New Jersey Offshore Wind Energy:

Feasibility Study

Final Version

Prepared For:

New Jersey Board of Public Utilities

Prepared By:

Atlantic Renewable Energy Corporation

AWS Scientific, Inc.

November 2004

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Citations

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Acknowledgements

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Executive Summary

This report presents the results of a study sponsored by the New Jersey Board of Public Utilities to investigate the feasibility of utility-scale wind energy development in the waters offshore of New Jersey. The only viable opportunities for significant large-scale wind development in New Jersey are considered to be offshore where the wind resources are much stronger and where certain land use conflicts can be avoided. Northern Europe has already begun to develop its offshore wind resources while a growing number of offshore projects have been proposed along the east coast of the U.S. <u>The information provided by this report is intended to inform potential stakeholders about the status of offshore wind energy technology and the suitability of New Jersey's offshore waters for future development. This study is not intended to substitute for an environmental review for any permit application for any particular project</u>.

The focus area of this study stretches approximately from Sandy Hook to Egg Island Point in the Delaware Bay and extends out to a water depth of 100 feet, the maximum viable depth for purposes of this report. The study area encompasses 2,465 square nautical miles and extends up to 20 miles from shore. The goal of the feasibility study is to characterize the siting considerations—including various geophysical, environmental, regulatory, and commercial parameters—that offshore wind energy development will have to address if it is seriously pursued in New Jersey.

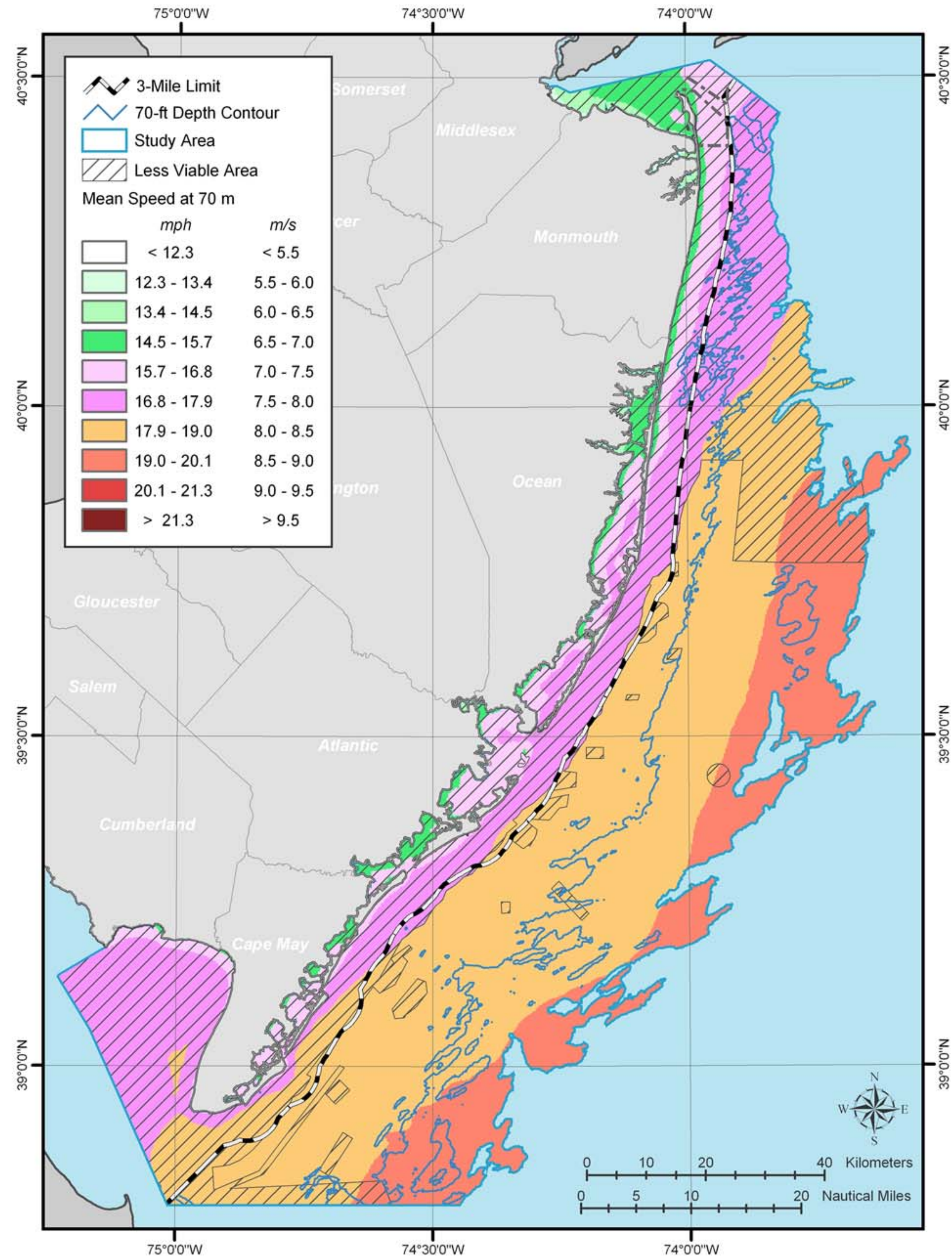
This study's approach is that of a desktop investigation that relies on existing data sources about New Jersey's coastal and offshore resources and on documented experiences and characteristics of offshore wind energy technology. In addition to the presentation of siting-related information, this study compares the relative viability of wind energy development among different portions of the study area. Associated development and logistical issues are discussed, including interconnection to the existing transmission system on land, legal and jurisdictional issues associated with the likely permitting process, the availability of ports for construction and maintenance vessels, and project economics.

Several key conclusions resulted from this study:

- Approximately half of the original study area (1,223 sq. nautical miles) is deemed to be conditionally viable for offshore wind development after excluding areas with conflicting water and air space concerns or with marginal wind resources (less than 8 m/s annually - see figure). The conditionally viable areas still contain important siting considerations that must be investigated in greater detail if specific projects are contemplated. It is likely that more in-depth study of environmental constraints would exclude additional offshore areas from considerations for development.
- The conditionally viable area lies mostly beyond the 3-mile limit and stretches roughly 75 miles from the Seaside Height/Seaside Park area south to Cape May.
- Offshore wind development could contribute significantly to New Jersey's renewable portfolio. Offshore wind would produce approximately 3,000 MWh/yr for each installed

MW of facility. Power densities of approximately 20 MW per square mile could be harvested while occupying less than 0.01% of the seabed within a project area.

- The cost of offshore wind energy modeled within the study area was found to be at the high end or above market price. Declining capital cost and other factors are expected to improve this situation over time.
- The existing transmission system along the coastline has sufficient capacity to accept significant amounts of new wind-based generation with the amount of this capacity dependent on the locations where wind projects are interconnected.
- Historical data suggest a high and favorable correlation between offshore wind speed and electricity demand during the peak hours of high demand summer days. This suggests a higher potential for offshore wind generation during peak summer demand hours than may be implied by summer monthly average wind speeds, which are lower than the balance of the year.
- The study area is actively used by commercial and recreational fishing, boating and shipping interests, and by wildlife (fish, shellfish, mammals, birds). It is within the viewshed of beach users, and includes sand borrow areas. These uses will be relevant considerations in evaluations of offshore project proposals.
- Several major ports exist within or near the study area that are suitable to support the shipping, installation or O&M requirements of an offshore wind project. These ports include the Port of New York and New Jersey, Atlantic City, and industrial ports accessible via the Delaware Bay and Delaware River in New Jersey, Delaware, and Pennsylvania.



Study Area Viability

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1.0. Introduction

1.1. Objective and Scope

For the past decade wind energy has been the world's fastest growing energy source on a percentage basis. This growth has been driven by rapidly growing demand for clean and renewable sources of energy and by government policies that promote broader use of such resources. Wind technology in particular has been successful due to the technological maturity, public support, and relatively low costs attained after more than 20 years of intense development. At the end of 2003, there was nearly 40,000 MW of operating wind capacity around the world, supplying the electricity needs of over 40 million people. The U.S. accounted for nearly 18% of this capacity, or 6400 MW, which was a 36% increase over the previous year.

Densely populated states, like New Jersey, have not been a part of this wind development experience because of a shortage of windy and compatible land. It is unlikely that this situation will change measurably in the foreseeable future with regard to utility-scale wind development, although opportunities for smaller-scale distributed applications do exist and have yet to be tapped. The only real opportunity for significant utility-scale wind development in New Jersey exists in its offshore waters where the wind resources are much stronger and where certain land use conflicts can be avoided. Northern Europe has already begun to develop its offshore wind resources while a growing number of potential offshore projects have been proposed along the east coast of the United States.

This report presents the results of a study sponsored by the New Jersey Board of Public Utilities to investigate the feasibility of utility-scale (>40 MW) wind energy development in the waters offshore of New Jersey. The focus area of this study is shown in Figure 1.1. It stretches from Sandy Hook to approximately Egg Island Point in the Delaware Bay and extends out to a water depth of 100 ft. This depth is the assumed practical limit of offshore wind turbine foundation designs within the next five years or so; to date, all offshore wind projects have been installed in waters shallower than 65 ft. The study area encompasses over 2465 square nautical miles[1].

The goal of this feasibility study is to characterize the siting considerations—spanning a broad range of geophysical, environmental, regulatory, and commercial parameters—that offshore wind energy development will have to address if it is seriously pursued in New Jersey. The information provided by this report is intended to inform potential stakeholders about the status of offshore wind energy technology and the suitability of the state's offshore waters for such development.

[1] 1 nautical mile = 1.15 statue miles = 1.85 kilometers

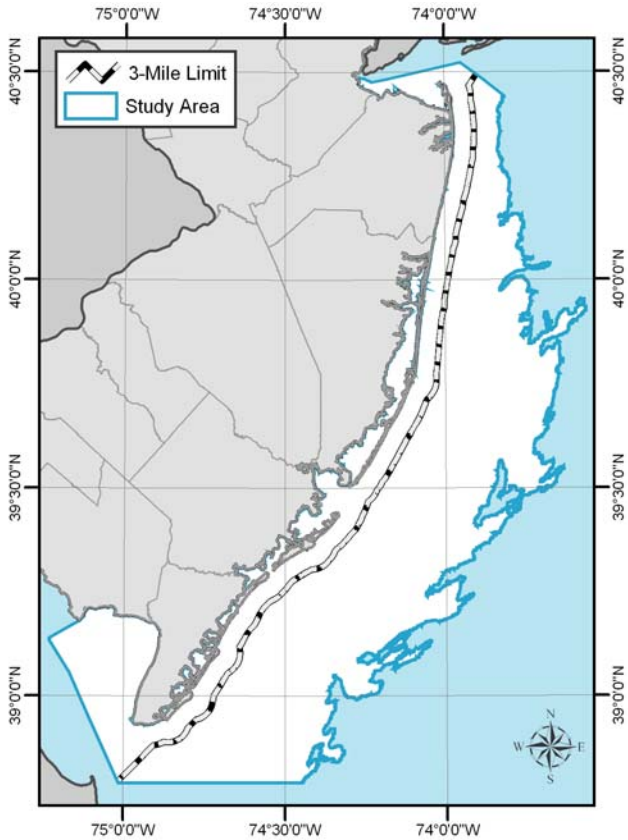

Figure 1.1: New Jersey Study Area Boundary

1.2. Participants

This report was prepared by the Atlantic Renewable Energy Corporation with the assistance of a multi-disciplinary team of technical consultants consisting of: AWS Scientific, Inc. (Albany, NY), Aviation Systems, Inc. (Torrance, CA), Curry and Kerlinger, LLC (Cape May, NJ), Energy and Environment Analysts, Inc. (Garden City, NY), Ocean Surveys, Inc. (Old Saybrook, CT), and the Rutgers University Coastal Ocean Observation Laboratory (Tuckerton, NJ).

Atlantic Renewable is an independent developer of wind projects on the East Coast. Since its inception in 1998 Atlantic Renewable has successfully developed six projects in New York, Pennsylvania and West Virginia with a combined nameplate capacity of 162 MW. They represent more than 60% of all the installed windpower capacity on the East Coast.

1.3. Approach

This study's approach is that of a desktop investigation that relies on existing data sources describing New Jersey's coastal and offshore resources and on documented experiences and characteristics of offshore wind energy technology. The study is intended to assess the general feasibility of offshore wind energy development in the vicinity of the New Jersey coast based on currently available information. It is not intended to substitute for an environmental review for any permit application for any particular project. The scope and impact of such a project would require that all technical, economic and environmental factors at the proposed site be thoroughly investigated in collaboration with all appropriate regulatory bodies and public stakeholders.

A broad range of databases considered potentially relevant to the siting and operation of offshore wind projects was obtained, analyzed, and summarized for this report. The following chapters present this information in a complementary blend of text, graphic, and tabular formats. To assist in the management of the large number of databases, electronic versions were obtained and incorporated into a geographical information system (GIS). A GIS is a system of hardware and software that manages, analyzes and displays geographically referenced data. A benefit of GIS is the ability to display multiple data layers on a single map, thus facilitating the assessment of several siting factors at once. It is also helpful in illustrating relative siting attributes across a large geographical area. Table 1.1 lists the types and sources of databases utilized by this study.

In addition to the presentation of siting-related information, this study compares factors influencing the relative viability of wind energy development among different portions of the study area. Associated development and logistical issues are discussed, including interconnection to the existing transmission system on land, legal and jurisdictional issues associated with the likely permitting process, the availability of ports for construction and maintenance vessels, and project economics. In some cases, information from existing projects in Europe is used to illustrate current site evaluation and engineering practices.

Table 1.1: Types and Sources of GIS Databases

Physical and Environmental Parameters	
Parameters	**Source**
Bathymetry	Geophysical Data System for Gridded Bathymetric Data, Volume 1, US North East Atlantic Coast, Volume 2, US South East Atlantic Coast (90m resolution) National Oceanic and Atmospheric Administration (NOAA), National Geophysical Data Center, Boulder, CO, 1998. http://www.ngdc.noaa.gov/mgg/coastal/coastal.html
Storms	Historical North Atlantic Tropical Cyclone Tracks, Relevant 1851-2002 U.S. Geological Survey, Reston, VA, 2003. http://nationalatlas.gov/atlasftp.html NOAA, National Hurricane Center, Miami, FL. http://www.nhc.noaa.gov/pastall.shtml
Wind Resource	Mid-Atlantic Wind Resource Map at 70 Meters (200m resolution) TrueWind Solutions, LLC, Albany, NY, 2002. http://www.truewind.com
Natural Resources	
Parameters	**Source**
Water Habitat	Significant Water Habitat Complex of New Jersey US Fish and Wildlife Service, Significant Habitats and Habitat Complexes of the New York Bight Watershed, Southern New England – New York Bight Coastal Ecosystems Program; US Fish and Wildlife Service, 1997. http://training.fws.gov/library/pubs5/begin.htm

Table 1.1 Continued: Types and Sources of GIS Databases

Natural Resources	
Parameters	**Source**
Open Space	New Jersey Department of Environmental Protection (NJDEP) State Owned, Protected Open Space and Recreation Areas in New Jersey NJDEP, Green Acres Program, 1999. http://www.state.nj.us/dep/gis/digidownload/zips/statewide/newstate.zip.
Parks	Environmental Systems Research Institute (ESRI) Data and Maps Media Kit, Disk 2; Redlands, CA, 2002. http://www.esri.com/
Federal Lands	ESRI, Data and Maps Media Kit, Disk 2; Redlands, CA, 2002. http://www.esri.com/
Natural Heritage Priority Sites	NJDEP Office of Natural Lands Management, 2001. http://www.state.nj.us/dep/gis/digidownload/zips/statewide/prisites.zip.
Land Habitat	Significant Land Habitat Complex of New Jersey US Fish and Wildlife Service, Significant Habitats and Habitat Complexes of the New York Bight Watershed, Southern New England – New York Bight Coastal Ecosystems Program, 1997. http://training.fws.gov/library/pubs5/begin.htm
New Jersey Coastal Heritage Trail	National Park Service. http://www.nps.gov/neje/home.htm
Additional Marine Considerations	
Parameters	**Source**
Waterways	National Waterway Network US Army Corps of Engineers, Navigation Data Center, New Orleans, LA, 2001. http://www.iwr.usace.army.mil/ndc/data/datanwn.htm
Shipping Lanes	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/ Department of the Interior Minerals Management Service (DOIMMS). http://www.mms.gov/
Anchorage Areas	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Precautionary Areas	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Restricted Areas	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Pilot Areas	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Two-Way Traffic Zones	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Oyster Grounds	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Fish Trap Areas	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Artificial Reefs	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/

Table 1.1 Continued: Types and Sources of GIS Databases

Additional Marine Considerations	
Parameters	**Source**
Fishing Ports	Major Commercial Fishing Ports EEA, Inc. http://www.eeaconsultants.com
Shellfish Classification	New Jersey Department of Environmental Protection (NJDEP) Shellfish Classification 2003 for New Jersey NJDEP, Division of Land Use Planning, Bureau of Marine Water Monitoring, Leeds Point, NJ, 2003. http://www.state.nj.us/dep/watershedmgt/bmw/serv01.htm
Fishing Code Areas	EEA, Inc. http://www.eeaconsultants.com Originator: National Marine Fisheries Service, Fishing Vessel Trip Reports. Preliminary Data 2000 – 2003. http://www.nmfs.noaa.gov/
Artificial Reefs	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Cables	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/ DOIMMS, Multiple Uses of the Outer Continental Shelf, Oct 2003. http://www.mms.gov/
Dump Sites	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Sewers and Pipelines	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Danger Areas	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Research Buoys	Ocean Surveys, Inc, digitized from Navigation Charts. http://www.oceansurveys.com/
Wrecks and Obstructions	NOAA, Automated Wreck and Obstruction Information System (AWOIS) NOAA, AWOIS, Silvers Springs, MD. http://chartmaker.ncd.noaa.gov/hsd/hsd-3.html
Surface Water Discharges	NJDPDES Surface Water Discharges in New Jersey NJDEP, Environmental Regulation (ER), Division of Water Quality (DWQ), Bureau of Point Source Permitting - Region 1 (PSP-R1), 2002. http://www.state.nj.us/dep/gis/digidownload/zips/statewide/njpdesswd.zip
Proposed Sand Borrow Areas	DOIMMS, Environmental Survey of Potential Sand Resource Sites, Environmental Surveys of Potential Borrow Areas Offshore North Jersey and Southern New York and the Environmental Implications of Sand Removal for Coastal and Beach Restoration http://www.oceanscience.net/mms_nj_ny/sitemap.htm DOIMMS, Environmental Survey of Potential Sand Resource Sites: Offshore New Jersey, 2000. http://www.mms.gov/

Table 1.1 Continued: Types and Sources of GIS Databases

Onshore Considerations	
Parameters	**Source**
Land Cover	New Jersey Land Cover Data Set, 2000 National Land Cover Dataset (NLCD) US Geological Survey, Sioux Falls, SD, 1997. http://edcwww.cr.usgs.gov/programs/lccp/nationallandcover.html
Open Space	NJDEP State Owned, Protected Open Space and Recreation Areas in New Jersey NJDEP, Green Acres Program, 1999. http://www.state.nj.us/dep/gis/digidownload/zips/statewide/newstate.zip.
Parks	ESRI Data and Maps Media Kit, Disk 2; ESRI, Redlands, CA, 2002. http://www.esri.com/
Airports	Aviations Systems, Inc. http://www.aviationsystems.com
Air Traffic Exclusion Zones	Aviations Systems, Inc. http://www.aviationsystems.com
Heliports	Aviations Systems, Inc. http://www.aviationsystems.com
Transportation	Major Roads, Railroads ESRI, Data and Maps Media Kit, Disk 2; Redlands, CA, 2002. http://www.esri.com/
Industrial Ports	US Coast Pilot, Reference 3, Atlantic Coast, 35th Edition, NOAA, 2002. http://www.noaa.gov/
Transmission	Platts, North America's Electrical Power Map, January 2004. http://www.maps.platts.com
Substations	Platts, North America's Electrical Power Map, January 2004. http://www.maps.platts.com
Other	
Parameters	**Source**
Political Boundaries	State and County Boundaries ESRI, Data and Maps Media Kit, Disk 3, Redlands, CA, 2002. http://www.esri.com/
Major Cities	ESRI, Data and Maps Media Kit, Disk 2, Redlands, CA, 2002. http://www.esri.com/
3-Mile Limit	State/Federal Jurisdiction Line (3-nm) DOIMMS. http://www.mms.gov/
Study Area	Study Area Limit (100-ft depth) AWS Scientific. http://www.awsscientific.com Partially captured from bathymetry contours referenced above. http://www.ngdc.noaa.gov/mgg/coastal/coastal.html Partially captured from 2000 TIGER Census County Lines, Geography Network. http://www.geographynetwork.com

1.4. Chapter Summary

The remaining chapters, as summarized below, present the various considerations, recommendations and conclusions addressed by this feasibility study.

Chapter 2: Background - This chapter gives an overview of the state-of-the-art of offshore wind energy development. The benefits and challenges of wind energy in general, and offshore applications in particular, are discussed.

Chapter 3: Physical and Climatic Parameters - This chapter characterizes the physical and meteorological environment of the study area. General topics of discussion include seabed geology, oceanography, and climatology.

Chapter 4: Natural Resources - The marine ecological resources of the study area are discussed. These resources include fin and larval fish, invertebrates, herpetiles, mammals, and birds.

Chapter 5: Additional Marine Considerations - Parameters relevant to navigation, fishing, obstructions on the sea floor, and sand borrowing in the offshore waters of New Jersey are presented. The potential sensitivities of these parameters to wind energy development are reviewed.

Chapter 6: Onshore Considerations - This chapter identifies coastal land uses that could be impacted by an offshore wind project. Land-based facilities and activities may also affect the siting of a project. Topics addressed include coastal land use, locations of ports, aviation, and the electrical transmission system.

Chapter 7: Siting Analysis - The foregoing information is collectively analyzed in this chapter to make preliminary qualitative and quantitative assessments of offshore wind energy development potential. Development viability is addressed for the northern, central, and southern portions of the study area.

Chapter 8: Legal and Jurisdictional Evaluation - The legal and jurisdictional requirements of siting and permitting offshore wind projects are addressed in this chapter. Federal, State, and local jurisdictions, together with application process overviews, are presented.

Chapter 9: Economics - This chapter presents the leading cost variables comprising a wind project investment and illustrates the capital costs experienced to date by European offshore projects. A cost of energy analysis for a hypothetical New Jersey offshore project is included, together with a discussion of financial incentives available to wind projects.

Chapter 10: Conclusions - A set of study conclusions is presented in this closing chapter.

2.0. Background

Interest in wind energy development in New Jersey has risen sharply in the recent years, much as it has throughout the United States and Europe. This is due in part to the public's increasing interest in expanding the use of clean, renewable energy sources. Wind is one of the lowest cost renewable technologies, and allows diversification of the power generation mix without fuel costs or long-term supply risks. Indigenous wind resources off of New Jersey's coast offer the potential for large amounts of wind-based energy production while displacing pollutants produced by conventional power plants. However, significant tradeoffs and challenges associated with offshore wind power development also exist. This chapter discusses the potential benefits and challenges of offshore wind energy based on worldwide experiences. This chapter also illustrates the major components comprising an offshore wind energy facility.

2.1. History

Since the early 1990's northern Europe has pioneered offshore wind technology. Over 500 MW of offshore wind power have been installed in 16 different projects (see Table 2.1), and more than 10,000 MW of new capacity are planned. Strong offshore winds, relatively shallow waters offshore, diminished development opportunities on land, and strong government support are all spurring this growth. In terms of available coastal areas, it has been estimated that in the long term the U.S. has the second greatest potential for offshore wind power production in the world, behind only China[2,3].

In the U.S., serious interest in offshore wind development has been a more recent trend. Two projects have reached advanced stages of planning or permitting: the Long Island Power Authority's proposed 140 MW project off the south shore of Long Island, and Cape Wind's 420 MW proposed project in Nantucket Sound of Massachusetts. The objective of these projects is to generate clean, renewable energy and deliver it to major coastal electric load centers.

These locales do not have direct access to equivalent amounts of land-based wind generation due to competing land uses and marginal wind resources. The shortage of windy and sparsely populated lands is the main reason why offshore wind energy has appeal for the east coast of the U.S. Although the U.S. has abundant windy land area, most of it is located in the middle of the country, far away from most major load and population centers, while over half of the country's population lives in coastal counties. Due to the shear distances involved, the existing transmission system constraints and the prohibitive costs to resolve them, delivery of wind power to the east coast is not feasible for the foreseeable future.

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[2] Offshore Wind Energy Potential Outside the European Union, Aerodyn Engineering GmbH Report 2001.

[3] Renewable Energy Country Attractiveness Indices, Ernst and Young, Structured Finance Documents, London, UK, February 2003.

Table 2.1: Existing Offshore Wind Energy Projects

Project Name	Country	Date Commissioned	Number of Turbines	Project Capacity (MW)
Vindeby	Denmark	1991	11	4.95
Nogersund[4]	Sweden	1991	1	0.22
Lely	Netherlands	1994	4	2
Tunø Knob	Denmark	1995	10	5
Dronten	Netherlands	1996	28	16.8
Bockstigen Valar	Sweden	1998	5	2.5
Blyth	United Kingdom	2000	2	4
Middelgrunden	Denmark	2000	20	40
Utgrunden	Sweden	2000	7	10
Yttre Stengrund	Sweden	2001	5	10
Horns Rev	Denmark	2002	80	160
Samsø	Denmark	2002	10	23
Arklow Bank	Ireland	2003	7	25
North Hoyle	United Kingdom	2003	30	60
Frederikshavn	Denmark	2003	4	10.6
Nysted	Denmark	2003	72	158.4

2.2. Benefits and Challenges

The U.S. Department of Energy's Wind Energy Program states that "wind energy diversifies the nation's energy supply, takes advantage of a domestic resource, and helps the nation meet its commitments to curb emissions of greenhouse gases, which threaten the stability of global climates."[5] Some specific advantages of wind power include:

Clean and inexhaustible source of energy: A single offshore-scale turbine can displace 8,360 tons of carbon dioxide, 44 tons of sulfur dioxide, and 27 tons of nitrogen oxides emissions annually that would otherwise be produced annually from conventional power plants.[6]

Promotes local economic development: Wind energy provides more jobs per dollar invested than most other energy technologies.

Modular and scalable: Wind energy projects can be built as single turbine installations or as large turbine arrays known as wind farms. In general, economies of scale favor large projects.

[4] Decommissioned 1998.

[5] U.S. Department of Energy's website. http://www.doe.gov/engine/content.do?BT_CODE=WIND.

[6] Based on GE 3.6 MW offshore turbine production estimates (8.25 m/s wind regime) and U.S. average utility generation fuel mix.

Promotes energy price stability: By further diversifying the energy mix, wind energy reduces dependence on conventional fuel sources that are subject to price and supply volatility.

Specific advantages of offshore wind power include:

- Winds are much stronger offshore. Average annual wind speeds just a few miles offshore are typically 25 to 40 percent stronger relative to adjacent land areas. This speed advantage yields a 50 to 75 percent gain in energy production from a wind turbine.[7]
- The potential for large, contiguous development areas exist.
- Offshore winds are less turbulent. Lower turbulence means more efficient energy production. It also translates into less wear and tear on the turbines and components.
- Wind shear offshore is lower. This means that the boundary layer of slow moving air near the sea-surface is much thinner than what exists on land. This allows for the use of shorter towers offshore to reach a desired hub-height average wind speed.
- Visual impact can be reduced. Depending on siting location, the turbines can be installed distant from residents and land-based activities.

Challenges and considerations for offshore wind include:

Limited Experience: The siting, permitting, construction and operation of offshore wind projects are still undergoing development. Equipment, techniques and infrastructure have yet to be developed or adapted in the U.S. for all aspects of offshore wind development.

Marine Environment: Hydrodynamic structure and foundation loading, water depth, collisions from air- and water-borne vessels, waves, currents, scour and sand waves, severe weather and high seas, logistics (of installation and operation and maintenance), corrosive marine environment, marine growth – these are all issues unique in an offshore environment.

Infrastructure: An extensive on- and offshore infrastructure is required to construct and operate an offshore project. Some of the necessary items include: port with deep draft facilities, large staging area with appropriate loading equipment, dedicated fleet of maintenance and construction vessels (possibly including a helicopter), reliable communication system, appropriate safety and rescue provisions, and skilled personnel.

Environmental Impact: Although research into wind turbine impacts on marine habitats, avian use and fisheries is ongoing, site-specific concerns must be addressed.

Aesthetics: A common concern regarding any wind project is its visibility. Depending on weather and sea conditions, tall turbines can be seen up to 20 miles away. Aesthetic impact is an issue that has led to the denial of some offshore project permit applications in Europe.

[7] The power from the wind is a cubic function of wind speed.

Foundations: Foundation design is a site-specific concern and represents a much larger portion of a project's installed cost compared to land-based installations. Water depth, extreme wind/wave loading conditions, and seabed geology dictate the design of the foundation.

Costs: The installed cost of an offshore wind plant can be 50 to 100 percent higher than an equivalent onshore plant. Offshore costs are much more dependent on site-specific factors than land-based projects. Access to financing is typically more difficult due to the higher perceived investment risk.

Maintenance and Availability: Early experiences in Europe have shown that wind turbines may be accessible only 80% of the time during good weather in the summer, and significantly less often during other times of the year. This is due to variable sea states, which can limit safe access to a wind project by work crews via boat or helicopter. As a result, turbine maintenance needs will take longer to address, potentially leading to longer down times and lost production.

The nature of offshore wind power siting and development necessitates the need for extensive preparation. Thorough project planning helps mitigate challenges associated with the lack of offshore wind experience in the US, the site-specific nature of each project and the scope of the over-all effort.

2.3. Offshore Wind Technology

This section discusses the primary components of an offshore wind project: turbines, towers, foundations, and the balance of plant. Factors that determine the layout of a particular wind project's components also are discussed.

2.3.1. Turbines and Towers

The primary and most visible part of an offshore project is the turbine. The turbine is composed of a 3-bladed rotor connected through the drive train to the generator, which are housed in the nacelle. Figure 2.1 illustrates an example turbine model and its various components.

Several manufacturers (e.g., GE Wind Energy, Vestas, Bonus) have recently engineered wind turbines specifically for offshore applications. These machines are based on proven technology but have been designed to meet the needs of a more remote and demanding offshore environment.

