in a range of 0-200 meters, which is within the turbine height (Exo *et al.* 2003).

The Atlantic Flyway is a common migratory route for many bird species. Care should be taken to identify where popular migration routes for offshore birds are located. Additionally, the greatest risk of impact is at night or in poor visibility areas. Some species of birds, such as the passerines, are drawn to the lights that will be required on the wind turbines (Fox *et al.* 2006 and Exo *et al.* 2003). Desholm and Kalhert (2005) found that there is some risk of avian collision after the initial construction, but geese and ducks learn to distance themselves from the turbines, by using the corridors as flight paths. Less than one percent of the studied population of birds, geese and ducks, migrate near enough to the turbines to be at risk of collision (Desholm and Kalhert, 2005). The turbines in this study were only 2.5 MW turbines and are smaller and closer together than the 5 MW turbines being proposed in the Mid-Atlantic. Therefore, it can be extrapolated that, at least this type of bird population, would have negligible risk of collision. Other estimates, based on onshore wind turbine data, conclude that

the death rates for birds would be between one and ten birds per MW of turbine per year (Snyder and Kaiser, 2009).

Despite the concern over collisions, some impacts on birds may be positive. Cormorants were discovered using the turbines as resting platforms and feeding in the areas around the farm (Lindeboom et al 2011). This is not surprising given the fish that the birds are likely feeding on will aggregate near the turbine fields as well. Though at the same time, the fish aggregation may cause some birds to be attracted to the area, which may increase collision impacts. Depending on the species of bird, some deflect their flight patterns and avoid the area completely, while others are found within the area of the farm feeding (Lindeboom et al 2011).

Figure 5.1: Flight patterns of birds on offshore turbines (Desholm and Kahlert, 2005).



Erickson *et al.* (2005) compiled data regarding the anthropogenic impacts on birds in the United States. Their findings show that land based turbines account for 28.5 thousand annual bird deaths, however, this only makes up less than 0.01 percent of the total anthropogenic bird mortality in the United States. The research suggests that there are approximately one billion bird deaths per year in the United States. So, although there is an impact on offshore birds, careful consideration of the placement of the turbines should reduce the impact. Additionally, the global impact on bird mortality is a negligible percentage in total annual anthropogenic bird deaths. Bats are unlikely to be affected by offshore wind turbines as their feeding habits are closely tied to the land (BOEM, 2007).

5.2.3C Marine Mammals

Offshore wind turbines make noise during operation. This noise may deter marine mammals from entering the area. Avoidance behavior may impact their feeding or reproduction grounds. Additionally, wind farms may continue to provide additional resources for the marine mammals, as they may actively hunt within the farm area. During the operation phase, there is a limited effect on marine mammals.

5.2.3D Fishes

While operation is occurring, fishes are not likely to be impacted by acoustics in the water (Bailey et al. 2014). Additionally, the cables transmitting the generated electricity may affect species of fishes and other animals, such as sharks and turtles (Bailey *et al.*, 2014 and Gill, 2005). The electric field from the AC cables is shielded, per industry standard, however, the electric and magnetic field may still leak from the DC cables (Gill, 2005). Elasmobranchs are attracted to DC electric fields between 0.005-1.0 uV/cm and avoid them greater than 10 uV/cm (Gill, 2005). Fields in the lower range mimic the electric field put out by some of their prey. Additionally, magnetic fields of over 50 uT, approximately equal to the Earth's natural magnetic field, are detectable by animals within 6 meters (Gill, 2005).

The ecological effect is not well known, but may have impacts on the navigation of animals that depend on the magnetic fields. The field detection area is fairly small so the impacts should be negligible, causing only mild confusion for the animals (Gill, 2005). However, there are already many other cables carrying electricity under the sea and the addition of cables for an offshore wind facility would not significantly increase the impact. It is also worth noting that some fishes have been found to be impacted by certain frequency sounds underwater (Gill, 2005). These impacts are at greater than 150 dB and generally result in the fish being startled (Blaxter *et al.*, 1981).

Not all impacts on fishes may be negative. Some studies have shown that wind turbines act as fish aggregating devices (FADs), which play to the natural behavior of fish to aggregate around objects in the water (Fayram & De Risi, 2007). FADs act as shelter for small fish. The small fishes act as a food source, attracting larger fish, which then attract even larger fish. This would continue up and down the food chain to create a dynamic ecosystem, that is centered around the wind turbines. The turbine matrix combined with the benthic organisms that may colonize the shafts, may create a rich habitat that could support a biodiverse community (Fayram & De Risi, 2007). The offshore wind areas could then be listed as a designated recreational fishing area, which would support the fish populations and the local tourism industry.

5.2.4 Decommission Phase

After the wind facility has reached the end of its life, BOEM requires the structures be removed. Many of the impacts are similar to the construction phase as removal of foundations creates noise and vessel traffic will increase during this activity (Gill, 2005). The difference is that, rather than adding structures, monopiles inhabited by fouling organisms will be removed. Unfortunately, the rich ecosystem they can create will likely diminish, depending upon whether any artificial reef remains after decommissioning. Removing these structures will reduce the amount of hard surfaces and shelter available for animals to occupy, and therefore, there will be a possibility of reducing the biodiversity of the region. BOEM has stated that if there is significant reason for the foundations of the WTG to not be removed, they are willing to allow parts of the foundation to be left intact (MMS, 2007).

5.3 Conclusions

There will be impacts on the environment, as there are with all anthropogenic activities. Though, there are ways to mitigate these impacts. Careful site selection and thorough assessment of the area prior to construction are necessary to ensure minimal impacts. Damages may also be mitigated by utilizing different technologies for wind turbine construction and operation. For instance, some technologies do not require pile driving, which enables them to cause less damage to the benthic zone (Snyder and Kaiser, 2009). Finally, there are mitigation measures the lessee can take during the construction, such as incidental take permits, which will allow a certain number of takes of different animals.

Site assessment and construction will be the most damaging to the ecosystem. However, the ocean is resilient, and many animals will adapt and recover from the initial damage. The operational phase is most dangerous to birds, though they have been shown to avoid the area. Additionally, bird strikes on turbines make up less than 0.01 percent of annual anthropogenic bird deaths in the U.S. and therefore present a relatively negligible effect on global bird populations. For the most part the operation phase is low impact and may provide more benefits in the form of habitat for marine organisms, fish, and birds.

Impacted Sector	Phase			
	Site Characterization	Site Assessment	Construction	Operation
Benthic Resources	Negligible	Negligible to Minor	Negligible to Minor	Negligible to Minor
Marine Mammals	Negligible to Minor	Negligible to Moderate	Minor to Moderate	Negligible to Moderate
Air Quality	Minor	Minor	Minor	Negligible
Water Quality	Minor	Minor	Minor	Negligible
Birds and Bats	Negligible	Negligible to Minor	Negligible	Negligible to Moderate
Coastal Habitats	Negligible	Negligible	Negligible	Negligible
Sea Turtles	Minor	Minor to Moderate	Negligible	Negligible to Minor
Essential Fish Habitat and Finfish	Negligible to Minor	Negligible	Minor	Negligible to Moderate

Table 5.3: All impacts of project phases to each environmental sector.

6. Economic Analysis

6.1 Introduction

The coast of North Carolina holds a wealth of energy resources. Historically, the fields of natural gas, oil, and methane hydrates off of North Carolina's coast have held the attention of those in the energy business; but recently, with an increased focus on conservation and technological development, there may be another efficient energy source waiting offshore. Offshore wind energy holds incredible potential as a clean and relatively efficient energy source. Our current culture and technology has reached a point where offshore wind is considered feasible. As a result, steps are being taken to evaluate different potential wind facility locations off the coast of North Carolina and are being explored for leasing by the Bureau of Ocean Energy Management. However, the question remains as to whether offshore wind energy would be economically advantageous for North Carolina.

There are many different factors involved in the investigation into an offshore wind facility's potential, but the economic impacts of offshore wind energy will be heavily relied upon in the decision making process. Wind energy is cleaner than coal, oil, and natural gas, but is lacking in efficiency and is known to have large capital costs. Advocating for wind energy use is difficult when compared to natural gas, especially considering that a combination of natural gas and nuclear has the potential to entirely replace coal energy production in North Carolina. Offshore wind energy may end up being nothing more than a portion of North Carolina's renewable energy portfolio requirements if its capital costs remain high. A solid study of the potential economic impacts offshore wind might impose upon North Carolina's is necessary to assess its economic viability as a potential REPS addition. .

Economics play a significant role in the eyes of policymakers, investors, and tax paying citizens. The following sections will evaluate whether offshore wind is an advantageous economic investment for the use of our coastal resources or as a future energy source for the region.

6.2 Methodology

The economic viability of an offshore wind project for North Carolina will be evaluated by two common economic analysis methods: the cost-benefit analysis (CBA) and the cost effectiveness analysis (CEA). The CBA will factor into the majority of our evaluation, as it is the more robust of the two analyses. However, the CEA will provide an additional economic perspective which may not be effectively evaluated through a CBA. There are also a few simple

additional calculations conducted for comparison's sake, which are not explicitly part of either the CBA or CEA, but are beneficial to better evaluate and display the economics of offshore wind energy's economic potential in North Carolina.

6.2.1 Cost-Benefit Analysis (BCA)

While a CEA is fairly straight forward, including only concrete economic factors, a CBA can be much more complicated in its evaluative measures. The cause of this complication is primarily due to the notion of standing, which is used to determine the complexity of a CBA. At its simplest, standing is the perspective a CBA takes during the analysis (Whittington, D. et al, 1986). The perspective taken determines which costs and benefits are considered relevant to the project, controlling whether they are included in the overall analysis or not. There are differing perspectives on what should be given standing. Standing may be wide or comprehensive enough to include all parameters. Though, that notion may not be feasible for every analysis. However, it does suggest that anyone who has rights should be considered relevant while conducting the CBA (Zerbe, 1991). In the end, a CBA is only relevant if all parties involved agree over the standing chosen for the analysis (Trumbull, 1990).

In addition to standing, there are other factors included in the Benefit-Cost Analysis, such as discount rates, horizon values, obtuse data, and the projected length of the analysis, which will add to the complexity of the analysis. The analysis will be conducted using the standard growth rate of one percent, discount rates of three and seven percent, and for a period of 30 years after year zero. Using both three percent (the social discount rate) and seven percent (USACE requirement) allows the analysis to evaluate the projects outcome when near future outcome is favored (7 percent rate) or when future outcomes are favored (3 percent rate). The analysis will also take into account a disaster, such as damage from a hurricane occurring in year 15, to see if there is significant impact on the overall BCR. This disaster will be simulated via the half destruction/reconstruction of the total number of wind turbines.

Ultimately, the goal of this analysis is to provide a Benefit-Cost Ratio (BCR) and Net-Present Value (NPV) for each of the considered perspectives to demonstrate which the best option to take is. A BCR of greater than 1.0 is considered positive, indicating the total benefits are greater than the costs. A value lower than 1.0 indicates a project is undesirable from an economic viewpoint, or the costs are greater than the total benefit. As an example, for navigation and flood control projects the USACE usually wants a BCR of greater than 2.5 for ongoing projects and a BCR higher than 3.2 for new projects.

A NPV is simply the sum of the present value of the total costs and benefits discounted over a period of time. A positive NPV is good sign while a negative value is not a good indicator of success for the project. While there is never one correct point of view for an analysis, this study will attempt to be as all-encompassing and comprehensive as possible.

6.2.2 Cost-Effectiveness Analysis

A cost effectiveness analysis (CEA) is designed to determine whether money is being spent in an efficient manner. Its analysis is focused on concrete, known, or easily calculable values. Unlike the BCA, a CEA is not concerned with benefits the project may provide or any values that cannot be reliably monetized. Instead, the CEA focuses on the solid economic factors which alone do not provide a full picture of the project. Its goal is to find the most economically efficient means of completing an objective (EPA, n.d.). As a result, it is considered a limited form of analysis. The CEA will have economic values, but it will be evaluated in a more qualitative manner, as direct comparisons do not show the whole picture. For example, renewable energy sources have high capital installation costs, but have little to no fuel costs. In this instance, a quantitative value comparison may not be adequate or robust enough for an accurate analysis.

Cost Effectiveness Analyses are commonly used in healthcare fields. CEAs are used to determine where money needs to be spent to save the most lives. While the circumstances are different, when discussing offshore wind, rather than medical care, the general functions and principles are the same. Healthcare fields see cost effectiveness as a method of determining where money should be spent to maximize quality of life and health care (Muennig, 2008). If money is spent on one project, it cannot be spent on another. If the United States and North Carolina choose to invest in offshore wind, there will be capital invested that will not be available for other projects. This analysis will help to determine whether investing in offshore wind energy is a good option for North Carolina when compared to traditional energy sources.

The CEA will compare capacity factor, megawatt hours, levelized capital costs, operation and maintenance, fuel costs, and total cost per megawatt hour. The six energy sources compared are natural gas, coal, nuclear, hydroelectric electric, solar, and wind. In order to provide a better comparison to renewable energy sources, fossil fuel based energy sources are assumed to be using the most efficient and clean processes for the fuel type. While it provides a better direct comparison to energy sources, levelized costs may not reflect actual market cost or values for capital costs or energy cost per megawatt hour. Capacity factor for wind is assumed to be 40 percent in order to stay consistent with the cost-benefit analysis.

6.2.3 Data Sources

Data in this analysis were collected by a variety of means. However, the primary method was a literature review. Offshore wind, despite its prevalence in Europe, is still a relatively new technology in the U.S. Subsequently there are very few data when compared to onshore wind and other traditional energy sources. Therefore, comparable onshore wind literature and foreign reports were used to find the most relatable values. United States government agencies were another significant source of data; both the U.S. Energy Information Administration (EIA) and the Bureau of Ocean Energy Management (BOEM) reports were used to identify associated costs for wind projects and for data on other energy sources. Additionally, many private

companies have provided consultation services for state and municipal agencies considering various wind projects. Those reports were used to provide values that were used to represent North Carolina offshore wind as closely as possible. For the CEA, values were obtained from the EIA's 2011 levelized cost report for energy sources, and state energy profiles.

6.2.4 Benefits and Costs

The BCA portion of the economic analysis featured several criteria for benefits and costs. In **Table 6.1** below lists the costs and benefits that pertain to this project. The costs and benefits are organized as a direct or indirect cost/benefit, and then whether that cost/benefit is tangible or intangible. Direct or indirect indicates whether each potential economic value can be directly associated to the project, or if it occurs indirectly from the project. Tangible or intangible refers to whether the benefit or cost can be easily monetized or calculated. Intangible costs/benefits are difficult to determine or calculate. Tangible costs and benefits are therefore more easily included in the analysis. For example, a direct, but intangible, benefit is the potential for the attraction of non-support businesses due to the wind facility being constructed. That value cannot be easily monetized given the number of variables, but studies indicate that it can be a direct result of an offshore wind facilities presence (Jackson et. al., 2014). An example of indirect, but tangible would be results of decommissioning fossil fuel energy facilities. Constructing an offshore wind facility does not require fossil fuel facilities be decommissioned; but decommissioning may become more likely if renewable energy resources become more viable and efficient in the future. The resultant reduction of CO₂ produced can be roughly monetized and will be included in the analysis.

It should also be noted that **Table 6.1** does not represent every possible cost or benefit. There are variables which are not included in this analysis' standing, even though they may contribute to the project, or result from the project's undertaking. Additionally, each variable noted in the table may not be included in the final CBA. Their inclusion will depend on how the values can be monetized and whether they are determined to have a significant impact on the analysis.

Costs				Benefits			
Direct		Indirect		Direct		Indirect	
Tangible	Intangible	Tangible	Intangible	Tangible	Intangible	Tangible	Intangible
Construction	Alternative Use	Real Estate Property Values	Aesthetics	Renewable NRG	Pollution Reduction	Price (Competition)	Hurricane Reduction
Operation and Maintenance	Seafloor Damage	Prices (Competition)	Noise	Fish Habitat	Hurricane Reduction	Econ Growth	
Grid/ Infrastructure	Wildlife	Taxes		Jobs/ Econ Growth	Diversify NRG	Decommission Coal	
Recreation		Lost Jobs (Competition)		Tourism	Business Attraction	Real Estate Property Values	
Disaster		Tourism		Health			

Table 6.1: Costs and Benefits considered and included in the analysis.

6.2.5 Caveats

Utilizing values from related studies, literature review, government agencies, and private organizations, this study attempted to quantify the various intangible factors included in the analysis. However, not all values have solid estimates. Some of them feature little substantiating research or significance, rendering them ineffective data for the analysis. Some of the factors above were primarily the simplest and most readily available data for an offshore wind facility.

More complicated and difficult values are environmental, real estate, tourism, industry, and other intangible cost. While intangibles generally have no established values, these values will be calculated, extrapolated, and estimated to be included in the analysis. Close approximate values can be indirectly calculated by using data from various related sources, such as insurance, real estate, and medical costs, to provide relevant estimates robust enough to be included in an economic analysis (Malpezzi, 2002). Additionally, reports contracted by government agencies and the private sector sometimes contain speculative and projected data that could be obsolete or invalid in the future due to numerous factors.

The economic analysis, in particular will be utilizing some data that may be more dated than ideal due to lack of available resources. Naturally, inflation will be taken into account, but it would be preferred if the values could have been collected and/or calculated in more recent years. For the Cost Effective Analysis, megawatt hours for each energy source was calculated from North Carolina's reported energy production to the EIA during November 2014. This value was then calculated out for the yearly average. This value may be higher or lower, dependent on the megawatt rating of the turbines and number of turbines. Since it is a calculation, it will not take into account seasonal fluctuations in energy production or consumer use.

The biggest caveat is the comparison between Brunswick County, North Carolina and Cape May, New Jersey. The two counties have similar populations and also would be the most immediate area affected by proposed wind facilities. Wilmington East and West are both primarily off the coast of areas which are part of Brunswick County. However, there are difference in the tourism and development of the two counties as a result of their geographic region and resultant population density. Brunswick County averages only 129 people/mi². On the other hand, Cape May County is more than double that averaging 379 people/mi². So, while they are excellent for a generalized comparisons, they are not completely synonymous.

In 2008, Global Insight, a private analytics company, was hired to conduct a cost-benefit analysis of New Jersey's potential for wind energy as a lead up to the State's new Offshore Wind Economic Development Act in 2010. The report studies three different potential wind areas in New Jersey, similar to North Carolina. The Global Insight analysis examined the economic impacts of an offshore wind facility on the communities of Cape May County, Atlantic County, and Ocean County. The study examined several different costs, benefits, and the extent of impact from an offshore wind facility. It examined the indirect economic impacts on those communities as well (Global Insight, 2008). The offshore wind facility's impacts were evaluated

at different distances from shore: 3mi, 6mi, and beyond 12mi. Given the similar population of Cape May and Brunswick Counties, for this analysis we chose to extrapolate the real estate and tourism impacts for North Carolina from its analogous counterpart, Cape May County New Jersey.

Another caveat is the “maximum” turbine estimate. In order to evaluate a more realistic number of turbines, other than of the chosen 100 and the BOEM recommended 200 turbine values for the analysis, a value was calculated based on the leasing plot of Wilmington East. Wilmington East is the largest of the designated leasing areas. Therefore we determined that Wilmington East best location to calculate a realistic number of turbines for this analysis. The number of turbines which could fit in a leasing area was calculated based on the turbine blade diameter and appropriate spacing for maximizing captured wind. These values were determined from the “NREL offshore 5-MW baseline wind turbine” (Jonkman, 2009). The spacing for those ideal turbines was then divided by the plot area determining that the maximum number of turbines for the WEA is 340. While this number is the maximum number of turbines estimated to fit in the plot, the actual number may be less due to a number of factors such as topography, transmission lines, and infrastructure for operations and maintenance.

6.3 Data Analysis

After significant research into the various costs and benefits the several impacts were chosen to be included in the Cost Benefit Analysis. Table 6.1 previously demonstrated the perspective taken for the CBA. While it is preferable to give more values standing, some criteria initially chosen did not possess data reliable enough to be included in the CBA. Also some of the impacts, while able to be calculated, were simply beyond the capabilities of this analysis. The calculations for the costs and benefits featured in the analysis can be seen in Appendix 11.6 There were seven individual CBAs conducted, which are summarized in Table 6.2.

CBA Iteration	Discount Rate	Growth Rate	Disaster	Turbines
CBA 1	3.0%	1.0%	No	100
CBA 2	7.0%	1.0%	No	100
CBA 3	3.0%	1.0%	No	200
CBA 4	3.0%	1.0%	No	340
CBA 5	3.0%	1.0%	Yes	100
CBA 6	3.0%	1.0%	Yes	200
CBA 7	3.0%	1.0%	Yes	340

Table 6.2: The basic components of the seven CBAs conducted in this analysis.

6.4 Results and Evaluation

6.4.1 Cost Benefit Analysis

The results of the seven CBAs are summarized in the following tables. Table 6.3 and Table 6.4 display all of the costs and benefits used in the analysis and their values. The tables will also indicate between “one-off” values and ongoing or recurring yearly values of the project.

Costs (Million of dollars)		100 Turbines	200 Turbines	340 Turbines	Year
One-Time	Turbine Construction Cost	\$1,085	\$2,169	\$3,688	0
	Grid Integration Cost	\$21	\$42	\$71	0
	Property Value Loss	\$549	\$549	\$549	0
	Tourism Revenue Loss	\$4	\$4	\$4	1
	Disaster	\$731	\$1,462	\$2,485	15
On-Going	Turbine Maintenance	\$35	\$70	\$119	1

Table 6.3: Monetary value of the costs in this analysis.

Benefits (Millions of dollars)		100 Turbines	200 Turbines	340 Turbines	Year
One-Time	Construction Jobs	\$478	\$956	\$1,625	0
On-Going	CO ₂ Reduction	\$1	\$1	\$2	1
	Energy Generated	\$65	\$130	\$220	1
	O/M Jobs	\$20	\$40	\$68	1
	Tourism Revenue Gain	\$6	\$6	\$6	2

Table 6.4: Monetary values of the benefits in this analysis.

In Table 6.4, the values associated with Operation and Maintenance Jobs and Tourism Revenue are considered a yearly increase. The assumption is that once a region starts using renewable energy source, it will attract tourism. Additional jobs at the wind facility and additional ecotourism may result of a sustainable green marketing niche for the region would continue to generate additional money for the region year after year.