The tower provides support to the turbine assembly, housing for balance of plant components, and importantly, a sheltered interior means of access for personnel from the surface. As with turbines, tower technology and coatings have been adapted to meet the corrosive demands of a marine setting. Towers are typically made of welded sections of steel with diameters of up to 5 m and wall thicknesses of roughly 3 cm. More efficient transportation and installation techniques are being developed with every new offshore project.

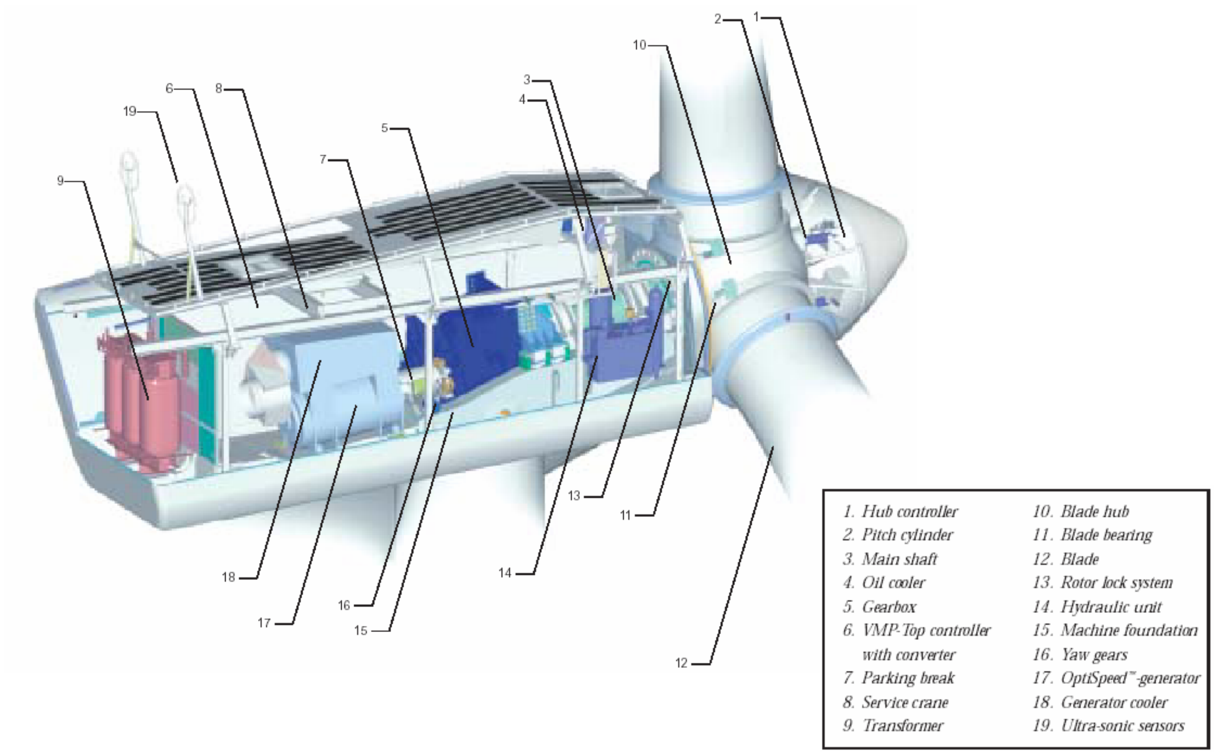

Figure 2.1: Vestas V80 2.0 MW Turbine diagram[8]

Manufacturing trends indicate that future turbines will be larger than today's typical size range of 2-4 MW. Figure 2.2 illustrates the dimensions of an entire turbine, tower, and foundation structure at the Horns Rev offshore project in Denmark, which was commissioned in 2002. The 2 MW turbine size selected for that project is now at the low end of the size range anticipated for future offshore projects. Future turbines will also have optimally matched generator and rotor diameters (up to 120 m) for greater efficiency, higher tip speeds, and high voltage generation (possibly in DC instead of AC). GE's 3.6 MW offshore turbine is the largest commercially installed model (at Arklow Bank in Ireland) and has a 104 m rotor diameter. Enercon, of Germany, has a 4.5 MW machine ready for offshore prototype testing; it has a 114 m rotor diameter and uses a 100 m tower.

Further advancements are likely to occur in specific turbine components. Some blade designs are transitioning from fiberglass to lighter weight and stronger carbon epoxy composites. Power control systems are progressing towards variable speed designs to improve energy capture. Communications and maintenance components are advancing to provide long-term reliability with fewer scheduled maintenance trips. For example, permanent onboard lifting cranes within the turbine itself eliminate the need for crane ships when components need to be replaced for maintenance. Enhanced watercraft access, emergency crew accommodation, and helicopter compatibility are some of the accessibility factors being addressed.

[8] Diagram extracted from Vestas V80 2.0 MW turbine documentation on http://www.vestas.com.

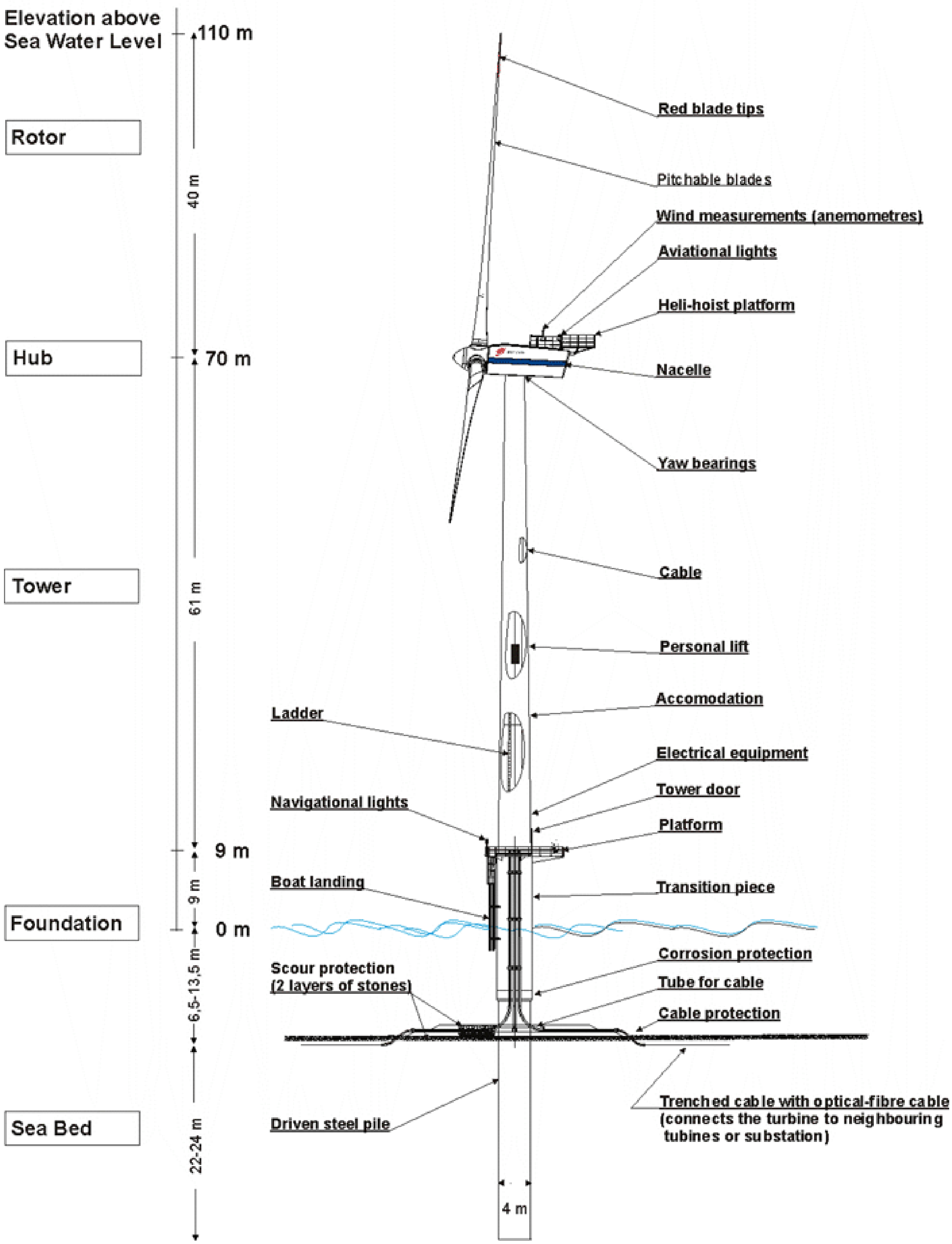

Figure 2.2: Principle Dimensions in an Offshore Wind Turbine Layout[9]

[9] Graphic courtesy Horns Rev wind project (http://www.hornsrev.dk), copyright Elsam A/S.

2.3.2. Foundations

Foundation design is driven by site-specific conditions. Water depth, wind/wave conditions (including extremes), and seabed geology dictate the foundation design. Figure 2.3 illustrates the three standard offshore foundation types: monopile, gravitation, and multi-leg. The most common foundation for water depths up to 20 m (65 ft) is the monopile. The installation technique (drilling, driving, or combination) is determined by site-specific soil properties and water depth. Gravity-based foundations (concrete or steel) have also been used. They are effective in relatively shallow water but transportation challenges and extensive seabed preparations make them more costly.

The current monopile technology is effective over a broad range of depths and involves much less seabed impact. The foundation itself is composed of a singular steel tube with an approximate diameter of 4-5 m and a wall thickness of about 5 cm. The foundations are driven with a hydraulic ram to a depth of about 25 m[10]. Once in place the pile is fitted with a prefabricated transition piece that generally includes ladders, conduits and other necessary assemblies and allows for small deviations from vertical to be corrected. It is this transition piece that is used to ensure a level mounting surface for the tower. Figure 2.4 illustrates a tower erection at the Samsø project in Denmark.

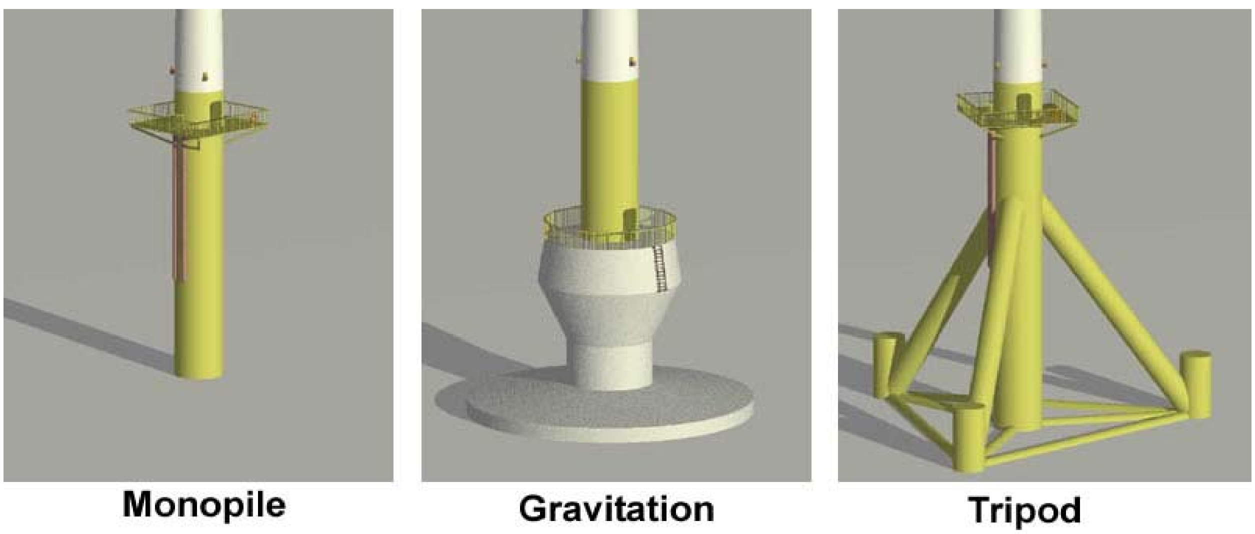

Figure 2.3: Offshore Wind Turbine Foundations[11]

As waters deeper than approximately 25 m are considered for offshore development, monopile foundations may no longer be feasible. Deeper water concepts include suction-bucket and driven tripod or quadrapod foundations. Floating or rafted turbines may be feasible as long-term options in even deeper water.

[10] Example dimensions from Horns Rev wind farm in Denmark. Vestas V80 2MW turbines.

[11] Graphic courtesy of http://www.offshorewindenergy.org.

Figure 2.4: Installation Barge installing Bonus Turbine at Samsø, Denmark[12]

2.3.3. Balance of Plant

Additional components of an offshore wind project are the undersea electrical collection and transmission cables, the substation, and the meteorological mast.

Electrical cabling is split into two functions: collection and transmission. The collection cables connect series of turbines together and are operated at a distribution grade voltage (such as 13.2 kV). The outputs of multiple collection cables are combined at a common collection point (or substation) and stepped up in voltage (such as 69, 115, or 138 kV) for transmission to shore. The transmission cable(s) delivers the project's total output to the onshore electric grid, where the power is then delivered to loads. Both types of cable may have trenching requirements and specifications for armoring.

A wind park's substation is typically sited offshore but it can alternatively be sited onshore. It typically includes one or more stepup transformers, switchgear and remote control and communications equipment. Foundation designs are consistent with those for turbines. Figure 2.5 is a photo of the offshore substation at the Nysted project in Denmark.

[12] Photograph courtesy Samsø wind project (http://www.samsohavvind.dk).

Figure 2.5: Nysted Offshore Substation and Wind Farm[13]

The meteorological mast plays an important role in the project development process and serves two primary purposes. First, the meteorological mast is erected to collect on-site wind resource data at multiple heights (including hub height), plus other environmental data (air and water temperature, wave heights and periods, current, etc.). The measurement program is generally conducted for a year in order to verify the project area's meteorology and sea state conditions. The resulting data are used to optimize the wind project's design and layout and to predict the project's annual average energy production. Second, after the wind park is installed and commissioned, the data from the meteorological mast serves new functions, such as power performance testing, due diligence evaluation, and O&M management. Figure 2.6 contains photos of meteorological masts at one proposed (U.S.) and one existing (Denmark) offshore project.

2.3.4. Layout

There are three primary drivers of a wind farm's layout. One is siting related with bathymetry, subsurface geology, wind resource, and geopolitical boundaries serving as governing factors. The second is performance. The spacing between turbines and the arrangement of turbine rows relative to the prevailing wind direction impact the project's production efficiency. In general, spacing between machines in a row is on the order of 4 to 7 rotor diameters, and spacing between rows is between 7 and 12 rotor diameters. The spacing goal is to minimize the wind flow disturbances at individual turbine locations. The third is sensitivity to environmental and aesthetic impacts and to competing water uses (such as fishing) within the project area. For example, the arrangement of a wind park in a long single row will have a different aesthetic impact when viewed from shore compared to a compact, multi-rowed array. Figure 2.7 illustrates the turbine layout and the relative location of the substation and meteorological mast for the 160 MW Horns Rev project in Denmark.

[13] Graphic courtesy Nysted wind project (http://uk.nystedhavmoellepark.dk/), copyright Elsam A/S.

Figure 2.6: Cape Wind Meteorological mast (USA), Nysted Meteorological mast (Denmark)[14]

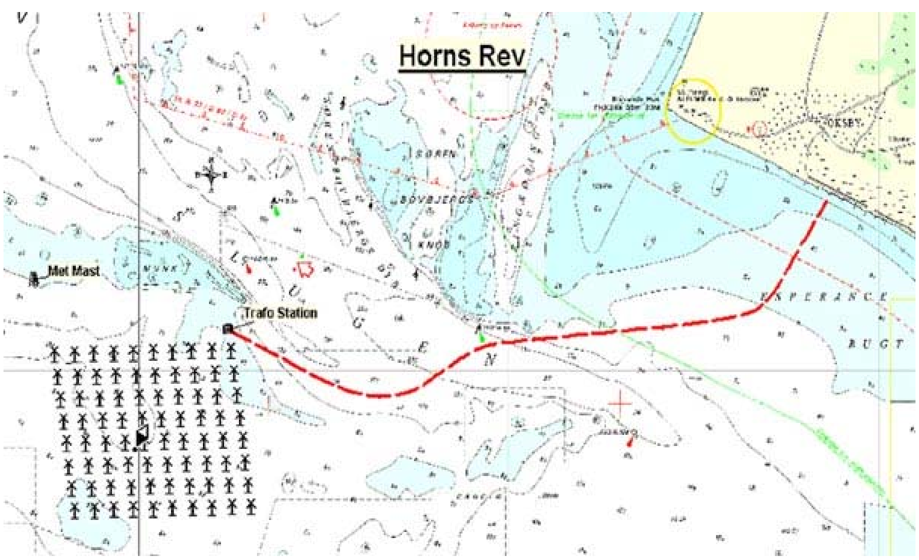

Figure 2.7: Horns Rev project layout[15]

[14] Graphic courtesy of Nysted wind project (http://uk.nystedhavmoellepark.dk/), copyright Elsam A/S.

[15] Graphic courtesy Horns Rev wind project (http://www.hornsrev.dk), copyright Elsam A/S.

3.0. Physical and Climatic Parameters

This chapter provides detailed descriptions of the geological, oceanographic and climatic conditions of the offshore New Jersey study area. The geological material addresses seabottom and subsurface conditions relevant to project siting and to wind turbine foundation design. Physical oceanography, which includes such characteristics as water depth, tides, and waves, provides load parameters for the engineering of wind turbine towers and foundations. Oceanography is also relevant to planning for project access during and after installation. Climatology describes both the weather patterns and the wind resource of the project area. Information on weather patterns and extreme storm events provide engineering requirements for all components of a wind project.

3.1. Geology and Bottom Types

A geological study, as presented in this section, can form a basis for the selection of methods and extent of a geotechnical site investigation. A geophysical survey using seismic methods combined with soil borings and in-situ cone penetration tests can establish information about sediment stratification. A thorough understanding of the regional and local geology gives initial reason for the selection of foundation structural properties.

Field investigations provide geotechnical site data for the sediment relevant to the design basis. Such data includes:

- Data for soil classification and description of the soil
- Shear strength parameters
- Deformation properties
- Permeability
- Stiffness and damping parameters (for prediction of the dynamic behavior of the wind turbine structure).

The analysis of the material underling a wind farm is used to determine the axial and lateral pile response and ultimate bearing capacity.

3.1.1. Geologic Setting

The continental shelf offshore New Jersey is a broad (120–150 km) and gently sloping region between the shoreline and the continental slope (Figure 3.1). The region is a passive margin formed by the separation of the North American plate from Africa since the Triassic initiation of plate tectonic rifting.

During the Paleogene (65 to 24 million years ago), low rates of siliciclastic[16] sediment supplied to the New Jersey margin led to the development of a slightly dipping platform dominated by carbonate deposition. Low subsidence rates, coupled with the preexisting platform geometry, favored development of well-defined sequences when the supply of siliciclastic sediment began to increase in the late Oligocene (38 to 26 million years ago). A major pulse of sedimentation occurred during the middle Miocene (26 to 7 million years ago), when uplift of the Appalachians and climatic cooling led to a tenfold increase in the rate of siliciclastic sediment input to the margin. This geometry has prevailed throughout the upper Miocene and Pliocene (7 to 2 million years ago).

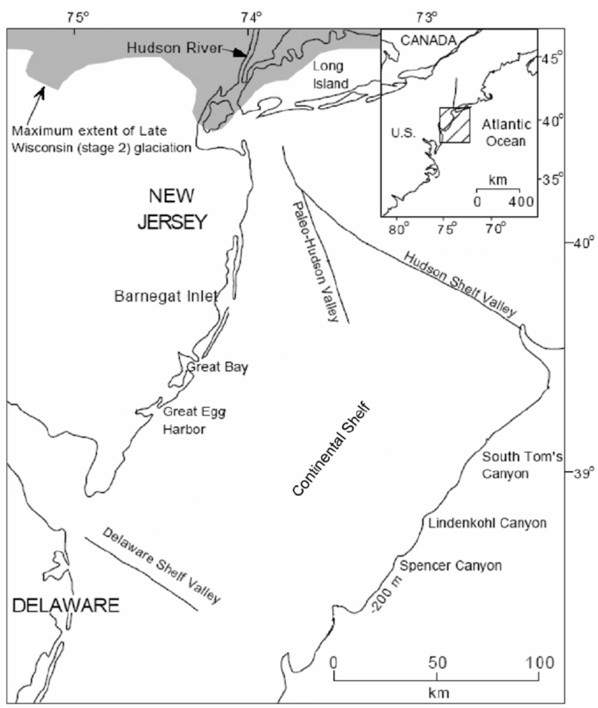

Figure 3.1: Map of New Jersey Continental Shelf

In contrast, the Holocene (10,000 years ago to present) and present day shelf configuration consists of a single slope without significant inflections, but characterized by a multiplicity of canyons, descending to the continental rise (Figure 3.1). The increased steepness associated with the shelf break begins between 120 and 160 m water depth. The hydrographic regime exhibits mixed energy, with a tidal range of 1–2 m and mean significant wave heights of roughly 1 m. The shelf generally is classified as storm dominated. Terrigenous sediment supply to the shelf is minimal because sediment is trapped in estuaries and lagoons.

[16] Silica-based sediments broken from preexisting rocks, transported and redeposited forming another rock.

3.1.2. Stratigraphy

The New Jersey Coastal Plain is the emergent part of a classic passive margin that formed following Triassic–Early Jurassic rifting. Post-rift tectonics has been dominated by simple thermal subsidence, sediment loading, and flexure. Jurassic strata have not been identified in the coastal plain. The coastal plain did not form until the Cretaceous, when the crust attained sufficient flexural rigidity for offshore thermal subsidence to cause accommodation onshore. The coastal plain consists of Lower Cretaceous to Holocene strata that dip gently (<1°) seaward and thicken down-dip. The sediments are primarily unconsolidated siliciclastic sands and muds that were deposited in fluvial and shelf environments, with a strong deltaic influence in the Cretaceous and in the Miocene to Holocene. Paleowater depths generally increased from the mid- to late-Cretaceous, attaining maximum water depths onshore in the early Eocene. A general regression occurred over the last 50 million years and upper Miocene–Holocene strata are primarily marginal marine to nonmarine. Cretaceous outcrops are exposed but weathered, whereas much of the Cenozoic (65million years ago to present), record is derived from subsurface boreholes where strata are thicker and more marine.

New Jersey Coastal Plain siliciclastic strata have been studied since the early 1800's. Unconformity-bounded transgressive/regressive cycles in the coastal plain were first attributed to tectonic processes. Planktonic foraminifers and nannofossils were used to compare New Jersey Coastal Plain Sequences to the record and interpreted the transgressions and regressions in terms of global sea level. The U.S. Geological Survey (USGS) improved Tertiary stratigraphic correlations in New Jersey in 1986 by continuously coring the Mays Landing (ACGS#4) borehole. Drilling of this and other continuous boreholes at Belleplain, Allaire and Clayton provided material for integrated biostratigraphic, Strontium (Sr)-isotopic and magnetostratigraphic studies. The success of these initial drilling efforts led to planning of the New Jersey Coastal Plain drilling project.

Stratigraphic information for the coastal and offshore shelf areas of New Jersey comes mainly from the New Jersey Coastal Plain Drilling Project and the New Jersey Sea-level Transect projects.[17] As part of this program four boreholes were drilled along New Jersey's coast, one at Island Beach (total depth 1223 ft), one at Atlantic City (total depth 1452 ft), one at Cape May (total depth 1500 ft), and one at Ocean View (total depth1575 ft). Figure 3.2 shows the location of these boreholes plus the location of seismic profiles acquired on the New Jersey's shelf and continental slope as part of the New Jersey Sea-level Transect project.

The uppermost sedimentary formations along the New Jersey coast down to approximately 500 ft are the Cape May Formation and the Kirkwood Formation. Figure 3.3 shows a correlation of these formations across three boreholes from the Cape May site to the Island Beach site. The main lithological characteristics of these uppermost sedimentary formations are also shown in Figure 3.3.

[17] These projects were funded by the National Science Foundation (Earth Science Division, Continental Dynamics Program and Ocean Science Division, Ocean Drilling Program), the New Jersey Geological Survey (NJGS), the Delaware Geological Survey, and the United States Geological Survey Eastern Earth Surface Processes Team (EESPT).

3.1.2.1. Cape May Formation

The surficial units (7-78 ft) consisting of unconsolidated sands, silts, clays, and gravels containing lignite and shell layers are shown in Figure 3.4. These units correspond to the undifferentiated Cape May Formation. The age of the Cape May Formation is inferred to be upper Pleistocene-Holocene (2 million years ago to 10,000 years ago).

The interval from 7 ft to 39 ft is primarily medium to coarse sand containing shells. It is interpreted to be a nearshore deposit; this is supported by the continuity of facies from the present-day barrier island to this level. There is a facies change between 39 and 43 ft with sands lying above a fining-upward succession of pebbly coarse sands to sandy muds (43-51 ft). A gamma log places the contact at 40 ft. This surface is interpreted as either a disconformity or transgressive surface. The section above this is Holocene as established by radiocarbon age measurement of 4532 years (± 58 yr) on a lignite layer at 25 ft.

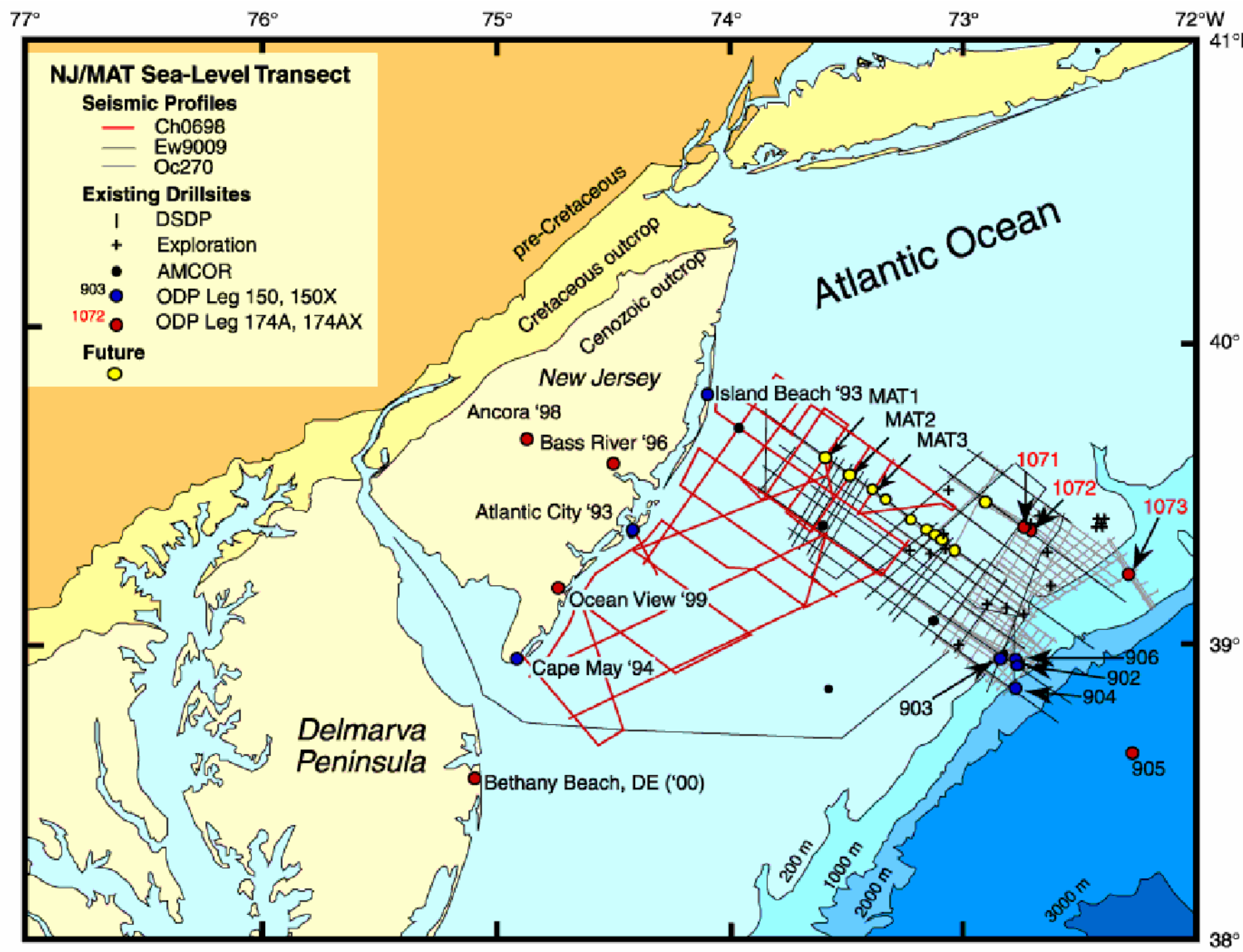

Figure 3.2: Ocean Drilling Program (ODP) Borehole Map

From 40 to 70 ft, there are two upward-fining successions from pebbly very coarse sand to sandy clays (40-51 and 51-70 ft), with surfaces separating the successions at 51 and 70 ft. The muddy sands and sandy clays are interpreted as lower estuarine, lagoonal, or innermost neritic. A radiocarbon age of 5,625 years (± 200 yr) was obtained from a lignite at 58 ft. This suggests that the facies are lagoonal or shelf deposits of the Holocene transgression and may be part of the sequence that includes the present-day barrier.

A basal coarse gravel at 76 ft becomes fines upsection and is capped by a sulfide-rich clay at 70 ft. This succession is interpreted as a fluvial gravel/point bar/overbank deposit. A distinct facies break from gravels above to stiff clays below occurs between 76 ft and 78 ft. The gravels represent the base of the Cape May formation that disconformably overlies the Miocene Kirkwood formation.