Additionally, property value loss is only expected in year 0. After a year of activity most residents and property values, are not projected to be negatively impacted by a wind facility at least six miles offshore. Therefore, the property value decrease is only temporary. Reports indicate that commercial property values would actually increase after construction from to an increase in tourism, and investment in the region due to branding as an eco-friendly area.

The most notable result of the seven Cost Benefit Analyses is that all analyses have a BCR above 1.0 (Table 6.5). However, none of the BCRs are significantly high values and all of

them were well below the 3.2 marker that the U.S. ACE uses for many new projects. It should also be noted that only the projects with no disaster and the 3 percent discount rate have a positive NPV after 30 years, and that NPV is not significantly profitable. Based upon this analysis, given the limited leasing time frame and significant capital costs, it is unlikely that any proposed project would be economically advantageous after 30 years.

CBA Iteration	Description	Disaster	Total Costs (Millions)	Total Benefits (Millions)	NPV (Millions)	BCR
CBA 1	100 Turbines	No	2,878	3,638	58	1.26
CBA 2	100 Turbines (7%)	No	2,878	3,638	(419)	1.26
CBA 3	200 Turbines	No	5,202	7,090	552	1.36
CBA 4	340 Turbines	No	8,457	11,922	1,244	1.41
CBA 5	100 Turbines	Yes	3,508	3,638	(346)	1.01
CBA 6	200 Turbines	Yes	6,462	7,090	(256)	1.06
CBA 7	340 Turbines	Yes	10,597	11,922	(130)	1.09

Table 6.5: Results of the seven CBAs conducted. Green indicates a positive result and Red indicates a negative result.

A major disaster will have a significant impact the economic efficiency of an offshore wind facility. In the analysis the NPVs for projects with the disaster went significantly into the red after 30 years.

Ultimately, the results from the various CBAs indicate that the project has a positive outcome over the 30 year period when no disaster and the social discount rate (3%) is used. However, with any type of disaster, or the use of the U.S. ACE 7% discount rate, this project is not economically viable. That being said, this CBA is far from an all-inclusive analysis, but it does provide a starting point for decision making and future analysis. Additionally, both the results of the CBA and the CEA will be taken into account for the economic recommendation of this report.

6.4.2 Cost Effective Analysis

When comparing capacity factor, nuclear is the highest at 90 percent and solar is the lowest at 25 percent. Wind power was second lowest at 40 percent. Renewable energy sources suffer from low capacity factors as weather and climate conditions influence the capacity factor. For solar and wind, the actual value may even be lower during normal conditions. Nuclear and fossil fuels are not limited by weather conditions and can be used or burned regardless of the time of day. The capability for 24-hour operations is especially important for large scale industry, as industrial processes require a constant stream of energy.

The megawatt hours for each energy source was calculated from North Carolina's reported energy production to the EIA during November 2014. This value was then calculated out for the yearly average. Since it is a calculation, it may not take into account

seasonal fluctuations in energy production or consumer use. Consumer energy use is often higher during the winter month due to heating. This is often reflected as an increase in the production of megawatt hours. The megawatt hours produced by wind power is our calculated value from a possible offshore wind turbine facility. This value may be higher or lower, dependent on the megawatt rating of the turbines and number of turbines. For North Carolina, coal produces the highest value of megawatt hours at 28.7 million megawatt hours, and solar power as the lowest value at 59 thousand megawatts. This is mostly due to the high percentage of coal power plants in the state compared to other energy sources. While the higher capacity factors of natural gas, coal, and nuclear influence the megawatt hours produced, these high values are because they are the most prominent energy sources for the state. Hydroelectric is limited by geography, and solar power is relatively new technology, which results in lower values of megawatt hours. This criteria indicates how wind produced megawatt hours would compare to the status quo of North Carolina's energy production.

Natural gas represents the lowest levelized capital cost at 30.3/MWh, while wind is the highest at \$175.4/MWh. Natural gas has low capital costs due to the minimal infrastructure needed for production. Natural gas facilities (as well as coal and nuclear to a lesser extent) can be in practically any location allowing costs for site location to be lower. Wind power requires expansive infrastructure and large sites. The sites suitable for wind turbine facilities are depended on the geography, wind conditions, and climate. This limits the amount of suitable locations for infrastructure, which can result in higher costs for site location and land purchase or leasing.

Operation and maintenance is highest for natural gas at \$59.8/MWh and lowest for wind at \$22.8/MWh. This criteria is highly influenced by the cost of fuel. Coal, natural gas, and to a lesser extent nuclear, require consumable fuel for energy production. Hydroelectric, solar, and wind require no consumable fuel cost that would add into the yearly operational costs. When compared to the other renewable energy sources, wind energy requires slightly more maintenance due to the large scale of the infrastructure and quantity of turbines for large facilities. Although consumables for Nuclear energy are expensive, labor and daily operations for facilities are low due to automation and minimal manpower required to operate the facility. For the total levelized cost, wind power has the lowest cost at \$80.3/MWh, while coal has the highest at \$147.4/MWh. This factors in capital costs, operational costs, fuels costs, and transmission investment which was not included in our cost effective analysis.

For the results of the cost efficiency analysis, wind power has the highest levelized cost at \$204.1/MWh. This criteria is the most important, as it includes all capital costs, operational costs, and fuels costs. This indicates that wind power has the lowest cost efficiency of the examined energy sources. While wind energy has a lower capacity factor when compared to traditional fossil fuels and nuclear, the lower operating and maintenance costs offset the low capacity, but not the high capital costs. Additionally, wind power requires no fuel further reducing the total cost over longer periods of time.

Energy Source	MWh/Year	Capacity Factor (%)	Levelized Capital Cost (\$/MWh)	O&M, Fuel, Misc (\$/MWh)	Total Cost (\$/MWh)
Natural Gas	28,704,000	87	30.3	59.8	91.3
Coal	47,676,000	85	97.8	48.4	147.4
Nuclear	39,132,000	90	71.4	23.6	96.1
Hydro Electric	3,720,000	53	72.0	10.5	84.5
Solar	59,616	25	114.5	11.4	130.0
Wind	1,752,000	40	175.4	22.8	204.1

Table 6.6: The results of the CEA analysis. Red indicates poor values, while green indicates good values.

Wind has the highest levelized cost amongst the evaluated energy sources and it has a significantly lower capacity factor resulting in less energy generated than traditional fuels like coal and natural gas. Although wind has a relatively high capacity factor amongst the renewable energy sources, it is still less than half that of coal or natural gas. The high levelized cost of wind power does not make it an attractive renewable energy source outright, despite the lack of fuel and low maintenance costs. Its utilization by some industrial and commercial markets will entirely depend upon the affordability of its electricity and how the projects capital costs are managed.

In Table 6.7 coal, natural gas, and wind are compared by their total MWh produced. The number of wind turbines was calculated to equate the energy production from coal and natural gas. In North Carolina, an offshore wind facility (ies) would have to construct 819 5MW turbines to equal the current MWh production of natural gas. To equal coal the wind facility would need to construct 1,361 5MW turbines.

Energy Source	Coal	Natural Gas	Wind
Total Cost (\$/MWh)	147.4	91.3	204.1
MWh (Million)	47.7	28.7	1.8
Offshore MWh (5MW turbine)	35,040	35,040	-
Turbines Required	1,361	819	-
Total Cost (Billions of dollars)	\$ 7.03	\$ 2.62	\$ 0.36
Wind Adapted Cost (Billions of dollars)	\$ 9.73	\$ 5.86	-

Table 6.7: A table of comparison calculations for wind, natural gas, and coal in NC.

Depending upon the size of the leasing space, geography, costs, and use conflicts surrounding the construction of a wind facility, it may not be feasible to construct such a large number of turbines. However, if all three of the proposed WEAs in North Carolina were built to their maximum capacity with 5MW turbines there would be enough to equal the production of natural gas, but nowhere near enough to compete with coals current production. Although,

new technology and turbine development in the future may offset this gap in energy productivity. Increasing the capacity factor or total Megawatt rating may make wind power more comparable to coal or natural gas thereby expanding its use as a power source.

6.5 Conclusions and Recommendation

From a strictly economic perspective offshore wind energy is not an advantageous investment as neither the CBA nor the CEA provide significantly positive results. Offshore wind is simply not as efficient as the current energy production methods in North Carolina, especially when compared to the growing natural gas industry. Though both results do indicate that with subsidies offshore wind becomes significantly more economically feasible.

6.5.1 Hindsight, Improvements, and Future Steps

This analysis was missing investigations into how the construction of this wind facility would impact commercial fishing, recreational activities, shipping, and region branding; many which have numerous issues beyond economic factors, warranting further studies. The potential of wind turbine structures to act as artificial reefs is one area that warrants investigation. The created habitat would help fisheries, recreational water sports, and the regions fauna. This is especially important off the coast of North Carolina as fishing is a vital industry and tourism related recreational water sports are vital to big and small beach communities. .

Given what was identified as a missing costs or benefit, the next logical step to improve the economic analysis would be to conduct a CBA with a more extensive standing. While the benefits and costs included in this analysis are central to this project's outcome, some of the benefits and/or costs must be investigated further to provide a better perspective. The results of the CBAs indicate that this project will not be profitable until at least year 20 with no disaster included and if a disaster were to occur the project may not be profitable for the extent of the operation. Ultimately, the CBA results indicate that this project, based upon the limited standing, is not a good investment. However, with the use of subsidies and the consideration of additional intangible benefits, an offshore wind farm could be more economically viable.

It is also worth mentioning other CBAs which have been conducted for proposed and completed wind facilities. The results of those CBAs vary depending upon the project, but Europe is very much in favor of utilizing offshore wind. They are incentivizing the construction and nations are cooperating to build facilities which can sell electricity to multiple countries (Green, 2010). A mutually beneficial project between Ireland and the UK was also projected to have a positive BCR (KHSK, 2013). In fact many European reports indicate that, despite the use of subsidies to encourage construction, large wind facilities are by and large a good long term investment.

Offshore wind is still an unknown in the United States and as such will be inferior to onshore wind and fossil fuel energy sources for the time being. However, its construction at specific sites which reduce user conflicts present the best circumstances for the economic viability of offshore wind (Snyder, 2008). One CBA consulted during this analysis reported no economic upsides to offshore wind energy. This study was conducted by the Beacon Hill Institute of Suffolk University for New Jersey's wind project and it concluded that "the rush to offshore wind power in New Jersey will produce net economic costs, raise electricity costs and dampen economic activity" (Tuerck, 2011). This study comes in some contrast to others conducted in the U.S. and around the world. Their analysis may be accurate, however, the Beacon Hill Institute's ties to the Koch brothers, known antagonists to renewable energy and climate science, may take away some of the weight from this study. Recently many Beacon Hill studies have been called into question, with a Beacon Hill research analyst admitting he and his colleagues fudged their findings (Negin, 2012).

Similar to the Cost Benefit Analysis, the Cost Effective Analysis could also be improved in a number of ways. The first of which being a more direct comparison between natural gas and nuclear. Natural gas and nuclear represent the most productive, yet least polluting energy sources among traditional non-renewable fuels. The capacity factor and megawatt production for natural gas and nuclear is significantly higher than offshore wind; and would benefit from a more detailed evaluation and comparison. Levelized costs provide a good comparison between different energy sources and their efficiency per MWh, but the CEA may benefit from other economic values not included/considered in the levelized cost values obtained from U.S. Energy Information Administration.

The economic analysis could also benefit from a more locally focused analysis. While the data was calculated from reliable scientific and professional reports, more up-to-date and focused analysis of those same costs and benefits would provide a better perspective on the impacts of a wind facility on Wilmington East. The analysis would benefit from examination of the potential impacts of a wind facility in Wilmington West or Kitty Hawk areas as well. A comparison from wind projects in other states is limiting at projecting what unique difficulties or advantages a North Carolina project may possess.

Regardless of the many improvements which could be made to the analysis, it is already evident that offshore wind energy is simply not an advantageous economic investment. Given the limited leasing time frame and significant capital costs offshore wind energy will not provide an affordable production of energy, at least without significant subsidies. However it would be a viable component of North Carolina's renewable energy portfolio and another clean replacement for coal. .

7. Political Feasibility

7.1 Introduction

Public support and political authority are central components to establishing the political feasibility for any project, including North Carolina's potential offshore wind facilities. Political feasibility takes into account the landscape of political risks, support, and potential opposition that might result from choosing offshore wind energy.

An examination of the position of elected officials was conducted to determine the political atmosphere surrounding offshore wind energy projects for NC. Local public opinion was reviewed via polling data, public comments, letters to the editor, newspaper articles, and public meetings. Lastly, a survey was created and distributed to measure public opinion that was then compared with similar surveys in other states also pursuing offshore wind energy development.

Stakeholder support and participation is essential to completing this project. Efforts must be made to ensure that industry stakeholders are personally invested in current decisions and that they remain involved in future management decisions. The participation of all agencies and stakeholders is vital to negotiate the best possible solutions to any associated risks that this project might place on the local ecosystems and communities. Open communication between various stakeholders and a balance amongst government agencies is critical to offshore wind energy's success in North Carolina.

7.2 Political Climate

In 2009, the U.S. House of Representatives passed a Renewable Electricity Standard for the United States requesting that 20 percent of energy be produced through renewable energy sources by 2020. As of that year, U.S. wind power from onshore produced less than two percent of the nation's electricity supply. In the previous year, the Department of Energy issued a report stating that the United States could produce 20 percent of the nation's electricity from wind by 2030. To reach this goal, 293 gigawatts (GW) of wind energy would be needed with at least 50 GW coming from offshore wind energy. The federal government has several incentives for offshore wind energy such as the American Recovery and Reinvestment Act of 2009 which allocated \$100 million to offshore wind energy research and test facilities (Rock and Parsons, 2010). The Department of the Interior has heavily promoted the development of wind energy on the OCS by signing a Memorandum of Understanding with the Department of Energy to coordinate efforts across federal agencies to advance offshore wind development as well as

their formation of the Atlantic Wind Energy Consortium and initiation of the “Smart from the Start” program. Although these steps have been taken to support offshore wind energy at a federal level, challenges such as unpredictable tax credits and concerns over high construction costs still exist (Bowes and Allegro, 2012).

On August 20, 2007, North Carolina became the first state in the Southeast to implement a Renewable Energy and Energy Efficiency Portfolio Standard (REPS) with the signing of Session Law 2007-397, Senate Bill 3. The creation of the REPS in NC has promoted the use of renewable energy within the state and opened up many opportunities for developers and businesses, mostly in the form of solar energy. In 2011, the Offshore Wind Jobs and Economic Development Act was introduced in the North Carolina legislature with hopes to promote development of offshore wind energy by creating a competitive request for proposals for 2,500 MW of offshore wind energy (Bowes and Allegro, 2012).

Currently in North Carolina, there is no statutory or regulatory framework in place that governs offshore wind farms. The relevant state laws include the Coastal Area Management Act (CAMA), North Carolina Environmental Policy (NCEPA), North Carolina Dredge and Fill Act, North Carolina Public Utilities Act, and North Carolina Archives and History Act. Currently in North Carolina it is unclear who would have the authority in the state’s permit process for offshore wind energy. North Carolina should consider developing a management strategy for offshore wind energy implementation and would benefit from more comprehensive legislation regarding this proposed project (Schiavinato, 2008).

Although opening the area up for development and lease sales are a Federal decision, the political atmosphere of North Carolina regarding offshore wind farms will be influential in future development.

7.2.1 North Carolina Political Officials

In order to get a clear understanding of the political atmosphere in North Carolina regarding offshore wind energy development, specific political figures were researched to determine their stance on the issue. At the federal level, U.S. Senators Thom Tillis and Richard Burr were examined as representatives of North Carolina in Washington, DC as well as Congressman David Rouzer in the U.S. House of Representatives.

Within the state, Governor Pat McCrory and his administration are particularly influential. State Representatives were examined as well with the focus being the Wilmington area. Other influential people included in this analysis are Brian O’Hara, president of the Southeastern Wind Coalition and Donald van der Vaart, Secretary of the NC Department of Environment and Natural Resources (NCDENR).

7.2.2 Federal Representation

Senator Thom Tillis has voiced strong support for drilling and delivered his first speech on the Senate floor promoting it as a positive step for North Carolina. The fears of rising energy prices and the desire to work towards energy independence have proven persuasive arguments for those who agree with Tillis. As stated in recent correspondence with the Senator, he agrees that we should continue to pursue energy policies that reduce the United States' dependency on foreign oil. While he is open to exploring different types of renewable energy resources, he feels that North Carolina must pursue policies that are fiscally responsible and do not create any additional burdens on businesses and taxpayers. He feels that we need to ensure we are not taking ill-advised credit risks to develop "green energy." Although he is not a member of the Senate Committee on Energy and Natural Resources, he plans to continue following this issue as the Senate considers renewable energy initiatives. In addition, if this issue comes before the Senate, he indicates that he will carefully consider everything the public has said in making a decision on what is best for North Carolina and the country (Senator Thom Tillis, Personal Communication, 03/17/15).

As for Senator Richard Burr's thoughts on wind energy, he is committed to working in a bipartisan manner to reduce America's dependence on foreign energy sources and to develop cleaner, alternative sources of energy. He feels it is important for all energy options to be put on the table. Burr stated that "Congress passed the Tax Increase Prevention Act of 2014 (H.R. 5711) in December" as a way to "[extend] more than 50 tax incentives, including a tax incentive for wind energy production" and that he "voted in favor of this legislation." Burr also indicated that he is dedicated to the belief that America must be a leader in pursuing clean energy solutions that will produce energy more effectively, reduce emissions, decrease our reliance on foreign oil, and create new markets for American innovation.

On April 3, 2014, the Senate Finance Committee advanced a critically important package of renewable energy tax credits, moving one step closer toward renewing these expiring or expired investments that help support clean energy jobs all throughout the United States. Burr seemingly voted in opposition to the 23 wind facilities currently operating in North Carolina, where combined production from offshore and onshore wind power is capable of exceeding the state's energy needs several times over. His voting record shows very little consistency as he voted no oil and gas drilling off the NC coast in September 2014 but also voted no on protecting ocean, coastal, and Great Lakes ecosystems in May 2013. Additionally, he has voted against tax incentives for energy production and conservation in 2008 while protecting middle-income taxpayers from a national energy tax the following year. In 2010, Burr stated that ending offshore drilling leads to economic disaster in June 2010 and voted to bar the EPA from regulating greenhouse gases in April 2011.

Congressman David Rouzer (R) of the 7th District supports an all-of-the-above strategy in pursuit of energy independence, embracing hydraulic fracturing and offshore drilling as well as renewable energy sources. He supports policies that enable the United States to become an

energy superpower, including operations to drill for oil and natural gas reserves underneath the sea floor off the coast of North Carolina (Hamrick, *Lumina News*, 2014).

7.2.3 State Representation

In May 2014 Governor McCrory signed legislation-setting policies for issuing permits for offshore wind farms. McCrory leads the Outer Continental Shelf Governor's Coalition, which has pledged to continue to work with the Obama Administration and Congress in pursuit of a robust offshore energy program as well as expansion of revenue sharing to all states that host offshore energy development. Governor McCrory wrote a letter to BOEM saying that he backed its wind energy initiative in North Carolina. In the letter, he cited a statistic made by the National Renewable Energy Laboratory showing the state could potentially reel in \$22 billion to its economy with wind projects, along with 10,000 jobs (NREL, n.d.). However, McCrory has stated that a 50 mile buffer zone for offshore oil and gas is too far from the coast while also indicating that wind development should be farther from the shore. The closer to shore the oil and gas development the more likely that project will be pushed through, while the farther away the wind farms the less likely that project will be implemented (Cockerham, 2015).

Senator William "Bill" Peter Rabon (R) is the representative of the 8th District which includes Bladen, Brunswick, and New Hanover counties. Senator Rabon has not made a public stance on the proposed offshore wind energy project, but has shown support for other types of offshore energy. Senator Jane Smith (D) representing Columbus and Robeson counties attended a seminar in March 2015 concerning the need to learn more about offshore energy. From what was presented, she stated that offshore wind energy appears to be a beneficial project to our area in terms of jobs created (Senator Jane Smith, 2015).

As the state representative for New Hanover and Brunswick counties, Susi Hamilton (D) states that she is not convinced that offshore wind energy production is the right move for NC and that the state is a long way away from generating energy through wind resources. Hamilton believes that "we need to preserve the appearance of our beaches to the best of our ability" and that more analysis need to be done (Smith, WECT-TV6, 2015). However, Representative Hamilton voted against a senate bill in 2013 that would have reduced state support for renewable energy.

The Pender and Onslow county representative Chris Millis (R) sponsored a senate bill in 2013 to reduce state support for renewable energy, intending to lessen the burden of renewable energy subsidies and mandates on NC rate payers. Representative Rick Catlin of the 20th District voted for Millis' bill. Back in 2011, Catlin as County Commissioner was quoted saying in regards to offshore wind energy that "there are dollar considerations that we still don't have all the answers to" (Maurer, 2011).

7.2.4 North Carolina Department of Environmental and Natural Resources

North Carolina Governor Pat McCrory has been outspoken in his support of alternative energy. In 2013, the governor sent a letter to BOEM in support of moving forward with the leasing process for offshore wind development. In that letter, Governor McCrory wrote, "I believe an 'all of the above' energy plan that includes wind is vital to a prosperous energy future in North Carolina ... Development of North Carolina's offshore wind energy resources is not just good for this state's economy, but it will continue to fulfill work toward an 'all of the above' strategy to move our nation toward greater energy independence. However, Donald R. van der Vaart, McCrory's Secretary of the Department of Environment and Natural Resources (DENR), recently took a stance that does track with the Governor's past statements.

Van der Vaart's letter, sent to BOEM on February 23rd, 2015, asked that the agency not to offer wind farm lease sales within 24 nautical miles of the coast. His letter makes recommendations which not only subtly go against the message that McCrory has expressed in the past, but they would severely limit offshore wind leases by limiting construction to areas that are at in deeper water and thus less likely to be developed. In the letter, van der Vaart was specifically concerned with Wilmington East and Wilmington West and pointed to independent studies he said showed that visible offshore energy projects negatively affect tourism. His letter asserts that, "independent studies commissioned by the State of New Jersey found that a significant decline in tourism and a net loss to the state's economy would occur where offshore energy projects were visible from the coastline." If Van der Vaart's request is honored by BOEM, it would effectively halt offshore wind development for North Carolina in the near future.

At the North Carolina's Coastal Conference in Raleigh on April 14, 2015 in Raleigh, van der Vaart stated that DENR is working with BOEM to develop both offshore wind energy and oil and gas exploration off the state's coastline. He went on to state that Governor McCrory makes it clear that he wants to pursue offshore wind energy while still protecting the state's tourism industry. The McCrory Administration would like to see all wind turbines located beyond 24 nautical miles to prevent impact to aesthetics. The state thinks they will learn more from the Virginia offshore wind energy experience. Their position is to wait and see what distance from shore is needed to protect the aesthetics (van der Vaart, 2015).

However, none of the studies van der Vaart referenced were listed by name and no studies commissioned by the State of New Jersey made any claim that offshore wind would lead to a "significant decline in tourism." To the contrary, the North Carolina chapter of the Sierra Club found only one study commissioned by the New Jersey that directly addressed the potential impacts on tourism. *An Assessment of Potential Costs and Benefits of Offshore Wind Turbines* was a report commissioned by the New Jersey Department of Tourism in 2008 and prepared by the company Global Insight. It projects that there could be small drops in tourism and revenue if turbine installations were to be installed three to six nautical miles from shore. However, for offshore wind installations 12 or more nautical miles from the shore, the report

actually projects economic gains and increases in tourism. All of North Carolina's lease blocks are at least 10 nautical miles from shore.

Another noteworthy piece of van der Vaart's letter is that it references a study conducted in North Carolina by East Carolina University and Appalachian State University professors. The North Carolina study found no evidence that coastal tourism would be adversely impacted by offshore wind development located more than four nautical miles from land. In addition, the Sierra Club noted that in 2010, New Jersey Governor Chris Christie (R) signed the Offshore Wind Economic Development Act and stated that the bill would "provide New Jersey with an opportunity to leverage [its] vast resources and innovative technologies to allow businesses to engage in new and emerging sectors of the energy industry."

In response to van der Vaart's letter, Molly Diggins, state director for the North Carolina Sierra Club said, "the Governor is in a unique position, as chairman of the Outer Continental Shelf Governors Coalition, to educate and promote the value of clean offshore energy development from wind...we share the concerns expressed to protect coastal tourism, an economic engine for the region and the state. But we note that the McCrory administration has not expressed similar concerns about the potential for the very real threats to our coast and fisheries from oil spills. In fact, the Governor has called for allowing oil rigs closer to the coast than currently proposed....It's clear that the McCrory administration wishes to declare North Carolina open for business for offshore drilling. What is not clear is if this letter is intended to close the door for clean offshore energy development...We call for the Governor to reaffirm his support for offshore wind." (Sierra Club, 2015).

Brian O'Hara, president of the Southeastern Wind Coalition, mentions to the North Carolina Coastal Federation in a letter that wind farms farther offshore would drive up the expense and likely drive the industry elsewhere. "The practical impact is that we probably wouldn't see offshore wind development in North Carolina for quite some time," he said. O'Hara explained that installing turbines in deeper water involves steeper construction costs, more difficult maintenance, and more cable would be needed to transport the energy to the shore. O'Hara maintains that offshore wind energy is a huge opportunity for North Carolina in that it is a clean energy source that has no emissions, no ash, no water use, and no fuel cost and it is a great economic development opportunity (Smith, WECT-TV6, 2015). O'Hara states that, "offshore wind is one of those once-in-a-generation economic opportunities to build an entirely new industry while protecting and enhancing our existing coastal industries like tourism, fishing, shipping, and the military. Why would we kill it before it has a chance to get started?... If we approach this opportunity with an open mind and make our decisions based on facts rather than fear, we just might embark on one of the next great industries to power our economy," he said (O'Hara, 2015).

In response to van der Vaart, O'Hara maintains that offshore wind energy doesn't protect tourism and could actually harm it. DENR cites four studies from New Jersey to support this idea, but only one actually studied tourism. In that study, the negative effects estimated were for projects three to six miles offshore, but areas near Wilmington are already pushed out to 10 miles specifically to avoid visual impacts. Both experiences from Europe and studies in the United States, including the New Jersey study cited by DENR, suggest that wind farms 10 or more nm from shore could improve parts of the tourism economy. This is due to the fact that wind farms can attract visitors, enable eco-tourism, and become recreational water sport hot spots. Additionally, according to a BOEM visualization study, at those distances the turbines would generally not even be visible from the shore, especially during the peak tourist seasons.

O'Hara continues with saying that the DENR ignores the previous four years of work by local, state, federal, and tribal stakeholders to identify areas for potential development. Starting in 2010, BOEM has led a process to identify areas that avoid conflicts with sensitive environmental areas, commercial fishing, shipping and navigation, view sheds, and even shipwrecks. For example, over one million acres were excluded for military operations alone. It has been a thorough and transparent process, resulting in the identification of low-conflict sites with good wind resource. An indiscriminate 24 nautical mile exclusion zone would override years of work and effectively wipe out most of those potential sites.

Additionally, O'Hara believes that DENR's request is not based on what other tourism-dependent states are doing. Most states are using 10 miles or less as a minimum distance, and some have projects proposed much closer to shore. Virginia's WEAs are 25 miles offshore, but those distances were due to military and shipping conflicts, not tourism concerns, and many of the other stakeholders there would prefer options closer to shore. The practical effect of a 24 nautical mile exclusion zone is that little development off of North Carolina would be seen for a long time. Pushing WEAs out that far imposes unnecessary cost burdens due to water depth and distance. This change could prevent North Carolina from competing for the tens of thousands of supply jobs which would develop to support wind energy. Manufacturers will be attracted to states that embrace the industry, not those states that impose restrictions which effectively ban offshore wind development in the near term.

7.3 Public Opinion

In order to assess the public opinion regarding offshore wind energy in North Carolina, this analysis synthesizes comments collected from various public meetings, television interviews, and comments on the federal register in response to BOEM documents. Public opinion in the counties nearest to the WEAs were considered most important due to the direct influence offshore development would have on these communities.

7.3.1 New Hanover County

On January 23, 2015, BOEM released the Environmental Assessment (EA) to the public to view and submit comments via BOEM's website during a 30-day comment period. BOEM also held three public meetings in coastal areas of North Carolina which would be directly impacted by the potential projects. -The meetings provided an overview of the EA findings and offered additional opportunities for public comments. The first meeting was held February 9, 2015 at the Hilton Garden Inn in Kitty Hawk; the second meeting was held February 11, 2015 at the Coastline Conference and Event Center in Wilmington; and the third meeting was held February 12 at the South Brunswick Islands Center in Carolina Shores.

At the meetings representatives from BOEM's office of renewable energy programs presented a recap of the stages in the offshore wind authorization process stating that they are at Stage 1 in North Carolina and that they are conducting an environmental assessment. After reviewing public comments, BOEM will either move forward and begin leasing blocks in the area or revise the assessment. Based on the comments, the agency could determine that leasing poses severe environmental consequences. They will then do a more comprehensive Environmental Impact Statement. Representatives from BOEM's Office of Renewable Energy Programs in attendance were Desray Reeb (Marine Biologist), William Hoffman (Archaeologist), William Waskes (Project Coordinator) and Brian Krevor (Environmental Protection Specialist).

The comments given at this meeting included both statements of support and concern for the production of offshore wind energy, as well as a plethora of questions regarding all aspects of the development and implementation of the project. Table ? in Appendix ? summarizes all the comments made in the meeting and through WWAY TV News as part of their coverage of this workshop.

7.3.2 Dare & Currituck County

In February 2013, the Kitty Hawk Town Council made a plea to the federal government to keep any offshore wind energy project at least 20 nm off of its beaches and requested that municipal leaders be involved in any conversation regarding transmission lines coming ashore. Mayor Pro Tem Gary Perry initiated the request in the form of a resolution, and that "the federal government is going to do whatever they want, but if we give them a perimeter, they may listen." BOEM has also noted that this 20 nautical mile buffer from Kitty Hawk as well as the National Park Service 33.7 nm buffer from the Bodie Island Lighthouse.

In 2012, town officials balked at a proposal by shipbuilder Northrop Grumman and Gamesa USA Energy to erect an experimental windmill farm a half-mile off of the town's shores. The companies later abandoned the idea. Aesthetics and long-term maintenance concerns were among the reasons the council rejected the idea then. The two companies then looked at the construction of a 500-foot-tall wind turbine near the University of North Carolina's Coastal Studies (CSI) Institute in Skyco. According to CSI education associate David Sybert and Dare

County Planning Director Donna Creef, there are no plans for that project to move forward (Wagner, *The Outer Banks Voice*, 2013).

In 2009, the Department of Planning and Inspections in Kitty Hawk, North Carolina conducted an independent survey of property owners in Kitty Hawk. This survey provided a 91% response in support of offshore wind energy. Only 9% of survey takers stated they were concerned over the unattractive appearance of wind turbines. 65% of survey takers in Kitty Hawk felt that wind turbines were neither attractive nor unattractive (Town of Kitty Hawk, 2010).

7.3.3 Brunswick County

Brunswick County has several concerns about the proposed projects. The county commissioners composed a letter to BOEM expressing their concerns. In particular, they want to make sure that they understand the project's costs to its citizens, the impact on real estate values, impacts on tourism, impacts on navigation, and environmental impact (Murawski, 2015).

Recent local opposition from the state has come from the Bald Head Association and the Bald Head Island Stage 11 Association who submitted a letter of comments and concerns about the Commercial Wind Lease Issuance and Site Assessment Activities to the program manager at the Bureau of Ocean Energy Management (BOEM). These comments and concerns are in regard to the Wilmington West and Wilmington East Call Areas and the associated environmental assessment. These associations feel that the environmental assessment does not address the severity of potential impacts to Bald Head Island and suggest that like the Kitty Hawk Call Area, both of the Wilmington Call Areas be pushed farther offshore to avoid the possible effects of the visual impacts of the turbines. The letter does state support for the project but feels that for the best interests of the Bald Head Island communities the wind farms should be at least 20 nm from the shore. (Adcock & Barnard, 2015).

On February 12, BOEM held a public hearing at Brunswick Community College's South Brunswick Islands Center in Carolina Shores. At this meeting Sunset Beach Mayor Ron Watts and Bald Head Island Mayor Andy Sayre from Brunswick County have expressed concerns about wind energy strategy and future development of offshore wind energy off the North Carolina coast. In response to an attendee's questions, BOEM maintained that they have to do their due diligence to make sure that they do not negatively impact the environment. BOEM representatives stated that a preliminary site plan is slated for 2016 followed by a four-and-a-half years to conduct all other site assessment and an additional five years to start site construction no earlier than 2022. Sayre went on to state that "this [project] obviously has a visual impact on Bald Head Island" and asked how the turbines would be lit. BOEM responded that it would follow the guidelines set in place to determine lighting impacts, yet Sayre found it hard to believe that this can be done in an environmental assessment.

Sunset Beach Town Councilwoman Carol Scott, who clarified she wasn't speaking on behalf of the town, questioned the proximity of Wilmington West to Sunset Beach. "We're more affected by these wind farms than any other location in eastern North Carolina," she said. "The concern I have is not only where will it come ashore" but its effects on tourism. Scott added that she is also concerned about where such energy will go, saying she's "been told that the [energy] cost to [Sunset Beach] residents could skyrocket." Scott added she's glad to see the proposed site being eyed for wind turbines is now for 10 miles offshore instead of the previous six (Lewis, *The Brunswick Beacon*, 2015).

7.4 Conclusion

The majority of elected officials were unsure in their support of offshore wind energy for North Carolina or have not provided a stance on the issue. Those who are unsure, are mainly concerned with viability, any potential negative effects to the tourism industry, and the costs of implementing the project. Many officials feel that more extensive analysis needs to be conducted. Currently, the McCrory Administration is sending mixed signals on offshore wind energy.

The majority of the public in the Wilmington, Kitty Hawk, and Carolina Shores areas support offshore wind energy. We feel that in general the public sentiment at the BOEM meetings were in support of offshore wind energy. With this being said, the largest areas of concern were for the endangered Right Whale. Few people have outright opposed the project, but simply want to express concerns about possible environmental damage during the construction and development of the offshore wind facilities. Supporters in these coastal communities say the latest developments in the process are a step in the right direction by cutting carbon emissions and providing power with a renewable energy source. However, others are concerned about the impacts offshore wind could have on the environment and the economies of the affected beach communities. The main concerns are aesthetics, potential negative effects to tourism, expense and long-term maintenance. There is broad agreement that tourism is a major driver of North Carolina's coastal economies and it needs to be protected.

8. Public Opinion Survey

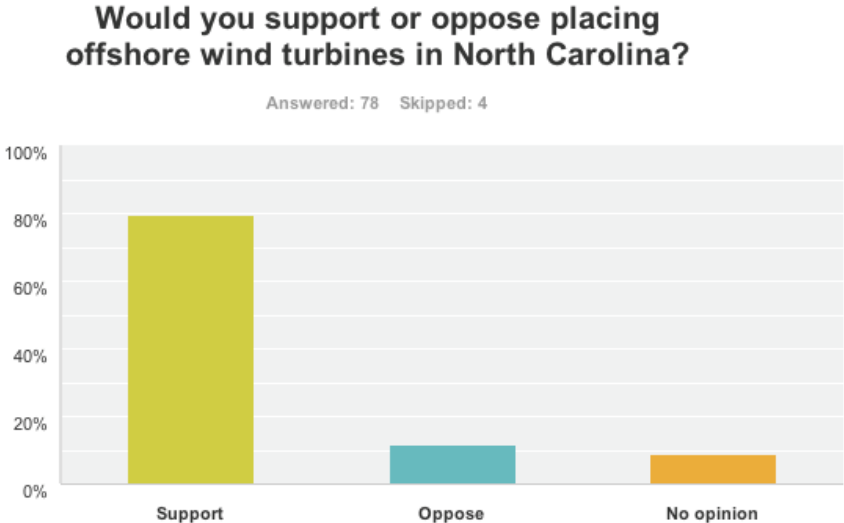
The purpose of this survey was to measure public opinion and political support concerning whether North Carolina should approve and promote the development of offshore wind energy or oppose it. The survey consists of questions related to five main categories: political viability, implementation challenges, economic analysis, environmental analysis and general household questions. Using descriptive research, the survey was structured in design so the information collected can be statistically presumed for the sampled population. The internet-based survey was created using Survey Monkey.

8.1 SURVEY RESULTS

The survey elicited 82 responses, the results and questions of the survey can be viewed in their entirety in Appendix 12.8. This section will provide a summary of the more significant or interesting results regarding the views and attitudes about renewable energy and specifically offshore wind energy. Questions Two and Four were specifically about renewable energy. Question Two shows that 84 percent of the survey takers feel it is very important or important for North Carolina to move away from fossil fuels. Only four percent of the survey takers feel it is very unimportant or unimportant. Question Four inquired about the respondent's attitude towards wind energy in general, showing that 81 percent of the respondents possessed very positive or positive attitudes about wind energy, while only five percent felt negatively towards wind energy. Overall, 75 percent of survey respondents supported offshore wind energy.

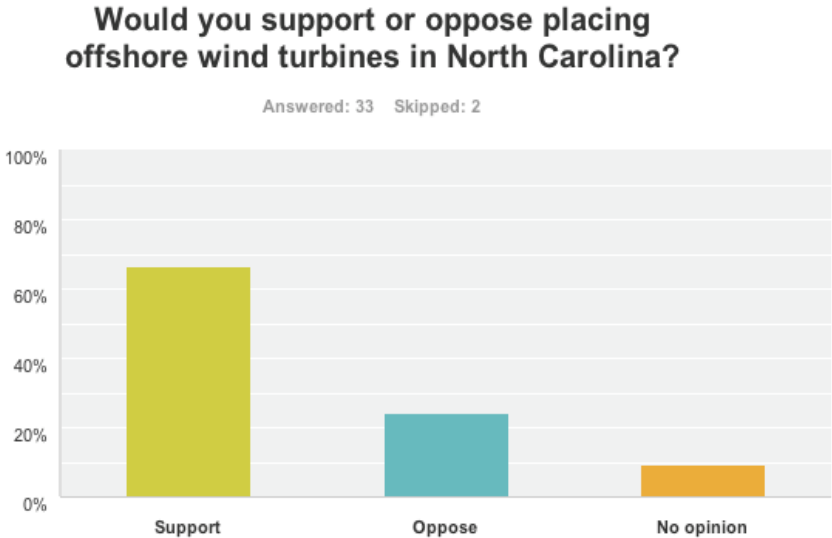
When asked what their primary concern about offshore wind energy in North Carolina was, 75 percent of respondents stated they support an offshore wind facility in North Carolina, and 12 percent of survey takers stated that the offshore facilities are not aesthetically pleasing. The sentiment of survey takers are expressed in Figure 8.1 below.

Figure 8.1: Question 19 responses.



As it appears to be a major concern of the North Carolina public, a few questions were asked regarding the aesthetics of offshore wind farms. Of the survey takers, 73 percent had seen a wind facility. Only 28 percent of the survey takers could see the ocean from their home. Of those who could see wind turbines from their house, 30 percent strongly supported offshore wind farms. The survey takers who could not see the offshore wind farms from their homes also strongly supported the offshore wind facilities. The majority of survey takers felt that the visibility of offshore wind turbines would not affect their decision to visit a one beach over another. The opinion of the 35 survey takers who own houses on the beach in North Carolina regarding effects on local industries and environmental aspects are expressed in Figure 8.2 below.

Table 8.2: Question 19 responses filtered for just beach property owners.



When comparing the responses between the survey takers who own a house at a North Carolina beach and those who do not, both feel that protecting the environment is the most important reason for implementing offshore wind farms. Respondents who can see the ocean from their beach house placed great importance on aesthetics and were more likely to oppose offshore wind farms if seen from the beach. Also, as displayed in the above table, residents who own homes at the beach feel that local industry and environmental concerns will receive greater harm. When filtering the survey to include only the results from the 42 respondents who do not own a house at a North Carolina beach, 62.5% of these respondents support offshore wind farms even if visible from the shoreline, 76.19% feel that offshore wind farms in North Carolina should be encouraged and promoted. A total of 88.10% of these 42 respondents support offshore wind farms in North Carolina.

When filtering these results further to only include responses of the 35 survey takers who own property at the North Carolina coast where they can see the ocean from their house slightly different results were found than the general survey results. These results are expressed in the Figures 8.3 & 8.4 below.

Figure 8.3: Question 10 responses filtered for just beach property owners.

Generally speaking, how do you feel about the placement of offshore wind turbines in North Carolina if you CANNOT see them from your house?

Answered: 35 Skipped: 0

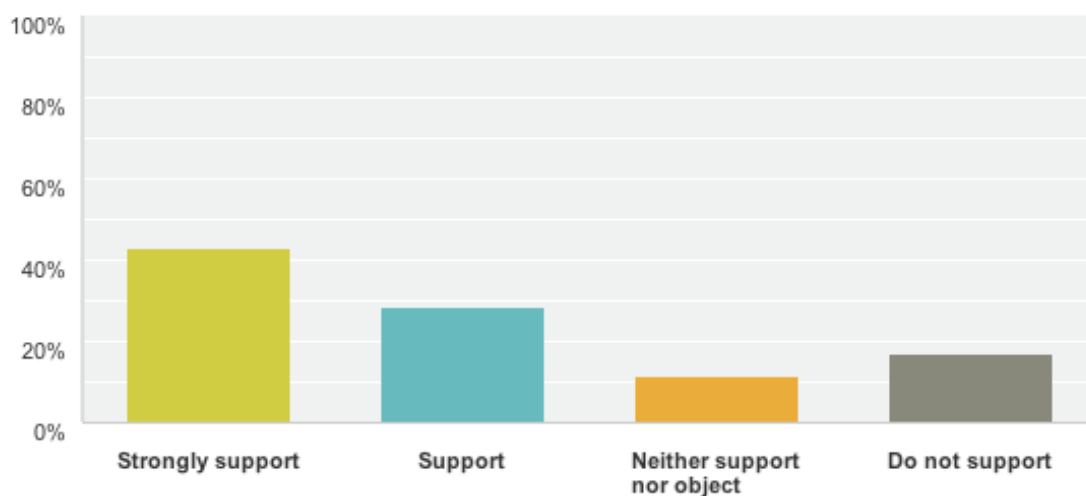
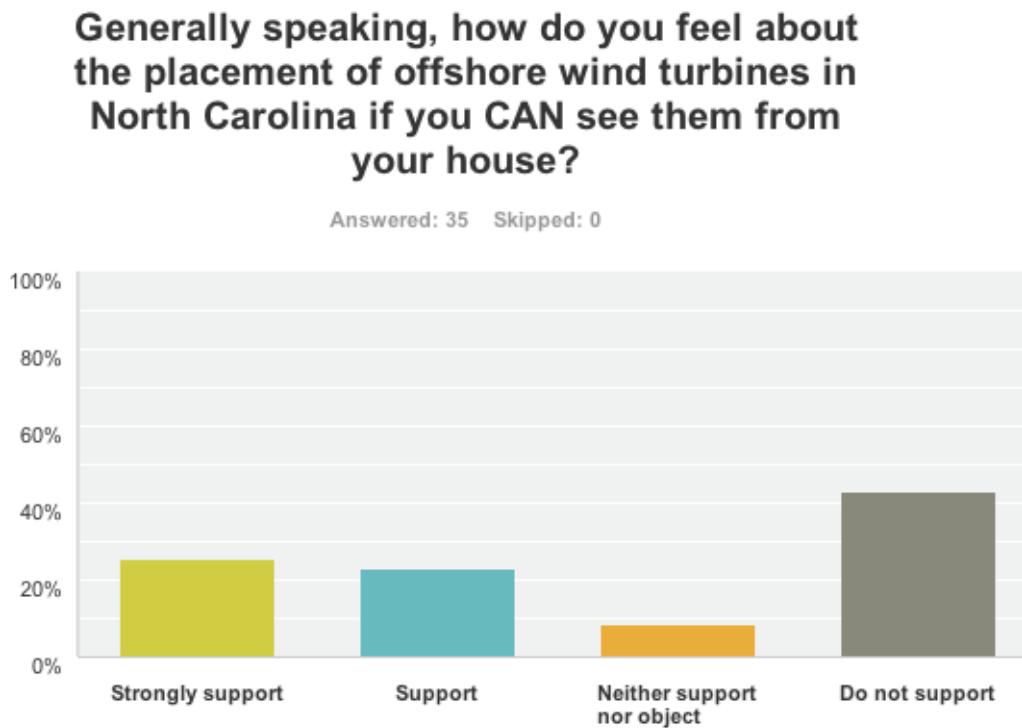


Figure 8.4: Question 9 responses filtered for just beach property owners.