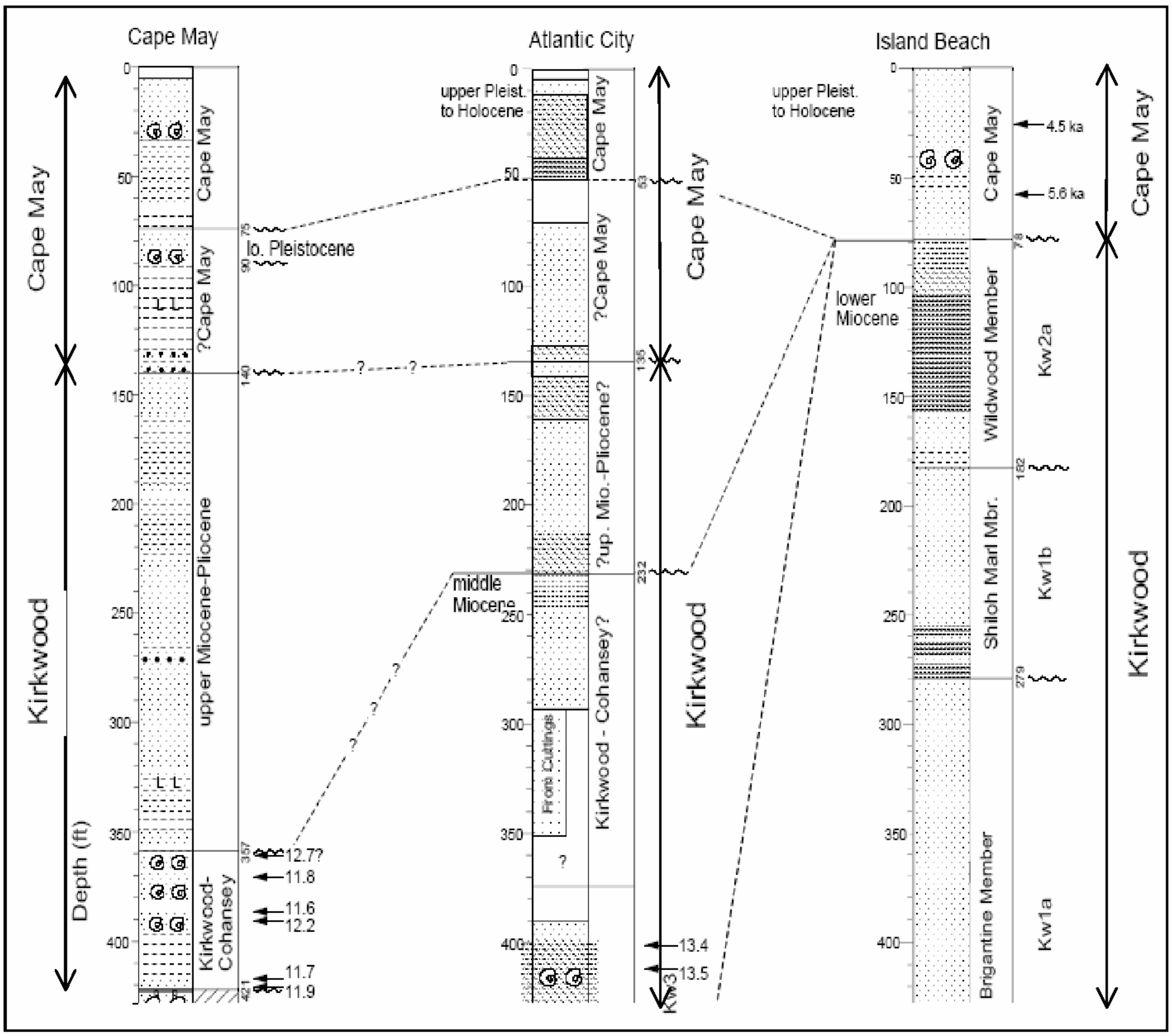

Figure 3.3: Comparison of lithographic units, sequences, and chronostatigraphic units at Island Beach, Atlantic City, and Cape May

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3.1.2.2. Kirkwood Formation

The 427 ft thick Kirkwood Formation consists of successions of unconsolidated silty clay overlain by sands. The facies represent diverse fluvial, near-shore, and inner neritic environments. Diatoms were used to correlate the Kirkwood Formation at the Island Beach drill site to lowermost middle to lower Miocene, whereas Sr isotopes were used to date the lowermost Kirkwood Formation early Miocene. Other age constraints are lacking for the Kirkwood Formation at Island Beach because of shallow-water and nonmarine facies; however, the lithostratigraphic subdivisions at the Island Beach drill site can be correlated to the Atlantic City borehole, where they are dated using Sr-isotopic stratigraphy.

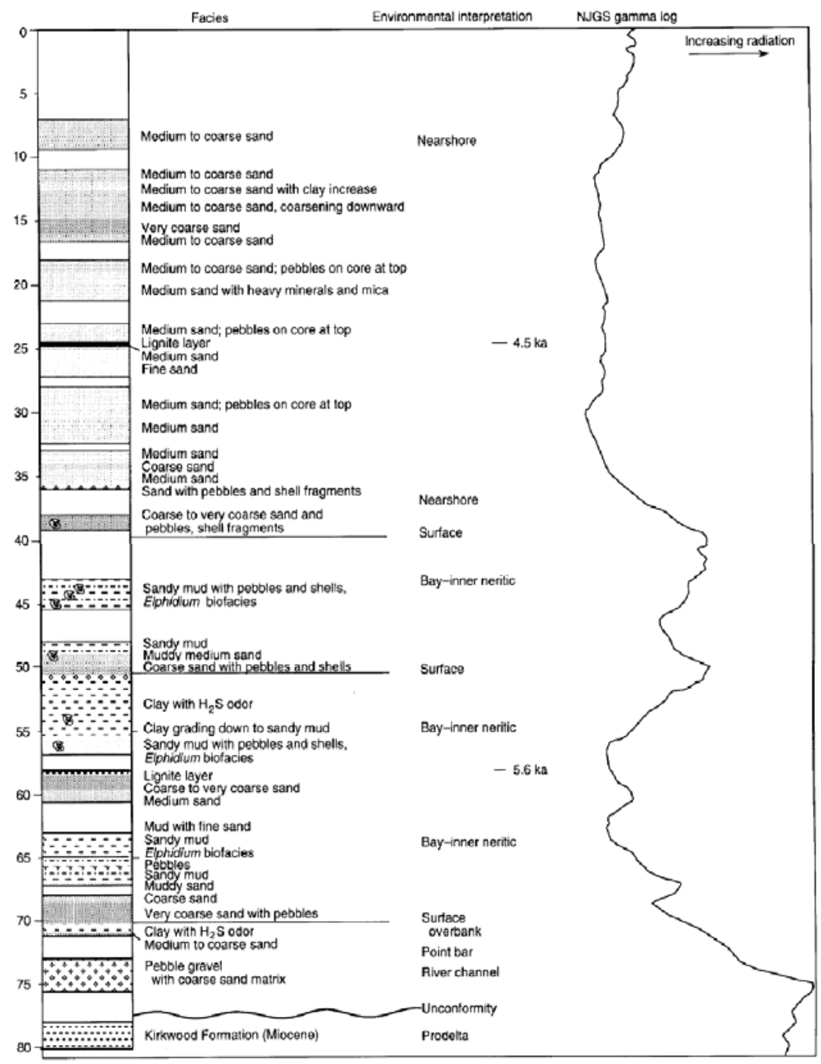


Figure 3.4: Cape May Formation lithostagraphy, sequences, and New Jersey Geological Survey (NJGS) gamma log.

3.1.3. New Jersey Inner-Shelf Sedimentary Bedforms

The seafloor geomorphology and the surficial stratigraphy of the New Jersey middle continental shelf provide a detailed record of sea-level change during the last advance and retreat of the Laurentide ice sheet (120,000 yr before present to present). Geophysical studies carried out in the middle shelf between water depths of approximately 120 ft and 300 ft produced the results shown in Figure 3.5.

The stratigraphic units and surfaces occurring in the sedimentary column from bottom to top are:

1. "R", a high-amplitude reflection that separates sediment >~46.5 kyr old (by AMS Carbon 14 dating) from overlying sediment wedges;
2. The outer shelf wedge, a marine unit up to ~50 m thick that onlaps "R";
3. "Channels", a reflection sub-parallel to the seafloor that incises "R", and appears as a dendritic system of channels in map view;
4. "Channels" fill, the upper portion of which is sampled and known to represent deepening-upward marine sediments ~12.3 kyr in age;
5. The "T" horizon, a seismically discontinuous surface that caps "Channels" fill;
6. Oblique ridge deposits, coarse-grained shelly units comprised of km-scale, shallow shelf bedforms;
7. Ribbon-floored swales, bathymetric depressions parallel to modern shelf currents that truncate the oblique ridges and cut into surficial deposits.

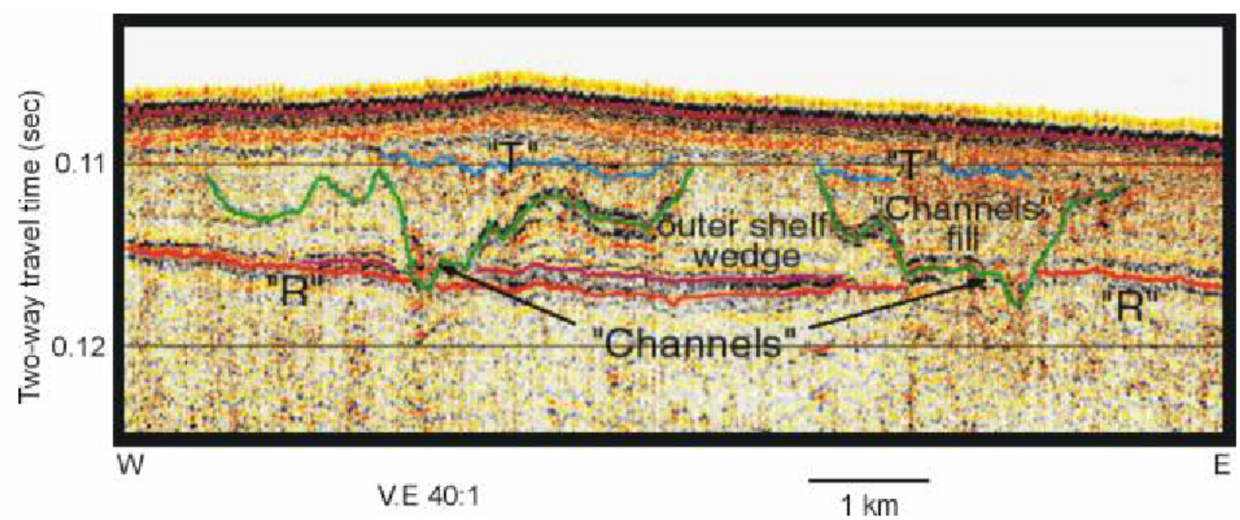


Figure 3.5: Boomer seismic profile on the New Jersey middle shelf in approximately 80 m deep water

This succession of features has been interpreted in light of a global eustatic sea-level curve and the consequent migration of the coastline across the middle shelf during the last 120,000 years. There is no systematic relationship between modern seafloor morphology and the very shallowly buried stratigraphic succession.

3.1.3.1. Shelf Sand Ridges

Sand ridges are among the largest and most pervasive bedforms on the New Jersey continental shelf (Figures 3.6 and 3.7), yet they are also the most enigmatic. Their puzzle comes from the fact that they are oriented obliquely to the direction of formative bottom current flow. Knowledge of the evolution and stability of the ridges is critical if structures such as pipelines, offshore structures, or waste disposal are planned in the vicinity of the ridges. The response of the sand ridges to the hydraulic regime of the shelf is an essential component of structural design and location.

The grain-size pattern over the dunes, larger on the East flanks, is consistent with formation transverse to the modern current because the eroding, upcurrent flanks should have a coarser residue. On the contrary larger ridges do not respond to the modern current. Their NE-SW ridge orientation is what might be expected if these had been formed oblique to a SSW paleoshoreline. However, their slope asymmetry contradicts this interpretation. Near-shore, the seaward flanks in the lee of a SSW-directed alongshore flow are steeper. Offshore, landward flanks tend to be steeper, suggesting a response to a seaward current.

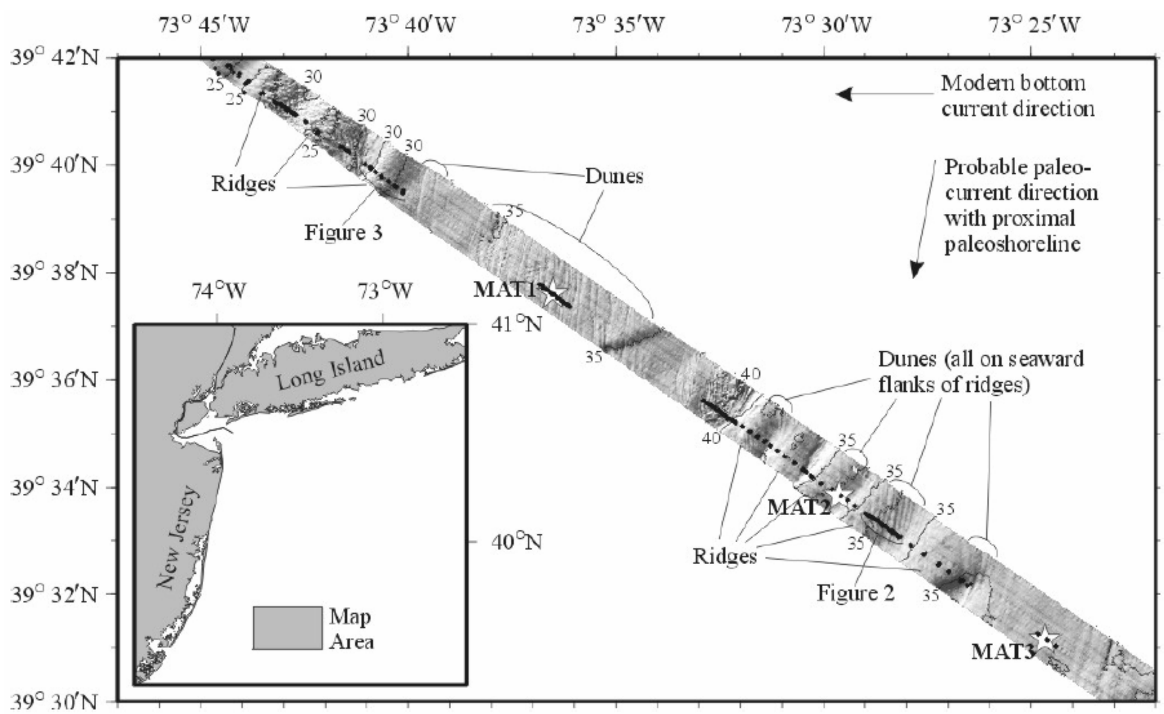


Figure 3.6: Simrad EM1000 multibeam bathymetry along part of the New Jersey shelf

The slope break on the seaward ridge flank is another common feature of these ridges, which gives them a somewhat trapezoidal cross section. Similar shapes have been observed in sand waves in tidal regimes, and interpreted as resulting from alternation between primary and secondary current directions. Like the tidal bedforms, these ridges may have formed under the influence of more than one current direction. Goff et al. (1999) hypothesized that they formed originally in a nearshore paleoenvironment under a SSW directed flow when sea level was lower, and have subsequently been heavily modified, but not entirely deconstructed, at their present water depth by the modern, westward bottom currents.

3.1.3.2. Reef Bedforms

Rocky reefs and outcrops of glauconitic marl (soft sedimentary rock) are known to occur off New Jersey, such as the Shrewsbury Rocks, north of Monmouth Beach, although these do not appear to be commonplace within the study area. There are reports by fishermen of cobbles and loose rock and gravel that may represent paleo-river deltaic deposits. Other evidence of offshore reef forms was found on a diver's website[18] that describes locations off the mid New Jersey coast containing large boulders, possibly a marl unit. In some instances, the reported dive sites coincide with charted fish havens.

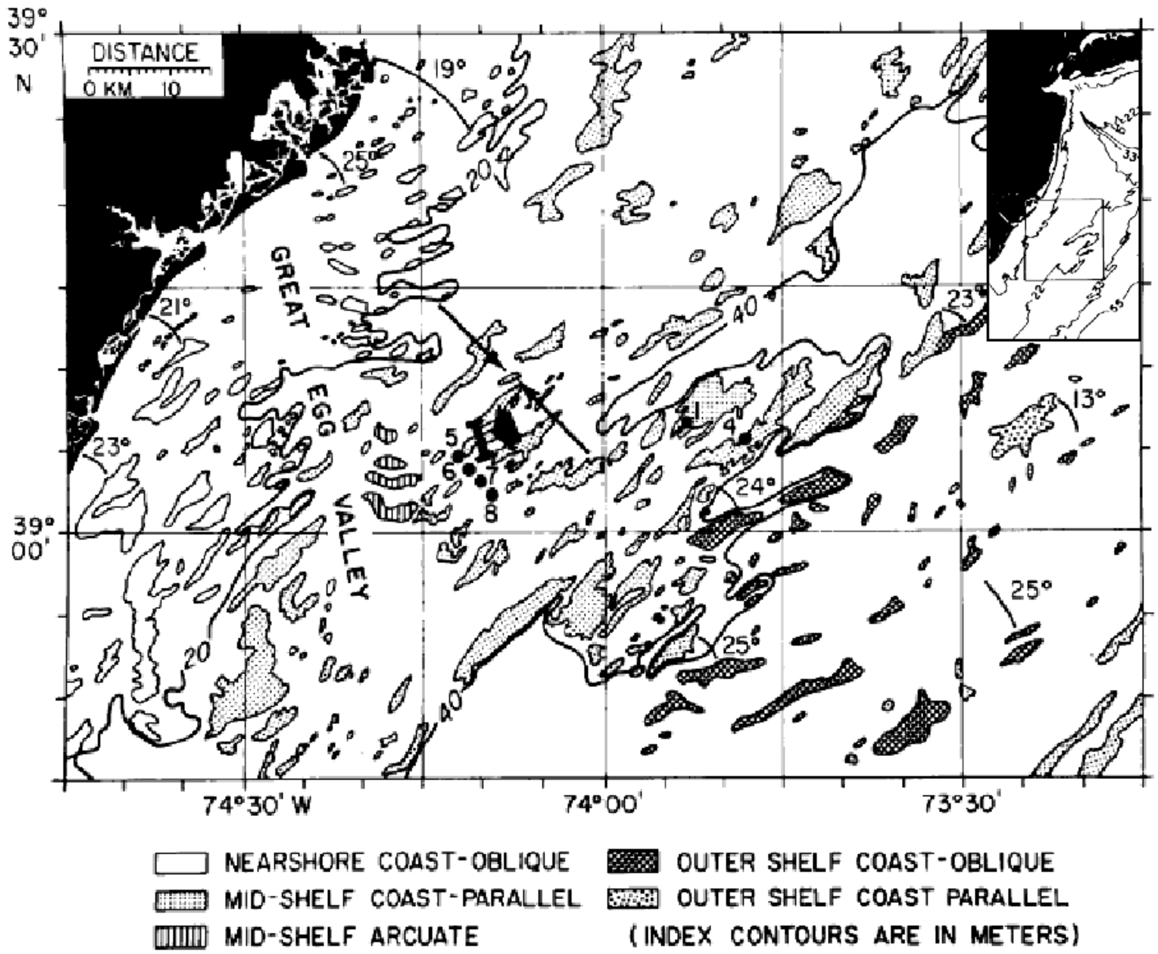


Figure 3.7: Shelf ridges as defined by deepest closed bathymetry contour

[18] http://njscuba.net

3.1.4. Delaware Bay Shelf

Delaware Bay is an estuary formed as the result of drowning of the Delaware River valley after post-glacial sea-level rise. The bottom of Delaware Bay is blanketed by sandy sediments dominated mineralogically by quartz with organic content of less than 1% carbon. The upper estuary consists of quartz-rich, muddy sediments with more abundant clays and a higher content of organic matter. The estuary may be divided into two zones north and south of Liston Point (39º 25'): the zone north characterized by muddy sediments, and the zone south to the sea characterized by coarser sediments.

The characteristic sediment types found in the upper estuary are over 90% muds and sandy muds. Locally important exceptions can occur, especially in the lower estuary shallow waters where sands may dominate, or in certain channel pockets where silts dominate. Weil (1977) has described the lower portion of this reach as the submarine delta of the Delaware River. The area in the vicinity of Artificial Island is approximately the null point of the Delaware Estuary (the location in the estuary where bottom currents are exactly balanced during ebb and flood tidal phases). The null point is a likely place for fine sediments to accumulate.

Lower Delaware Bay sediments (south of 39º 25') are texturally distinct from those upstream of the null point. While the upper estuary bottom is 90% sandy muds and muds, the lower estuary contains less than 25% sediments of these textures. Weil (1977), using statistical techniques, has identified three major sedimentary environments in the lower estuary: channel sands and gravels, open estuarine fine sands with mud, and estuarine quiet water muds (Table 3.1). The principal sources of these sediments are shore and bottom erosion, the remains of estuarine organisms, and input from the ocean (USACE, 1973). The sands just inside the bay mouth appear to be derived from the New Jersey and Delaware coasts or the shallow continental shelf. The New Jersey and Delaware ocean coasts contribute approximately 200,000 and 350,000 tons per year respectively, of sands to the bay (USACE, 1973).

The principal processes responsible for the observed sediment texture in the lower estuary are the strong tidal currents, which produce coarse sediments in the bottom of deep channels, and wind-wave suspension of bottom sediments in shallow areas. Superimposed on and modifying these processes is a circulation pattern that causes ocean-derived waters to dominate on the New Jersey side of the bay and fresher waters from the river to hug the Delaware. Sands containing characteristic minerals derived from the New Jersey ocean coast are swept around Cape May into the bay and can be traced as far upbay as the Cohansey River mouth. Sands derived from the Delaware ocean coast are swept around Cape Henlopen into the bay where they are deposited almost immediately, causing the Cape to grow rapidly to the northwest. Fine sediments, carried downstream from the river in the fresher waters, are preferentially deposited on the Delaware side of the estuary. Figure 3.8 illustrates the main paths of sediment transport.

There is little available public domain information about the thickness of Holocene sediments within the lower Delaware estuary. As part of a geological study carried out by the Delaware Geological Survey (DGS) along the Atlantic Coast of Delaware, the DGS drilled a borehole offshore Cape Henlopen at the mouth of the Delaware Estuary. This borehole crossed 10 ft of Holocene fine to coarse sand, sandy to clayey silt, silty clay, and organic rich clayey silt beds with abundant plant fragments. Opposite to this borehole, on the northern coast of Delaware Bay, the Cape May borehole was drilled through approximately 75 ft of Holocene sediments corresponding to the Cape May Formation. The stratigraphy of this sedimentary section was described in an earlier section.

Table 3.1: Sediment Characteristics for Lower Delaware Bay

Sediment Type	Bottom Area (km^2)	% Total Area
Gravel	21	7
Gravelly sand	53	18
Slightly gravelly sand	12	4
Sand	115	37
Muddy sand	30	10
Sandy mud	67	22
Mud	5	2
Percent mud in the sediments		
0-10	155	51
10-25	54	18
25-50	21	7
50-75	67	22
75-100	6	2

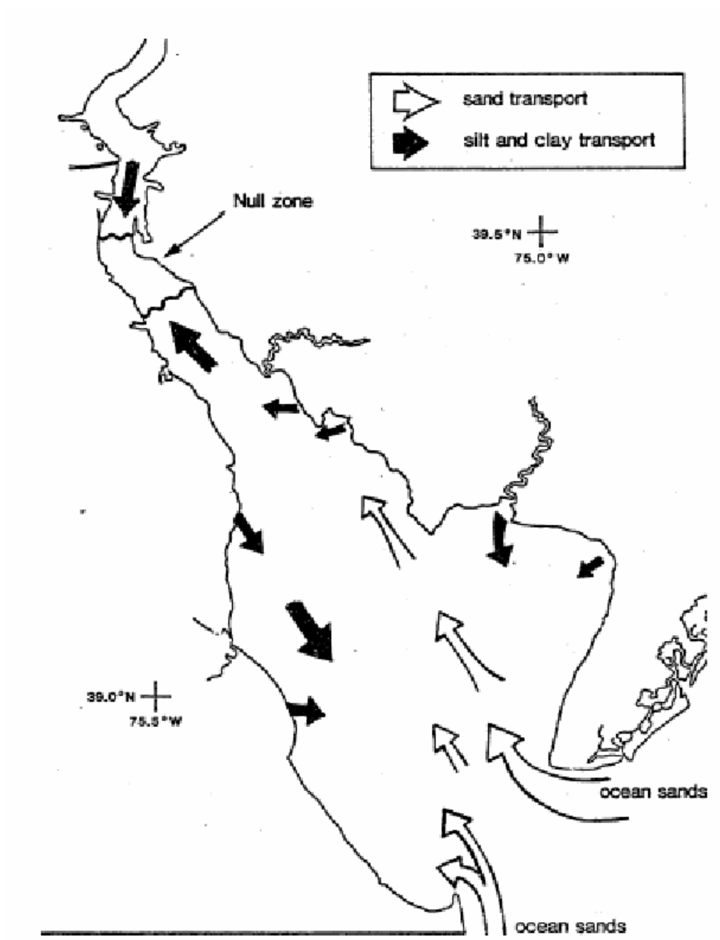


Figure 3.8: Generalized sediment transport pattern for Delaware Bay

3.2. Physical Oceanography

3.2.1. Bathymetry

Bathymetry, the measure of a water body's depth, is a significant siting factor for offshore wind development. An area's water depth has a direct impact on the design and construction of turbine foundations; installation costs can increase sharply with water depth. Commonly used monopile foundations are appropriate in water depths of up to 70 feet, depending on a site's subsurface geology and wave conditions. Near term foundation advancements are expected to expand the water depths of interest for offshore wind development to 100 ft .

Map 3.9 provides an overview of New Jersey's coastal water bathymetry. The continental shelf extends approximately 75 nautical miles from the shore and provides water depths shallower than 100 ft up to12 nautical miles from shore.

The northern segment of the study area, extending from New York Harbor to Island Beach State Park, exhibits a variety of water depth characteristics. New York Harbor is composed entirely of shallow water with depths not exceeding 40 ft, except in navigation channels. This trend continues out and around Sandy Hook where 50 ft deep waters stretch out to the 3-mile limit. Further south along the shore, the sub-100 ft waters reach to the Paleo-Hudson Valley, which runs southeast from the harbor.

The central part of the coast, Island Beach State Park to Atlantic City, has shallow water slightly further offshore. Waters out to the 3-mile limit are almost all less than 40 ft deep; 100 ft and shallower waters extend out 10 nautical miles from shore on average. Near the southern end of this region, the seabed slope becomes gentler, providing for larger areas of relatively shallow water (50-60 ft), particularly 11 nautical miles east of Barnegat Inlet and the areas south and east of the Great Bay.

The southern shore area extends from Atlantic City to Cape May, and includes the northern section of Delaware Bay. Waters 70 ft and shallower in depth extend nine nautical miles from shore through most of this area. To the east and southeast of Cape May these depths extend out to 15 nautical miles from shore.

Delaware Bay is a predominantly shallow area with numerous shoals and depths rarely exceeding 40 ft. The study area's southern boundary is the deep water of the Delaware Shelf Valley.

Tables 3.2 and 3.3 summarize the bathymetric characteristics of the study region. Table 3.2 gives a breakdown of the area by 10 ft depth interval. The average distance from shore of three significant depth contours is shown in Table 3.3.

Table 3.2: Study Area Depth Breakdown

Depth Bin (ft)	Area (nm^2)
0 – 10	278
10 – 20	123
20 – 30	119
30 – 40	146
40 – 50	222
50 – 60	274
60 – 70	315
70 – 80	331
80 – 90	366
90 – 100	276
> 100	15
Total	2465

Table 3.3: Average Distance from Shoreline

Depth Contour (ft)	Average Distance (nm)
50	4.94
70	8.57
100	18.52

3.2.2. Waves

Waves off the New Jersey coast are composed of the combination of short period/wavelength local wind-generated waves and longer period/wavelength swells propagating from the open North Atlantic Ocean. When winds are from the west, there is limited fetch for build-up of wind-generated waves. Winds from the north can have a limited fetch near the northern end of the study. Winds out of the south and east have an unlimited fetch and can generate large waves through out the study region.

Sea swells originate as wind-generated waves. Due to dispersion, waves propagate away from the area of generation and can travel for thousands of miles. The predominant swell direction in the study area is the southeast.

Instrumentation at C-MAN (Coastal-Marine Automated Network) stations and moored observation buoys measure the combined characteristics of weather and waves (see Map 3.2 and Table 3.4), including annual mean and maximum significant wave heights for stations in the vicinity of the study area. Significant wave height is defined as the average of the highest 33% of observed waves. Other wave height statistics can be derived from the significant wave height, as shown in Table 3.5.

Sea states follow annual weather patterns, with the roughest conditions occurring September through March. In January, waves of 8 ft (2.4 m) occur 15 – 25 percent of the time in deeper water. Summer thunderstorms will also bring transient elevated sea states on a less frequent basis. Rough seas are most common with northwest or west winds above 20 knots. Wave heights have reached 12 m under storm conditions. Waves moving into shallow water become steeper and break when the depth is about 1.3 times the wave height, posing large loads on turbines sited in shallower coastal waters.

Wave heights off the New Jersey coast are comparable to those of recent and pending offshore wind plants in Europe. Foundation design will require careful climatic analysis to accommodate New Jersey's expected wind and wave loading environment. Periodically rough seas will place limitations on access to a project site by surface construction and maintenance vessels. Current maintenance vessels can safely operate in 3-5 ft seas to perform scheduled maintenance inspections, which are required once or twice per turbine per year. Specially designed vessels are currently being developed which will permit operations in more sever weather. Access in rougher seas may be accomplished by helicopter or purpose built maintenance vessels.