These results demonstrate the high level of aesthetic concerns for beach homeowners in North Carolina. Support of offshore wind energy is much lower in general with this survey sample. Although these survey respondents are expressing their concerns over aesthetics and the associated effects, there is still support for offshore wind turbines, as long as they cannot be seen.

8.2 Narragansett Beaches Clean Energy Survey Results

Several of our questions were designed around two separate surveys from the University of Delaware, School of Marine Science and Policy, College of Earth, Ocean and Environment, Robinson Hall, Newark, DE 19716. Permission was sought and granted by the authors.

The results of the *Narragansett Beaches Clean Energy Survey* and the original survey documented here were very similar. The general attitude toward offshore wind power was very positive with the majority of respondents indicating the importance of moving away from fossil fuels and use more clean energy. Respondents believe that the placement of offshore wind turbines for electricity generation should be encouraged and promoted in appropriate circumstances. The surveys both indicate the respondents believe that offshore wind energy would benefit jobs creation, air quality, and electricity rates while not harming the environment

like other fuel sources. The majority of respondents are very likely to frequent a local beach with a visible wind turbine.

In 2009, The Richard Stockton College of New Jersey- William J Hughes Center for Public Policy, produced a survey for the Fishermen's Energy, LLC. This survey measured attitudes and issues of approximately 1000 residents and visitors to the area in regards to a proposed wind turbine project for 3 miles off of the New Jersey shoreline. Of these respondents, 76% indicated that a wind farm would not impact rental properties and only 13% of survey takers felt it would be harder to rent a beach property with offshore wind turbines in the vicinity. (Schulman and Rivera, 2009).

8.3 Conclusion

The majority of survey takers expressed support for offshore wind energy in North Carolina. However, results differ slightly when filtering results to only include answers of respondents who own a house at the beach in North Carolina. These respondents show less support than the other respondents and are much more concerned with the associated aesthetic issues. All respondents placed importance on fact that this renewable energy source would be better for the coastal environments of North Carolina. The survey shows interest in this proposed project and over half of the respondents expressed that they would like to attend an educational program about offshore wind energy and even more participants expressed interest in a boat tour of the wind farms once they were constructed?. These survey results are a good indicator of the public support and interest in offshore wind energy. Based on this survey, the concerns surrounding implementation costs and aesthetics do not outweigh the potential economic and environmental benefits.

9. Recommendations

Based on the analysis in this document, our recommendation is that the North Carolina legislature move forward with the offshore wind projects. The economic analyses indicate that the best way to maximize the benefits of the WEAs is to fit as many turbines as possible within them, roughly between 300 and 400 turbines. There are some concerns with the connectivity to our grid and natural disasters, however those do not outweigh the benefits of having a significant source of clean energy. In terms of the environment, there is no indication of negative long term effects on any of the sectors evaluated. The greatest risk occurs when animals enter the impact zone of construction activities. There are ways to mitigate risks such as having spotters on the vessels while seismic surveys and pile driving takes place.

The greatest hurdle is the current political climate in the state as views are mixed as to whether offshore wind facilities are favorable. However, there is also concern about tourism impacts from being able to see the wind turbines from the beach. This concern is dampened by our survey results, which claim that 50 percent of beachfront homeowners still support wind facilities regardless of aesthetics. Additionally, the economic study showed that “eco-friendly” branding of a city may increase tourism to the state and not hinder it.

Currently, Rhode Island is moving forward with building the first offshore wind facility in the United States, slated to be in operation in 2016. This recent development will most likely lead the North Carolina politicians to wait until those turbines are in operation, before they consider development. However, there is limited action that the North Carolina government can take against the development because of the provisions in OCSLA. The biggest barrier the states could put up would be to limit the access of connection of the cables into the grid.

Overall, the best location for the turbines is the Wilmington East WEA. This is because they are close enough to shore, reducing the cost, but far away enough to have less visibility from shore. This should placate the public who does not want to be able to see the turbines from the beach. North Carolina should embrace the future of wind energy, recognizing that there are trade-offs that must be dealt with by the state and its residents.

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11. Glossary

BOEM: Bureau of Ocean Energy Management
CAA: Clean Air Act
CFR: Code of Federal Regulations
COP: Construction and Operation Plan
EA: Environmental Assessment
EFH: Essential Fish Habitat
ESA: Endangered Species Act
G&G: Geological and Geophysical
GAP: General Activities Plan
EA: Environmental Assessment
MMPA: Marine Mammal Protection Act
MMS: Minerals Management Service
MPA: Marine Protected Area
MSFMCA: Magnuson-Stevens Fishery Management Conservation Act
NAAQS: National Ambient Air Quality Standards
NARW: North Atlantic right whale
NEPA: National Environmental Policy Act
NMFS: National Marine Fisheries Service
NOAA: National Oceanic and Atmospheric Administration
OCS Outer Continental Shelf
OCSLA: Outer Continental Shelf Lands Act
O&M: Operation and Maintenance
SAP: Site Assessment Plan
SPI: Sediment-profile imaging
USCG: United States Coast Guard
USEPA: United States Environmental Protection Agency

Units of Measurement

bbl: barrel (unit), 42 US gallons, 159 liters
nm: nautical mile
dB re 1 μ Pa: decibels per 1 micropascal

12. Appendices

12.2 Legislative Framework

Figure 12.2.1: Best Available Wind Resources (UNC, 2009) (Figure 2.1 in text).

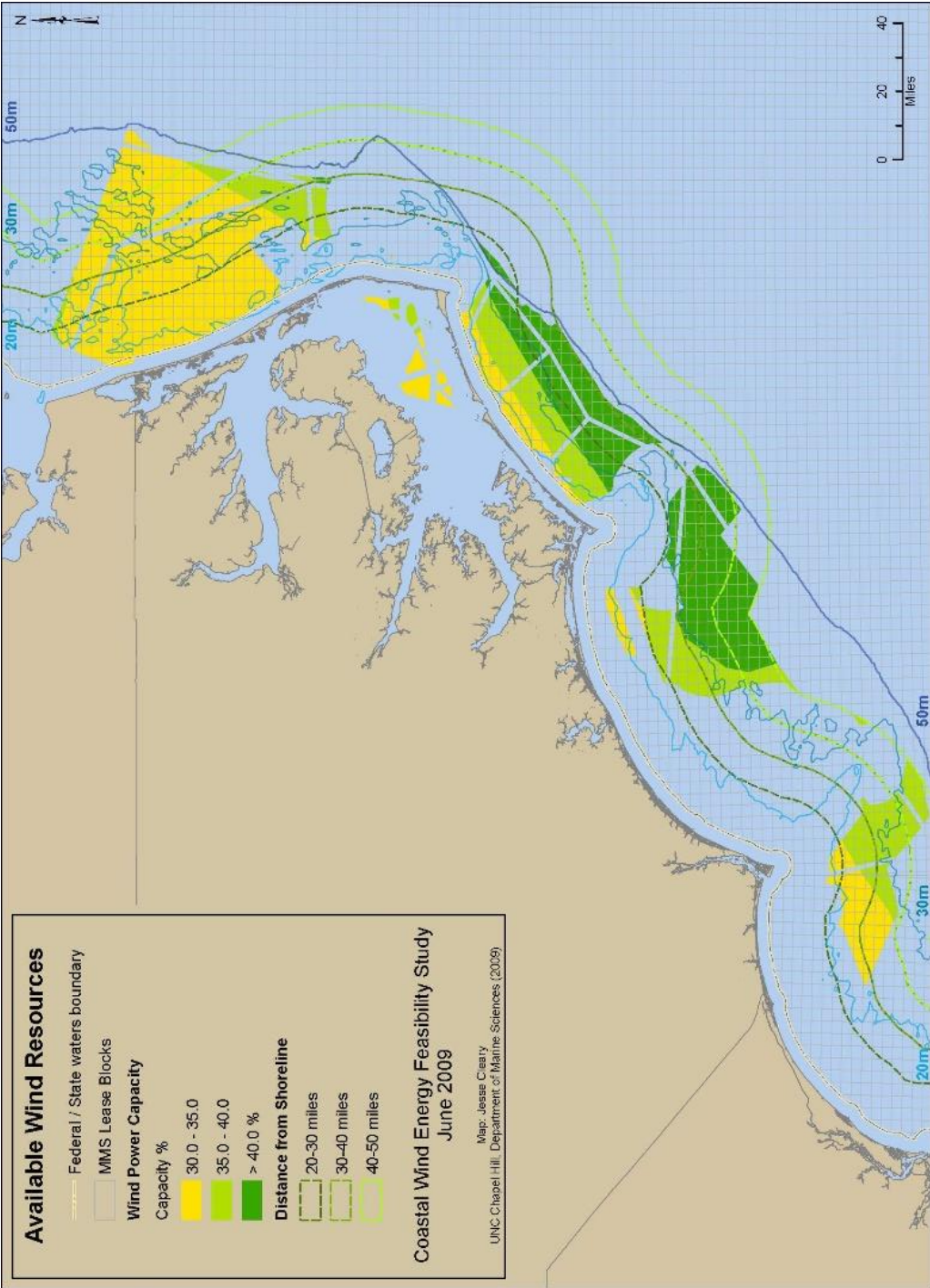


Figure 12.2.2: Ideal Construction Geology Areas (UNC, 2009) (Figure 2.2 in text).

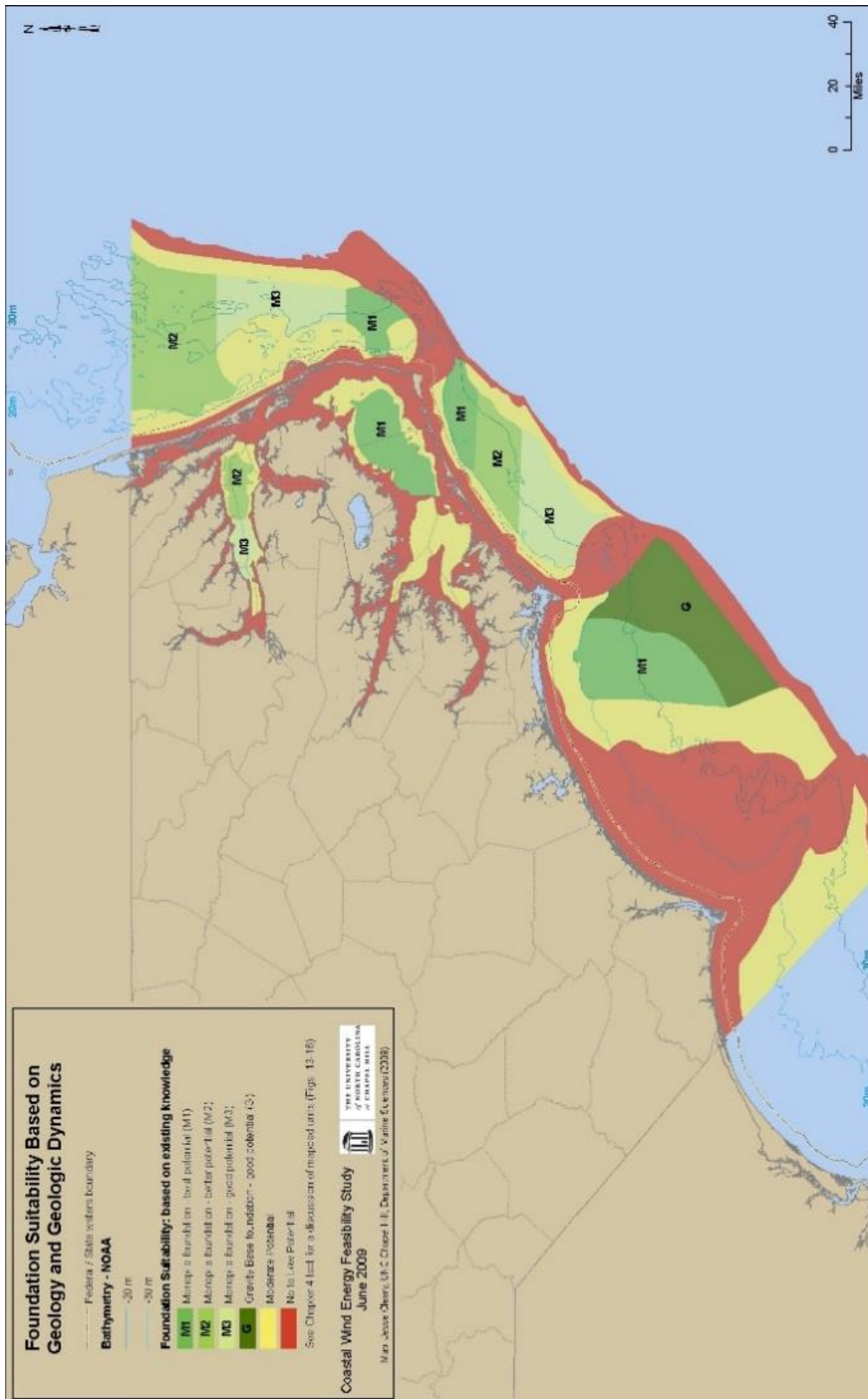


Figure 12.2.3: Fishery and Fish Habitat Locations (UNC, 2009) (Figure 2.3 in text).

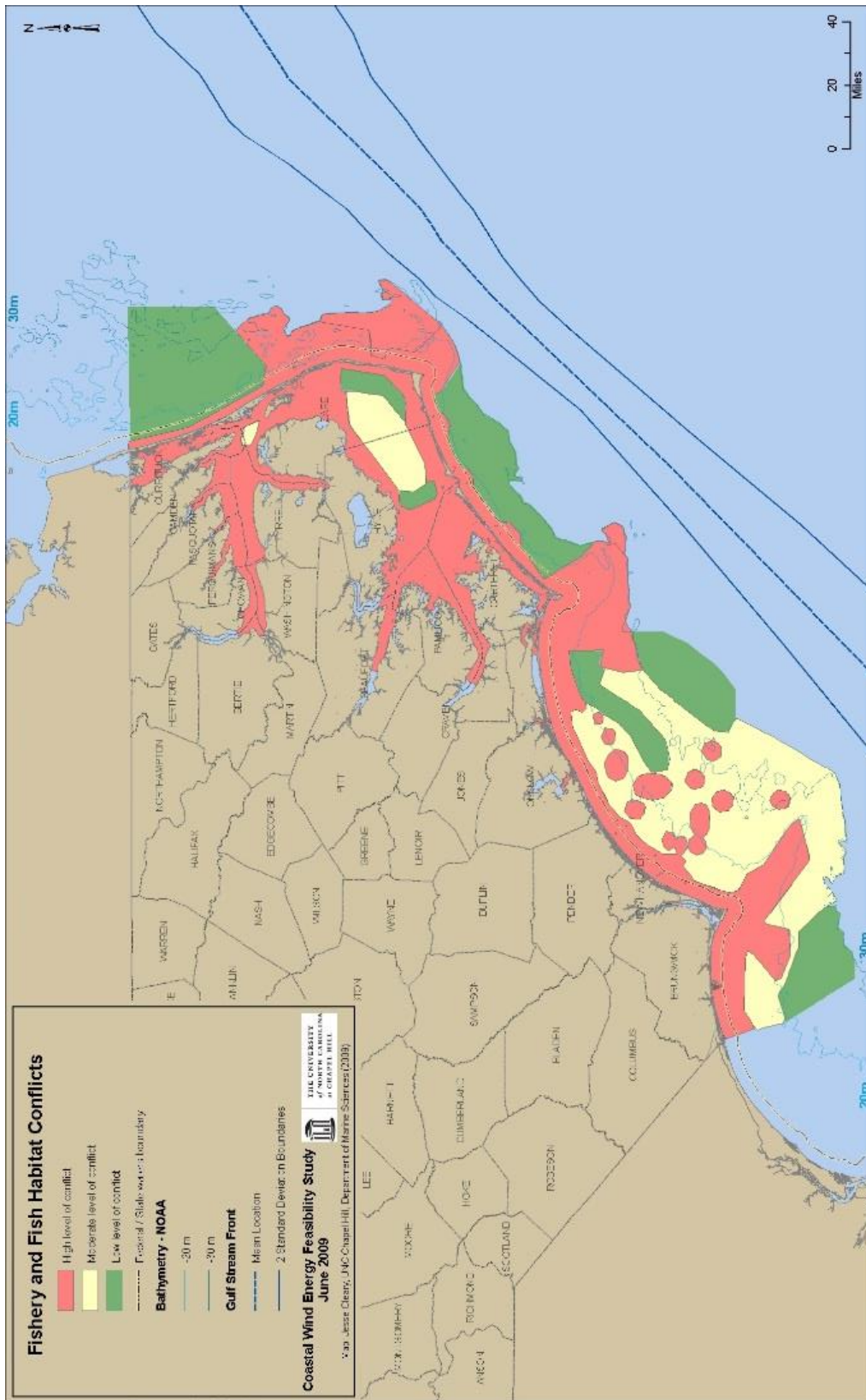


Figure 12.2.4: Bird and Bird Habitat Locations (UNC, 2009) (Figure 2.4 in text).

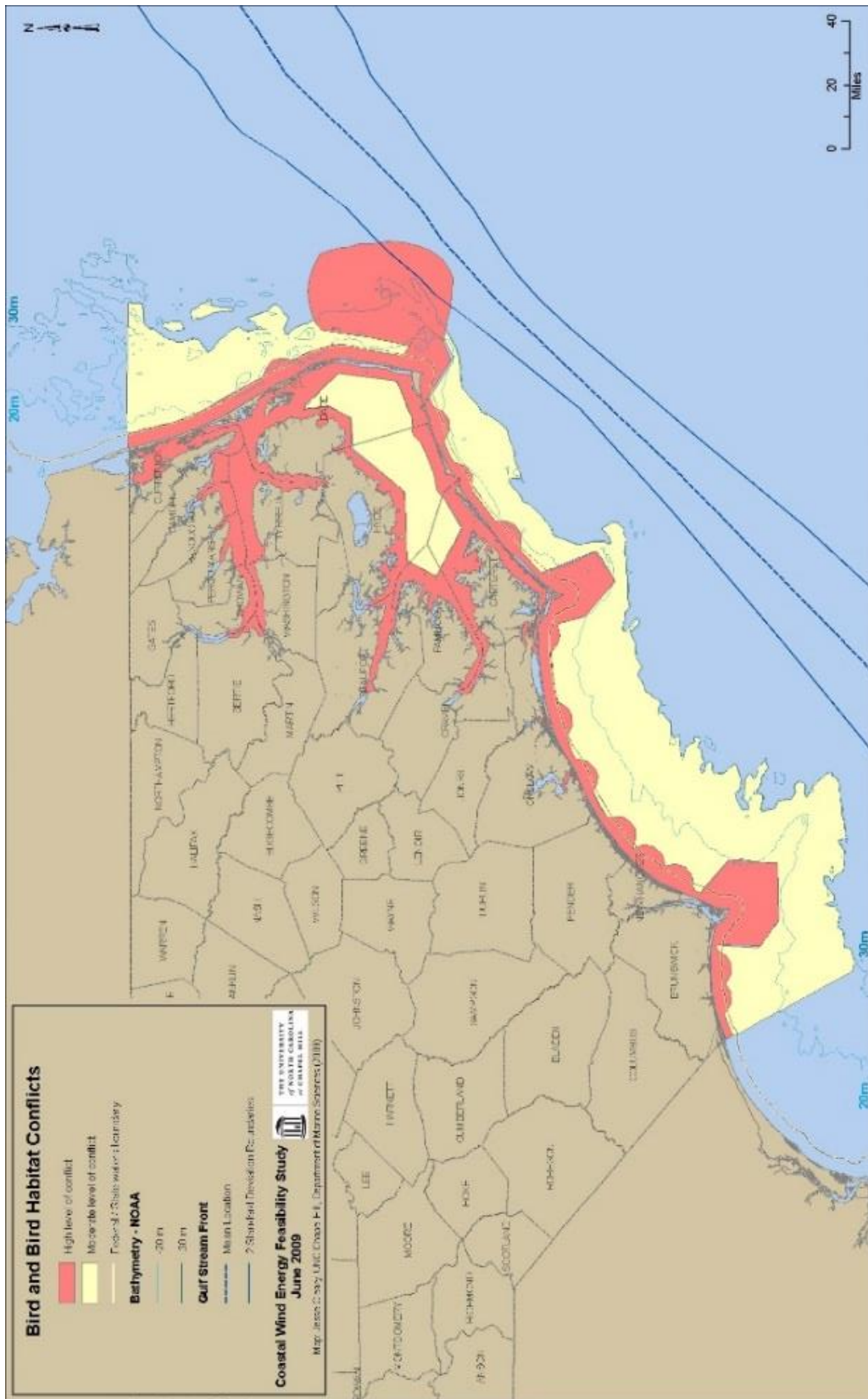


Figure 12.2.5: Military Airspace (UNC, 2009) (Figure 2.5 in text).