Table 3.4: Significant Wave Height Measurements Near Study Area (in meters)

Month	C-MAN Station									
	ALSN6		44009		44025		44001		44012	
	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
January	1.2	3.5	1.3	3.6	1.2	3.8	1.9	4.5	1.2	3.8
February	0.8	3.2	1.1	3.6	1.2	4.0	1.4	3.9	1.0	2.2
March	1.2	3.5	1.6	5.3	1.6	5.8	1.3	4.1	1.4	3.3
April	1.2	3.5	1.2	3.5	1.1	1.9	1.5	4.8	1.0	3.5
May	0.8	1.9	1.1	2.6	1.1	2.2	1.1	4.3	0.7	2.5
June	0.8	1.6	0.7	2.2	0.8	2.0	0.7	1.5	0.9	2.5
July	0.7	1.7	1.1	2.7	1.0	2.6	1.1	3.0	0.8	2.4
August	0.8	2.4	1.0	2.3	1.1	2.1	1.1	2.7	0.8	4.0
September	0.9	2.2	1.4	5.3	1.2	4.5	1.2	3.3	0.9	2.3
October	0.8	2.0	1.2	4.7	1.3	4.5	1.6	5.0	1.2	4.7
November	0.8	1.6	1.2	2.7	1.2	2.7	1.9	3.9	1.1	4.2
December	0.9	2.6	1.3	3.2	1.4	3.2	1.8	7.1	1.1	2.7
Annual	0.9	3.5	1.2	5.3	1.2	5.8	1.4	7.1	1.0	4.7

Table 3.5: Wave Height Relations

Wave Heights from Significant Wave Heights (SWH)	
Most frequent wave height:	0.5 x SWH
Average wave height:	0.6 x SWH
Significant Wave Height (Average of highest 33%):	1.0 x SWH
Height of highest 10% of the waves:	1.3 x SWH
One wave in 1,175 waves:	1.9 x SWH
One wave in 300,000 waves:	2.5 x SWH

3.2.3. Currents

Ocean currents are an important design and siting consideration. Currents drive sediment transport and foundation scouring. They can also affect sea bottom characteristics and vessel motion during installation.

There are five primary components to the currents in the study area. They are:

1. The north Gulf Stream countercurrent, consisting of cold water that is flowing slowly west to southwest. Along the border to the Gulf Stream, which is well south of the study area, some of this water is entrained in the Gulf Stream.
2. Wind generated near-surface currents. The currents may reinforce or oppose the general flow of the Gulf Stream countercurrent.
3. A swell and surf generated longshore current. The predominant southeast swell generates a north-south longshore current along the shore divide in Monmouth County, near Asbury Park. The longshore currents are responsible for the net transport of beach sand towards Sandy Hook in the north and towards the system of barrier beaches to the south.
4. Swell and surf generated rip currents, which counteract the net transport of water toward the beach. Rip currents form narrow zones of low waves and rapid (up to 5 knots) seaward flow that extend out to a half-mile offshore.
5. Over most of the New Jersey shore, tidal currents are most important in the vicinity of the numerous inlet channels (Manasquan Inlet, Barnegat Inlet, Little Egg Inlet, Absecon Inlet, Great Egg Inlet, and Hereford Inlet). Flow is along the axis of the channels in and out of the inlets, roughly perpendicular to the coastline.

The first two components can be predicted by NOAA's Coastal Ocean Forecast System (COFS)[19]. Typical values are roughly 0.4 to 1.1 knots east of New Jersey. These are the primary current components in open water. They are felt at distance of more than a half mile from beaches and a mile from inlets

[19] Real time data is available at the NOAA COFS website http://polar.wwb.noaa.gov/cofs.

The longshore and rip currents are generated by surf zone dynamics and exist primarily within a half mile of the shore. Most case studies and models deal with these phenomena only as local effects. There are wave and current meters (past or present NJ stations) that measure in these zones, but they are also close to the inlet channels and contain significant tidal current components. The U.S. Army Corps of Engineers has an active research program with a coastal inlet database and archive of documentation related to inlet measurement and modeling activities.

Figure 3.9 displays water temperatures and the generally divergent flow of surface currents along the New Jersey coast during July of 2003. Surface currents were measured using high frequency Coastal Radar (CODAR) emitted from sites established by Rutgers University along the shoreline. Water temperature data was obtained from an overhead NOAA weather satellite.

Tidal current measurements and predictions are available for several inlets along the New Jersey shore. Both speed and time of tidal currents for the stations along the shore are referenced to The Narrows and the Delaware Bay Entrance. The maximum predicted tidal current speed at The Narrows is 2.7 knots and at the Delaware Bay Entrance it is 1.9 knots. The maximum speeds are observed in the restricted channels, which breach the barrier beach. The influence of the tidal currents can be measured up to a kilometer or more seaward from the inlets. Table 3.6 provides tidal current data for five stations within the study area.

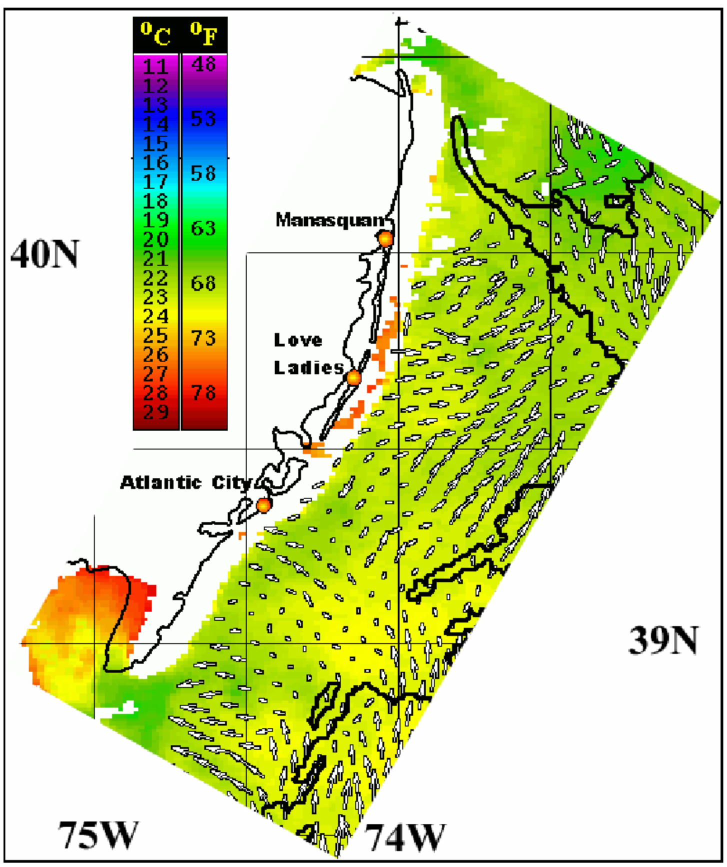


Figure 3.9: Surface Currents and Temperatures

Table 3.6: Average Tidal Currents

Station Name	Max Flood Speed (knots)	Max Flood Direction	Max Ebb Speed (knots)	Max Ebb Direction
Sandy Hook Channel 40° 29.1N 74° 00.1W	1.6	286°	1.9	094°
Manasquan Inlet 40° 06'N 74° 02'W	1.7	300°	1.8	120°
Barnegat Inlet 39° 46'N 74° 07'W	2.2	270°	2.5	090°
Cape May Harbor Entrance 38° 57'N 74° 52'W	1.8	333°	2.2	150°
Delaware Bay Entrance 38° 46.85'N 75° 02.58'W	1.4	327°	1.3	147°

3.2.4. Tides

Tides are one of the driving components of currents along the New Jersey Shore. The effect is greatest near the numerous coastal inlets and can be felt up to a kilometer from the shore. Tidal variations in depth may also be important for fatigue loading of the turbine. Siting near the coast necessitates consideration of tidal effects on turbine structures and access.

Tides along the New Jersey shore are semi-diurnal with mean tidal ranges typically of 4.1-5.8 ft. There are three reference stations for tidal heights: Sandy Hook, Atlantic City and Cape May. Predictions for subordinate stations are expressed in terms of height and speed ratios and time offsets from the reference stations. Table 3.7 lists the locations of the reference and subordinate stations from the NOAA Center for Operational Oceanographic Products and Services. The station locations are also displayed in Map 3.2.

Table 3.7: Tide Station Locations

No.	Station	Type	Latitude	Longitude
1	Sandy Hook, NJ	Reference	40° 28'N	074° 00.6' W
2	Manasquan Inlet, NJ	Subordinate	40° 06.1'N	074° 02.1'W
3	Barnegat Inlet, NJ	Subordinate	39° 45.4'N	074° 7.7' W
4	Atlantic City, NJ	Reference	39° 21'N	074° 25'W
5	Cape May Ferry Terminal, NJ	Reference	38° 58.1'N	074° 57.5'W
6	Cape Henlopen, DE	Subordinate	38° 48' N	075° 05'W

Daily tide height predictions for the subordinate stations are available from the NOAA COOPS web site. The summary statistics for each of the reference and subordinate stations are presented in Table 3.8.

Table 3.8: Average Tide Values

Station	Mean Range (ft)	Spring Range (Ft)	Mean Tide Level (Ft)
Sandy Hook, NJ	4.66	5.6	2.53
Manasquan Inlet, NJ	4.0	4.8	2.18
Barnegat Inlet, NJ	2.44	2.9	1.36
Atlantic City, NJ	4.09	4.95	2.2
Cape May Ferry Terminal, NJ	4.92	5.81	2.62
Cape Henlopen, DE	4.1	4.9	2.2

3.3. Climatology

3.3.1. Overview

New Jersey is located in the heart of the mid-latitudes between roughly 39^{o} N and 41.5^{o} N latitude, with the southern two-thirds of the state lying along the Atlantic coastal plain. Because of its location with respect to the equator and polar region, the climate and prevailing winds in New Jersey and its immediate offshore waters are controlled primarily by the large-scale mid-latitude westerlies. During the colder months (October through April), prevailing winds are northwesterly; otherwise they are southerly during the warm season. In addition, a small-scale sea breeze circulation often develops along the immediate coastline, driving the localized climate during periods of large land-ocean temperature contrasts.

Temperatures throughout New Jersey exhibit a strong marine influence. In general, coastal areas experience cooler weather during the summer and warmer weather during the winter than interior sections. In addition, coastal areas normally observe fewer temperature extremes.

Seasonal effects also govern the wind climatology in the offshore area. Wind speeds tend to be highest from October to April because of large atmospheric temperature and pressure gradients. These conditions are driven by an increase in extratropical cyclone activity during this period. While extratropical storms are generally the most extreme during the winter, they can occur at anytime during the year. During the warmer months, tropical cyclones can impact the offshore area, potentially causing some of the most extreme weather conditions that affect the region.

Contained within the following sections is a detailed discussion of the New Jersey offshore climate. Seasonal climatology is presented, focusing on mean temperatures, winds, and weather patterns. Weather extremes are presented to give a scope of system design parameters and potential cost increases. Severe weather events can result in prolonged, intense loading on the turbines and foundations. Implications of these events on wind project engineering are discussed. Finally, some of the most potent storms to impact the New Jersey coastline are highlighted.

3.3.2. Temperature

Table 3.9 shows the monthly mean, maximum, and minimum temperatures for offshore monitoring sites at Ambrose Light Station and Buoy 44012 and for land sites at Atlantic City and Newark. The data show roughly a 21°C offshore seasonal temperature range at both observing sites and an inland range between 24°C and 26°C.

Near or below freezing conditions have been observed during each month from November through April at both offshore monitoring sites and at the inland sites between October and May. Based on a four-year data sample (1985 – 87, 1991), freezing conditions (i.e., temperatures below 0°C) were observed at Ambrose Light Station roughly 9% of the time, while freezing conditions occurred roughly 5% of the time at Buoy 44012. The coldest temperature observed at the offshore stations was approximately -19°C. The hottest temperature at the same stations was around 36 °C.

Table 3.9: Monthly Mean and Extreme Temperatures (°C) at Four Monitoring Sites

Month	Ambrose Light Station (Offshore) (11/1984 – 2/2001)			Buoy 44012 (Offshore) (1985 – 1987, 1991)			Atlantic City (Inland) (1971 – 2000)			Newark (Inland) (1971 – 2000)		
	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
Jan	1.4	16.9	-18.9	2.9	13.2	-15.5	0.1	13.9	-23.3	-0.4	23.3	-22.2
Feb	1.8	20.8	-13.3	3.1	12.1	-9.6	1.2	14.4	-23.9	1.0	24.4	-25.6
Mar	4.5	25.8	-9.9	6.2	17.5	-7.8	5.4	18.3	-15.0	5.7	31.7	-14.4
Apr	8.9	26.8	-4.0	9.3	19.9	0.5	10.3	25.0	-11.1	11.3	36.1	-8.9
May	14.1	32.7	4.9	14.5	25.3	7	15.8	29.4	-3.9	17.1	37.2	0.6
Jun	19.2	32.4	10.4	19.8	29	12.8	20.9	31.1	2.8	22.2	38.9	5.0
Jul	22.4	35.7	13.1	23.5	30.4	17.4	24.0	33.9	5.6	25.1	40.6	11.1
Aug	22	33.1	11	23.9	29.2	18.2	23.0	33.9	4.4	24.4	40.6	7.2
Sep	19.3	30.2	8.5	21.2	28.3	13	19.1	28.9	0.0	19.9	40.6	1.7
Oct	14.1	27.8	3	16.0	24.8	7.6	12.8	24.4	-6.7	13.6	33.9	-3.9
Nov	8.8	23.3	-6.2	11.3	19.5	-3	7.7	20.6	-12.2	8.5	29.4	-11.1
Dec	3.8	21.7	-12.5	6.0	15.9	-8	2.6	13.9	-21.7	2.4	24.4	-22.2

Wind project components are designed to operate within this temperature range. However, over the course of the year, the energy production of a wind project will vary somewhat as a result of varying air density, which is a function of air temperature. Cold air is naturally denser than warm air and at a given wind speed contains more energy. Consequently a 10% increase or decrease in air density can change the output of a wind turbine by nearly the same percentage. Based on data from Ambrose Light Station and Buoy 44012, the annual average sea-level site air density off the New Jersey coast is between 1.23 kg/m^3 and 1.24 kg/m^3. However, based on the temperature extremes defined in Table 3.9, the site air density can range from 1.14 kg/m^3 to 1.40 kg/m^3.

Sub-freezing temperatures can pose challenges to wind park operation. When combined with other weather events, freezing temperatures can result in ice accumulation on blades and other components and may lead to turbine down time. Extended periods of cold produce ice packs and floes in some areas; these can pose a structural threat to turbines and other offshore components of the wind farm.

3.3.3. Winds

The winds throughout New Jersey and its immediate offshore region were modeled in 2002 by Truewind Solutions as part of a separate study sponsored by the New Jersey Board of Public Utilities and the U.S. Department of Energy. According to the resulting New Jersey wind map (Map 3.3), the annual average wind speed at 70 m above the surface ranges from 7.0 m/s to 9.0 m/s throughout most of the study area, with the resource generally improving to the south and east. Seasonally, wind speeds tend to be higher during cold periods because of extratropical cyclone activity and stronger pressure gradients. The highest mean speeds are observed in December and January and the lowest occur during July and August. Figure 3.10 graphs the monthly mean wind speeds observed at two offshore monitoring sites.

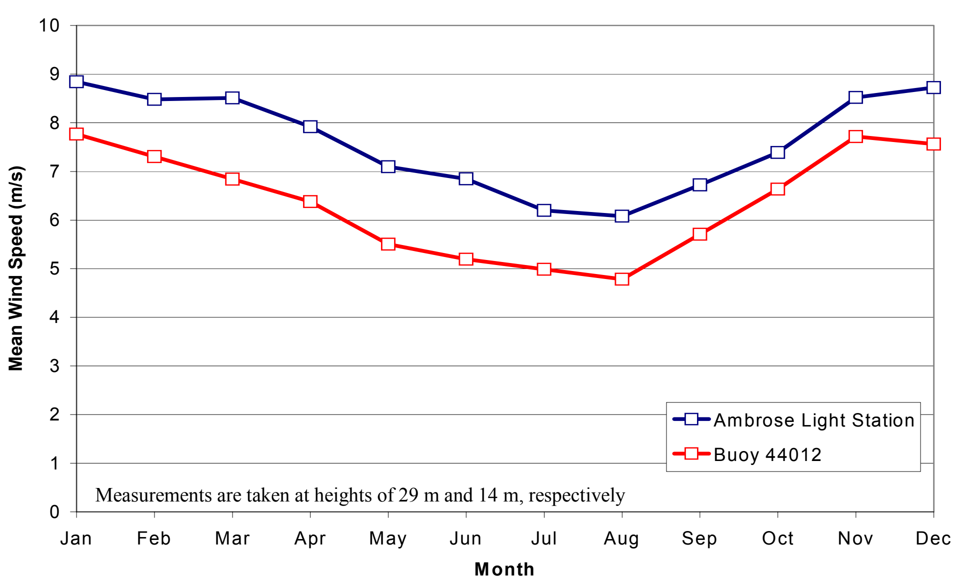


Figure 3.10: Monthly Mean Wind Speeds at Two Offshore Monitoring Sites

The diurnal wind speed distribution at the two offshore monitoring sites shows relatively uniform winds during the nighttime hours, followed by a dip during the late morning hours (see Figure 3.11). During the afternoon, the wind speeds increase, particularly at the Ambrose Light Station, which peaks in the late afternoon and early evening before leveling off at its overnight speeds. The diurnal range is roughly 1.5 m/s. The sharper afternoon increase in speeds at Ambrose, which is closer to land, is likely due to sea breeze effects. The energy production and utility load matching implications of these wind characteristics are examined in Section 9.4.

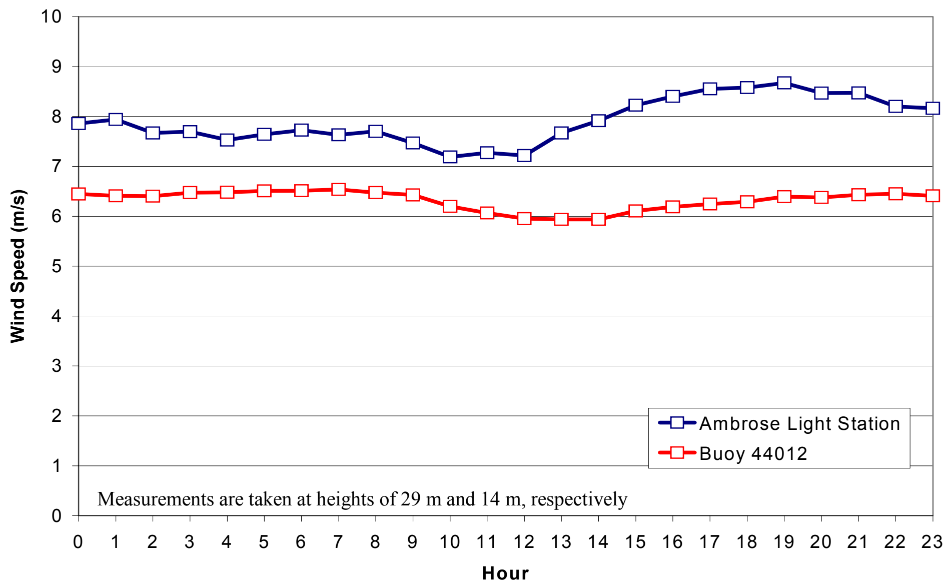


Figure 3.11: Hourly Mean Wind Speeds at Two Offshore Monitoring Sites

Gale force winds (>17.5 m/s) are observed roughly 6% of the time, primarily during the winter. These strong winds are usually observed from westerly quadrants and often occur during extratropical cyclones. They rarely occur during the summer months, unless associated with localized thunderstorms or tropical cyclones. While winds of this strength may negatively impact navigation, they are beneficial for wind energy production. Offshore turbines operate at peak output in 14-25 m/s winds.

Table 3.10: Wind Resource Breakdown

Speed Bin (70m)	Area (nm^2)
< 7.5 m/s	337
7.5 – 8.0 m/s	557
8.0 – 8.5 m/s	1150
8.5 – 9.0 m/s	421

According to measurement stations, the prevailing offshore wind directions are generally westerly, with maxima from the south to southwest and west to northwest. Figure 3.12 illustrates this pattern in the form of wind direction roses. The gray (light) wedges indicate the absolute time frequency in 16 direction sectors while the blue (dark) wedges indicate the percentage of total wind energy by wind direction. Table 3.10 gives a breakdown of the study area's wind resource.

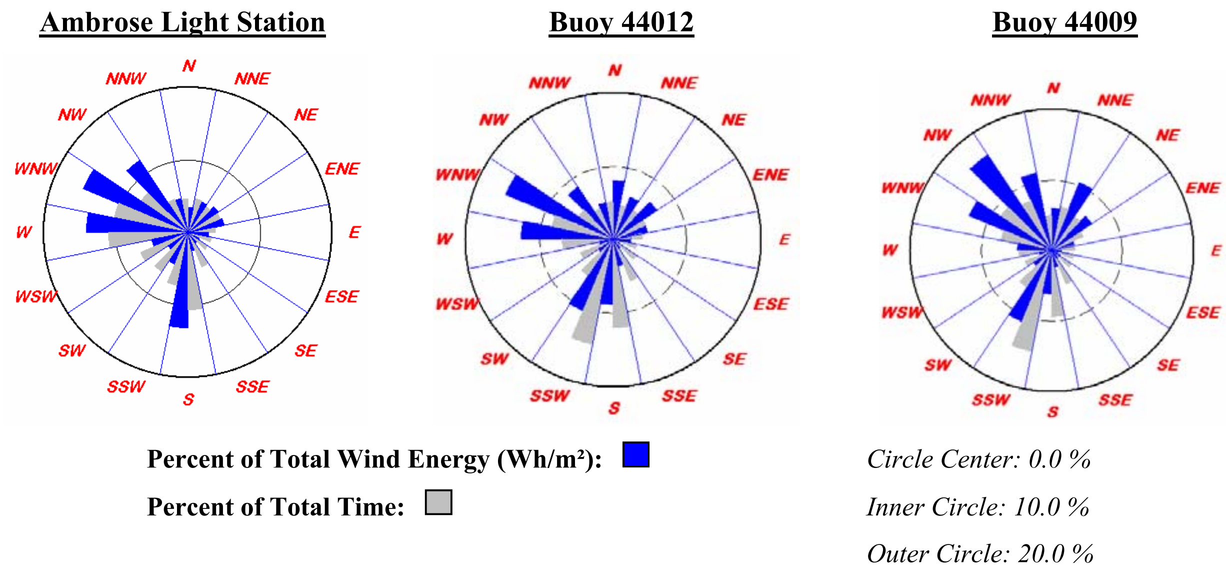


Figure 3.12: Wind Roses

3.3.4. Sea Breeze Circulation

During the warm months, land-ocean thermal contrasts often cause a sea breeze circulation to develop along the New Jersey coast during the late morning and early afternoon hours (Figure 3.13). The physical properties of water enable this phenomenon to occur during periods of strong solar heating and minimal large-scale pressure gradients. The warming of the land forces the overlying air to rise, subsequently forming lower surface pressure with respect to the marine environment. In response, an onshore flow ensues in response to the local pressure gradient. The effects of the sea breeze are generally felt within 6 miles of the coastline. The sea breeze can increase wind speeds by anywhere from about 1 m/s at a distance 6 miles offshore, to nearly 4 m/s a half-mile offshore. At 5 miles, the effect is a roughly 2 m/s increase. However, areas up to 20 miles from the shoreline can be affected during periods when the large-scale pressure gradient is extremely small.

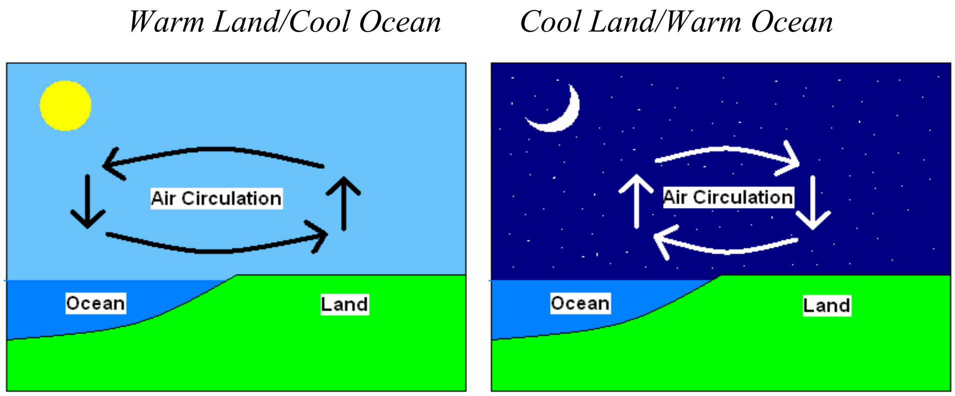


Figure 3.13: Diagrams of Sea Breeze Circulation

A sea breeze circulation also occurs under the opposite scenario at night, albeit on a smaller scale. At night, the air overlying land cools more rapidly than marine air, resulting in offshore low pressure with respect to the land. This pressure pattern prompts an offshore flow and occurs most often during the autumn months.

3.3.5. Weather Extremes

This section provides a detailed look at some of the most devastating storms to impact the coastal area, their effects, and the likelihood that similar (or greater) magnitude systems could approach New Jersey.

Extreme weather events are among the climatic and environmental parameters used for designing a wind farm. Such events can incur prolonged, extreme loads on turbines, foundations and other wind farm components. Significant hydrodynamic loading during storms may necessitate stronger foundations and towers. Storms also generate increased currents and sediment transport, affecting seabed characteristics and foundation design. Offshore turbines are designed to safely withstand severe wind events (e.g., 70 m/s gusts and 50 m/s sustained speeds[20]); however, the turbines will shut down in winds over 25 m/s to limit loading on the structure and components. Ultimately, site-specific climatic and environmental extremes may influence costs through equipment design requirements and project engineering expenditures.

3.3.5.1. Extratropical Storms

Extratropical storms are meteorological phenomena that occur regularly in mid-latitude locations like New Jersey. They are most often observed during the cold months because they are driven by strong temperature and pressure gradients. However, they can occur at any time during the year. Extratropical storms are also known as nor'easters because of the strong northeasterly winds that are usually observed. These gusty winds are responsible for onshore flow that can be especially damaging to the shoreline because of large waves and flooding that often occur during

[20] GE 3.6 Offshore Turbine, IEC 61400-1 Safety Class IB.

strong storms. While typically not as severe as tropical events, nor'easters are more frequent and may provide coupled wind/wave loading criteria for potential projects. Depending on storm conditions, the strong winds during these periods may yield favorably high production levels from offshore wind plants.

3.3.5.2. Notable Extratropical Events

Based on available data, the most potent extratropical storm to occur during the past 22 years occurred 11-12 December 1992. During the storm, winds at Ambrose Light Station gusted to over 40 m/s. The average significant wave height was recorded at 7.3 m. At Buoy 44025 (about 35 miles offshore), average significant wave heights greater than 9 m were observed.

One of the strongest extra-tropical storms ever observed along the Atlantic Coast affected the region on 6-8 March 1962. At the height of this storm, 12 m waves impacted the shoreline and winds gusted to well over 30 m/s. This storm was especially dangerous because it occurred during a period of high astronomical tides. The exceptionally long period of onshore flow also caused considerable alteration to the New Jersey coastline. At Whale Beach (just south of Atlantic City), this storm left a layer of beach sediment well inland, suggesting storm impacts comparable to those of an intense hurricane.

Another storm occurred 25 November 1950 and is known as "The Great Appalachian Storm". Despite tracking inland, this storm produced damaging winds throughout the Northeast. Newark observed winds gusting to 48 m/s and New York City also observed gusts over 40 m/s.

3.3.5.3. Tropical Cyclones

Tropical cyclones are important factors in wind plant siting and development because of the severe wind and wave conditions associated with them. Turbine and foundation design load criteria may be driven by the extreme conditions experienced during a direct hurricane impact. While the entire storm system may generate strong winds and waves over a broad area, the probability and consequences of a direct hit are of primary interest for establishing the magnitude of extreme events.

Tropical cyclones occasionally affect the offshore region during the warmer months. These storms are classified based on their wind speeds (see the Saffir-Simpson Scale, Table 3.11). The weakest systems are known as tropical depressions and they have winds less than 17.5 m/s. Tropical storms – containing winds between 17.5 m/s and 32.4 m/s – form the next category on the Saffir-Simpson Scale. Tropical storms are generally equal in strength to strong extratropical storms. Hurricanes are the highest classification and are divided into five categories. The threshold wind speed for a tropical cyclone to be classified a hurricane is 32.4 m/s. Hurricanes with wind speeds greater than 48.9 m/s (categories 3, 4, and 5) are further classified as intense – or major – hurricanes.

Despite their relative infrequency along the New Jersey coast, Atlantic basin tropical cyclone formation must be constantly monitored because the powerful winds and storm surge associated with strong hurricanes can inflict great damage to coastal areas. Over the past 50 years, 28 tropical cyclones have affected New Jersey. Of the 28 storms, only 10 were hurricanes (2 intense) at their time of closest approach to Atlantic City.

Table 3.11: Saffir-Simpson Scale for Tropical Cyclone Classification

Classification	Category	Wind Speed (m/s)	Minimum Pressure (mb)	Storm Surge (ft)
Tropical Depression	TD	< 17.5	N/A	N/A
Tropical Storm	TS	17.5 – 32.4	N/A	N/A
Hurricane	1	32.4 – 42.2	> 980	4 – 5
Hurricane	2	42.2 – 48.9	965 – 980	6 – 8
Hurricane	3	48.9 – 58.1	945 – 965	9 – 12
Hurricane	4	58.1 – 69.4	920 – 945	13 – 18
Hurricane	5	> 69.4	< 920	> 18

Figure 3.14 illustrates the typical track of tropical cyclones along the eastern seaboard. Also shown is the basic structure of a tropical cyclone, indicating the sectors of the storm where the winds and surges are strongest and weakest. Storms that make landfall south of New Jersey and track northward tend to rapidly weaken and are often classified as tropical storms or depressions by the time they impact the study area. Thus, the impact is minimal. On the other hand, the great majority of tropical cyclones remaining off the coast often track far enough away that the tropical storm and hurricane force winds (> 17.5 m/s) do not impact the area. The only effect may be high waves propagating westward from the storm center. Over the last 50 years, only 12 storms tracked within 50 miles of Atlantic City. However, only Hurricanes Gloria in 1985 (10 miles from shore) and Belle in 1976 (20 km) tracked through the New Jersey offshore waters without a prior landfall. Tropical Storm Floyd (1999) tracked within 6 miles of Atlantic City following an initial landfall in North Carolina.