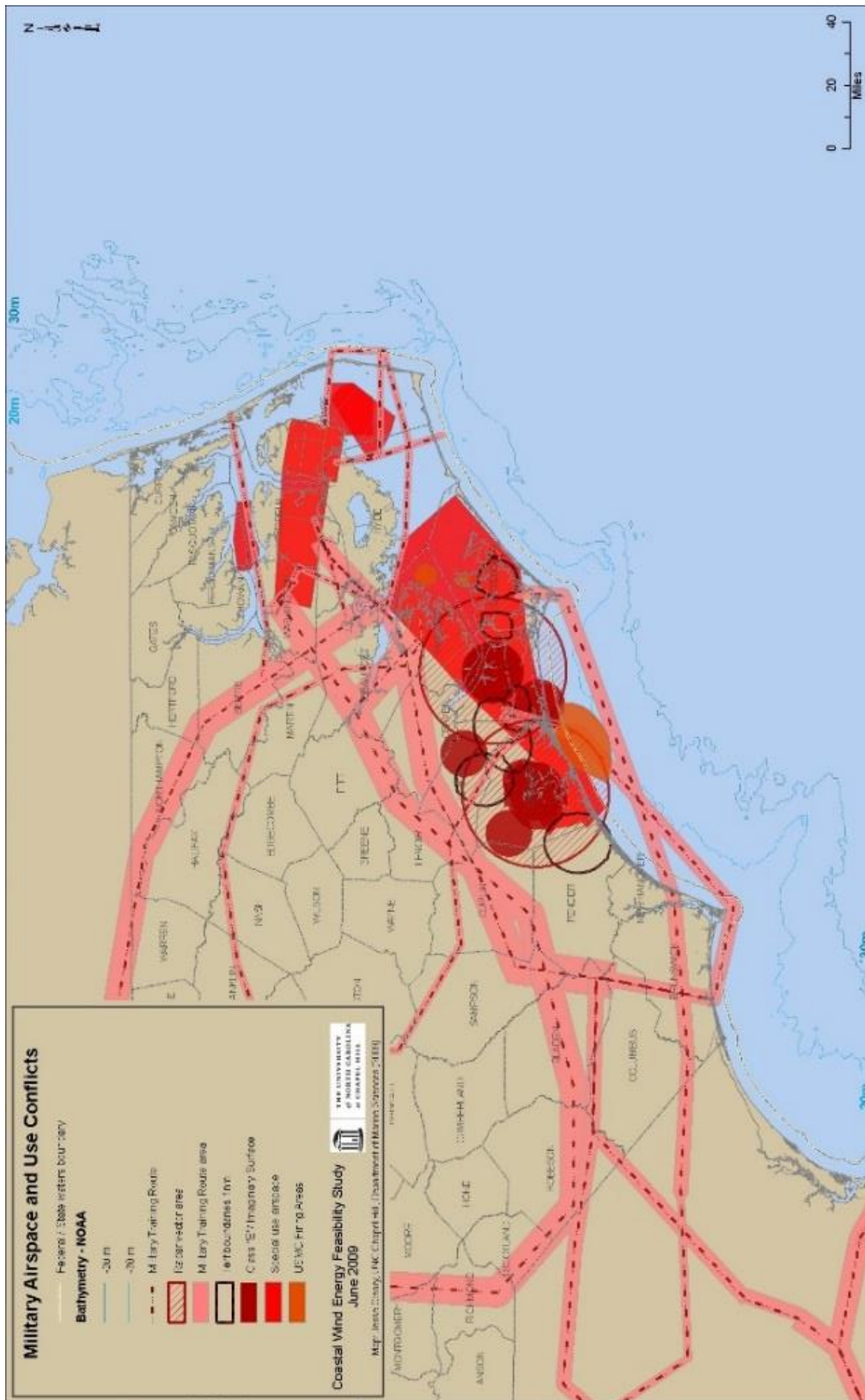


Figure 2.6: Vessel Transportation Corridors, Cultural Resources, and Reef Habitats (UNC, 2009) (Figure 2.6 in text).

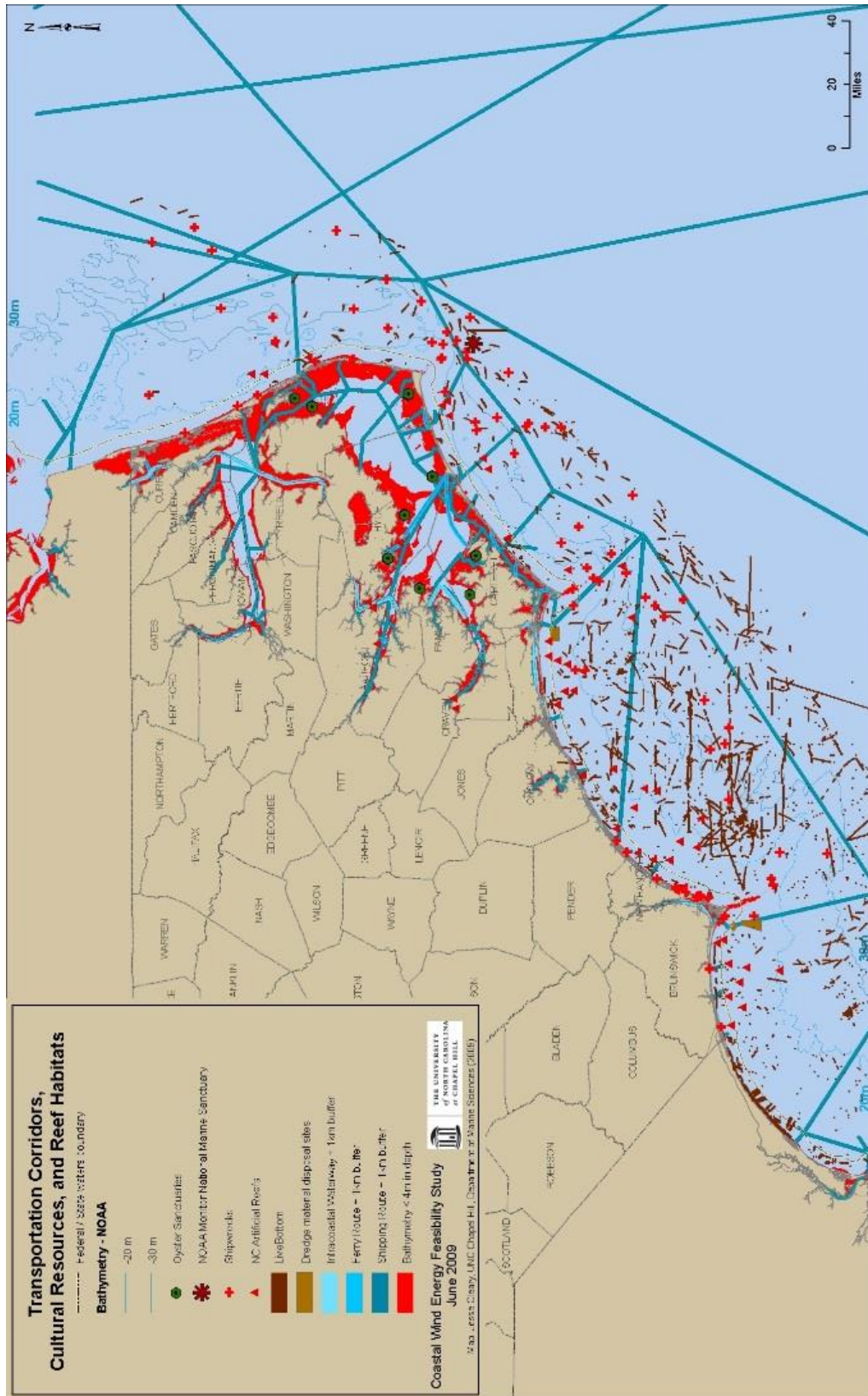


Figure 12.2.7: Existing Onshore Electrical Transmission Infrastructure (UNC, 2009) (Figure 2.7 in text).

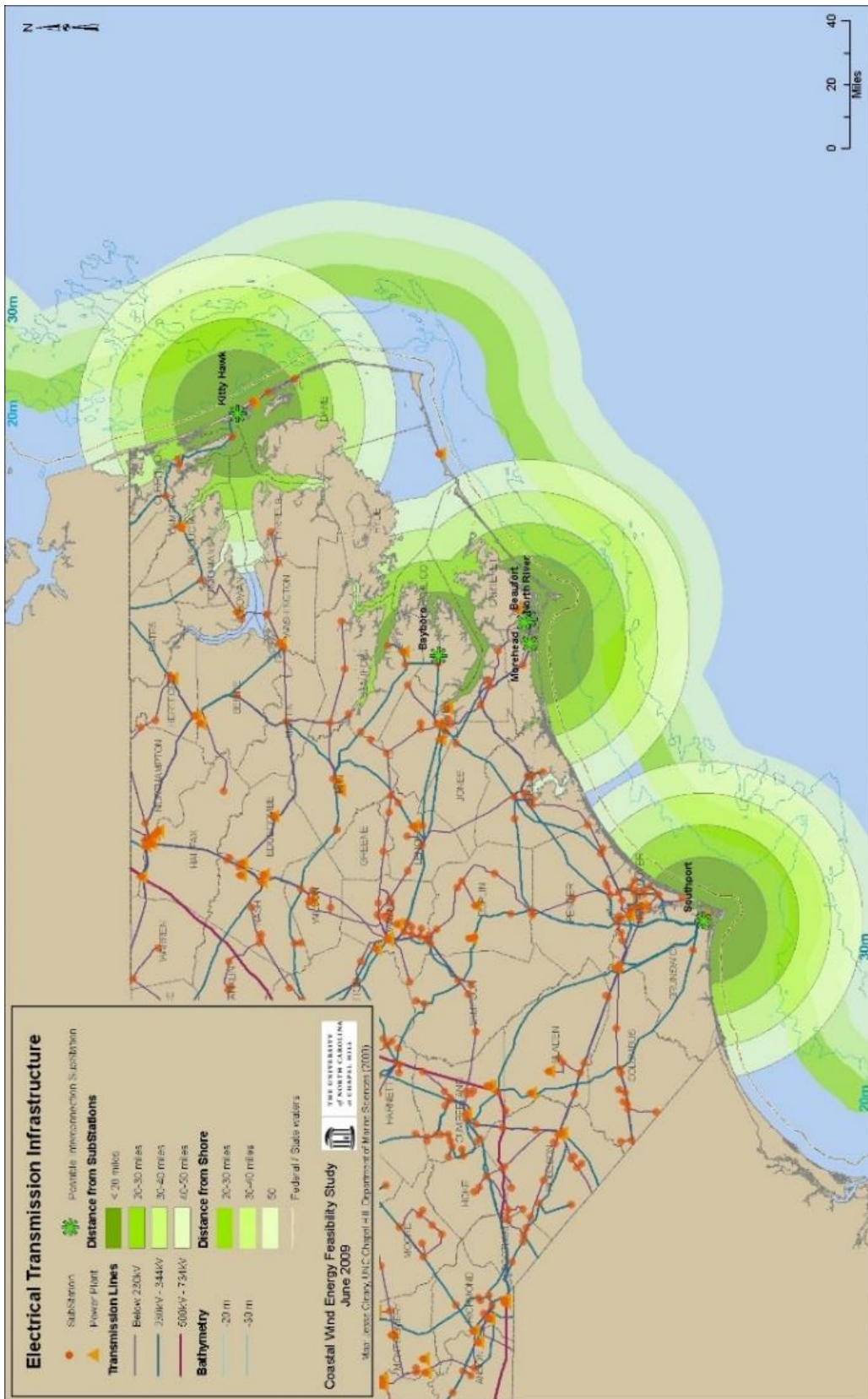
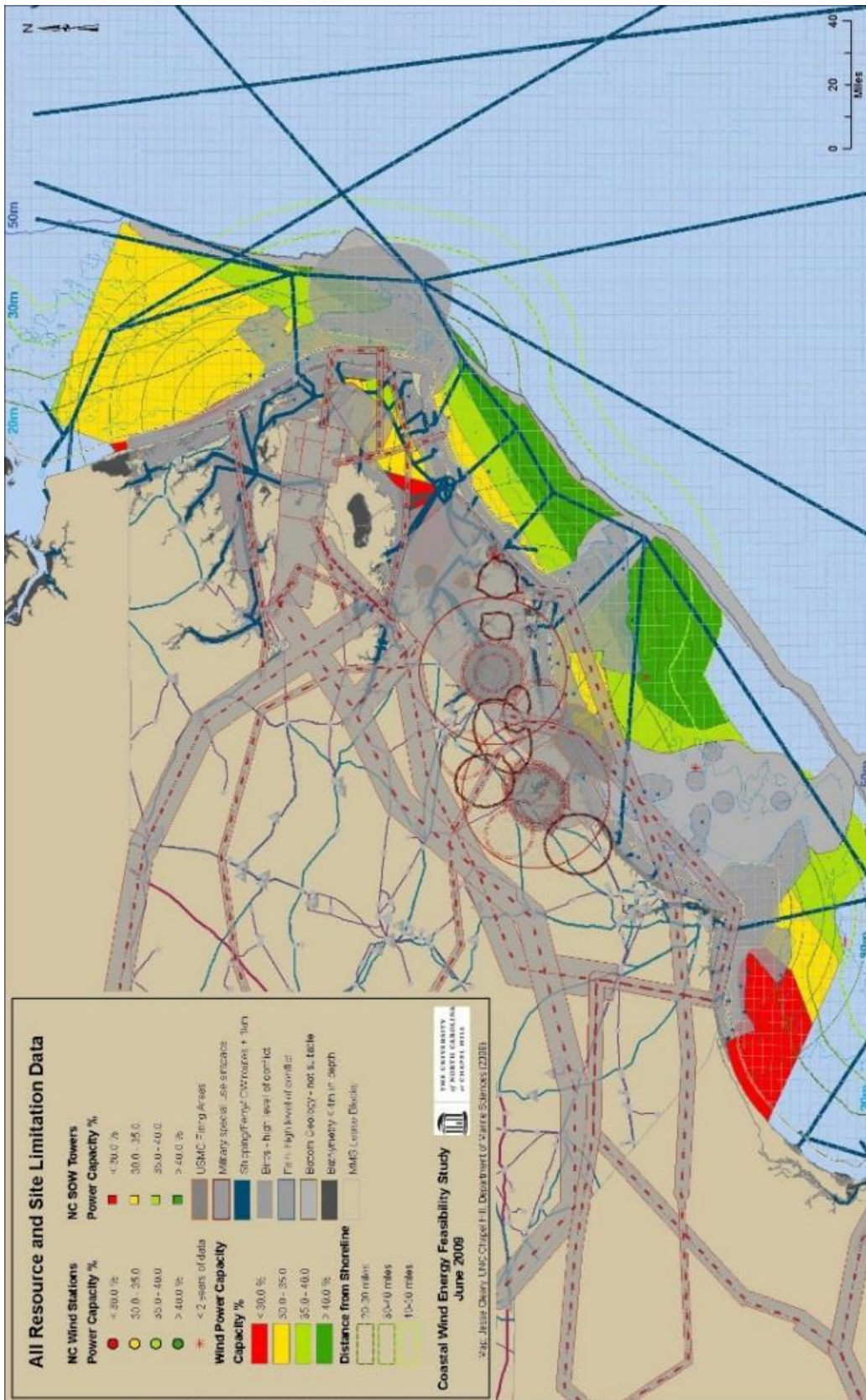


Figure 12.2.8: All Use Conflicts (UNC, 2009) (Figure 2.8 in text).



12.3 Implementation Appendix

Table 12.3.1-12.3.4: Land Use Policies related to offshore wind development.

Brunswick		
Town	CAMA	Land Use Plan/UDO
Brunswick County	not clear	SUP (RU-I,I-G)
Sunset Beach	not allowed	not permitted
Ocean Isle Beach	not clear	N/A
Holden Beach	unavailable	unavailable
Oak Island	not clear	not clear
Southport	not clear	permitted
Shallotte	not clear	conditional
Caswell Beach	opposed	N/A

New Hanover		
Town	CAMA	Land Use Plan/UDO
New Hanover County-Wilmington	not clear	SUP
Wrightsville Beach	opposed	P (C1,C2,C3,GI) C (R1,R2,C5)
Carolina Beach	not clear	not clear
Kure Beach	not clear	N/A

Dare		
Town	CAMA	Land Use Plan/UDO
Dare County	not clear	not clear
Kitty Hawk	not clear	not clear
Nags Head	not clear	not clear
Duck	not clear	not clear
Corolla	N/A	not clear
Kill Devil Hills	not clear	not clear
Wanchese	unavailable	unavailable
Manteo	unavailable	not clear

Currituck		
Town	CAMA	Land Use Plan/UDO
Currituck County	unavailable	SUP
Southern Shores	unavailable	unavailable
Corolla	unavailable	unavailable

12.5 Environmental Appendix

12.5.1 Additional Environmental Figures:

Figure 12.5.1: HRG Survey of Cable Route to Wilmington-West WEA (BOEM, 2015).

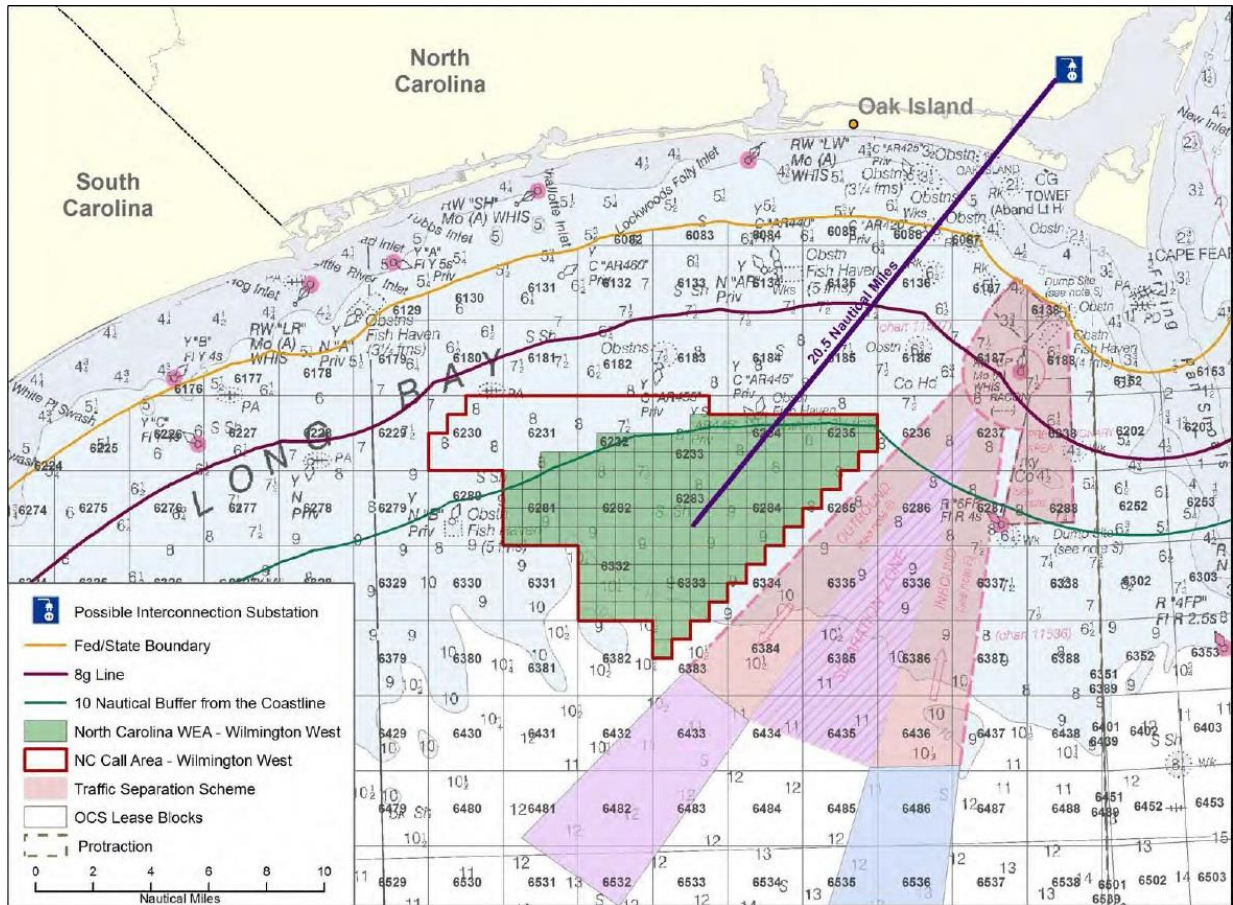


Figure 12.5.2: HRG Survey of Cable Route to Wilmington-East WEA (BOEM, 2015).