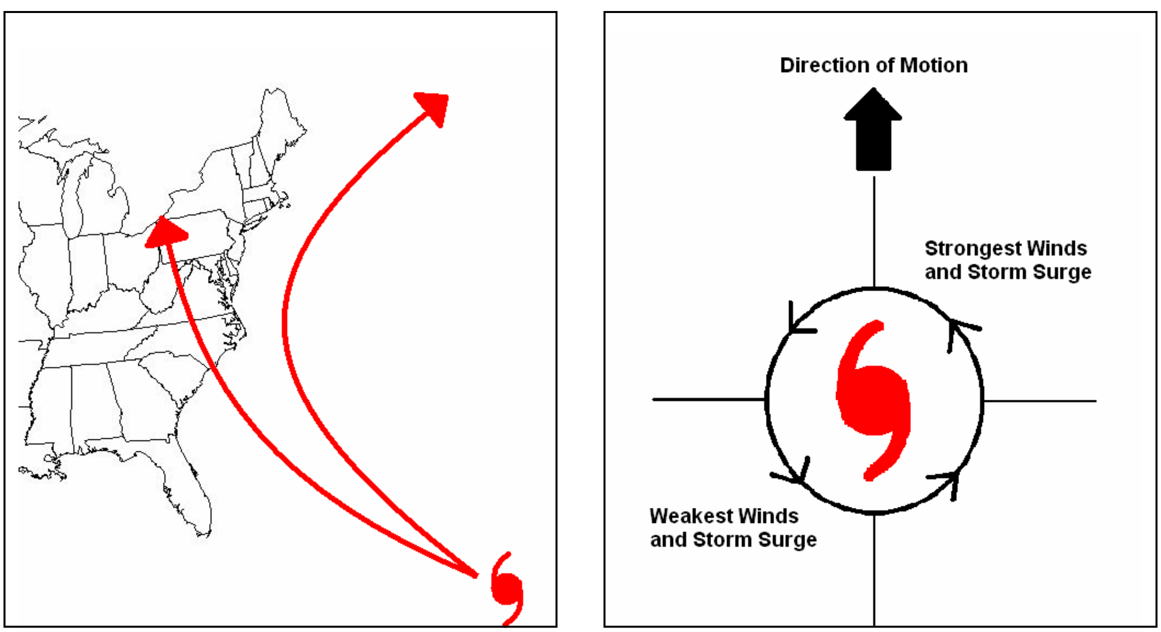


Figure 3.14: Tropical Cyclone Track Climatology and Structure

Map 3.4 charts all of the tropical cyclones to impact the New Jersey offshore area since 1851. Incidentally, the extratropical storms shown on the map are listed because of their tropical origins. When tropical cyclones reach mid and high latitudes, they occasionally transition into extratropical cyclones. In looking at the map, 20 storms tracked offshore near the study area.

According to the Tropical Prediction Center, there is a 15 to 25 year return period for a category 1 hurricane along the New Jersey coastline. Based on the storm tracks shown, the overall average return period has been 7 to 8 years for a tropical system of any type and about 17 years for hurricanes. When considering category 3 or stronger storms, the Tropical Prediction Center estimates the return period at between 70 years (north) and almost 200 years (south). Further studies at Sandy Hook and Whale Beach support those estimates as they approximate the return periods at about 80 and 300 years, at the respective locations.

In general, the strongest winds and storm surge are experienced northeast of the tropical cyclone center. Because of its geographic location and the typical storm tracks, the New Jersey coastline has not experienced a direct hurricane hit since 1903 when a category 1 storm moved onshore from the southeast. With the exception of the 1903 storm, every system to impact the area followed climatology in that the easterly components to their movement suggest recurvature and rapid storm movement.

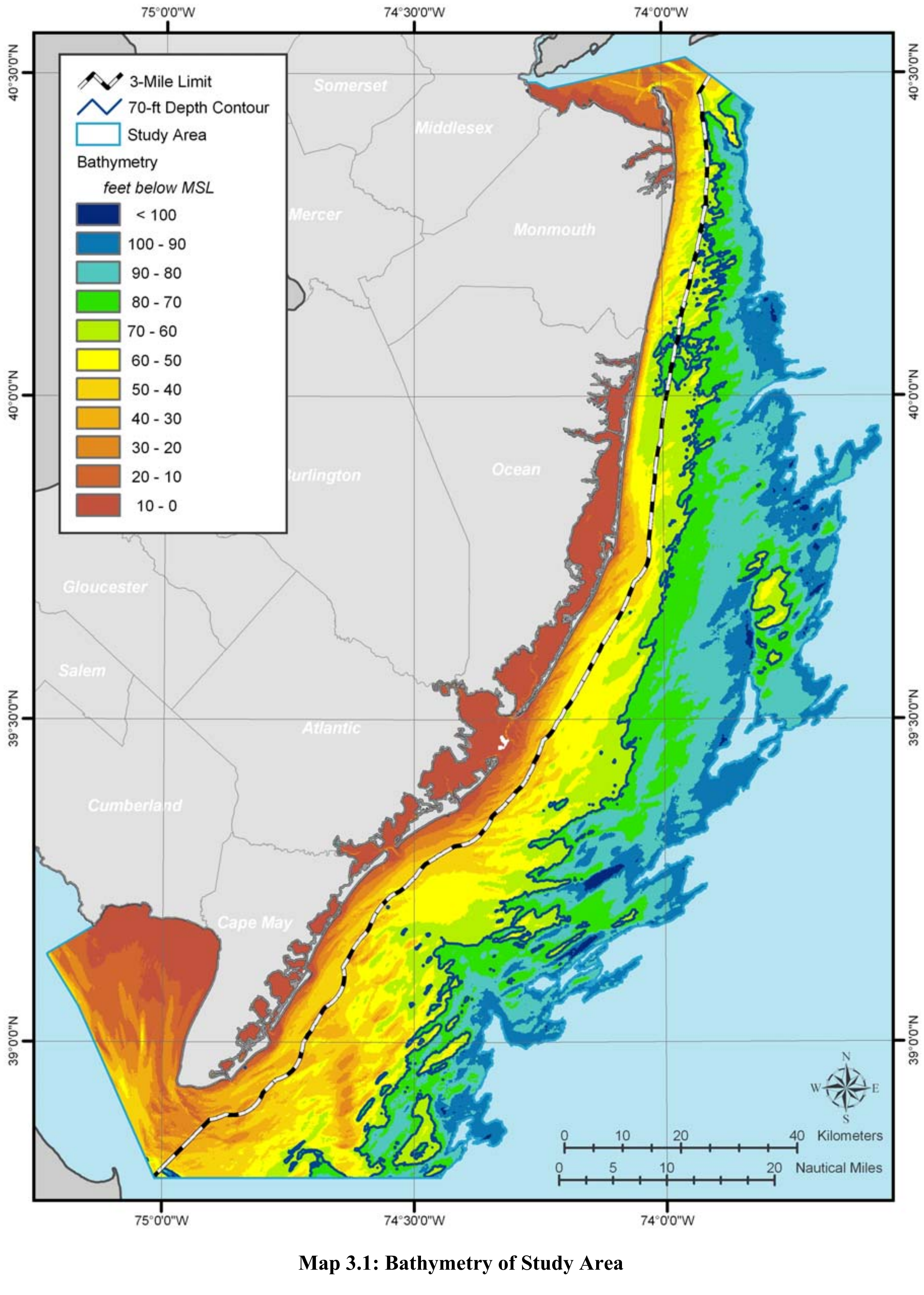
3.3.5.4. Notable Tropical Cyclones

Hurricane Gloria (category 2) in 1985 is the most recent storm to directly impact the study area. At Buoy 44009, the observed maximum sustained winds were 25 m/s with gusts to 33 m/s. Based on data collected from Long Island and Connecticut monitoring sites, a storm like Hurricane Gloria could affect a wind project in the study area with winds exceeding 35 m/s and gusting to 50 m/s. These conditions would be within the certified safety limits of offshore turbines. Plant design criteria would use the return period for the direct impact of a stronger storm for its extreme load cases.

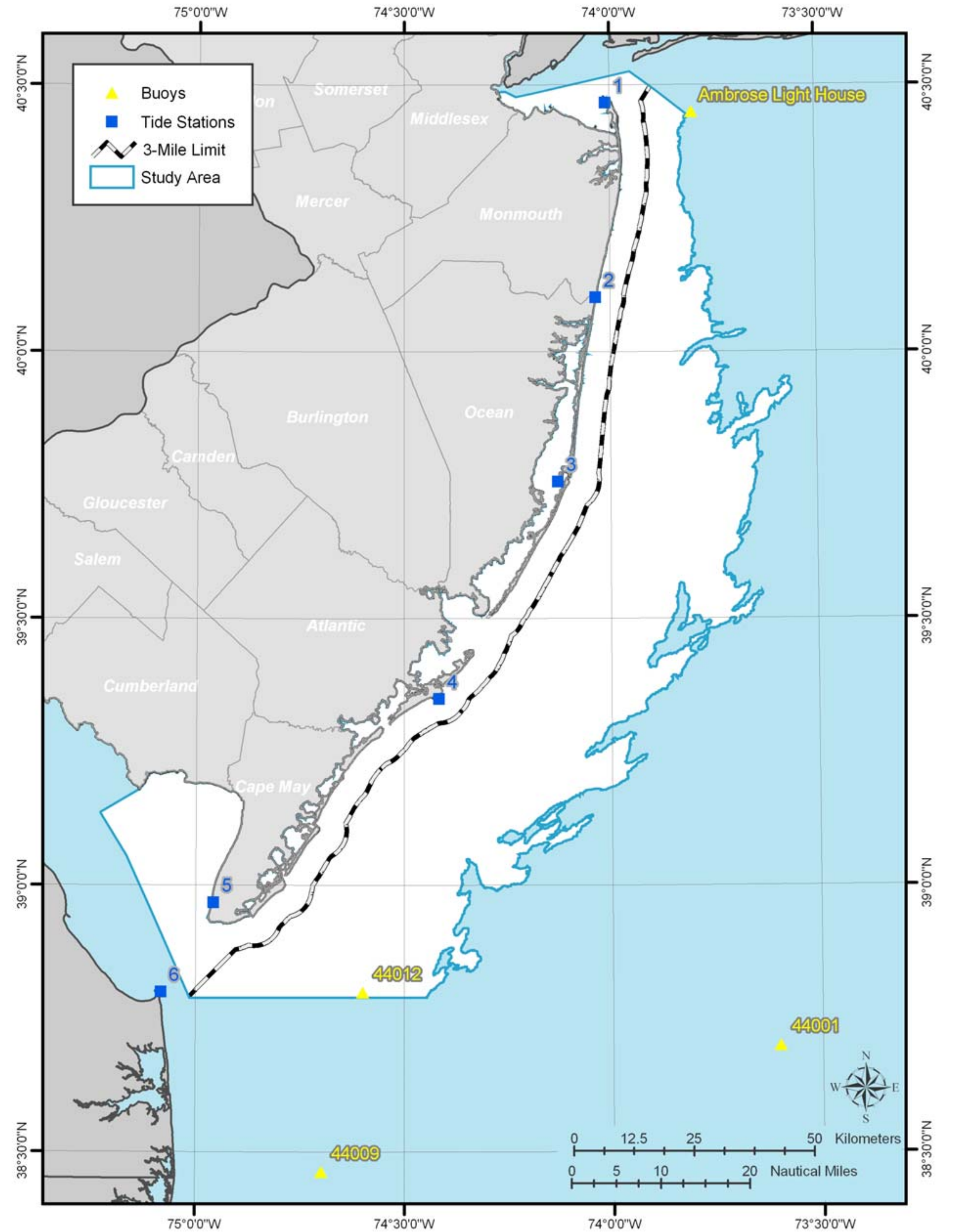
Since 1893, the centers of four other similar strength hurricanes have passed within 50 miles of Atlantic City. These storms occurred in 1976, 1960, 1944, and 1936. Category 2 hurricanes in 1954 and 1938 also passed close to the New Jersey coastline. Each of these storms made landfall along the Long Island coast, with the 1938 storm bringing winds gusting to near 60 m/s. While each storm tracked east of the study area, the potential exists for a storm of this magnitude to make a direct hit along the New Jersey coast.

The most extreme storm to impact the New Jersey coastline made direct landfall over Cape May in 1821. The storm is estimated to be a category four hurricane. A storm of this magnitude could produce onshore winds exceeding 55 m/s and gusting to 70 m/s accompanied by a 5 m storm surge. Prior to this intense hurricane, soil sediment evidence at Whale Beach suggests that similar strength storms made landfall between 1278 and 1428.

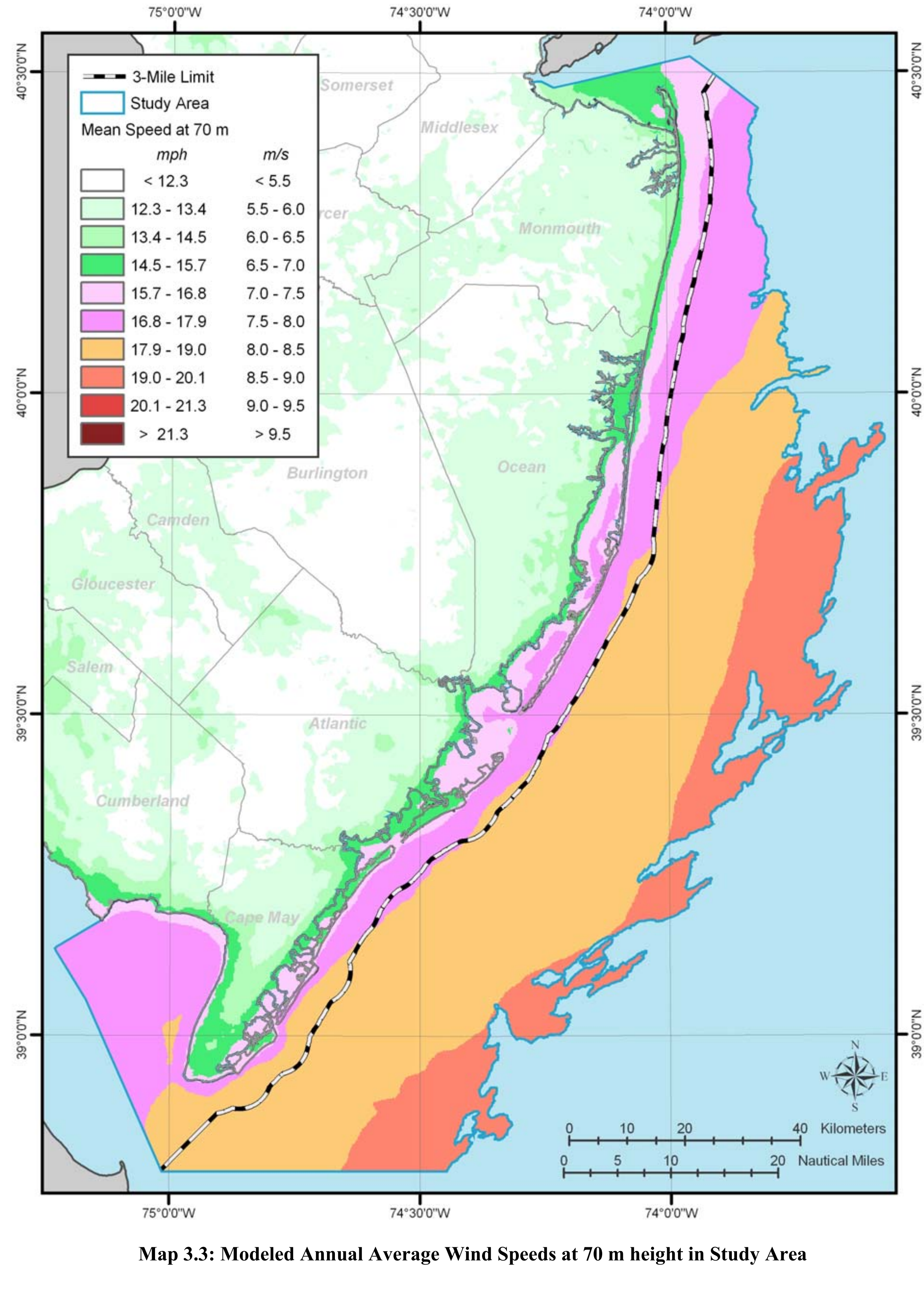
3.4. Maps



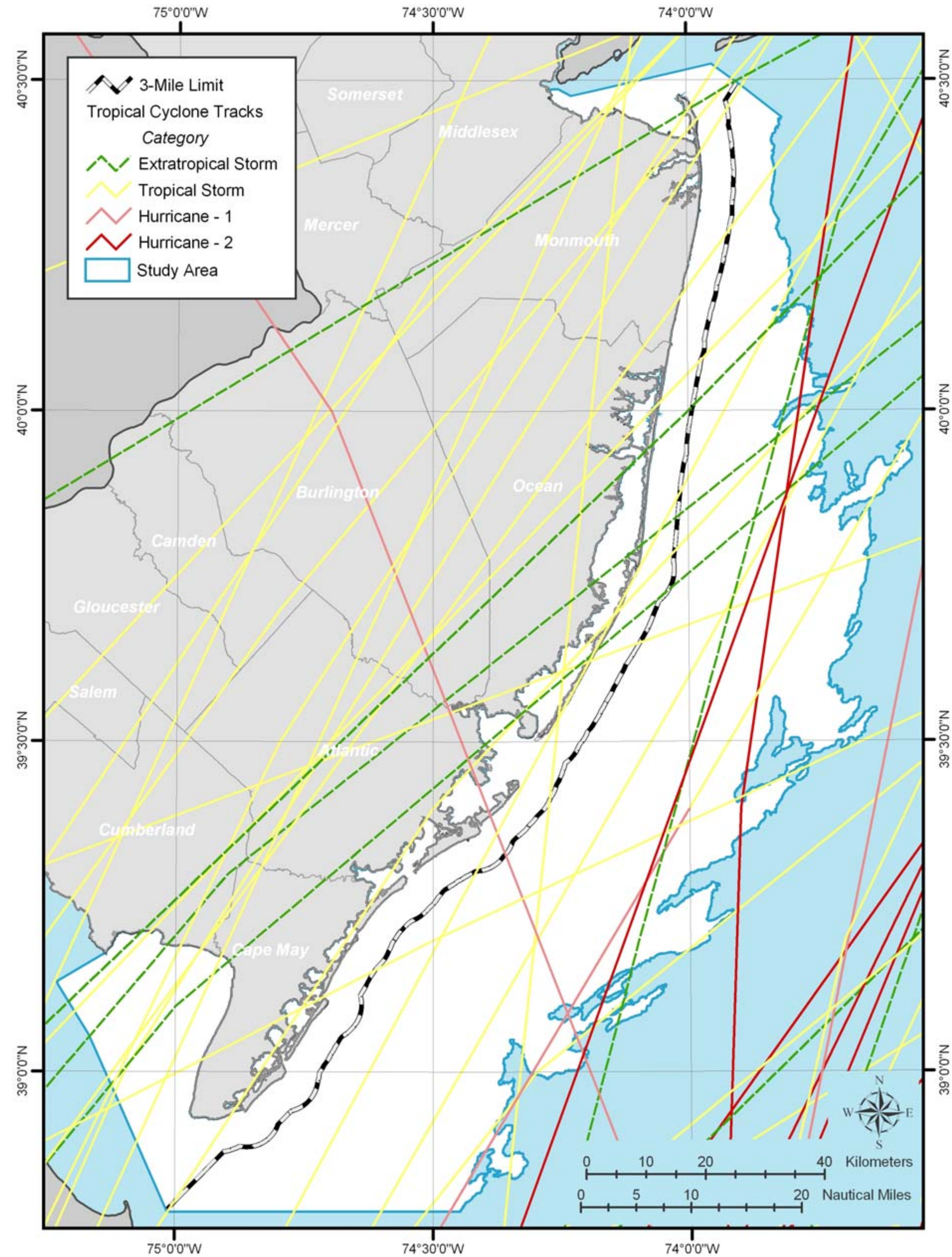
Map 3.1: Bathymetry of Study Area



Map 3.2: Reference Station and Buoy Locations



Map 3.3: Modeled Annual Average Wind Speeds at 70 m height in Study Area



Map 3.4: Map of Tropical Cyclones to Impact New Jersey Offshore Region Since 1851

3.5. References

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4.0. Natural Resources

This chapter presents an overview of the marine ecological resources in the waters along New Jersey's east coast and in the Sandy Hook and Delaware Bays. Some information presented herein is limited to NJ state waters although no effort to subjectively limit the information to state waters was made. Further studies would likely be required for a specific development to augment the existing body of knowledge where data deficiencies exist. This section is not an impact analysis such as would be found in an environmental impact statement (EIS); it is meant to be a reference document for guidance in the development of initial siting plans. An EIS for a specific project would explore the baseline and impact scenarios in much greater depth.

The Atlantic waters along the east coast of New Jersey and the large bays to the west of Sandy Hook, in the northern part of the state, and Cape May Point, at the southern end of the state, are rich in natural resources. The backbays, barrier beaches, and nearshore waters along the Atlantic coastline have been designated as significant habitat by the US Fish and Wildlife Service because significant populations of endangered, threatened, special concern, rare, and migratory species occur naturally in the region. The offshore portion of the zone of significant water habitat and significant water habitat complex extends from the shoreline to approximately ¼ mile offshore along the Atlantic coastline and increases to 6 miles offshore around Cape May Point. The significant water habitat complexes in New Jersey are pictured in dark blue on Map 4.1. Numerous species of fish and shellfish inhabit New Jersey waters, sea turtles and marine mammals migrate along the New Jersey coastline, and coastal birds have migratory routes over the state. These natural resources are discussed below.

4.1. Finfish

4.1.1. Federally Managed Species

The Atlantic waters of New Jersey support several commercially important finfish species. Essential Fish Habitat (EFH) has been designated for many of the federally managed species that are found in New Jersey waterways. EFH is defined in the Magnuson-Stevens Fishery Conservation and Management Act as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Species found in New Jersey waters that have EFH designations are listed in Table 4.1. The designations have been broken down into life stages: eggs, larvae, juveniles, and adults. Boxes marked indicate Essential Fish Habitat for life stages of each species.

Finfish found in New Jersey waters that are managed by the Mid-Atlantic Fishery Management Council (MAFMC) include: Atlantic mackerel, butterfish, bluefish, spiny dogfish, summer flounder, scup, black sea bass, tilefish, and monkfish. Table 4.2 provides habitat information for these species. Other finfish species found in the waters off New Jersey, which are managed by the New England Fishery Management Council (NEFMC), include: American plaice, Atlantic cod, Atlantic halibut, Atlantic herring, Atlantic salmon, haddock, ocean pout, offshore hake, pollock, red hake, redfish, white hake, whiting, windowpane flounder, winter flounder, witch flounder, and yellowtail flounder. Finfish found off the New Jersey coast, which are managed by the South Atlantic Fishery Management Council (SAFMC), include: cobia, king mackerel, red drum, and Spanish mackerel. Tables 4.3 and 4.4 provide habitat information for species managed by NEFMC and SAFMC. There are also numerous highly migratory species found off the coast of New Jersey including: albacore tuna, Atlantic angel shark, Atlantic bigeye tuna, Atlantic bluefin tuna, Atlantic sharpnose, Atlantic skipjack, Atlantic swordfish, Atlantic yellowfin tuna, basking shark, blue marlin, blue shark, dusky shark, longfin mako, porbeagle, sand tiger shark, sandbar shark, scalloped hammerhead, shortfin mako, silky shark, thresher shark, tiger shark, white marlin, and white shark. The habitat information for these species is provided in Table 4.5.

4.1.2. Federal and State Listed Species

There are two federally listed endangered species, the shortnose sturgeon and the Atlantic salmon, found off the coast of New Jersey. Both species are anadromous, meaning they spawn in rivers and spend their adult lives in the open ocean. Adult Atlantic salmon can be found offshore of New Jersey in their migration route to New England rivers to spawn. They represent the last wild population of Atlantic salmon and are from the Gulf of Maine stock. The shortnose sturgeon is found in nearshore estuaries and rivers, and a significant population of this fish is found in the tidal portion of the Delaware River, which empties into the Delaware Bay. It is also found in the Hudson River, which empties in the New York Bight, and the Maurice River and Dividing Creek.

Other species found in New Jersey waters that are candidate species for federal listing are the Atlantic sturgeon, dusky shark, night shark, barndoor skate, and sandtiger shark. The Atlantic sturgeon, also anadromous, has been reported in the Hudson River, Raritan River, and the Delaware River, although populations are declining in all. Larvae of both the dusky and sand tiger shark, juvenile dusky sharks, and adult sand tiger sharks have been reported along New Jersey’s coast. Major nursery grounds for dusky sharks are located along the coast from New Jersey to South Carolina, and juvenile sand tiger sharks are highly dependant on the Delaware Estuary. Both the night shark and barndoor skate are found in deeper waters. The barndoor skate summers offshore, but migrates inshore for the winter months. It is generally found between depths of 30 to 460 feet. The night shark is a deep water tropical species that is usually found in waters 500 to 1100 feet deep.

Two finfish species that are listed as threatened in New Jersey are the American shad and the Atlantic tomcod. The American shad is anadromous, and most spawning occurs in New York’s Hudson River and farther north. The Atlantic tomcod is found in brackish waters, and the only known population remaining in New Jersey is in Sandy Hook Bay (the bay located just west of Sandy Hook, nestled between the island and the mainland). Table 4.6 lists the endangered, threatened, and candidate fish and their habitats.

4.1.3. Finfish Surveys

The US Army Corps of Engineers – New York District has conducted several finfish surveys along the northern coast of New Jersey, from Asbury to Manasquan, as part of a beach erosion control project. A three-year baseline survey (1994 – 1996) of finfish in the surf zone showed silversides to be the numerically dominant species, comprising approximately 50% to 80% of beach seine hauls. Other notable species in the surf zone were bluefish, northern kingfish, and striped anchovy. Finfish in the surf zone were monitored during and after the dredging and beach nourishment process, and although the dominant species were the same, their abundances changed. There appeared to be a shift of dominant species from forage fish to predatory fish after the beach nourishment process. Bluefish dominated catches in 1997, followed by silversides. In 1998, bluefish were dominant in the surf zone adjacent to nourished beaches, while anchovies were dominant farther south along the coast, and silversides were second in dominance for both study areas.

Studies conducted between 1.5 to 5.5 miles offshore, in and around the sand borrow areas, showed herring as the numerically dominant fish collected by otter trawls during the pre-dredging period in the spring of 1995 and 1996. Other numerically dominant finfish collected during those years were hake, American sand lance, winter flounder, windowpane, spiny dogfish, striped bass, skates, butterfish, and scup. Numerically dominant finfish collected during the fall of those years were butterfish, anchovies, skates, searobins, summer flounder, mackerel, scad, weakfish, scup, windowpane, smallmouth flounder, and smooth dogfish. During the 1997 dredging process, dominance shifted to predatory species, skates and windowpane in the spring and butterfish and searobins in the fall. Dominance shifted back to blueback herring and anchovies in the spring of 1998 and butterfish and searobins again dominated in the fall of that year. It is important to note that even though the dominant species shifted over time, and in response to habitat flux, the species composition did return to pre-dredging constitution after the beach nourishment process was completed.

Finfish studies conducted farther south along the New Jersey coast indicate similar species compositions along the entire coast. Demersal trawls conducted near Little Egg Inlet, along the Beach Haven Ridge, at depths between 7 and 62 feet showed dominant species to be bay anchovy, red hake, silver hake, spotted hake, weakfish, and windowpane.

Bottom trawl surveys conducted in the Middle Atlantic Bight between the shoreline and approximately 300 feet of water in 2002 show similar species compositions to those found in the above-mentioned studies. Winter trawls were all conducted beyond the 100 ft isobath. Dominant species observed were spiny dogfish, winter skate, summer flounder, goosefish, and ocean pout. Spring surveys showed the dominant finfish beyond the 100 ft isobath to be spiny dogfish, little skate, and Atlantic mackerel. Dominant finfish collected from inside the 100 ft isobath were spiny dogfish, little skate, winter flounder, windowpane, Atlantic herring, and Atlantic mackerel. During the fall of that year, the dominant offshore species were spiny dogfish, winter flounder, butterfish, and bluefish. However, total finfish numbers were lower than earlier in the year. Those species collected in 100 feet of water or less were dominated by Atlantic croaker, weakfish, scup, and summer flounder. Atlantic croaker outnumbered the other species collected by an order of magnitude. This data set is an example of the migratory patterns of finfish in the Middle Atlantic Bight. It shows the entry of some species into the local waters from farther south and also shows the migration of finfish landward for the summer months (e.g. summer flounder).

Summer finfish populations in Sandy Hook Bay are dominated by winter flounder, striped searobin, windowpane, and northern searobin. Other commercially and recreationally important species found in the bay during the summer are red hake, bluefish, scup, weakfish, butterfish, and summer flounder. Species populations are larger and more diverse in the northern section of the bay (the portion closer to open waters of the New York Bight).

Finfish populations in the lower Delaware River, which connects to the Delaware Bay, are dominated by the American eel, Atlantic menhaden, crevalle jack, weakfish, spot, rough silverside, bluefish, and northern pipefish. Other abundant species in the lower portion of the river include: striped anchovy, carp, Atlantic silverside, Atlantic croaker, summer flounder, Spanish mackerel, Atlantic needlefish, and hogchoker. The Delaware River is tidally influenced, and the dominant species found in the lower portion of the river would most likely also be dominant species in the Delaware Bay.

4.1.4. Commercial Species

Many of the numerically dominant fish found in New Jersey's coastal waters are also major commercial species. Table 4.7 presents the major annual landings for the years 2000 to 2002 of species from New Jersey waters in pounds and dollars. Atlantic menhaden, Atlantic mackerel, goosefish, and summer flounder are the top four species landed by weight during those three years. These four species also yielded the highest price, with goosefish leading in value (over $18 million) for the three years. Summer flounder was the next most valuable finfish landed, yielding over $8 million between 2000 and 2002. Atlantic menhaden and Atlantic mackerel each yielded over $4 million during the three years. Table 4.8 summarizes the commercial landings of major commercial species caught at various distances offshore for 2002. Results from fishing vessel trip reports, which must be submitted by commercial fishermen to identify fishing grounds, indicate that the Atlantic menhaden catch occurred entirely within state waters (zero to three miles from shore). Atlantic mackerel and goosefish landings were entirely from federal waters (three to two hundred miles offshore) and the majority of summer flounder landings also came from federal waters, with a small catch from state waters.

4.2. Larval Fish

The majority of fish that spend a portion or all of their lives in the New Jersey waters of the Mid-Atlantic Bight either spawn offshore in the Middle or South Atlantic Bight or in nearshore estuaries and rivers, with the exception of eels, which spawn in the Sargasso Sea. Table 4.9 details the time of year that these fish spawn, where they spawn, their egg type, and adult habitat preferences. Many of the fish migrate between offshore waters and estuaries or rivers during their life cycle. A large number of species migrate from tropical and boreal waters to spawn in the Middle Atlantic Bight, and these seasonal migrations influence the species composition and dominant finfish and larvae.

Finfish spawning in the Middle Atlantic Bight reaches a peak in mid-to-late summer and is lowest during the winter. The most abundant larval species found in the Middle Atlantic Bight during the winter include: American sand lance, rock gunnel, and winter flounder. Spring larval assemblages are dominated by American sand lance, yellowtail flounder, and Atlantic mackerel.

Dominant larval species found in the summer include: fourbeard rockling, fourspot flounder, butterfish, cunner, and hake species. Spotted hake, Gulf Stream flounder, smallmouth flounder, and windowpane dominate larval species assemblages in the fall.

Larval fish collected in the surf zone off of northern New Jersey (Asbury to Manasquan) in the spring and summer months of 1994 – 1996 show populations to be dominated by silversides and anchovies. Other larval fish observed in the surf zone include black sea bass, windowpane, northern pipefish, goosefish, cunner, tautog, searobins, conger eel, Atlantic needlefish, northern puffer, weakfish, fourbeard rockling, hake, and winter flounder. Larval fish identified in surface waters farther offshore include: anchovies, silversides, Atlantic menhaden, and windowpane. Larval fish collected from the bottom of the water column offshore include: tautog, black sea bass, conger eel, windowpane, anchovies, cunner, butterfish, longhorn sculpin, fringed flounder, and summer flounder.

After fish spawn, their larvae are dependant on currents for dispersal. Some larvae may stay locally in an estuary, while others may travel down river or across the continental shelf. Some larvae may travel north from the South Atlantic Bight, where fish such as crevalle jack, grey snapper, striped mullet, white mullet, and bluefish spawn. Larvae may be carried northward in the Gulf Stream and be transported inshore in warm-core rings that break off the Gulf Stream and move landward. Many fish that spawn in the Middle Atlantic Bight, such as Atlantic herring, anchovies, hakes, searobins, weakfish, cunner, tautog, butterfish, black sea bass, windowpane, and flounders move inshore to develop and may be found in estuaries during part of their life cycle. Larvae of anadromous fish make their way down rivers towards the nurseries of bays and estuaries. Some anadromous fish that spend part of their lives in rivers and part in estuaries or ocean waters include: blueback herring, alewife, shad, white perch, striped bass, and sturgeon. The mummichog, killifishes, silversides, sticklebacks, and gobies spawn in estuaries and spend most of their lives in marshes and estuaries. They do not undergo the large migration that several of the other fish in the Middle Atlantic Bight do to spawn. However, they are important because they provide food for piscivorous fish, including many of the juvenile fish that migrated to estuaries to mature. They also provide a food source for shorebirds and diving ducks.

Backbays, estuaries, and marshes are important nurseries for larval and juvenile fish. Several New Jersey bays have been designated as EFH for many life stages of finfish species found in local waters. Bays designated as EFH include: Sandy Hook Bay, Raritan Bay, Barnegat Bay, Great Bay, Delaware Bay, and some inland bays. The Hudson River also has EFH designations. Table 4.10 lists the finfish species and the corresponding bays for which EFH designations have been assigned for particular life stages.

4.3. Invertebrates

Several commercially important megainvertebrates, such as Atlantic surfclam, ocean quahog, American lobster, Atlantic sea scallop, blue crab, short-finned squid, and long-finned squid, are also found in New Jersey waters. Species managed by the Mid-Atlantic Fishery Management Council include: long-finned squid, short-finned squid, Atlantic surfclam, and ocean quahog. The Atlantic sea scallop is managed by the New England Fishery Management Council. Landings data from the years 2000 to 2002 indicates the Atlantic surfclam to be the most valuable shellfish collected in New Jersey waters (Table 4.7). During those three years, over 164,000,000 pounds of meat was collected, yielding over $89 million. During those three years, sea scallop was the next most valuable catch (over $87 million), followed by ocean quahog (over $28 million), blue crab (over $15 million), quahog (over $12 million), long-finned squid (over $9 million), and American lobster (over $7 million).

The Atlantic surfclam is a species that is found in open ocean waters in the low intertidal and subtidal zone close to the coastline. They are generally not found in water deeper than 100 feet, but have been reported to depths of 480 feet. Commercial landings from Middle Atlantic States have historically shown a large percentage of Atlantic surfclam landings to be from New Jersey waters and historical stock assessments show the greatest abundance of Atlantic surfclams, between Montauk Point, NY and Cape Hatteras, NC, at water depths between 40 and 480 feet, to be between Barnegat and Cape May, NJ. More recently, the Mid-Atlantic Fishery Management Council (1998) determined that 80% of the total Atlantic surfclam catch in the United States comes from northern New Jersey waters. Figure 4.1 illustrates Atlantic surfclam and other shellfish abundances in 2002.

A 2002 survey conducted by the National Marine Fisheries Service (NMFS) in the continental shelf waters of the Middle Atlantic Bight indicates the presence of Atlantic surfclams to be concentrated in nearshore waters (see Figure 4.1). The densest nearshore populations are between Hereford and Townsend's Inlets (near Cape May Peninsula), between Little Egg and Absecon Inlets (off Brigantine Island), and near Shark River Inlet. Other surveys have found similar results. The Atlantic surfclam was one of the dominant benthic invertebrates in waters between Asbury and Manasquan, northern New Jersey. They were found in samples collected in water 16 to 21 ft deep (approximately the edge of groin fields) and in samples taken 1.5 to 5.5 miles offshore. Samples collected in less than 100 ft of water from the central portion of New Jersey also indicate the Atlantic surfclam to be one of the dominant benthic species. It has also been cited as a dominant species offshore of Cape May Meadows and Great Egg Harbor.

Landings data for 2002 (Table 4.8) show that over 20,000,000 pounds of Atlantic surfclam meat were collected in state waters (between the shoreline and 3 miles offshore) and over 32,000,000 pounds of meat were landed from federal waters (3 to 200 miles offshore). EFH has been designated for juvenile and adult Atlantic surfclams in New Jersey's coastal waters (Table 4.1). Table 4.2 shows the EFH information and habitat preferences of this species.

The sea scallop and ocean quahog are also oceanic species, but are generally found farther offshore than Atlantic surfclams. The sea scallop is found to water depths of 600 feet, and the ocean quahog is generally found in waters of 30 to 800 feet. Recent population surveys of both sea scallops and ocean quahogs show their populations to be concentrated farther offshore than the Atlantic surfclam (see Figure 4.1). Commercial landing data from 2002 (Table 4.8) show that all landings for sea scallop and ocean quahog were taken from federal waters. There are EFH designations for adult ocean quahogs in New Jersey waters (Tables 4.1 & 4.2).

Long-finned squid and short-finned squid both migrate seasonally, moving inshore during the summer and offshore during the winter months. Trawl surveys from 2002 show the long-finned squid to be extremely abundant in New Jersey offshore waters during winter months. Offshore populations were lower during the spring, and some individuals were collected in water less that 100 ft deep. Populations were observed in water less that 100 ft deep and farther offshore in the fall, however, long-finned squid was more abundant offshore than nearshore. All commercial landings in 2002 were taken from federal waters (Table 4.8). EFH has been designated for juveniles in New Jersey waters.

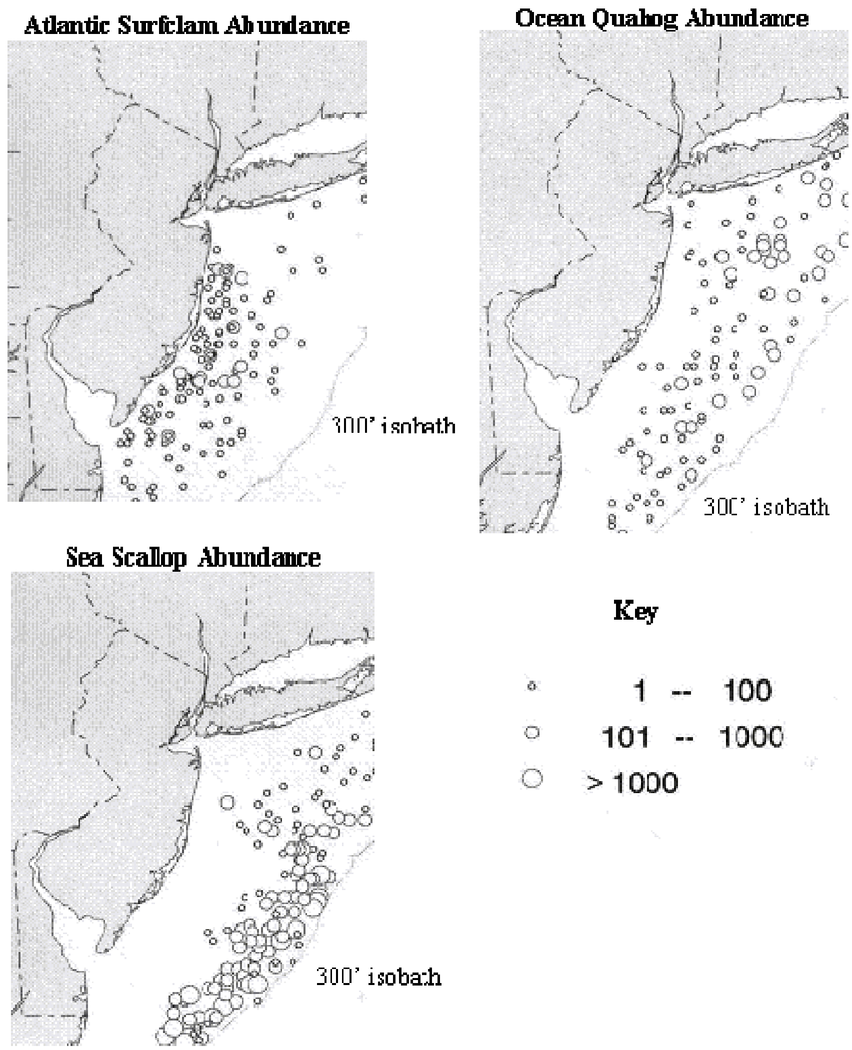


Figure 4.1: Shellfish Abundances in 2002

The valuable crustaceans, blue crab and American lobster, yielded over $15 million and $7 million, respectively, in 2000 – 2002 (Table 4.7). The majority of American lobster landings were taken beyond the state line in 2002 (Table 4.8) and the largest lobsters were reported to be at the edge of the continental shelf. Interestingly, very few American lobster were observed offshore and in state waters during a fishery trawl survey in 2002. The lobster catches were probably incidental, as lobsters tend to congregate near submerged structures such as rock piles and artificial reefs and trawl surveys are taken over open sandy bottoms. Blue crabs range from estuaries to offshore waters of 120 ft deep. They winter in deep water, but are abundant in shallow inshore water during the summer. All blue crabs commercially taken in 2002 were from state waters (Table 4.8), and most crabbing is conducted in backbays and estuaries.

4.4. Herpetiles

Sea turtles have migratory patterns that include the New Jersey coastline. Sea turtles are found in Northeast Atlantic waters during the warmer months of the year. It is estimated that their presence in New York-New Jersey Harbor Complex extends from May 1 to October 31. During the warmer months, sea turtles, mostly juveniles, are generally found in coastal embayments foraging in water depths of 16 to 49 feet. When the water becomes cooler in the fall, turtles move offshore and migrate south along the continental shelf. Turtles that may be found in New Jersey's coastal waters include: Atlantic leatherback, Kemp's Ridley, Atlantic hawksbill, Atlantic loggerhead, Atlantic green, and northern diamondback terrapin. The Atlantic leatherback, Kemp's Ridley, and Atlantic hawksbill turtles are state and federally endangered, the Atlantic loggerhead turtle is state endangered and federally threatened, the Atlantic green turtle is state and federally threatened, and the northern diamondback terrapin is a species of special concern in the state. The preferred habitat of these sea turtles is shallow, sheltered areas along the coastline and in estuaries. The hawksbill turtle prefers vegetated areas in water less than 50 ft and the Atlantic leatherback turtle is a more open ocean species. Critical habitat for nesting leatherback, hawksbill, and green turtles has been designated around Puerto Rico and the US Virgin Islands. The Atlantic loggerhead turtle has been reported to nest on beaches as far north as New Jersey, with a specific nest cited in Island Beach State Park (just north of Barnegat Inlet). One loggerhead turtle stranded on New Jersey beaches between January and February of 2001, however, it did not strand alive. Table 4.11 lists the sea turtles' status, range, and habitat.

4.5. Marine Mammals

All marine mammals are federally endangered. Several marine mammals have migratory routes in the waters along New Jersey. Species that have been observed in waters off New Jersey are presented in Table 4.12, along with their range and distance from shore. The cetaceans that are found closest to the coast are the bottlenose dolphin, harbor porpoise, and North Atlantic right whale. The harbor porpoise and the coastal stock of the bottlenose dolphin are found from the shoreline to the 650 ft isobath (harbor porpoise) or 80 ft isobath (bottlenose dolphin). During a fall migration, tagged harbor porpoises were observed by satellite migrating farther offshore, along the 300 ft isobath. Large populations of the harbor porpoise, however, congregate off New Jersey from October through June. The bottlenose dolphin resides in New Jersey's waters during the summer. The North Atlantic right whale, the most endangered of the large whales, can be found from coastal waters to the continental shelf, and generally migrates within 20 miles of the shore. These whales are generally found in New Jersey's waters in the spring and fall. Pinnipeds that are found in nearshore New Jersey waters are the harbor seal and the harp seal. These marine mammals are generally seen during the winter months. Sightings of both these species are increasing in New Jersey waters. Stranding records help to determine which mammals are migrating along the New Jersey coast. In January and February of 2001, eight harbor seals, fourteen harp seals, and three hooded seals stranded on New Jersey beaches, most of which stranded live. By the end of 2001, 45 harp seals had stranded in New Jersey. Three harbor porpoises, one common dolphin, and one finback whale stranded during the winter months, but most of the animals were not alive.

4.6. Birds

Existing avian studies represent a diverse array of habitats and geographic locations, such that robust generalizations about risk to birds posed by wind power developments can be made for terrestrial habitats. However, fewer generalizations can be made for offshore or marine habitats and for those made the degree of uncertainty is much greater than in terrestrial situations.

Many species of birds are found within the study area. A detailed review of the avian resource can be found in Annex at the end of this report. A chapter summary of this annex is provided below:

Chapter 1. Introduction – A summary of the issues is given surrounding wind power development and risk to birds. This chapter identifies sources of information used for the review, agencies and environmental organizations contacted for information, and the type of hardware/equipment that is used or being proposed for offshore wind power projects.

Chapter 2. Avian Legal and Ecological Issues – A brief overview is given of legal issues regarding bird protection that must be considered during the development process. These include the Endangered Species Act, the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act, the National Environmental Policy Act, and the Coastal Areas Facility Review Act. In addition, a summary of the ecological issues, direct collision fatality and indirect impacts to habitat via disturbance and displacement/avoidance are reviewed.

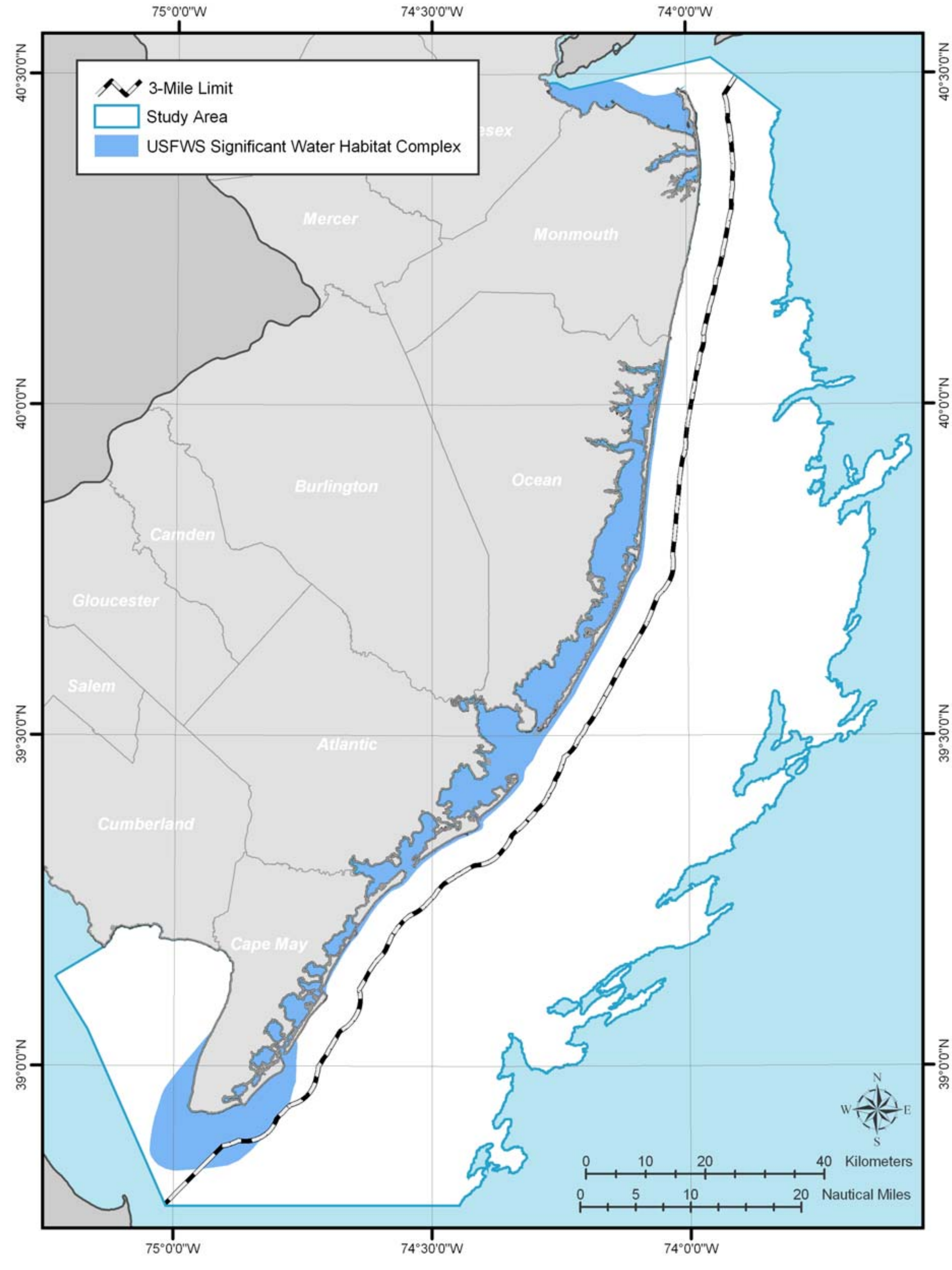
Chapter 3. Review of Avian Risk at Wind Plants in North America and Europe – A detailed literature review of quantitative studies of avian impacts due to wind power projects is presented. The studies include numbers of fatalities, species impacted, the degree of habitat impacts as they relate to disturbance and displacement of birds, as well as the significance of those impacts.

Chapter 4. Birds of the New Jersey Offshore Wind Power Study Area – The literature regarding avian presence, abundance, seasonal presence, distribution, and behavior while in New Jersey waters is summarized. Areas with large concentrations of birds are identified along with information regarding their behavior there. A separate section addresses issues relating to foraging, migrating, staging, wintering, roosting, and listed (endangered and threatened) species present in New Jersey waters.

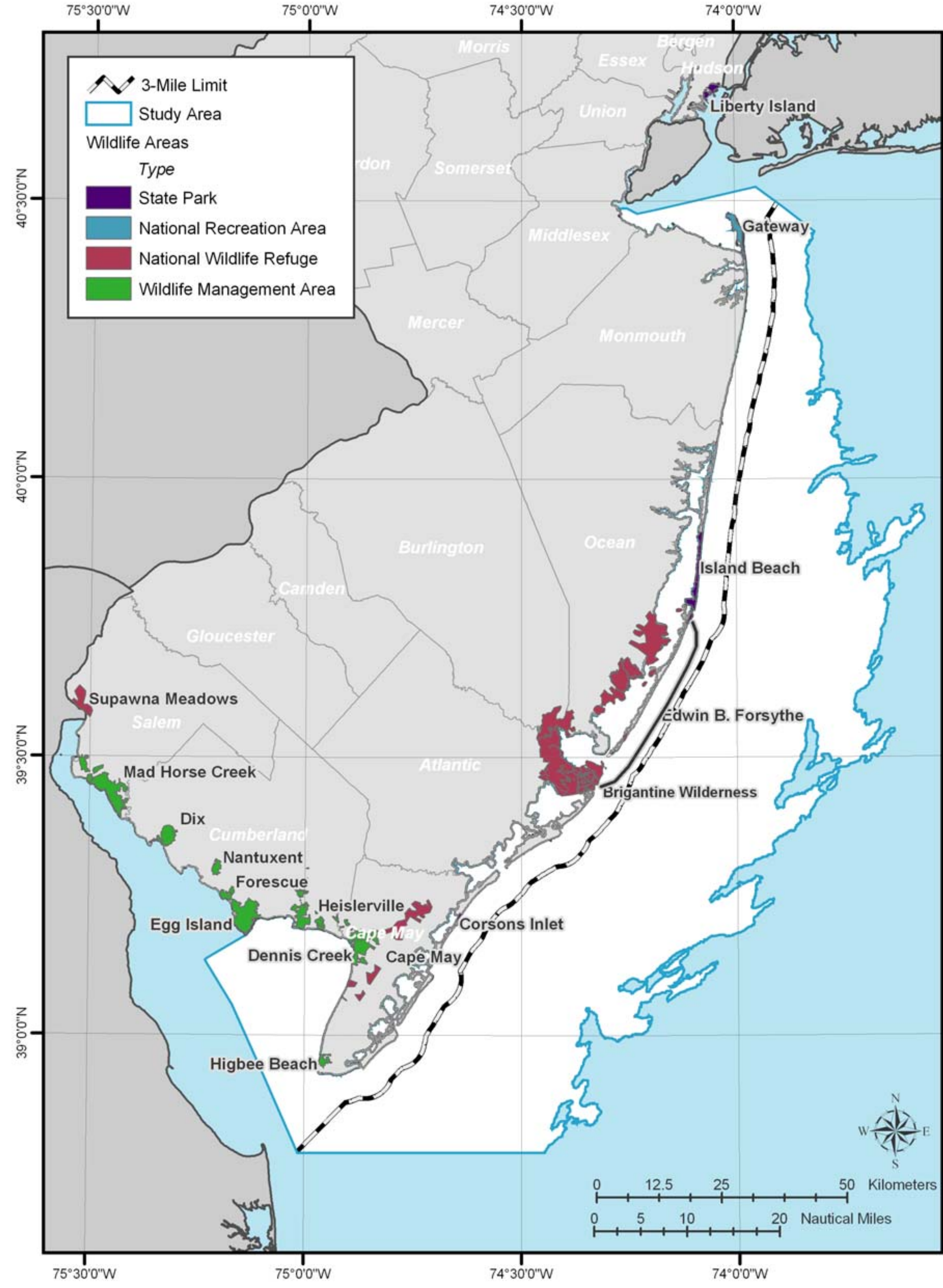
Chapter 5. Prevention and Mitigation of Risk in Wind Plants – A summary of what is known about prevention of risk at wind plants is provided along with a discussion of potential mitigation of impacts.

Chapter 6. Information Gaps, Research Needs, and Potential Research Methodologies – Based on what was presented in Chapter 4, gaps in our knowledge of avian abundance and behavior are discussed along with specific research needs and the methodologies needed to fill in the gaps.

4.7. Maps



Map 4.1: Significant Water Habitat along the New Jersey Coast



Map 4.2: Wildlife Refuges and State Parks

4.8. Tables

Table 4.1: EFH Designations for Life Stages of Federally Managed Species - Species Found in New Jersey Coastal Waters

Species	Life Stage			
	Eggs	Larvae	Juveniles	Adults
Finfish				
Species Under New England Council Management				
Atlantic Cod				X
Atlantic Herring		X	X	X
Ocean Pout	X	X		X
Red Hake	X	X	X	X
Whiting	X	X	X	X
Windowpane Flounder	X	X	X	X
Winter Flounder	X	X	X	X
Witch Flounder	X	X		
Yellowtail Flounder	X	X		
Species Under Mid-Atlantic Council Management				
Atlantic Butterfish		X	X	X
Atlantic Mackerel			X	X
Black Sea Bass			X	X
Bluefish	X	X	X	X
Monkfish	X	X		X
Scup	X	X	X	X
Spiny Dogfish			X	X
Summer Flounder	X	X	X	X
Species Under South Atlantic Council Management				
Cobia	X	X	X	X
King Mackerel	X	X	X	X
Spanish Mackerel	X	X	X	X
Highly Migratory Species				
Atlantic Angel Shark		X	X	X
Atlantic Sharpnose Shark				X
Blue Shark		X	X	X
Bluefin Tuna			X	X
Dusky Shark		X	X	
Sand Tiger Shark		X		X
Sandbar Shark		X	X	X
Scalloped Hammerhead Shark			X	
Shortfin Mako		X	X	X
Skipjack Tuna				X
Swordfish			X	
Tiger Shark		X	X	
White Shark			X	
Invertebrates - Under Mid-Atlantic Council Management				
Atlantic Surf Clam			X	X
Long-Finned Squid			X	
Ocean Quahog				X

Source: National Marine Fisheries Service Web Page.
http://www.nero.noaa.gov/ro/doc/index2a.htm

Table 4.2: Essential Fish Habitat Information for Species Managed by the Mid-Atlantic Fishery Management Council

Species	Life Stage	EFH Geographic Extent	Habitat	Notes
Finfish				
Summer Flounder	Eggs	Coast - 200 miles offshore	Pelagic waters Seagrass beds	Most within 9 miles of shore 9 - 110 isobath
	Larvae	Coast - 200 miles offshore	Pelagic waters Seagrass beds	12 - 50 mi. offshore, 10 - 70 m isobath Temperature 9 - 10 C, Salinity 23 - 33 ppt
	Juveniles	Coast - 200 miles offshore	Demersal waters Estuaries, bays, seagrass beds	0.5 - 5 m isobath Temperature > 11 C, Salinity 10 - 30 ppt
	Adults	Coast - 200 miles offshore	Demersal waters Coast to the Continental Shelf	Summer - coastal waters Winter - offshore to 500 ft.
Scup	Eggs	None designated offshore	Pelagic waters	< 30 m isobath Temperature 13 - 23 C, Salinity > 15 ppt
	Larvae	None designated offshore	Pelagic waters Near shore	< 20 m isobath Temperature 13 - 23 C, Salinity > 15 ppt
	Juveniles	Coast - 200 miles offshore	Demersal waters Sand / mud bottom, shell / eelgrass beds	0 - 38 m isobath Temperature > 7 C, Salinity > 15 ppt
	Adults	Coast - 200 miles offshore	Demersal waters Sand / mud bottom, shell / eelgrass beds	Adults winter offshore, 2 185 m isobath Temperature > 7 C, Salinity > 15 ppt
Black Sea Bass	Eggs	None designated offshore	Pelagic waters	0 - 200 m isobath
	Larvae	Coast - 200 miles offshore	Pelagic waters Coasts / estuaries / sponge beds	< 100 m isobath Temperature 11 - 26 C, Salinity 30 - 35 ppt
	Juveniles	Coast - 200 miles offshore	Demersal waters Rough bottom / shell beds / artificial reefs	Winter offshore, 1 - 38 m isobath Temperatures > 6 C, Salinity > 18 ppt
	Adults	Coast - 200 miles offshore	Demersal waters Artificial reefs / sand / shell bottom	Winter offshore, 20 - 50 m isobath Temperatures > 6 C, Salinity > 20 ppt
Bluefish	Eggs	Coast - 200 miles offshore	Pelagic waters Mid-Continental shelf	Mid-shelf depths Temperature > 18 C, Salinity > 31 ppt
	Larvae	Coast - 200 miles offshore	Pelagic waters Mid-Continental shelf	> 15 m isobath Temperature > 18 C, Salinity > 30 ppt
	Juveniles	Coast - 200 miles offshore	Pelagic waters Mid-Continental shelf to estuaries	Temperature 19 - 24 C, Salinity 23 - 36 ppt
	Adults	Coast - 200 miles offshore	Pelagic waters Mid-Continental shelf to estuaries	Highly migratory Temperature 14 - 16 C,Salinities > 25 ppt

Table 4.2 Continued
Essential Fish Habitat Information for Species Managed by the Mid-Atlantic Fishery Management Council

Species	Life Stage	EFH Geographic Extent	Habitat	Notes
Atlantic Mackerel	Eggs	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	0 - 15 m isobath Temperature 5 - 23 C, Salinity 18 - > 30 ppt
	Larvae	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	10 - 130 m isobath Temperature 6 - 22 C, Salinity > 30 ppt
	Juveniles	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	0 - 320 m isobath isobath Temperature 4 - 22 C, Salinity > 25 ppt
	Adults	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	0 - 360 m isobath isobath Temperature 4 - 16 C, Salinity > 25 ppt
Butterfish	Eggs	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	0 - 1829 m isobath Temperature 11 - 17 C, Salinity 25 - 33 ppt
	Larvae	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	10 - 1829 m isobath Temperature - 19 C C, Salinity 604 - 37 ppt
	Juveniles	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	10 - 365 m isobath Temperature 3 - 28 C, Salinity 3 - 37 ppt
	Adults	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	10 - 365 m isobath Temperature 3 - 28 C, Salinity 4 - 26 ppt
Spiny Dogfish	Juveniles	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	10 - 390 m isobath Temperature 3 - 28 C
	Adults	Coast - 200 miles offshore	Pelagic waters Continental shelf to estuaries	10 - 450 m isobath Temperature 3 - 28 C, Salinity 30 - 32 ppt
Invertebrates				
Atlantic Surfclam	Juveniles	Coast - 200 miles offshore	Throughout substrate to depth of 3 ft. below sediment / water interface	0 - 60 m isobath, Temperature 2 - 30 C Fewer in water deeper than 38 m
	Adults	Coast - 200 miles offshore	Throughout substrate to depth of 3 ft. below sediment / water interface	0 - 60 m isobath, Temperature 2 - 30 C Fewer in water deeper than 38 m
Ocean Quahog	Juveniles	Coast - 200 miles offshore	Throughout substrate to depth of 3 ft. below sediment / water interface	8 - 245 m isobath Temperature < 18 C, salinity > 25 ppt
	Adults	Coast - 200 miles offshore	Throughout substrate to depth of 3 ft. below sediment / water interface	8 - 245 m isobath Temperature < 18 C, salinity > 25 ppt
Long-Finned Squid	Pre-Recruits	Coast - 200 miles offshore	Pelagic waters Continental shelf to shore	0 - 213 m isobath Temperature 4 - 27 C, Salinity 31 - 34 ppt
	Recruits	Coast - 200 miles offshore	Pelagic waters Continental shelf to shore	0 - 305 m isobath Temperature 4 - 28 C
Short-Finned Squid	Pre-Recruits	Coast - 200 miles offshore	Pelagic waters Continental shelf to shore	0 - 182 m isobath Temperature 2 - 23 C
	Recruits	Coast - 200 miles offshore	Pelagic waters Continental shelf to shore	0 - 182 m isobath Temperature 4 - 19 C

Sources: Summary of Essential Fish Habitat Description and Identification for Mid-Atlantic Fishery Management Council Managed Species:
Summer Flounder, Scup, Black Sea Bass, Bluefish, Atlantic Surfclam, Ocean Quahog, Atlantic Mackerel, *Loligo, Illex*, Butterfish, and Dogfish.
Summary of Essential Fish Habitat (EFH) and General Habitat Parameters for Federally Managed Species.