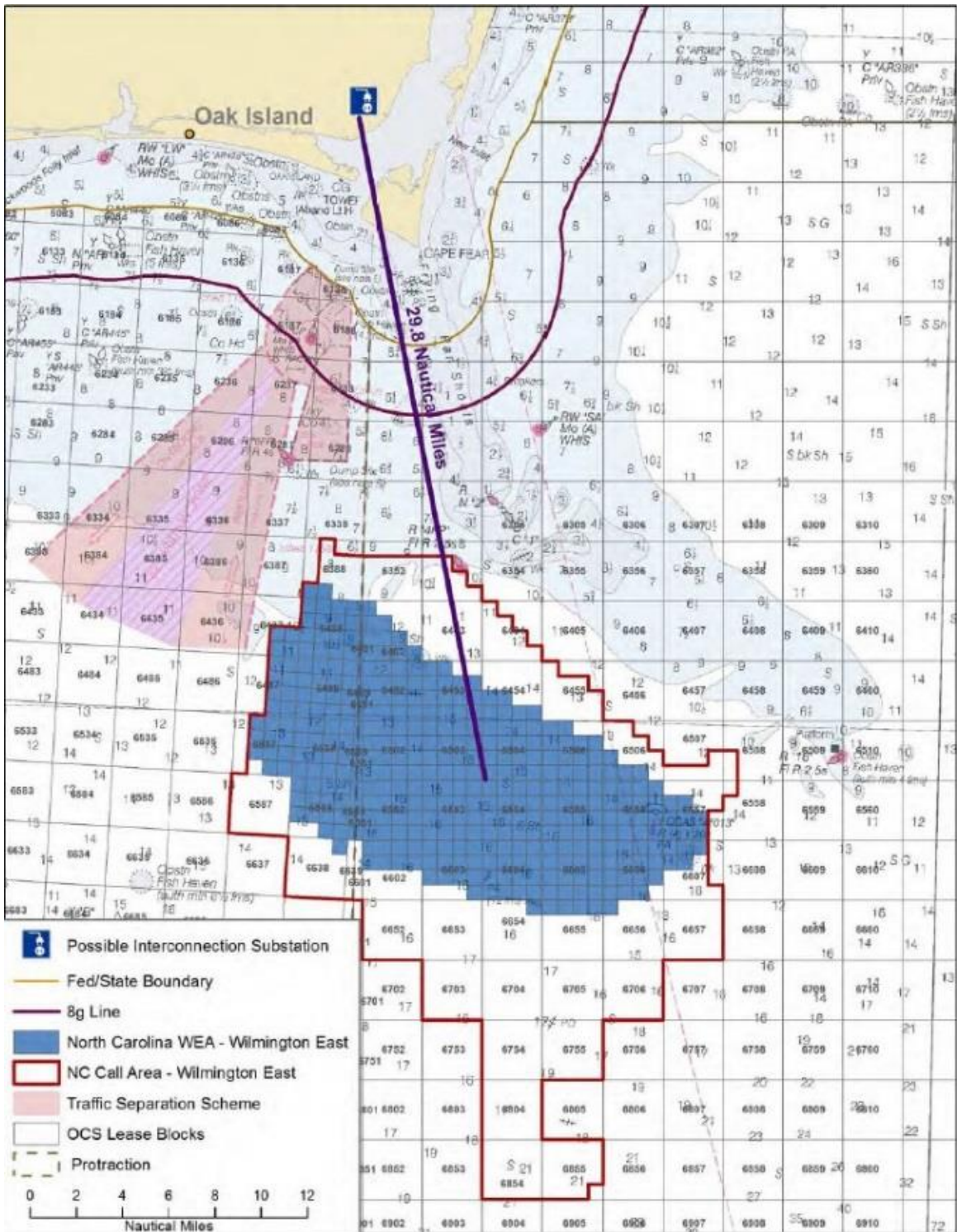


Figure 12.5.3: HRG Survey of Cable Route to Kitty Hawk WEA (BOEM, 2015)

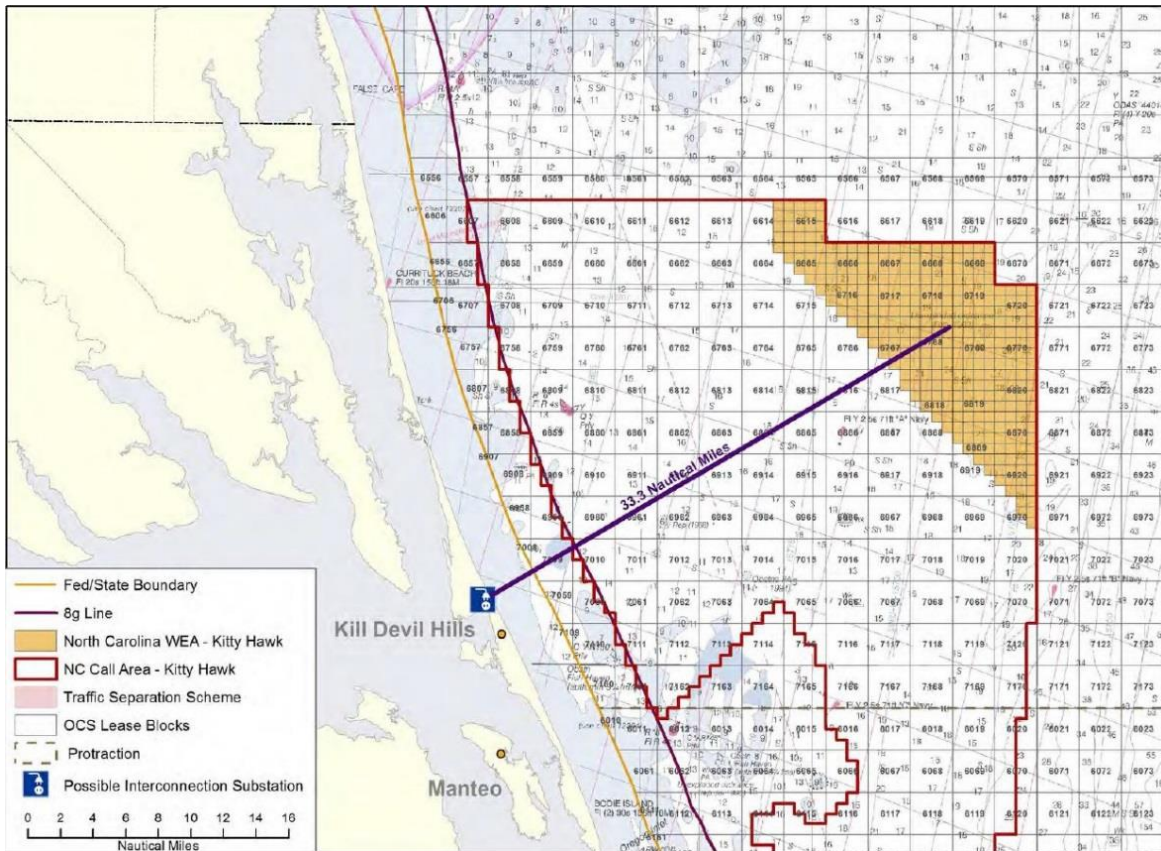


Figure 12.5.4: Hard Bottom Habitat at Wilmington-West WEA (BOEM, 2015).

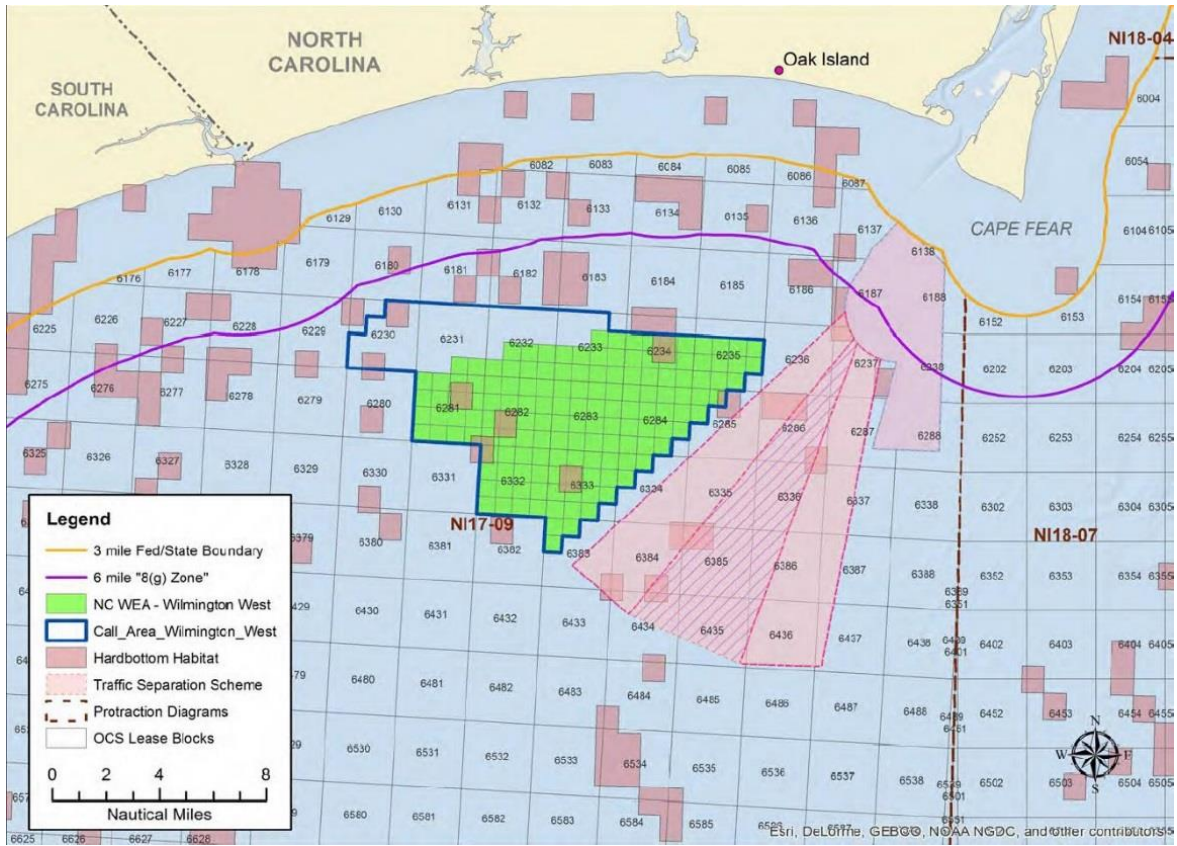


Figure 12.5.5: Hard Bottom Habitat at Wilmington-East WEA (BOEM, 2015)

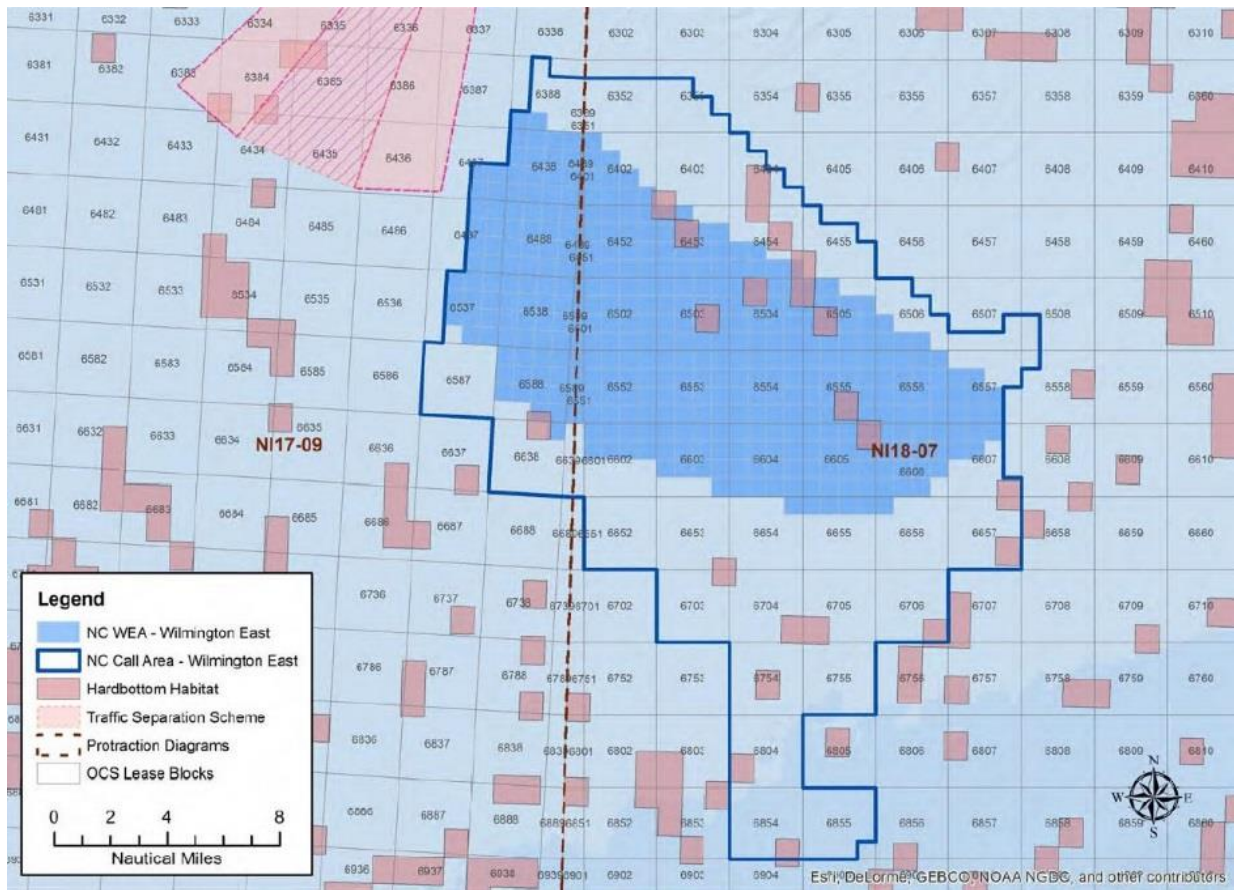
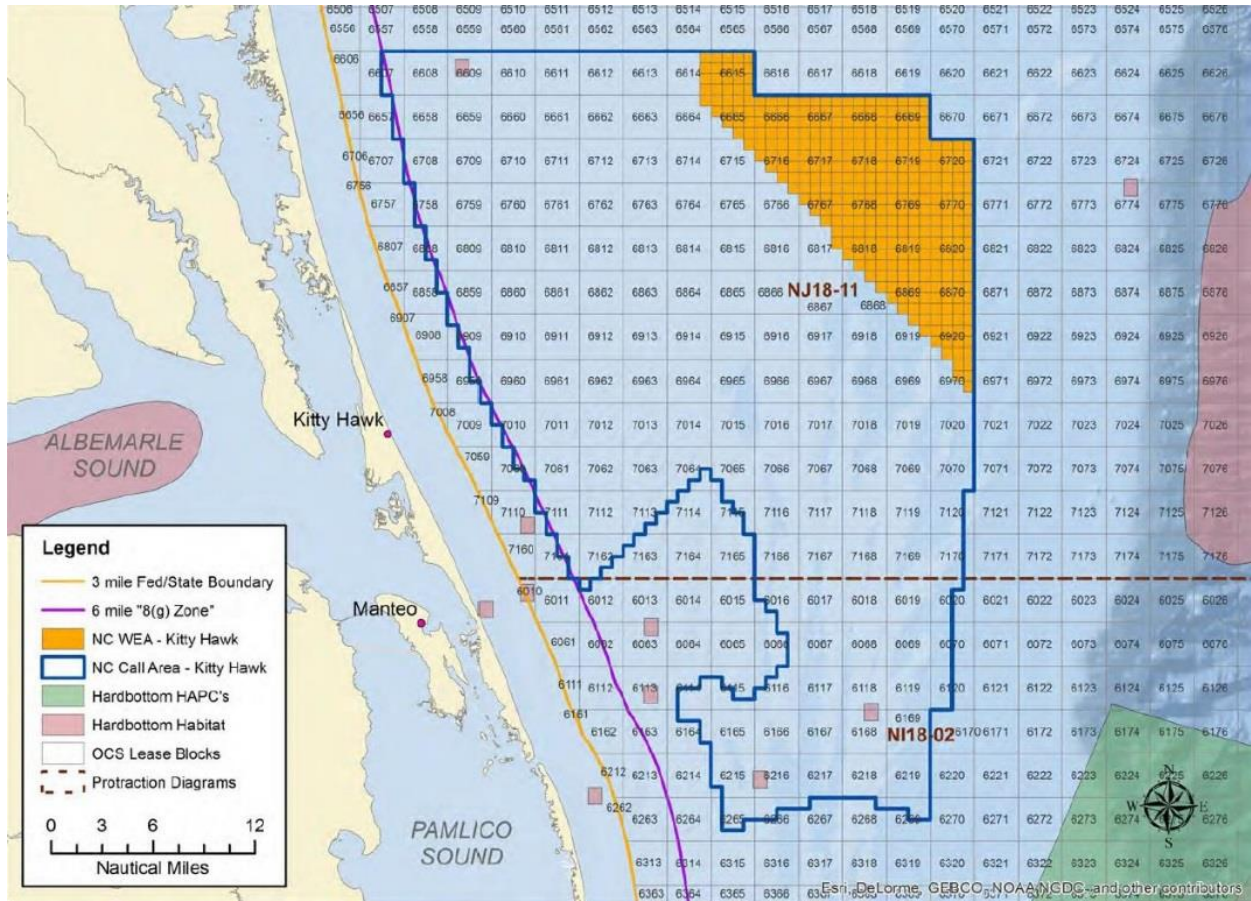


Figure 12.5.6: Hard Bottom Habitat at Kitty Hawk WEA (BOEM, 2015).



Coastal Migratory Pelagics of the Gulf of Mexico and South Atlantic			
Cobia	King mackerel	Spanish mackerel	
Coral, Coral Reefs, and Live/Hard Bottom Habitats of the South Atlantic Region			
Ahermatypic stony corals	Antipatharia (black corals)	Hermatypic stony corals	
Octocorals, except Pennatulacea	Pennatulacea (sea pens and sea pansies)		
Gulf of Mexico/South Atlantic Spiny Lobster			
Slipper lobster		Spiny lobster	
South Atlantic Golden Crab			
Golden crab	Jonah crab	Red crab	
South Atlantic Shrimp			
Brown shrimp	Royal red shrimp	White shrimp	
Pink shrimp	Rock shrimp		
South Atlantic Snapper-Grouper			
Almaco jack	French grunt	Porkfish	Smallmouth grunt
Atlantic spadefish	Gag	Puddingwife	Snowy grouper
Banded spadefish	Grass Porgy	Queen snapper	Spanish grunt
Bank sea bass	Gray (Mangrove) snapper	Queen triggerfish	Speckled hind
Bar jack	Graysby	Red grouper	Tiger grouper
Blackfin snapper	Gray triggerfish	Red hind	Tilefish
Black grouper	Greater amberjack	Red porgy	Tomtate
Blueline tilefish	Hogfish	Red snapper	Vermillion snapper
Black margate	Jolthead porgy	Rock hind	Warsaw grouper
Black sea bass	Knobbed porgy	Rock sea bass	Whitebone porgy
Blue runner	Lane snapper	Sailor's choice	White grunt
Black snapper	Lesser amberjack	Sand tilefish	Wreckfish
Bluestriped grunt	Longspine porgy	Saucereye porgy	Yellowedge grouper
Coney	Mahogany snapper	Scamp	Yellowfin grouper
Cottonwick	Margate	Schoolmaster	Yellow jack
Crevalle jack	Misty grouper	Scup	Yellowmouth grouper

Cubera snapper	Mutton snapper	Sheepshead	
Dog snapper	Ocean triggerfish	Silk snapper	
Atlantic Highly Migratory Species			
Atlantic albacore tuna	Atlantic angel shark	Dusky shark	Sandbar shark
Atlantic bigeye tuna	Atlantic sharpnose shark	Finetooth shark	Scalloped hammerhead
Atlantic bluefin tuna	Basking shark	Great Hammerhead	Shortfin mako shark
Atlantic skipjack tuna	Bigeye thresher shark	Lemon shark	Silky shark
Atlantic yellowfin tuna	Blacknose shark	Longfin mako shark	Spinner shark
Atlantic swordfish	Blue marlin	Night shark	Tiger shark
Blue marlin	Blue shark	Nurse shark	Whale shark
Longbill spearfish	Bonnethead shark	Oceanic whitetip shark	White shark
Sailfish	Bull shark	Porbeagle shark	Smooth dogfish
White marlin	Caribbean reef shark	Sand tiger shark	

Table 12.5.1: Essential Fish Habitat and Fisheries (BOEM, 2014b).

12.6 Economic Appendix

12.6.1 CBA Calculations:

Construction Costs: The construction costs were calculated based upon the work of the European Wind Energy Association. In their 2009 book, *Wind energy-- the facts a guide to the technology, economics and future of wind power*, they indicate that wind prices were equal to a maximum price of €2.06m/MW. As of the exchange rate on March 15, 2015 that value was equivalent to approximately \$2.16m/MW. Knowing this value enabled the total construction cost of the wind turbines to be calculated using either 100, 200, or 340 5MW turbines, depending upon the particular analysis.

Grid Integration Costs: Integrating the wind facility to the grid on land is another one-off cost of this project. A 2013 report, *Assessing Wind Power Cost Estimates*, established that it could cost from \$5/MWh to \$12/MWh to integrate a wind facility into a grid. Since that report primarily focused on the integration of onshore wind facilities this analysis will take the maximum estimated value (\$12/MWh) for grid integration cost to best represent the potential costs of offshore wind facility integration. Using the expected MWh produced, based upon the number of turbines and the capacity factor of 40 percent, the value for grid integration costs was calculated.

Operation and Maintenance Costs: Operation and maintenance costs were also based upon the same *Assessing Wind Power Cost Estimates* report. Again there was a range in the costs/MWh, ranging from \$9-20/MWh, and again this analysis will take the high value given the offshore component of this wind facility (Giberson, 2013). Using the MWh produced the yearly operational costs were calculated and then expanded over the next 30 years with a one percent rate of growth.

Disaster Costs: For this analysis the disaster scenario was kept simple. It was used as a method to create a rough estimate on increased costs due to unforeseen events. In this case, the analysis assumes that there is a 50% destruction of the wind facility. Therefore the value used in the disaster scenario is simply equivalent to half the original construction costs, with 15 years of growth added as well. This value does not take into account whether any debris, created from an event destroying half the facility, would cause damage to any other public or private property. Nor does this number take into account infrastructure related damage.

Property Values Decrease: The impact a wind facility might have on Brunswick County property values was determined by comparing the North Carolina project to another in Cape May County, New Jersey. The initial loss of value due to the wind facility's construction in Cape May County was estimated to be 3.4 percent (Global Insight, 2008). This value in conjunction with the total property value of Brunswick County was used to calculate the initial value lost.

Tourism Costs: Like property values, there is a likely chance that tourism revenue will be impacted initially. Once again the Brunswick County and Cape May County parallel was used. The percent decrease in tourism expected in Cape May County was calculated. This percentage was then used to calculate the potential tourism revenue lost in Brunswick County from its 2013 revenue of \$477.7million (Callison, J. 2014).

Energy Generated: The cape wind project estimated that each kWh of energy produced by a wind facility was equivalent to \$0.037. This theoretical project's output in kWhs was used to determine the resultant value of the energy generated.

Job Creation Benefits: The benefit of job creation, in both construction and regular operations, was calculated by using a 250MW turbine estimated value, solving for the value per MW, and then multiplying that value by the theoretical full MW capacity of the various wind facilities in the analysis.

Tourism Benefits: Similar to the calculation for tourism costs, tourism benefits again used the percentage increase in tourism from Cape May County. It then used the 2013 tourism revenue from Brunswick County to estimate the increase in revenue from the presence of an offshore wind facility in Brunswick County.

CO₂ Reduction Benefits: The starting value for CO₂ emissions is \$37 per metric ton via the U.S. Interagency Working Group on the Social Cost of Carbon. ExxonMobil, in an energy market future outlook report, prospected the free market value for CO₂ emissions to be \$80 per

metric ton, for the year 2040. Starting from year 1, we calculated a growth of 1.0 percent for the free market value of CO₂, to correspond to ExxonMobil's projections. It was considered necessary to meet the \$80 per metric ton value for 2040, as the value of CO₂ will continue to rise with further global growth, industrialization, and expansion of the energy market.

Reduced CO₂ emissions is considered a benefit, due to the relatively high cost per metric ton of CO₂ created from fossil fuel based energy production. For the energy production sector, as well as other heavy industries, CO₂ emissions are often limited or capped at standardized values. Emissions higher than the standard require extra fees or credits for the producer. This cost is most associated with abatement for climate change and the increasing concentration of CO₂ in the atmosphere from anthropogenic sources, such as the burning of fossil fuels and heavy industry. Since offshore wind energy does not require any burning of fossil fuels for energy production, a significant source of emitted CO₂, the cost value of CO₂ is considered a savings and therefore is a benefit in our analysis.