Table 4.3: Essential Fish Habitat Information for Species Managed by the New England Fishery Management Council

Species	Life Stage	EFH Geographic Extent	Habitat	Notes
Atlantic Cod	Eggs	Coast - 200 miles offshore	Surface Waters	< 110 m isobath Temperatures < 12 C, Salinity 10 - 35 ppt
	Larvae	Coast - 200 miles offshore	Pelagic waters	30 - 70 m isobath Temperatures < 10 C, Salinity 32 - 33 ppt
	Juveniles	Coast - 200 miles offshore	Bottom Habitats Cobble / gravel substrate	25 - 75 m isobath Temperatures < 20 C, Salinity 30 - 35 ppt
	Adults	Coast - 200 miles offshore	Bottom Habitats Cobble / gravel substrate	10 - 150 m isobath Temperatures < 10 C, Salinity 29 - 34 ppt
	Spawning Adults	Coast - 200 miles offshore	Bottom Habitats Cobble / gravel substrate	10 - 150 m isobath Temperatures < 10 C, Salinity 10 - 35 ppt
Atlantic Herring	Eggs	Coast - 200 miles offshore	Bottom Habitats Cobble / gravel substrate	20 - 80 m isobath Temperatures < 15 C, Salinity 32 - 33 ppt
	Larvae	Coast - 200 miles offshore	Pelagic waters	50 - 90 m isobath Temperatures < 16 C, Salinity 32 ppt
	Juveniles	Coast - 200 miles offshore	Pelagic waters Bottom Habitats	15 - 135 m isobath Temperatures < 10 C, Salinity 26 - 32 ppt
	Adults	Coast - 200 miles offshore	Pelagic waters Bottom Habitats	20 - 130 m isobath Temperatures < 10 C, Salinity > 28 ppt
	Spawning Adults	Coast - 200 miles offshore	Bottom Habitats Cobble / gravel substrate	20 - 80 m isobath Temperatures < 15 C, Salinity 32 - 33 ppt
Ocean Pout	Eggs	Coast - 200 miles offshore	Bottom Habitats Hard substrates / crevices	< 50 m isobath Temperatures < 10 C, Salinity 32 - 34 ppt
	Larvae	Coast - 200 miles offshore	Bottom Habitats Hard substrates / crevices	< 50 m isobath Temperatures < 10 C, Salinity > 25 ppt
	Juveniles	Coast - 200 miles offshore	Bottom Habitats Smooth bottom / algae	< 80 m isobath Temperatures < 14 C, Salinity > 25 ppt
	Adults	Coast - 200 miles offshore	Bottom Habitats Sediment depressions	< 110 m isobath Temperatures < 15 C, Salinity 32 - 34 ppt
	Spawning Adults	Coast - 200 miles offshore	Bottom Habitats Hard substrates / crevices	< 50 m isobath Temperatures < 10 C, Salinity 32 - 34 ppt

Table 4.3 Continued: Essential Fish Habitat Information for Species Managed by the New England Fishery Management Council

Species	Life Stage	EFH Geographic Extent	Habitat	Notes
Red Hake	Eggs	Coast - 200 miles offshore	Surface waters Inner Continental Shelf	Surface waters Temperatures < 10 C, Salinity < 25 ppt
	Larvae	Coast - 200 miles offshore	Surface waters	< 200 m isobath Temperatures < 19 C, Salinity > 0.5 ppt
	Juveniles	Coast - 200 miles offshore	Bottom Habitats Shell fragments	< 100 m isobath Temperatures < 16 C, Salinity 31 - 33 ppt
	Adults	Coast - 200 miles offshore	Bottom Habitats Sediment depressions	10 - 130 m isobath Temperatures < 12 C, Salinity 33 - 34 ppt
	Spawning Adults	Coast - 200 miles offshore	Bottom Habitats Sediment depressions	< 100 m isobath Temperatures < 10 C, Salinity > 25 ppt
Whiting	Eggs	Coast - 200 miles offshore	Surface waters	50 - 150 m isobath Temperatures < 20 C
	Larvae	Coast - 200 miles offshore	Surface waters	50 - 130 m isobath Temperatures < 20 C
	Juveniles	Coast - 200 miles offshore	Bottom habitats All substrate types	20 - 270 m isobath Temperatures < 21 C, Salinity > 20 ppt
	Adults	Coast - 200 miles offshore	Bottom habitats All substrate types	30 - 325 m isobath Temperatures < 22 C
	Spawning Adults	Coast - 200 miles offshore	Bottom habitats All substrate types	30 - 325 m isobath Temperatures < 13 C
Windowpane	Eggs	Coast - 200 miles offshore	Surface waters	< 70 m isobath Temperatures < 20 C
	Larvae	Coast - 200 miles offshore	Pelagic waters	< 70 m isobath Temperatures < 20 C
	Juveniles	Coast - 200 miles offshore	Bottom Habitats Fine grained substrate	1 - 100 m isobath Temperatures < 25 C, Salinity 5.5 - 36 ppt
	Adults	Coast - 200 miles offshore	Bottom Habitats Fine grained substrate	1 - 75 m isobath Temperatures < 26.8 C, Salinity 5.5 - 36 ppt
	Spawning Adults	Coast - 200 miles offshore	Bottom Habitats Fine grained substrate	1 - 75 m isobath Temperatures < 21 C, Salinity 5.5 - 36 ppt

Table 4.3 Continued: Essential Fish Habitat Information for Species Managed by the New England Fishery Management Council

Species	Life Stage	EFH Geographic Extent	Habitat	Notes
Winter Flounder	Eggs	Coast - 200 miles offshore	Bottom habitats Sand / gravel substrate	< 5 m isobath Temperatures < 10 C, Salinity 10 - 30 ppt
	Larvae	Coast - 200 miles offshore	Pelagic waters Bottom waters	< 6 m isobath Temperatures < 15 C, Salinity 4 - 30 ppt
	Juveniles	Coast - 200 miles offshore	Bottom habitats Fine grained substrate	1 - 50 m isobath Temperatures < 25 C, Salinity 10 - 30 ppt
	Adults	Coast - 200 miles offshore	Bottom habitats Mud / sand / gravel	1 - 100 m isobath Temperatures < 25 C, Salinity 15 - 33 ppt
	Spawning Adults	Coast - 200 miles offshore	Bottom habitats Mud / sand / gravel	< 6 m isobath Temperatures < 15 C, Salinity 5.5 - 36 ppt
Witch Flounder	Eggs	Coast - 200 miles offshore	Surface waters	Deep Temperatures < 13 C, Salinity Hight
	Larvae	Coast - 200 miles offshore	Surface waters to 250 m	Deep Temperatures < 13 C, Salinity Hight
	Juveniles	Coast - 200 miles offshore	Bottom habitats Fine grained substrate	50 - 1500 m isobath Temperatures < 13 C, Salinity 34 - 36 ppt
	Adults	Coast - 200 miles offshore	Bottom habitats Fine grained substrate	20 - 300 m isobath Temperatures < 13 C, Salinity 32 - 36 ppt
	Spawning Adults	Coast - 200 miles offshore	Bottom habitats Fine grained substrate	25 - 360 m isobath Temperatures < 15 C, Salinity 32 - 36 ppt
Yellowtail Flounder	Eggs	Coast - 200 miles offshore	Surface waters	30 - 90 m isobath Temperatures < 15 C, Salinity 32.4 - 33.5 ppt
	Larvae	Coast - 200 miles offshore	Surface waters	10 - 90 m isobath Temperatures < 17 C, Salinity 32.4 - 33.5 ppt
	Juveniles	Coast - 200 miles offshore	Bottom habitats Sand / mud substrate	20 - 50 m isobath Temperatures < 15 C, Salinity 32.4 - 33.5 ppt
	Adults	Coast - 200 miles offshore	Bottom habitats Sand / mud substrate	20 - 50 m isobath Temperatures < 15 C, Salinity 32.4 - 33.5 ppt
	Spawning Adults	Coast - 200 miles offshore	Bottom habitats Sand / mud substrate	10 - 125 m isobath Temperatures < 17 C, Salinity 32.4 - 33.5 ppt

Source: Summary of Essential Fish Habitat (EFH) and General Habitat Parameters for Federally Managed Species.

Table 4.4: Essential Fish Habitat Information for Species Managed by the South Atlantic Fishery Management Council

Species	Life Stage	EFH Geographic Extent	Habitat	Notes
Cobia	All	Coast - 200 miles offshore	Sandy shoals Rock bottoms Seagrass	EFH decignated for all coastal inlets
King Mackerel	All	Coast - 200 miles offshore	Sandy shoals Rock bottoms	EFH decignated for all coastal inlets
Spanish Mackerel	All	Coast - 200 miles offshore	Sandy shoals Rock bottoms	EFH decignated for all coastal inlets

Source: Summary of Essential Fish Habitat (EFH) and General Habitat Parameters for Federally Managed Species.

Table 4.5: Essential Fish Habitat Information for Highly Migratory Species

Species	Life Stage	EFH Geographic Extent	Habitat	Notes
Atlantic Angel Shark	Neonate / Early Juveniles	Coast - 200 miles offshore	Shallow coastal waters	1 - 25 m isobath Found in mouth of Delaware Bay
	Late Juvenile / Subadults	Coast - 200 miles offshore	Shallow coastal waters NJ to MD coast	1 - 25 m isobath Found in mouth of Delaware Bay
	Adults	Coast - 200 miles offshore	Shallow coastal waters NJ to MD coast	1 - 25 m isobath Found in mouth of Delaware Bay
Atlantic Bluefin Tuna	Spawning Eggs / Larvae	Coast - 200 miles offshore	Pelagic waters Near coastal surface waters	0 - 200 m isobath North Carolina to Florida
	Juveniles / Subadults	Coast - 200 miles offshore	Pelagic waters	20 - 200 m isobath Temperature > 12 C
	Adults	Coast - 200 miles offshore	Pelagic waters	50 - 200 m isobath
Atlantic Sharpnose Shark	Neonate / Early Juveniles	Coast - 200 miles offshore	Shallow coastal areas Bays / estuaries	1 - 25 m isobath
	Late Juvenile / Subadults	Coast - 200 miles offshore	Shallow coastal areas Bays / estuaries	1 - 25 m isobath
	Adults	Coast - 200 miles offshore	Shallow coastal areas Bays / estuaries	1 - 25 m isobath
Atlantic Skipjack Tuna	Spawning Eggs / Larvae	Coast - 200 miles offshore	Offshore waters	200 m isobath to EEZ Florida and Gulf waters
	Juveniles / Subadults	Coast - 200 miles offshore	Pelagic surface waters	25 - 200 m isobath - Florida Temperature 20 - 31 C
	Adults	Coast - 200 miles offshore	Pelagic surface waters	25 - 200 m isobath - Mid Atl. Bight Temperature 20 - 31 C
Swordfish	Spawning Eggs / Larvae	Coast - 200 miles offshore	Pelagic waters	200 m isobath to EEZ North Carolina to Caribbean
	Juveniles / Subadults	Coast - 200 miles offshore	Pelagic waters	25 - 200 m isobath - NJ to FL Temperature > 18 C
	Adults	Coast - 200 miles offshore	Pelagic waters Surface to 500 m deep	100 m isobath to EEZ - MA - FL Temperature > 13 C

Table 4.5 Continued: Essential Fish Habitat Information for Highly Migratory Species

Species	Life Stage	EFH Geographic Extent	Habitat	Notes
Dusky Shark	Neonate / Early Juveniles	Coast - 200 miles offshore	Shallow coastal waters Inlets / estuaries	1 - 25 m isobath New York to North Carolina
	Late Juvenile / Subadults	Coast - 200 miles offshore	Coastal and pelagic waters	25 - 200 m isobath New England to Florida
	Adults	Coast - 200 miles offshore	Pelagic waters	25 - 200 m isobath North Carolina to Florida
Sand Tiger Shark	Neonate / Early Juveniles	Coast - 200 miles offshore	Shallow coastal waters	1 - 25 m isobath Barnegat Inlet, NJ to Florida
	Late Juvenile / Subadults	Coast - 200 miles offshore	Insufficient Information for EFH	Insufficient Information for EFH
	Adults	Coast - 200 miles offshore	Shallow coastal waters	1 - 25 m isobath Barnegat Inlet, NJ to Florida
Sandbar Shark	Neonate / Early Juveniles	Coast - 200 miles offshore	Shallow coastal waters	1 - 25 m isobath Great and Delaware Bays - pupping
	Late Juvenile / Subadults	Coast - 200 miles offshore	Coastal and pelagic waters	1 - 25 m isobath Winter - benthic, 100 - 200 m iso.
	Adults	Coast - 200 miles offshore	Coastal and pelagic waters	1 - 50 m isobath
Scalloped Hammerhead Shark	Neonate / Early Juveniles	Coast - 200 miles offshore	Shallow coastal waters	Shoreline - 25 miles offshore South Carolina - Florida
	Late Juvenile / Subadults	Coast - 200 miles offshore	Shallow coastal waters	1 - 200 m isobath Atlantic seaboard
	Adults	Coast - 200 miles offshore	Pelagic waters	25 - 200 m isobath South Carolina - Florida
Shortfin Mako Shark	Neonate / Early Juveniles	Coast - 200 miles offshore	Pelagic waters	25 - 2000 m isobaths
	Late Juvenile / Subadults	Coast - 200 miles offshore	Pelagic waters	25 - 2000 m isobaths
	Adults	Coast - 200 miles offshore	Pelagic waters	25 - 2000 m isobaths

Table 4.5 Continued: Essential Fish Habitat Information for Highly Migratory Species

Species	Life Stage	EFH Geographic Extent	Habitat	Notes
Tiger Shark	Neonate / Early Juveniles	Coast - 200 miles offshore	Shallow coastal - deep waters	1 - 200 m isobath
	Late Juvenile / Subadults	Coast - 200 miles offshore	Shallow coastal waters	1 - 100 m isobath
	Adults	Coast - 200 miles offshore	Offshore	25 - 200 m isobaths Maryland to Florida
White Shark	Neonate / Early Juveniles	Coast - 200 miles offshore	Insufficient Information for EFH	Insufficient Information for EFH
	Late Juvenile / Subadults	Coast - 200 miles offshore	Pelagic waters	25 - 100 m isobath New York Bight
	Adults	Coast - 200 miles offshore	Insufficient Information for EFH	Insufficient Information for EFH

Source: Guide to Essential Fish Habitat Descriptions. Highly Migratory Species.

Table 4.6: Endangered, Threatened, and Candidate Listed Fish – New Jersey Coastline

Species	State Status	Federal Status	Range in North Atlantic	Habitat	Notes
Shortnose Sturgeon	Endangered	Endangered	St. John River (Canada) to St. Johns River (Florida)	Nearshore estuaries of rivers	Significant population in tidal portion of Delaware River
Atlantic Sturgeon	Threatened	Candidate Species	Labrador (Canada) to St. Johns River (Florida)	Rivers to open ocean	Population declining
Atlantic Salmon	Not Listed	Endangered	Greenland to New York Bight	Rivers to open ocean	Last wild population from Gulf of Maine
Dusky Shark	Not Listed	Candidate Species	Southern New England to Southern Brazil	Coastal surf zone to offshore	Major nursery grounds New Jersey to South Carolina nearshore waters
Night Shark	Not Listed	Candidate Species	Delaware to Brazil	Deep water (150 - 350 m)	Tropical shark rarely found in cooler waters
Barndoor Skate	Not Listed	Candidate Species	Gulf of St. Lawrence to Northeast Florida	Deep cold water (10 - 140 m)	Summer - swim offshore Winter - migrate inshore
Sand Tiger Shark	Not Listed	Candidate Species	Gulf of Maine to Florida	Coasts to continental shelf	Juveniles dependant on Delaware Estuary
American Shad	Threatened	Not Listed	Newfoundland to Florida	Rivers to open ocean	Little spawning in Delaware River More spawning in Hudson River
Atlantic Tomcod	Threatened	Not Listed	Labrador to Virginia	Brackish water / estuaries	Only known NJ population in Sandy Hook Bay

Sources: Andromonous and Marine Fishes. NOAA - Office of Protected Resources. http://www.nmfs.noaa.gov/prot_res?PR3/Fish/fishes.html

South Jersey Resource Conservation and Development Council. Endangered Fish of New Jersey. http://www.sjrcd.org/wildlife/fish.htm

Table 4.7: Major Commercial Finfish and Shellfish Annual Landings 2000 – 2002 – New Jersey

Species	2000		2001		2002		Total	
	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Finfish								
Atlantic Menhaden	31,266,780	1,875,061	26,375,537	1,506,823	24,725,015	1,577,936	**82,367,332**	**4,959,820**
Atlantic Mackerel	9,645,344	1,205,301	25,224,193	1,694,996	20,486,409	1,779,596	**55,355,946**	**4,679,893**
Goosefish	4,414,210	6,505,343	5,855,391	6,134,956	5,703,080	5,901,839	**15,972,681**	**18,542,138**
Summer Flounder	1,848,119	2,604,285	1,745,488	2,312,504	2,407,081	3,504,599	**6,000,688**	**8,421,388**
Atlantic Croaker	2,130,465	609,845	1,389,837	371,411	1,828,615	523,049	**5,348,917**	**1,504,305**
Spiny Dogfish	5,222,164	978,612	17,149	2,425	NR	NR	**5,239,313**	**981,037**
Bluefish	1,341,403	543,080	1,286,644	583,855	1,324,949	568,076	**3,952,996**	**1,695,011**
Skates	1,244,621	189,354	1,377,271	169,045	1,286,671	220,586	**3,908,563**	**578,985**
Weakfish	1,071,428	722,574	837,550	480,304	863,088	481,769	**2,772,066**	**1,684,647**
Scup	510,769	552,185	1,055,954	680,660	923,084	576,867	**2,489,807**	**1,809,712**
Black Sea Bass	587,292	1,032,566	646,824	721,384	620,153	942,182	**1,854,269**	**2,696,132**
Atlantic Herring	NR	NR	708,080	32,492	1,138,427	59,886	**1,846,507**	**92,378**
Swordfish	614,446	1,543,205	446,523	1,097,474	534,992	1,053,266	**1,595,961**	**3,693,945**
Winter Flounder	570,441	567,139	553,616	540,575	241,732	273,292	**1,365,789**	**1,381,006**
Bigeye Tuna	230,979	922,079	326,807	1,027,896	182,494	567,615	**740,280**	**2,517,590**
Total	**60,698,461**	**19,850,629**	**67,846,864**	**17,356,800**	**62,265,790**	**18,030,558**	**190,811,115**	**55,237,987**
Shellfish								
Atlantic Surf Clam	58,047,629	31,371,354	52,872,341	29,326,676	53,614,421	29,184,923	**164,534,391**	**89,882,953**
Ocean Quahog	14,810,080	6,394,288	21,027,780	11,865,975	20,358,290	10,631,701	**56,196,150**	**28,891,964**
Sea Scallop	4,948,862	24,107,816	8,217,333	29,974,809	8,645,130	33,339,750	**21,811,325**	**87,422,375**
Longfin Squid	5,637,300	3,010,006	5,638,330	3,264,392	4,613,738	2,776,219	**15,889,368**	**9,050,617**
Blue Crab	4,863,858	4,924,705	4,430,330	4,098,293	5,999,612	6,173,797	**15,293,800**	**15,196,795**
Northern Shortfin Squid	8,708,586	1,515,559	1,297,217	204,617	489,239	103,606	**10,495,042**	**1,823,782**
Quahog	1,622,221	6,757,227	1,357,128	5,636,397	NR	NR	**2,979,349**	**12,393,624**
Horseshoe Crab	1,098,980	246,217	725,942	134,800	691,572	116,458	**2,516,494**	**497,475**
American Lobster	891,183	3,693,527	579,753	2,471,324	264,425	1,138,867	**1,735,361**	**7,303,718**
Eastern Oyster	202,443	966,531	412,264	1,918,117	379,284	1,852,523	**993,991**	**4,737,171**
Total	**100,831,142**	**82,987,230**	**96,558,418**	**88,895,400**	**95,055,711**	**85,317,844**	**292,445,271**	**257,200,474**

Source: Annual Commercial Landing Statistics. National Marine Fisheries Service Web Page.
http://www.st.nmfs.gov/pls/webpls/mf_lndngs_grp.data_in

Table 4.8: Major Commercial Finfish and Shellfish Landings by Distance from Shore 2002 – New Jersey

Species	Distance from Shore 0 - 3 miles Pounds	Dollars	3 - 200 miles Pounds	Dollars	High Seas Pounds	Dollars	Total Pounds	Dollars
Finfish								
Atlantic Menhaden	24,725,000	1,578,000	———	———	———	———	**24,725,000**	**1,578,000**
Atlantic Mackerel	———	———	20,486,000	1,780,000	———	———	**20,486,000**	**1,780,000**
Goosefish	———	———	5,703,000	5,902,000	———	———	**5,703,000**	**5,902,000**
Summer Flounder	< 1,000	1,000	2,407,000	3,504,000	———	———	**2,407,000**	**3,505,000**
Atlantic Croaker	5,000	2,000	1,824,000	521,000	———	———	**1,829,000**	**523,000**
Bluefish	1,000	1,000	1,324,000	568,000	———	———	**1,325,000**	**569,000**
Skates	27,000	2,000	1,259,000	219,000	———	———	**1,286,000**	**221,000**
Atlantic Herring	———	———	1,138,000	60,000	———	———	**1,138,000**	**60,000**
Scup	———	———	923,000	577,000	———	———	**923,000**	**577,000**
Black Sea Bass	< 1,000	1,000	620,000	941,000	———	———	**620,000**	**942,000**
Swordfish	———	———	535,000	1,053,000	———	———	**535,000**	**1,053,000**
Winter Flounder	———	———	242,000	273,000	———	———	**242,000**	**273,000**
Bigeye Tuna	———	———	182,000	568,000	———	———	**182,000**	**568,000**
Total	**24,758,000**	**1,585,000**	**36,643,000**	**15,966,000**	———	———	**61,401,000**	**17,551,000**
Shellfish								
Atlantic Surf Clam	20,648,000	11,979,000	32,966,000	17,206,000	———	———	**53,614,000**	**29,185,000**
Ocean Quahog	———	———	20,358,000	10,638,000	———	———	**20,358,000**	**10,638,000**
Sea Scallop	———	———	8,645,000	33,340,000	———	———	**8,645,000**	**33,340,000**
Longfin Squid	———	———	4,614,000	2,776,000	———	———	**4,614,000**	**2,776,000**
Horseshoe Crab	692,000	116,000	———	———	———	———	**692,000**	**116,000**
Northern Shortfin Squid	———	———	489,000	104,000	———	———	**489,000**	**104,000**
Eastern Oyster	379,000	1,853,000	———	———	———	———	**379,000**	**1,853,000**
American Lobster	8,000	37,000	257,000	1,102,000	———	———	**265,000**	**1,139,000**
Blue Crab	6,000	6,174	———	———	———	———	**6,000**	**6,174**
Total	**21,733,000**	**13,991,174**	**67,329,000**	**65,166,000**	———	———	**89,062,000**	**79,157,174**

Source: Landings by Distance from U.S. Shores, 2002, State of New Jersey. National Marine Fisheries Service Web Page. http://www.st.nmfs.gov/pls/webpls/mf_8850_landings.results

Table 4.9: Life History Characteristics of Finfish Found in the Central Part of the Mid-Atlantic Bight

Scientific Name	Common Name	Spawning Time	Spawning Location	Egg Type	Habitat Summer	Habitat Winter
Mustelus canis	Smooth Dogfish	March - May	Estuary / Mid-Atlantic Bight	Live	Estuary	Ocean
Anguilla rostrata	American Eel	March - May	Sargasso Sea	?	Estuary	Estuary
Conger oceanicus	Conger Eel	June - February	Sargasso Sea	?	Estuary	?
Alosa aestivalis	Blueback Herring	March - May	Fresh Water	Pelagic	Estuary	Ocean
Alosa mediocris	Hickory Shad	March - May	Fresh Water	Demersal / Pelagic	?	?
Alosa pseudoharengus	Alewife	March - May	Fresh Water	Pelagic	Estuary	Ocean
Alosa sapidissima	American Shad	March - May	Fresh Water	Demersal / Pelagic	Fresh Water / Estaury	Ocean
Brevoortia tyrannus	Atlantic Menhaden	Sept.-Nov. & Mar.-May	Mid and South Atlantic Bight	Pelagic	Estuary	Ocean
Clupea harengus	Atlantic Herring	March - May	Mid-Atlantic Bight	Demersal	?	?
Anchoa hepsetus	Striped Anchovy	June - August	Mid-Atlantic Bight	Pelagic	Estuary / Ocean	Estuary / Ocean
Anchoa mitchilli	Bay Anchovy	June - August	Estuary / Mid-Atlantic Bight	Pelagic	Estuary	Ocean
Osmerus mordax	Rainbow Smelt	March - May	Fresh Water	Demersal	Brackish	Estuary
Synodus foetens	Inshore Lizardfish	?	South Atlantic Bight	?	?	Ocean
Microgadus tomcod	Atlantic Tomcod	December - February	Fresh Water	Demersal	Estuary / Fresh Water	Fresh Water
Pollachius virens	Pollock	September - February	Mid-Atlantic Bight	Pelagic	Estaury	Ocean
Urophycis chuss	Red Hake	June - August	Mid-Atlantic Bight	Pelagic	Ocean	Ocean
Urophycis regia	Spotted Hake	June-Nov. & Mar.-May	Mid-Atlantic Bight	Pelagic	Ocean	Ocean
Urophycis tenuis	White Hake	March - May	Mid-Atlantic Bight	Pelagic	Ocean	Ocean
Ophidion marginatum	Striped Cusk-Eel	June - November	Mid-Atlantic Bight	Pelagic	Estuary / Ocean	Ocean
Opsanus tau	Oyster Toadfish	March - August	Estuary	Demersal	Estuary	Estuary
Strongylura marina	Atlantic Needlefish	March - May	Estuary	Demersal	Estuary	?
Cyprinodon variegatus	Sheepshaed minnow	March - August	Estuary	Demersal	Marsh	Estuary
Fundulus heteroclitus	Mummichog	March - August	Estuary	Demersal	Marsh	Estuary
Fundulus luciae	Spotfin Killifish	March - August	Estuary	Demersal	Marsh	Estuary
Fundulus majalis	Striped Killifish	March - August	Estuary	Demersal	Creeks / Shores	Estuary
Lucania parva	Rainwater Killifish	March - August	Estuary	Demersal	Marsh	Estuary
Gambusia holbrooki	Eastern Mosquitofish	June - August	Fresh Water	Live	Fresh Water / Estaury	Fresh Water / Estuary
Menidia beryllina	Inland Silverside	March - August	Estuary	Demersal	Marsh	Estuary
Menidia menidia	Atlantic Silverside	March - August	Estuary	Demersal	Estuary	Ocean
Apeltes quadracus	Fourspine Stickleback	March - May	Estuary	Demersal	Eelgrass	Estuary
Gasterosteus aculeatus	Threespine Stickleback	March - May	Estuary	Demersal	Marsh	Ocean
Hippocampus erectus	Lined Seahorse	March - August	Estuary / Mid-Atlantic Bight	Live	Estuary	Ocean
Syngnathus fuscus	Northern Pipefish	June - August	Estuary	Live	Estuary	Ocean
Prionotus carolinus	Northern Searobin	June - November	Mid-Atlantic Bight (Estuary?)	Pelagic	Estuary / Ocean	Ocean
Prionotus evolans	Striped Searobin	June - November	Mid-Atlantic Bight (Estuary?)	Pelagic	Estuary / Ocean	Ocean
Myoxocephalus aenaeus	Grubby	December - February	Estuary / Mid-Atlantic Bight	Demersal	Estuary / Ocean?	Estuary / Ocean?