12.7 Political Feasibility

12.7.1 Visualization Study Images

Figure 12.7.1: Bald Head Island Visualization Study, 7MW Turbines at 10 nm.



T. J. Boyle Associates
landscape architecture • planning • consulting

VISUALIZATION STUDY FOR OFFSHORE NORTH CAROLINA
015 Bald Head Island Simulation, Late Afternoon, Vestas V164-7.0 MW, 10 nm

Figure 12.7.2: Currituck Lighthouse Visualization Study, 7MW Turbines at 20 nm.



Figure 12.7.3: Oak Island Visualization Study, 7MW Turbines at 10 nm.



Figure 12.7.4: Holden Beach Visualization Study, 7MW Turbines at 10 nm at night.



12.8 Survey

12.8.1 Full Survey Distributed to Respondents

Survey Introduction: An offshore wind farm is a group of offshore wind turbines that capture wind to produce electricity. Currently, North Carolina has no offshore wind farms, but has the resources capable of providing alternative energy to North Carolina. Resources have been focused along North Carolina's coast in Kitty Hawk, and East and West Wilmington. The federal government supports the potential lease sale for more than 300,000 acres on an area off the northern Outer Banks (Kitty Hawk) and two near Wilmington (Wilmington East and Wilmington West). Wilmington West includes about 51,600 acres that begin about 10 nautical miles from shore and extend roughly 12.3 nautical miles in an east/west direction. Wilmington East includes about 133,600 acres that begin 15 nautical miles from shore and extend 18 nautical miles in a southeasterly direction. Kitty Hawk includes about 122,600 acres that begin 24 nautical miles from shore and extend seaward 13.5 nautical miles in a northeasterly direction.

Survey Description: The purpose of this survey is to measure public opinion and political support concerning whether North Carolina should approve and promote the development of offshore energy from wind power or oppose it. This survey consists of questions related to five main categories including political viability, technical feasibility, economic analysis, environmental analysis and general household questions. The purpose of the survey is to question resident views of the potential development of offshore energy from wind power along North Carolina's coast. It is our hope that this survey will assist in the development of sound policy for North Carolina's coast.

Survey Design: The survey is designed to provide statistically significant results to aid in understanding public sentiment concerning offshore wind energy development off of North Carolina's coast. Using descriptive research, the survey is structured in design so the information collected can be statistically presumed for the sampled population. Using descriptive research, the survey is structured to allow us to better define an opinion, attitude, or behavior held by a group of people on a given subject. By using multiple choice questions, we can group responses into predetermined choices which should then provide data that can be statistically presumed for the sampled population. This research allows us to measure the significance of our results on the study population as a whole, as well as the changes in respondent's opinions, attitudes, and behaviors over time.

Survey Process: The internet-based survey will be arranged in tables where each question will be viewed on a separate page so that participants can answer the questions without having to scroll (one page to the next page). The length for the survey should not exceed 10 minutes. It will be administered to different audiences and will be examined for any patterns. The survey will be posted on a public site and distributed to numerous entities. We will ask these entities to then forward the survey to any relevant contacts that they may have. These entities include, but are not limited to: builder associations, town/city managers, NC planners list serves, council of government directories list serves and planners/politicians to distribute. At the end of the survey, participants will be given the option of providing their email address if they wish to view the results of the survey. The results will be sent to participants through a separate link. We will be honest and upfront regarding the final distribution, participant audience, any discrepancies and results of our survey upon completion.

Survey Questions:

What is your general attitude toward wind power?

- Very positive
- Positive
- Neutral
- Negative
- Very negative

How important do you think it is for North Carolina to move away from fossil fuels like gas, oil and coal and use more clean energy?

- Very important
- Important
- Neutral
- Unimportant
- Very unimportant

What is your general attitude toward offshore energy from wind power?

- Very positive
- Positive
- Neutral
- Negative
- Very negative

Of the following issues, what matters the most to you from the choices below concerning offshore wind turbines off of North Carolina's coast?

- Good for the environment
- Reducing foreign oil dependence
- Lower electricity rates
- Boost to the local economy and job creation
- Air pollution levels would decrease

Have you ever seen a wind turbine in operation?

- Yes
- No

What is your primary reason from the choices listed below for not supporting offshore wind turbines off of North Carolina's coast?

- Too expensive and not cost-effective
- They are too noisy
- They are not aesthetically pleasing
- Property values would decline
- I do support an offshore wind farm for North Carolina

Do you own a house or beach house on the North Carolina Coast?

- Yes
- No

Can you see the ocean from your house or beach house?

- Yes
- No

Generally speaking, how do you feel about the placement of offshore wind turbines in North Carolina if you CAN see them from your house?

- Strongly support
- Support
- Neither support nor object
- Do not support

Generally speaking, how do you feel about the placement of offshore wind turbines in North Carolina if you CANNOT see them from your house?

- Strongly support

Support
 Neither support nor object
 Do not support

If you could see a wind turbine from a beach in North Carolina that you most frequent, would it make you more or less likely to visit that beach?

Very likely
 Slightly likely
 Neutral
 Unlikely
 Very unlikely

Approximately how many days have you spent at North Carolina beaches in the past 24 months?

_____ Days

Which beach are you most likely to visit in North Carolina?

Corolla Kitty Hawk
 Nags Head Emerald Isle
 Topsail Beach Wrightsville Beach
 Oak Island Ocean Isle
 No beach

Do you think offshore wind farms would benefit, harm or have no effect at all on the following:

Items	Benefit	No Effect	Harm	Unsure
Local Fishing Industry				
Tourism				
Job Creation				
Air quality				
Electricity Rates				
Aesthetics of ocean view				
Property Values				
Marine Life				
Bird life				
Recreational boating/fishing				
Reducing Climate Change				
Navigation Safety				
U.S. Energy Independence				

Would you attend an educational program about wind energy?

Yes
 Maybe
 No
 Not sure

Would you go on a boat ride/tour of the offshore wind farms?

Yes

Maybe
No
Not sure

Would you prefer North Carolina's offshore wind farms to be owned by:

State of North Carolina
Federal Government
Private Developer
Town/City

In general, the placement of offshore wind turbines in North Carolina for electricity generation should be:

Encourage and promoted
Allowed in appropriate circumstances
Tolerated
Prohibited in all instances
Not sure

Would you support or oppose placing offshore wind turbines in North Carolina?

Support
Oppose
No opinion

Is your community located within 5 miles of the ocean?

Yes
No

Is your community located on a barrier island?

Yes
No

Are you male or female?

Male
Female

What is your age?

Under 20 years
20-24 years
25-34 years
35-44 years
45-54 years
55-59 years
60-64 years
65-74 years
75-84 years
85 years and over

Which category best describes your household income (before taxes) in 2013?

Less than \$10,000
\$10,000 - \$14,999
\$15,000 - \$24,999
\$25,000 - \$34,999
\$35,000 - \$49,999
\$50,000 - \$74,999

\$75,000 - \$99,999
\$150,000 - \$199,999
\$200,000 - \$249,999
\$250,000 and above

What is the highest degree or level of school that you have completed?

Grade school
Some high school
High school graduate
Some college credit
Associate Degree
Bachelor's Degree
Graduate degree/Professional degree

Where is your residence?

Town _____
Zip Code _____

If you wish to view the results of this survey, please provide your email address. This survey is taken in complete autonomy and your email address and answers are completely confidential. Your contribution to this effort is greatly appreciated and your thoughts and opinions are important.

Survey Credit: Several of our questions were designed around two separate surveys from the University of Delaware, School of Marine Science and Policy, College of Earth, Ocean and Environment, Robinson Hall, Newark, DE 19716. Permission was sought and granted by the authors.

Jeremy Firestone - 2012 – *Public Acceptance of Offshore Wind Power across Regions and Through Time*
jf@udel.edu, 392-831-0228

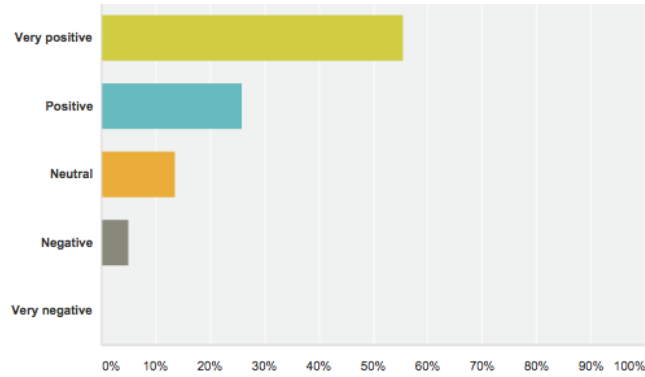
George Parsons - 2011 – *Valuing the Visual Disamenity of Offshore Wind Projects at Varying Distances from the Shore*
gparsons@udel.edu, 302-831-6891

12.8.2 Survey Results

Q1. What is your general attitude toward wind power?

Answered: 81

Skipped: 1

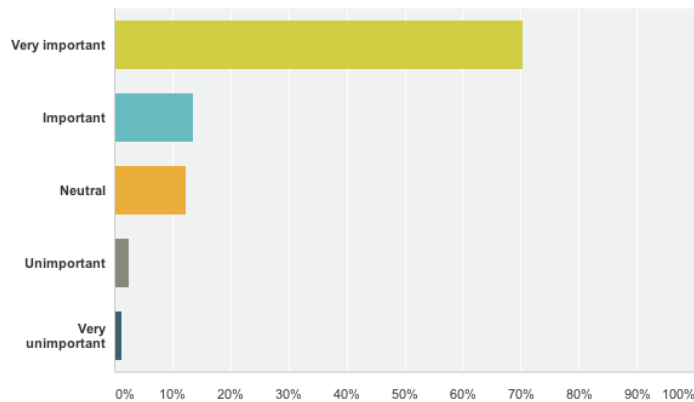


Answer Choices	Responses	Count
Very positive	55.56%	45
Positive	25.93%	21
Neutral	13.58%	11
Negative	4.94%	4
Very negative	0.00%	0
Total		81

Q2. How important do you think it is for North Carolina to move away from fossil fuels like gas, oil and coal and use more clean energy?

Answered: 81

Skipped: 1

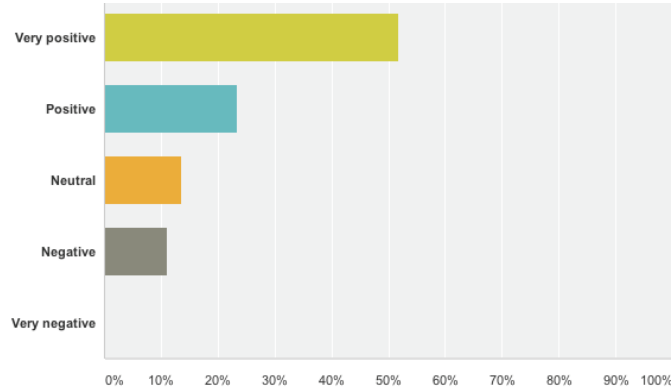


Answer Choices	Responses	Count
Very important	70.37%	57
Important	13.58%	11
Neutral	12.35%	10
Unimportant	2.47%	2
Very unimportant	1.23%	1
Total		81

Q3. What is your general attitude toward offshore energy from wind power?

Answered: 81

Skipped: 1

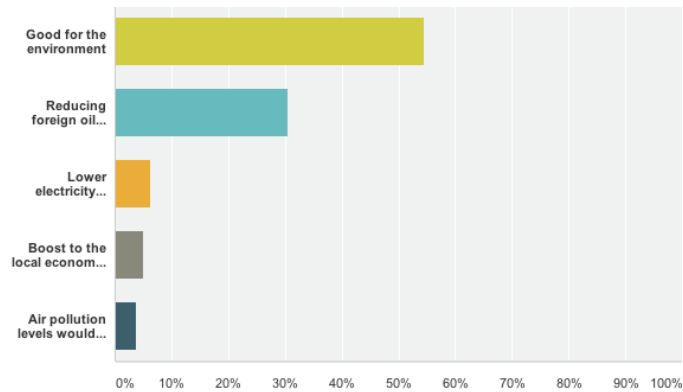


Answer Choices	Responses
Very positive	51.85% 42
Positive	23.46% 19
Neutral	13.58% 11
Negative	11.11% 9
Very negative	0.00% 0
Total	81

Q4. Of the following issues, what matters the most to you from the choices below concerning offshore wind turbines off of North Carolina's coast?

Answered: 79

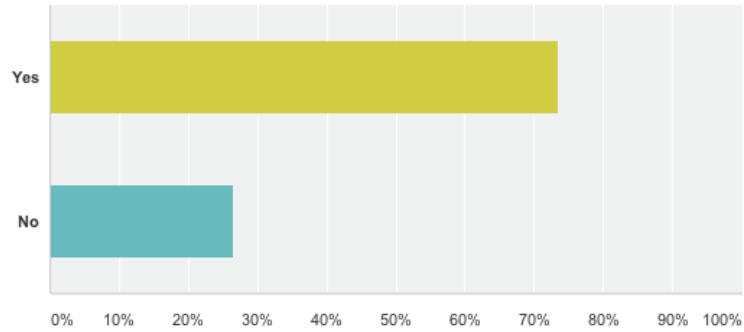
Skipped: 3



Answer Choices	Responses
Good for the environment	54.43% 43
Reducing foreign oil dependence	30.38% 24
Lower electricity rates	6.33% 5
Boost to the local economy and job creation	5.06% 4
Air pollution levels would decrease	3.80% 3
Total	79

Q5. Have you ever seen a wind turbine in operation?

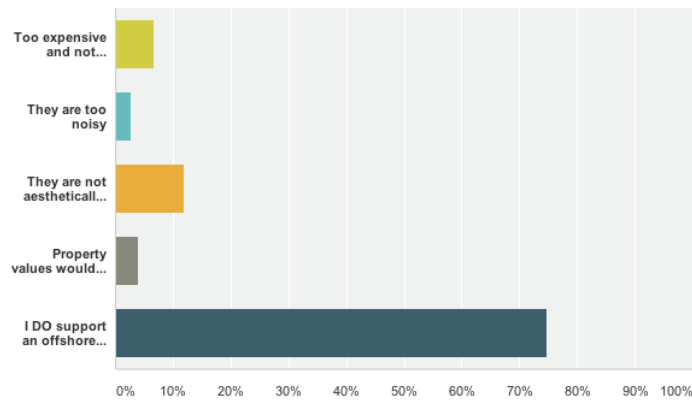
Answered: 79
Skipped: 3



Answer Choices	Responses
Yes	73.42% 58
No	26.58% 21
Total	79

Q6. What is your primary reason from the choices listed below for not supporting offshore wind turbines off of North Carolina's coast?

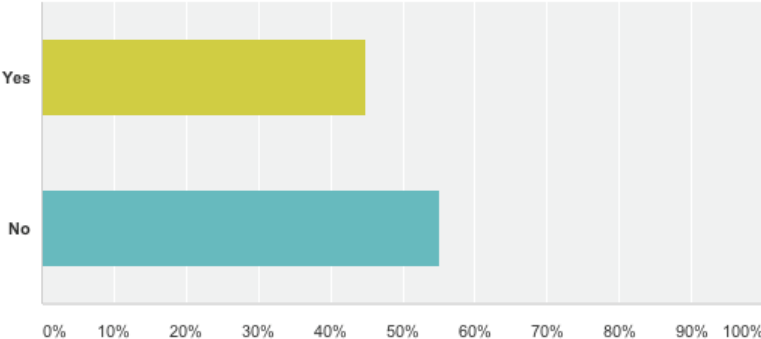
Answered: 75
Skipped: 7



Answer Choices	Responses
Too expensive and not cost-effective	6.67% 5
They are too noisy	2.67% 2
They are not aesthetically pleasing	12.00% 9
Property values would decline	4.00% 3
I DO support an offshore wind farm for North Carolina	74.67% 56
Total	75

Q7. Do you own a house or beach house on the North Carolina Coast?

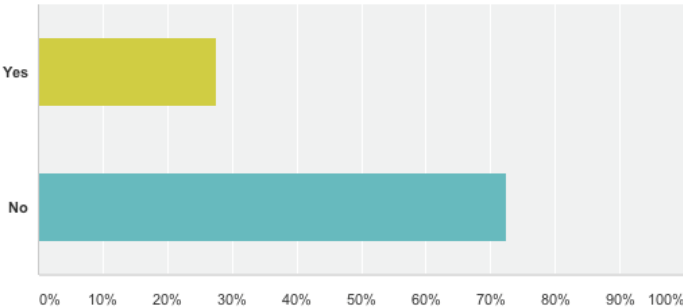
Answered: 78
Skipped: 4



Answer Choices	Responses	
Yes	44.87%	35
No	55.13%	43
Total		78

Q8. Can you see the ocean from your house or beach house?

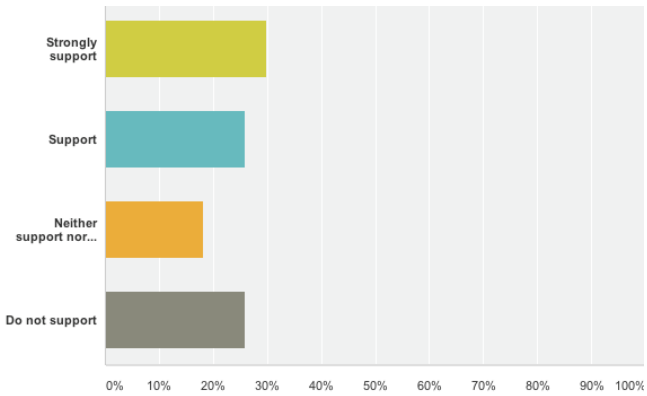
Answered: 80
Skipped: 2



Answer Choices	Responses	
Yes	27.50%	22
No	72.50%	58
Total		80

Q9. Generally speaking, how do you feel about the placement of offshore wind turbines in North Carolina if you CAN see them from your house?

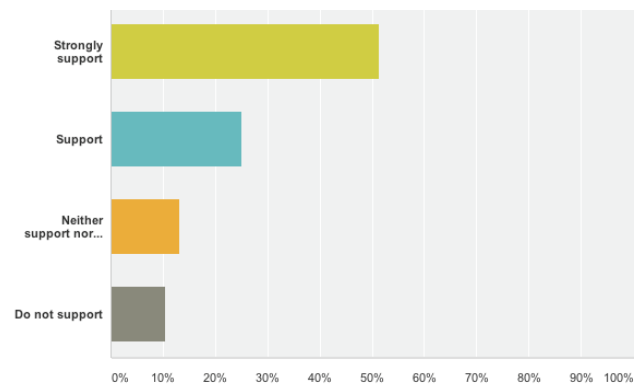
Answered: 77
Skipped: 5



Answer Choices	Responses
Strongly support	29.87% 23
Support	25.97% 20
Neither support nor object	18.18% 14
Do not support	25.97% 20
Total	77

Q10. Generally speaking, how do you feel about the placement of offshore wind turbines in North Carolina if you CANNOT see them from your house?

Answered: 76
Skipped: 6

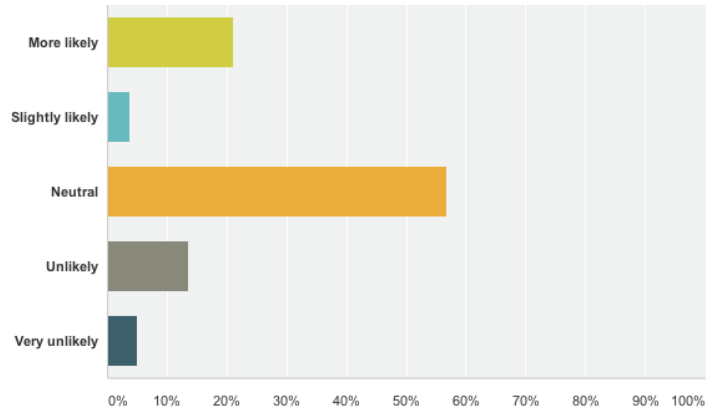


Answer Choices	Responses
Strongly support	51.32% 39
Support	25.00% 19
Neither support nor object	13.16% 10
Do not support	10.53% 8
Total	76

Q11. If you could see a wind turbine from a beach in North Carolina that you most frequent, would it make you more or less likely to visit that beach?

Answered: 81

Skipped: 1



Answer Choices	Responses
More likely	20.99% 17
Slightly likely	3.70% 3
Neutral	56.79% 46
Unlikely	13.58% 11
Very unlikely	4.94% 4
Total	81

Q12. Approximately how many days have you spent at North Carolina beaches in the past 24 months?

Answered: 77

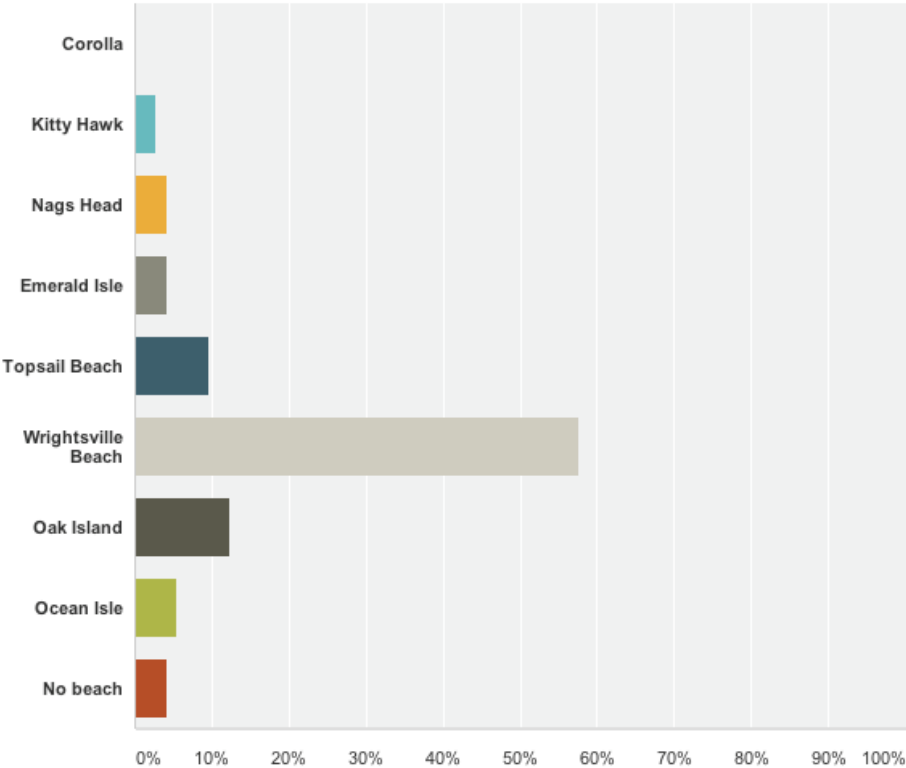
Skipped: 5

[Table not submitted, will add]

Q13. Which beach are you most likely to visit in North Carolina?

Answered: 73

Skipped: 9

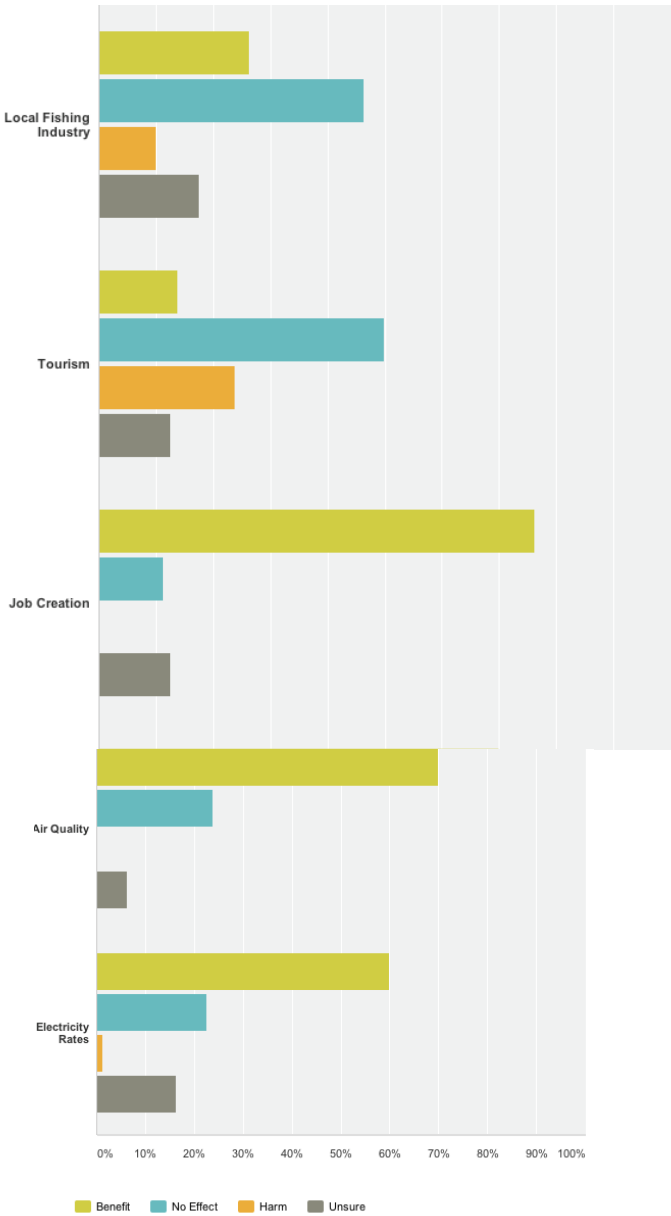


Answer Choices	Responses
Corolla	0.00% 0
Kitty Hawk	2.74% 2
Nags Head	4.11% 3
Emerald Isle	4.11% 3
Topsail Beach	9.59% 7
Wrightsville Beach	57.53% 42
Oak Island	12.33% 9
Ocean Isle	5.48% 4
No beach	4.11% 3
Total	73

Q14. Do you think offshore wind farms would benefit, harm or have no effect at all on the following:

Answered: 80

Skipped: 2

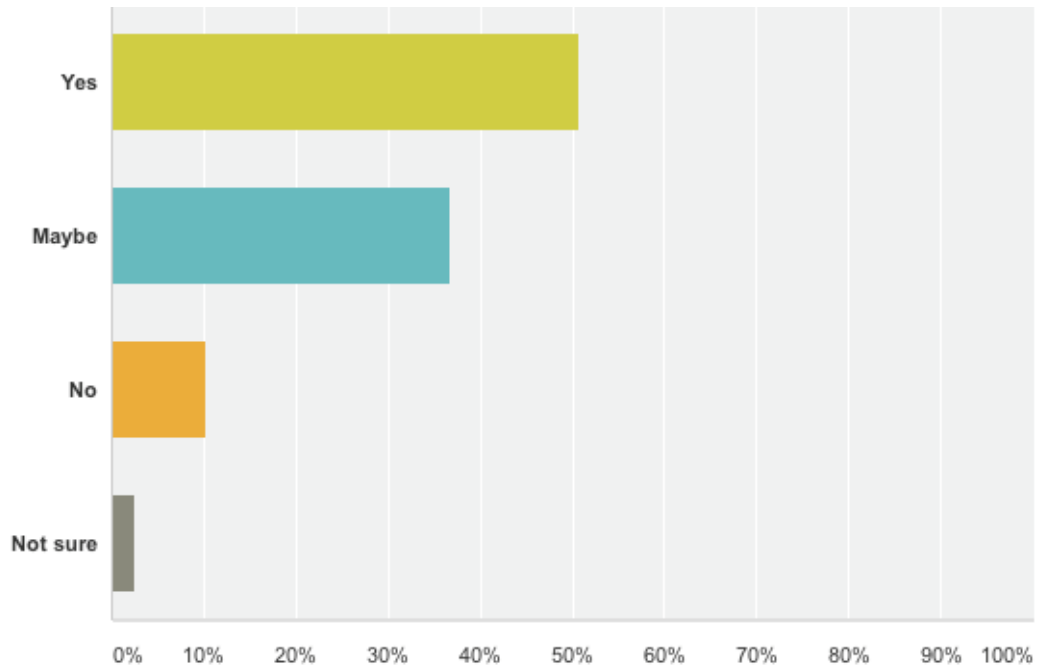


	Benefit	No Effect	Harm	Unsure	Total
Local Fishing Industry	26.25% 21	46.25% 37	10.00% 8	17.50% 14	80
Tourism	13.75% 11	50.00% 40	23.75% 19	12.50% 10	80
Job Creation	76.25% 61	11.25% 9	0.00% 0	12.50% 10	80
Air Quality	70.00% 56	23.75% 19	0.00% 0	6.25% 5	80
Electricity Rates	60.00% 48	22.50% 18	1.25% 1	16.25% 13	80

Q15. Would you attend an educational program about wind energy?

Answered: 79

Skipped: 3

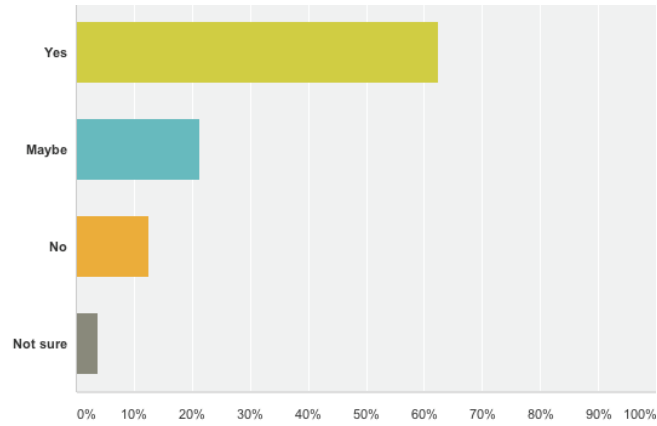


Answer Choices	Responses
Yes	50.63% 40
Maybe	36.71% 29
No	10.13% 8
Not sure	2.53% 2
Total	79

Q16. Would you go on a boat ride/tour of the offshore wind farms?

Answered: 80

Skipped: 2

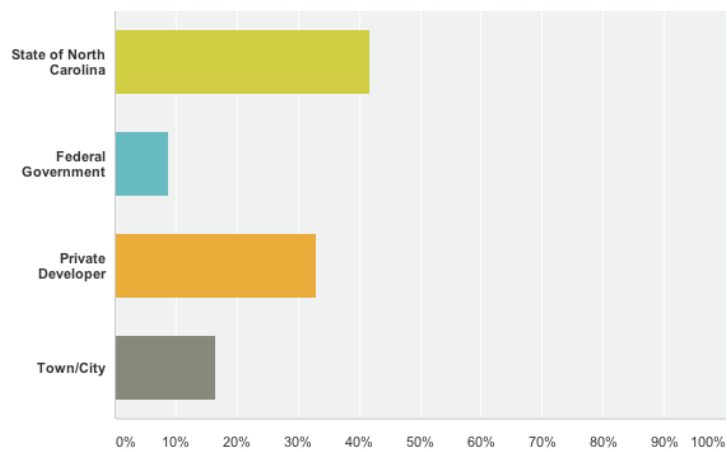


Answer Choices	Responses
Yes	62.50% 50
Maybe	21.25% 17
No	12.50% 10
Not sure	3.75% 3
Total	80

Q17. Would you prefer North Carolina's offshore wind farms to be owned by:

Answered: 79

Skipped: 3

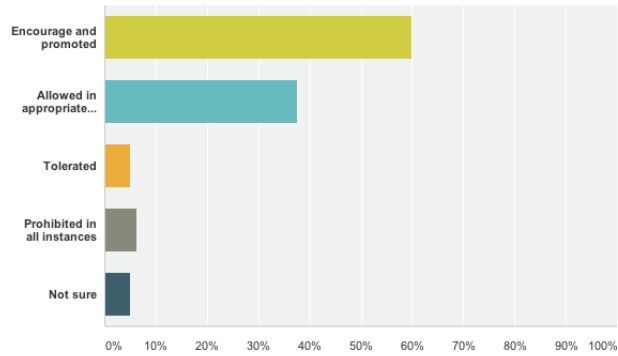


Answer Choices	Responses
State of North Carolina	41.77% 33
Federal Government	8.86% 7
Private Developer	32.91% 26
Town/City	16.46% 13
Total	79

Q18. In general, the placement of offshore wind turbines in North Carolina for electricity generation should be:

Answered: 80

Skipped: 2

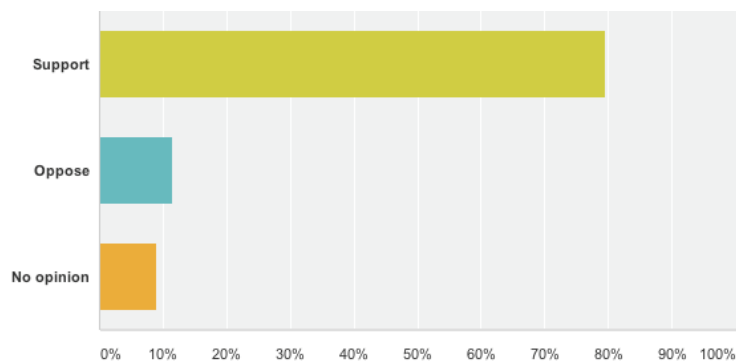


Answer Choices	Responses
Encourage and promoted	60.00% 48
Allowed in appropriate circumstances	37.50% 30
Tolerated	5.00% 4
Prohibited in all instances	6.25% 5
Not sure	5.00% 4
Total Respondents: 80	

Q19. Would you support or oppose placing offshore wind turbines in North Carolina?

Answered: 78

Skipped: 4

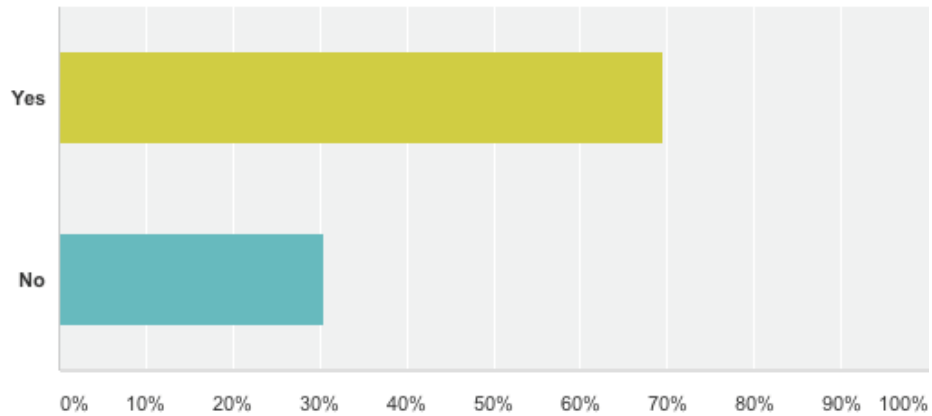


Answer Choices	Responses
Support	79.49% 62
Oppose	11.54% 9
No opinion	8.97% 7
Total	78

Q20. Is your community located within 5 miles of the ocean?

Answered: 79

Skipped: 3

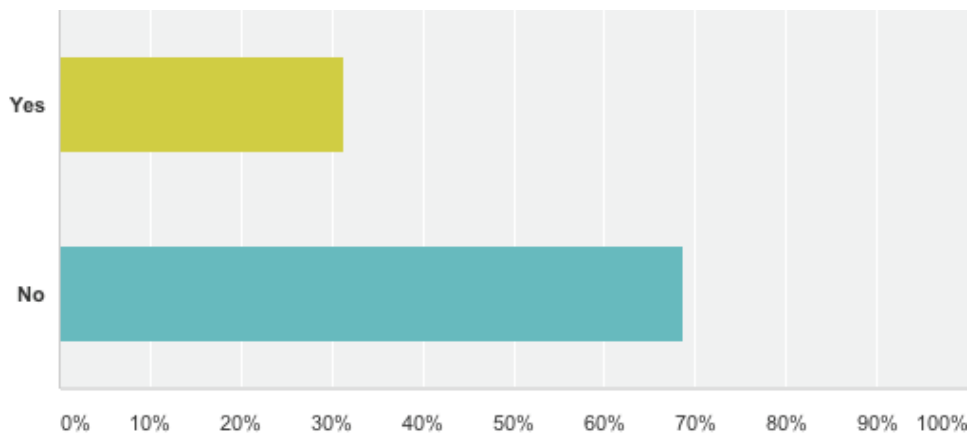


Answer Choices	Responses	
Yes	69.62%	55
No	30.38%	24
Total		79

Q21. Is your community located on a barrier island?

Answered: 80

Skipped: 2

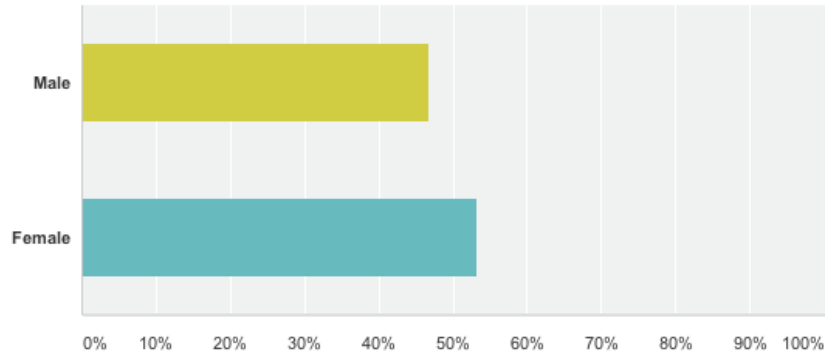


Answer Choices	Responses	
Yes	31.25%	25
No	68.75%	55
Total		80

Q22. Are you male or female?

Answered: 79

Skipped: 3

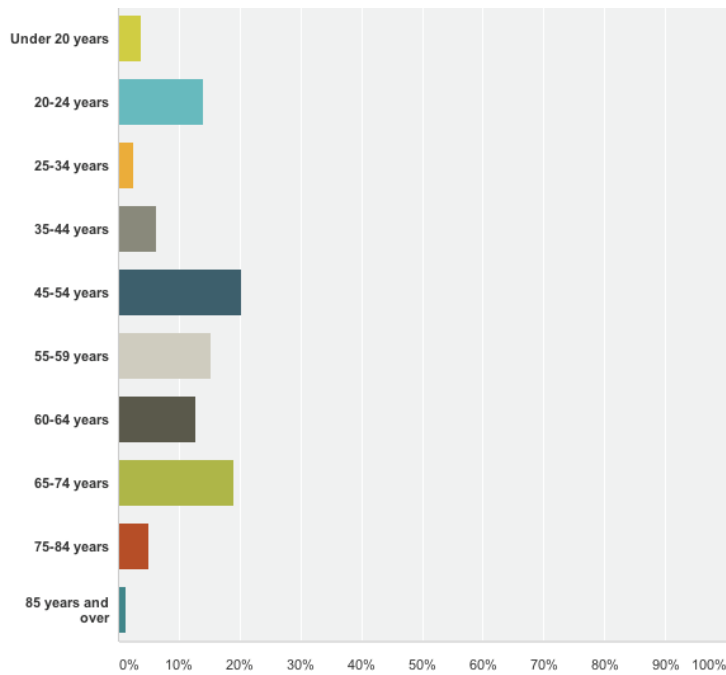


Answer Choices	Responses	
Male	46.84%	37
Female	53.16%	42
Total		79

Q23. What is your age?

Answered: 79

Skipped: 3

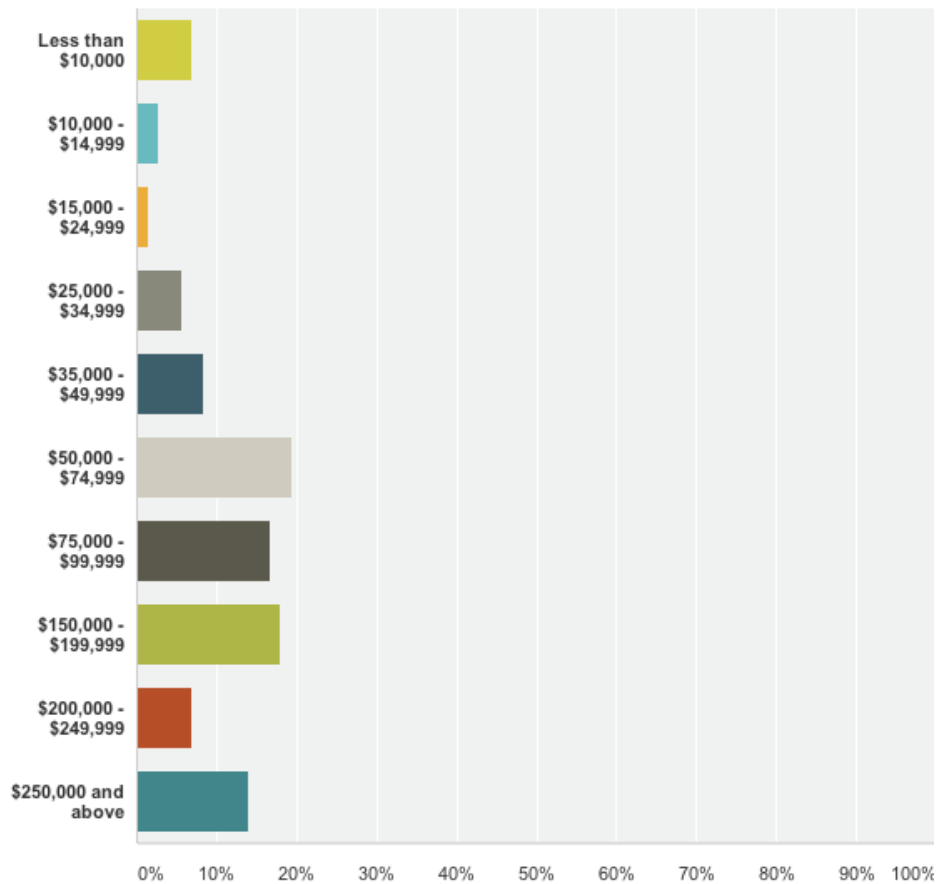


Answer Choices	Responses
Under 20 years	3.80% 3
20-24 years	13.92% 11
25-34 years	2.53% 2
35-44 years	6.33% 5
45-54 years	20.25% 16
55-59 years	15.19% 12
60-64 years	12.66% 10
65-74 years	18.99% 15
75-84 years	5.06% 4
85 years and over	1.27% 1
Total	79

Q24. Which category best describes your household income (before taxes) in 2013?

Answered: 72

Skipped: 10

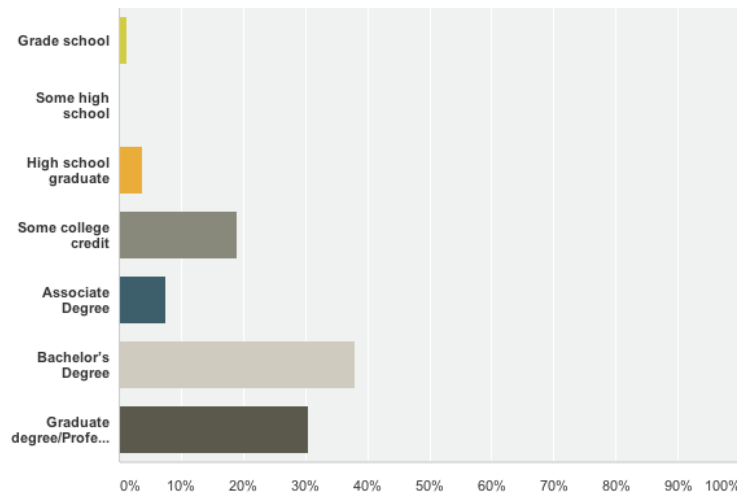


Answer Choices	Responses
Less than \$10,000	6.94% 5
\$10,000 - \$14,999	2.78% 2
\$15,000 - \$24,999	1.39% 1
\$25,000 - \$34,999	5.56% 4
\$35,000 - \$49,999	8.33% 6
\$50,000 - \$74,999	19.44% 14
\$75,000 - \$99,999	16.67% 12
\$150,000 - \$199,999	18.06% 13
\$200,000 - \$249,999	6.94% 5
\$250,000 and above	13.89% 10
Total	72

Q25. What is the highest degree or level of school that you have completed?

Answered: 79

Skipped: 3



Answer Choices	Responses
Grade school	1.27% 1
Some high school	0.00% 0
High school graduate	3.80% 3
Some college credit	18.99% 15
Associate Degree	7.59% 6
Bachelor's Degree	37.97% 30
Graduate degree/Professional degree	30.38% 24
Total	79