Table 4.9 Continued: Life History Characteristics of Finfish Found in the Central Part of the Mid-Atlantic Bight

Scientific Name	Common Name	Spawning Time	Spawning Location	Egg Type	Habitat Summer	Habitat Winter
Morone americana	White Perch	March - May	Fresh Water	Demersal / Pelagic	Estuary / Fresh Water	Estuary
Morone saxatilus	Striped Bass	March - May	Fresh Water	Pelagic	Estuary / Fresh Water	Estuary
Centropristis striata	Black Sea Bass	March - November	Mid-Atlantic Bight	Pelagic	Estuary / Ocean	Ocean
Pomatomus saltatrix	Bluefish	March - August	Mid and South Atlantic Bight	Pelagic	Estuary	Ocean
Caranx hippos	Crevalle Jack	?	South Atlantic Bight	Pelagic	Estuary	?
Lutjanus griseus	Gray Snapper	June - August	South Atlantic Bight	Pelagic	?	?
Stenotomus chrysops	Scup	March - August	Estuaries, Bays, Cont Shelf	Pelagic	Estuary	Ocean
Bairdiella chrysoura	Silver Perch	June - August	?	Pelagic	Estuary	?
Cynoscion regalis	Weakfish	March - August	Estuary / Mid-Atlantic Bight	Pelagic	Estuary	Ocean
Leiostomus xanthurus	Spot	December - February	Southern Mid-Atlantic Bight	Pelagic	Estuary	Ocean
Menticirrhus saxatilis	Northern Kingfish	June - August	Mid-Atlantic Bight	Pelagic	Ocean / Estuary	Ocean
Micropogonias undulatus	Atlantic Croaker	June - November	Southern Mid-Atlantic Bight	Pelagic	Estuary	Estuary
Pogonias cromis	Black Drum	June - August	Mid-Atlantic Night	Pelagic	Estuary	Ocean
Chaetodon ocellatus	Spotfin Butterflyfish	?	South Atlantic Bight	Pelagic	Estuary	?
Mugil cephalus	Striped Mullet	December - February	South Atlantic Bight	Pelagic	Estuary / Fresh Water	Ocean
Mugil curema	White Mullet	March - May	South Atlantic Bight	Pelagic	Estuary	Ocean
Sphyraena borealis	Northern Sennet	March - May	South Atlantic Bight	Pelagic	Estuary	?
Tautoga onitis	Tautog	March - November	Estuary / Mid-Atlantic Bight	Pelagic	Estaury	Estuary
Tautogolabrus adspersus	Cunner	March - November	Mid-Atlantic Bight	Pelagic	Estuary	Estuary / Ocean
Pholis gunnellus	Rock Gunnel	December - February	Estuary / Mid-Atlantic Bight	Demersal	Estuary	Ocean
Astroscopus guttatus	Northern Stargazer	June - August	Estuary / Mid-Atlantic Bight	?	Estuary / Ocean	?
Hypsoblennius hentz	Feather Blenny	June - August	Estuary	Demersal	Estuary	Estuary
Ammodytes americanus	American Sand Lance	December - February	?	Demersal	Estuary	Estuary
Gobionellus boleosoma	Darter Goby	June - August	Estuary	Demersal	Estuary	Estuary
Gobiosoma bosc	Naked Goby	March - August	Estuary	Demersal	Estuary	Estuary
Gobiosoma ginsburgi	Seaboard Goby	June - August	Estuary	Demersal	Estuary / Ocean	?
Peprilus triacanthus	Butterfish	June - August	Estuary / Mid-Atlantic Bight	Pelagic	Estuary / Ocean	Ocean
Scophthalmus aquosus	Windowpane	Mar.-May & Sept.-Nov.	Estuary / Mid-Atlantic Bight	Pelagic	Estuary / Ocean	Ocean
Eutropus microstomus	Smallmouth Flounder	March - November	Mid-Atlantic Bight	Pelagic	Estuary / Ocean	Ocean
Paralichthys dentatus	Summer Flounder	September - February	Mid-Atlantic Bight	Pelagic	Estuary	Estuary
Pseudopleuronectes americanus	Winter Flounder	December - February	Estuary / Mid-Atlantic Bight	Demersal	Estuary	Estuary / Ocean?
Trinectes maculatus	Hogchoker	March - November	Estaury	Pelagic	Estaury	Estuary
Sphoeroides maculatus	Northern Puffer	March - August	Estaury	Demersal	Estuary	Ocean

Source : Able, K.W. & Fahay, M.P. 1998 The First Year in the Life of Estuarine Fishes in the Middle Atlantic Bight. Rutgers University Press. New Brunswick, NJ.

Table 4.10: EFH Designations for Life Stages of Finfish in New Jersey Bays - Species Found in New Jersey Coastal Bays

Species	Bay				
	Hudson River Raritan Bay Sandy Hook Bay	Barnegat Bay	Great Bay	Delaware Bay	Inland Bays
Species Under New England Council Management					
American Plaice	L, J, A	J, A		J, A	
Atlantic Herring	L, J, A	J, A	J, A	J, A	
Red Hake	L, J, A			A	
Windowpne	E, L, J, A, SA	E, L, J, A, SA	E, L, J, A, SA	E, L, J, A, SA	E, L, J, A, SA
Winter Flounder	E, L, J, A, SA	E, L, J, A, SA	E, L, J, A, SA	E, L, J, A, SA	E, L, J, A, SA
Species Under Mid-Atlantic Council Management					
Bluefish	J, A	J, A	J, A	J, A	A
Atlantic Butterfish	L, J, A	J, A	J	L, J, A	J
Atlantic Mackerel	J, A				
Black Sea Bass	J, A	J, A		J, A	J, A
Scup	E, L, J, A	J	J	J, A	J
Summer Flounder	L, J, A	L, J, A	J, A	J, A	L, J, A
Species Under South Atlantic Council Management					
Cobia	E, L, J, A	E, L, J, A		E, L, J, A	E, L, J, A
King Mackerel	E, L, J, A	E, L, J, A		E, L, J, A	E, L, J, A
Spanish Mackerel	E, L, J, A	E, L, J, A		E, L, J, A	E, L, J, A

Key: E = Eggs
L = Larvae
J = Juveniles
SA = Spawning Adults

Source: Summary of Essential Fish Habitat (EFH) Designations. New Jersey Bays.

National Marine Fisheries Service Web Page.

Table 4.11: Endangered, Threatened, and Special Concern Sea Turtles – New Jersey Coastline

Species	State Status	Federal Status	Range in North Atlantic	Habitat	Notes
Atlantic Loggerhead Turtle	Endangered	Threatened	Newfoundland to Argentina	Continental shelves, bays, estuaries, lagoons	Nests Florida to Carolinas Nests reported in New Jersey
Atlantic Leatherback Turtle	Endangered	Endangered	Nova Scotia to Puerto Rico	Open seas	Nests Georgia to US Virgin Islands Critical Habitat - waters surrounding St Croix, US Virgin Islands
Kemp's Ridley Turtle	Endangered	Endangered	Nova Scotia to Gulf of Mexico	Coastline, estuaries, bays, lagoons	Most endangered sea turtle
Atlantic Hawksbill Turtle	Endangered	Endangered	Massachusetts to Puerto Rico	Warm coastal vegetated water depths less than 50 feet	Critical Habitat - waters surrounding Puerto Rico
Atlantic Green Turtle	Threatened	Threatened	Massachusetts to Puerto Rico	Shallow vegetated waters, inlets, bays, estuaries	Florida and Mexico breeding populations endangered Critical Habitat - waters surrounding Puerto Rico
Northern Diamondback Terrapin	Special Concern	Not Listed	Cape Cod to Cape Hattaras	Marshes, estuaries, beaches	

Sources: National Marine Fisheries. Sea Turtle Protection and Conservation. http://www.nmfs.noaa.gov/prot_res/PR3/Turtles/turtles.html
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Table 4.12: Marine Mammals Observed off the New Jersey Coast – Atlantic Stocks

Species	Range In North Atlantic	Distance from Shore	Notes
Cetaceans			
Atlantic Spotted Dolphin	New England to Venezuela	Continental Shelf to Slope Shallow, Inshore Water South of the Chesapeake Bay	Near 200m Isobath Within 350km of Coast
Blainsville's Beaked Whale	Nova Scotia to Florida	Continental Shelf Edge to Slope	Sighted in Gulf Stream Features Few Observed in Tropical Waters
Blue Whale	Arctic to Mid-Lattitude Waters	Open Ocean	Possible Occurrence to Florida
Bottlenose Dolphin	New Jersey to Florida	Shoreline to 25m Isobath Continental Shelf Break to Slope	Coastal Stock Offshore Stock
Common Dolphin	Georges Bank to Cape Hatteras	Continental Shelf to Slope	Near 200 - 300m Isobaths
Cuvier's Beaked Whale	Nova Scotia to the Caribbean	Continental Shelf Edge	
Dwarf Sperm Whale	Georges Bank to Florida Keys	Continental Shelf	
Fin Whale	Nova Scotia to Cape Hatteras	Continental Shelf to Deep Ocean	Dominant Large Cetacean in Area
Gervias' Beaked Whale	Georges Bank to Caribbean	Open Ocean	Observed in Gulf Stream Features
Harbor Porpoise	Arctic to North Carolina	Coastline to > 200m Isobath	Large Populations off NJ in Fall & Winter
Humpback Whale	Newfoundland to Chesapeake Bay	Continental Shelf	Water off the Mid-Atlantic & Southern States Provide Important Habitat for Juveniles
Killer Whale	Arctic to Massachusetts Bay	Offshore	Rare in US Atlantic EEZ
Long-Finned Pilot Whale	Iceland to Cape Hatteras	Continental Shelf Edge	Associated w/ Gulf Stream & Thermal Fronts on Shelf
North Atlantic Right Whale	Bay of Fundy to Florida	Coastal Waters to Continental Shelf	World's Most Endangered Large Whale

Table 4.12 Continued: Marine Mammals Observed off the New Jersey Coast – Atlantic Stocks

Species	Range In North Atlantic	Distance from Shore	Notes
Pantropical Spotted Dolphin	Georges Bank to Florida	Continental Shelf Edge to Slope	Prefer Deeper Water
Pygmy Sperm Whale	Georges Bank to Florida Keys	Deep Continental Shelf to Shelf Edge	
Risso's Dolphin	Newfoundland to Florida	Continental Shelf Edge to Open Ocean	Associated w/ Bathymetric Features & Gulf Stream Warm-Core Rings & Gulf Stream North Wall
Sei Whale	Nova Scotia to Cape Hatteras	Offshore	Will Move Inshore w/ Food Source
Short-Finned Pilot Whale	Georges Bank to Florida	Continental Shelf and Slope	Observed in the Gulf Stream
Sperm Whale	Georges Bank to Cape Hatteras	Continental Shelf Edge to Mid-Ocean	Associated with Gulf Stream Edge
Striped Dolphin	Nova Scotia to Jamaica	Continental Slope to Gulf Stream	Associated w/ Gulf Stream North Wall, Warm-Core Rings, & New England Sea Mounts Associated w/ 1000m Isobath
True's Beaked Whale	Nova Scotia to Bahamas	Offshore	Associated w/ Gulf Stream Features
White-Beaked Dolphin	Nova Scotia to Cape Hatteras	Continental Slope	
White-Sided Dolphin	Bay of Fundy to North Carolina	Continental Shelf	Associated with 100m Isobath
Pinnipeds			
Harbor Seal	Arctic to South Carolina	Nearshore Waters	Seasonal Interval in Southern New England to New Jersey Increasing
Harp Seal	Arctic to New Jersey	Nearshore Waters	Sightning Increasing from maine to NJ
Hooded Seal	Arctic to Puerto Rico	Offshore	Increased Occurrences from ME to FL

Source: National Marine Fisheries Service. September 2002. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessment - 2002. NOAA Technical Memorandum NMFS-NE-169.

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5.0. Additional Marine Considerations

Historically the waters of New Jersey have been high use areas for commercial and recreational activity such as vessel traffic and fishing. This chapter describes this activity in the context of wind energy development, and also identifies other marine considerations important to the siting of wind turbines.

5.1. Commercial and Recreational Vessel Traffic

The waters of New Jersey, New York Harbor and the Delaware Bay area are very active vessel traffic areas. Recreational boaters crowd the coastline, especially during summer months. The area is also a major commercial traffic route. Vessel Traffic Schemes exist in both the northern and southern ends of the study area (approaches to New York Harbor and Delaware Bay, respectively). Foreign vessels are required to use pilotage services when traveling through both of these areas.

There are designated traffic zones for both approaches. From New York Harbor, the Ambrose to Barnegat Traffic Lane is located 9 to 13 nautical miles from shore in water depths of 70-85 ft. The Barnegat to Ambrose Traffic Lane is further offshore in water depths greater than 90 ft. In the south, from Delaware Bay, a two-way traffic zone from Cape May to Hereford Inlet is located just 3.5 miles from shore in 30-50 ft water depths. Map 5.1 illustrates the primary traffic areas along the coast and where they intersect the study area.

5.2. Commercial and Recreational Fishing

Commercial and recreational fishing is a significant existing use in the waters of offshore New Jersey. Commercial fishing and shell fishing generate nearly $100 million in catch annually. Recreational and sport fishing are also significant; membership in saltwater fishing clubs throughout the state exceeds 30,000.[21] The industry and sport are well organized and well represented in local, state, and federal government.

5.2.1. Commercial and Recreational Finfish

New Jersey has five major commercial fishing ports: Belford, Point Pleasant, Barnegat Light, Atlantic City, and Cape May/Wildwood. Fishing Cooperatives are stationed at the Belford and Point Pleasant ports (Table 5.1). The Belford fleet is composed of gill netters, lobster boats, purse seiners, and otter trawlers. Otter trawlers are dependent on a mixed trawl fishery, meaning they adjust their target fish and fishing with annual migrations of fish. The Point Pleasant fleet

[21] Jersey Coast Anglers Association membership number, http://www.jcca.org.

has gill netters, otter trawlers, and clam dredges. This fleet primarily fishes in local waters, and the trawlers adjust to annual migrations as the Belford trawlers do. Barnegat Light's fleet has large offshore longliners and scallopers that stay at sea for long periods of time. Smaller inshore gill netters also depart from this port, though they have shorter duration fishing trips than their sister ships at this port. The Atlantic City fishing fleet is solely made up of clam dredges, and focuses on the Atlantic surfclam and ocean quahog fisheries. The Cape May/ Wildwood port is the largest port in New Jersey and one of the largest commercial fishing ports on the coast. It is also the center of fish processing and freezing in New Jersey. The fleet is composed of otter trawlers and clam dredges. This information is outlined in Table 5.1.

Virtually all of the study area is utilized in some manner by commercial fishing interests, although the usage varies by time and space. Federally permitted vessels are required to submit Fishing Vessel Trip Reports (FVTR) to the National Marine Fisheries Service. These reports can be used to determine the dominant gears used on different fishing grounds. The offshore waters are broken into "area codes" for reporting purposes. Area codes for New Jersey are shown in Figure 5.1. The area codes that include coastal New Jersey waters are 612, 614, 615, and 621. Area 612 extends southward from Long Island to just north of Toms River. Area 614 extends south to just above Cape May Point. Area 615 is adjacent to area 614, and just below 612. Area 621 extends from Cape May Point, southward.

Table 5.3 shows the preliminary results of FVTRs for commercial fishing operations submitted between 2000 and 2003. The greatest number of trips taken to commercial fishing grounds was for bottom otter trawling for fish (13,330 trips). The next most frequent trips were made for sinking gill net retrieval (11,075), sea scallop dredges (7,464), and lobster pot retrieval (5,621). The dominant gear used in area 612 (northern New Jersey) was the otter trawl, followed by the lobster pot and sinking gill net. The sinking gill net was by far the most dominant gear used in area 614 (southern New Jersey). The most trips were made to area 615 (farther offshore of southern New Jersey) to dredge sea scallops and retrieve sinking gill nets. The most trips made to area 621 (off Cape May Point) were for trawling, followed by sea scallop dredge use and retrieval of conch / whelk pots and sinking gill nets. Figure 5.1 shows the top ten gear used in each area code. It is important to note that some fishing methods allow long trips at sea (e.g. longliners, scallopers, and trawlers). The data obtained for this report lists only number of trips made to each area code, not the length of time spent fishing an area. Therefore, it is possible that effort spent fishing an area is underestimated in this report. However, the data indicates a general overview of dominant gears used on commercial fishing grounds.

The commercial fishing gear types that offshore wind projects would restrict the most are the mobile gear types (e.g. dredges and trawls). These gear types cover large sections of the sea floor as they fish; consequently structures may restrict usable fishing grounds. Dredges and trawls are operated in all area codes and one or both of these gear types often top the list of most frequently used gear. The fewest number of trips for trawling and dredging were located in area 614. Nets and pots appear to be the dominant gear used in this area. Another gear type that may be restricted by the presence of structures in the water is seine nets. Large open areas are utilized by commercial fishing boats to set nets. Purse seines are used in all area codes, and are more heavily used in the areas that touch the shoreline.

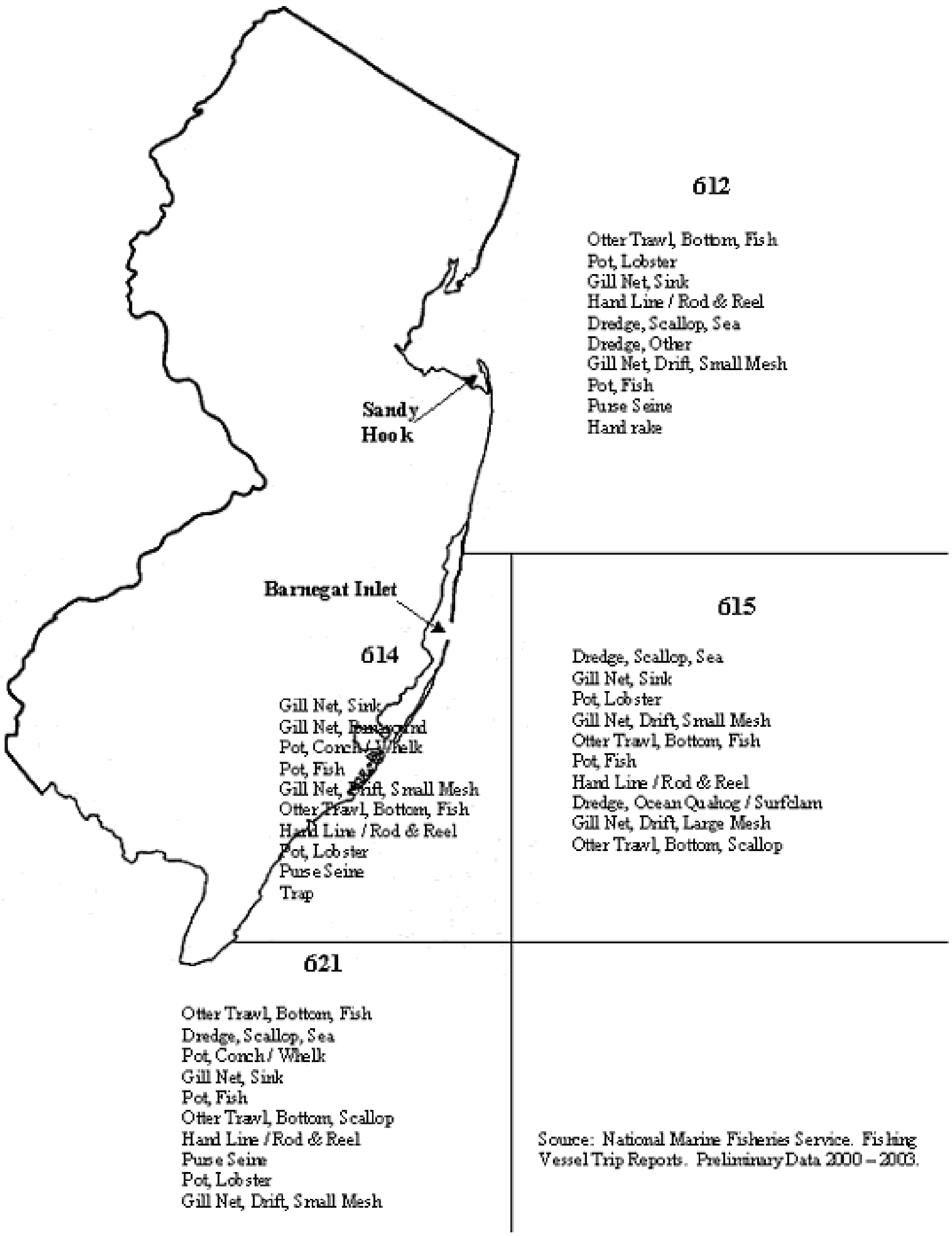

Figure 5.1: Fishing Area Codes & Primary Gear Usage Offshore New Jersey

There are approximately 250 charter and party boats listed in New Jersey. These boats depart from the entire coastline and from Sandy Hook and Delaware Bay. Most frequent activities on the party and charter boats are fishing and diving. Table 5.4 shows the results of FVTRs for party boats in New Jersey waters between 2000 and 2003. The most frequent activity was fishing with hand lines / rod and reels. Most trips were to area 612, followed by 621, 614, and 615. FVTRs for charter boats showed similar results (Table 5.5).

5.2.2. Commercial Shell fishing – Atlantic Surfclam Focus

A flourishing surfclam industry operates offshore of New Jersey and New Jersey manages the largest state fishery for Atlantic surfclams. Map 5.2 shows the shellfish classifications through state waters. In 2000, there were 57 commercial licenses for harvesting surfclams from state waters (within 3 miles of the coast). Between 2000 and 2003, Atlantic surfclams were the most valuable fishery in the state. In the 1999 – 2000 season, almost 700,000 bushels were harvested from New Jersey waters.

Clam dredgers yielded the most profitable catch in the state between 2000 and 2002, where over $119 million was earned with a catch of over 220,000,000 pounds of clams (Table 5.2). Dredges that targeted sea scallops yielded over $77 million and over 20,000,000 pounds of meat in those three years. The next most profitable catches by gear type were bottom otter trawl for fish (over $30 million), sinking gill nets (over $20 million), blue crab pots and traps (over $15 million) and scallop otter trawls (over $10 million). The purse seine caught the second largest weight of commercial catch; over 80,000,000 pounds of Atlantic menhaden, but dollar values were much less than the above-mentioned species.

Atlantic surfclams are harvested by hydraulic powered clam dredges that scour the clam beds and bring the clams to the surface on a conveyor belt. The gear used on clam dredges, hoses and hydraulic pumps, limits the operations to inshore waters. Atlantic surfclams are generally taken from water 60 to 120 feet deep. Most Atlantic surfclam beds are nearshore (see Figure 4.1) and a substantial fishery is focused within 3 miles of shore.

Commercial fishing for the ocean quahog and sea scallop takes place in deeper water than the Atlantic surfclam fishery does. These two species generally live in deeper water than surfclams (see Figure 4.1). Ocean quahogs are generally taken from water depths of 120 to 240 feet. Offshore wind farms should not impact these industries.

5.2.3 Seabed Use Compatibility

The commercial and recreational fishing communities of New Jersey are active users of the seabed within the study area. Compatibility between fishing interests and potential wind development will be influenced by a number of factors. Some of these include the gear and fishing technique, seabed and cable burial integrity, scour protection, and coordination between entities.

Some offshore wind farms in Europe (e.g. Rødsand, Horns Rev, Rhyl Flats, Lynn), but not all, restrict trawlers from entering the wind farm and cable area, because the gear could catch the bases of turbines and excavate the transmission cable itself. Other fishing methods, such as pot and net fishing and long-lines, are allowed within these wind farms. Dredging requires open spaces to pull equipment along the sea floor. The dredge used by the National Marine Fisheries Service for surveys, similar to that used by commercial fishermen, measures 198” long and 86” wide (16.5’ by 7.17’). The dredges are smaller than trawl nets and have more maneuverability than the trawlers, and therefore may be able to work within a wind farm. Further study and collaboration with the fishing communities are required to determine the effect of wind development on New Jersey’s fishing industry.

5.3. Obstructions

Non-geologic formations or occurrences in the sea often pose concern to navigation. These obstructions include a large variety of man-made debris and structures. Among the items that warrant the attention of navigators and potential wind developers are artificial reefs, sewer outfalls, dump sites, wrecks, danger areas (unexploded ordinances, mines, etc.), and other similar obstructions. The large size and historic high-usage of the New Jersey shore have produced a significant number of both point hazards and large area hazards. Map 5.3 illustrates the potential obstructions.

More than 20 marine cables are charted within the study area. Most of these are transatlantic telecommunications cables that converge near shore in three locations: North of Sandy Hook (within the vessel traffic separation zones for the approaches to New York); Manasquan Inlet, and along Long Beach. Inside Delaware Bay there is also a charted cable area from Brandywine Shoal light to Cape May. There is one charted gas pipeline which runs from Sandy Hook, NJ east northeast to the south shore of long Island. Sewer outfalls are also numerous along the coast, however, these generally extend only 0.5 to 1 mile off shore.

Several offshore dumping sites are located within the survey area. Most of these are in the northern third, near Long Island and Sandy Hook. Dump sites are regulated by the Army Corps of Engineers and the Environmental Protection Agency and permits must be obtained for dumping. In general, these sites do not pose a danger to navigation because dumping operations are designed to not cause significant shoaling.

Several fish trap areas are located within the study area (see Map 5.2). These areas generally extend from shore to 2-3 miles offshore and cover a large portion of NJ coastline, except in front of the inlets. Within Delaware Bay there are several charted oyster grounds as well as fish trap areas. Typically, fish stakes and nets are encountered in significant numbers within the fish trap areas. Individual stakes are not charted because they are not permanent structures and their locations can shift periodically. Stakes often become broken off and form a hazard to navigation.

Artificial reef structures are placed to provide hard surface for encrusting organisms and habitat for fish and invertebrates not normally encountered on open sand substrates. These areas are often labeled as fish havens on navigational charts. Fourteen major artificial reef sites have been created off the New Jersey coastline, 2 to 25 nautical miles offshore, from Sandy Hook to Cape May. Their locations are also illustrated on map 5.3.

There are several designated danger areas within the study area. Many of these areas are related to unexploded ordinances. Additional areas of unexploded ordinances are known to exist along the northern New Jersey coast in shallow waters but these are not charted. Army Corps of Engineers dredging operations, related to beach replenishment projects, have inadvertently encountered unexploded ordinances.

Not all of these obstructions necessarily preclude siting in the immediate area. Turbine foundations may increase the benefit of artificial reefs with more hard structure. Shipwrecks are small compared to spacing between turbines, thus can possibly be located without trouble in a farm. The implications of underwater obstructions warrant further investigation during a potential siting process.

5.4. Proposed Sand Borrow Areas

The Minerals Management Service (MMS) of the U.S. Dept. of Interior has identified several potential offshore sand borrow areas to be used on beaches for storm damage mitigation (see Map 5.4). All of the proposed sand borrow areas are in federal waters, outside of the 3-mile limit. The major sand resource areas are located seaward of Sea Girt, south of Barnegat Inlet, between Little Egg Inlet and Absecon Inlet, and between Corsons Inlet and Townsends Inlet. Sand would be dredged from the borrow site and transported to beaches. The sand borrow area off Sea Girt has already been used in erosion control projects between Asbury Park and Manasquan, in northern New Jersey. Because sand is physically being removed from the seabed, proposed sand borrow areas can affect project siting. The current and future use of these areas can be ascertained from MMS and the U.S. Army Corp of Engineers.

5.5. Other Marine Impacts

The long-term effects of offshore wind development on the marine environment are being studied at existing projects in Europe. Noise, avian risk, and marine wildlife impacts are important topics to consider prior to and during a more detailed Environmental Impact Analysis.

5.5.1. Noise

Offshore wind turbines can and do propagate noise through the air and surrounding water. The body of knowledge regarding offshore noise is being developed in Europe through studies of currently operating wind projects. Two reports from Ødegaard & Danneskiold-Samsøe A/S[22] provide the basis for characterizing noise from turbines installed in an offshore environment.

The first report, a March 2000 publication, examined underwater noise measurement, analysis, and prediction techniques for operating wind projects. The subjects of the study are two operating wind farms, one in Denmark (Vindeby) and one in Sweden (Gotland). This study examined two modes of noise transmission into the water. The first is airborne noise transmitted from the turbine components through the air, into the water. The second was the transmission of vibrations and noise through the turbine's foundation into the water. This structure-borne noise was determined to be the primary component of underwater noise, as the airborne noise had a negligible effect.

This study further characterized the plants' underwater noise emissions by foundation type. The specific concrete foundations (Vindeby) were found to be noisier than the specific steel monopile foundations (Gotland) below 50 Hz, while the monopiles were noisier between 50 Hz and 500 Hz. Over all, the noise emissions from the operating wind plants were found to be lower than ambient noise at frequencies above 1 kHz, and higher than the ambient sound levels below 1 kHz.

[22] Consulting Engineers specializing in noise and vibration control. Based in Denmark. Contracted for research by SEAS and Enron Wind (now GE Wind). Reports cited in Reference section.

The second report, published in October of 2000, examined underwater and above-water noise during offshore pile driving. The research was conducted during the installation of Sweden's Utgrunden project. The result of this study indicated that underwater noise from the pile driving is no greater than ambient noise at frequencies below 4 Hz. Underwater noise from the installation process is higher than ambient sounds at frequencies greater than 4 Hz.

Collectively, these two reports indicate that the underwater noise propagation of an operating wind park is a function of seabed conditions, foundation type, turbine design and other factors. The results of these studies and reports are forming a base for the evaluation of noise on marine wildlife and the nearest land residents.

5.5.2. Fish Sensitivity to Offshore Wind Farms

The effects of wind farm construction and operation on local fish species are being studied in Europe. These studies are being conducted to create a baseline dataset that will characterize the ecological and economic effects on the area's fish population. Among the more recent studies are two reports by Bio/consult AS[23] that provide an overview of construction and operation impacts on fish.

The effects of noise from offshore pile-driving on fish are examined in the first report. This study, which uses the data from the noise study at Utgrunden (see Section 5.5.1), first classifies fish into two categories by their hearing sensitivity: "hearing generalists" and "hearing specialists." The hearing specialists are species with physiological adaptations that enhance hearing, such as herring and American Shad. Fish without such specialization are referred to as hearing generalists, such as cod and flounder. The adaptations of hearing "specialists" allow them to detect sound with greater sensitivity and over a wider bandwidth than the hearing "generalist" species.

The report concludes that while the noise of pile driving is relatively loud to human hearing, fish species may react differently. Hearing "generalists" may display avoidance response while in close proximity (approx 30 m) to the sound source. Within that range, the low frequency noise they detect will be loudest. Hearing "specialists" can be more sensitive to the spectrum of pile driving noise and will likely display escape responses in the vicinity of the construction. The pile-driving site may also be avoided by other species due to sensitivity to suspended sediment.

The second report, dated January 2002, examined the effects of noise and electromagnetic fields from an operating wind farm in Denmark. It concluded that the operational noise from the turbines, in high and low winds, would likely not elicit an avoidance reaction by local fish species. The magnetic fields immediately around the cables may be detectable by some fish; however, the strength of the magnetic field was weak, equal to the geomagnetic field of the earth less than 1 meter from the cables. Burial of the cables under the seabed may mitigate any effect of induced magnetic fields.

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[23] Bio/consult AS is a biological science consultancy based in Denmark. These reports were contracted by SEAS. Report citations are in reference section of this chapter.

5.5.3. Marine Mammal Sensitivity

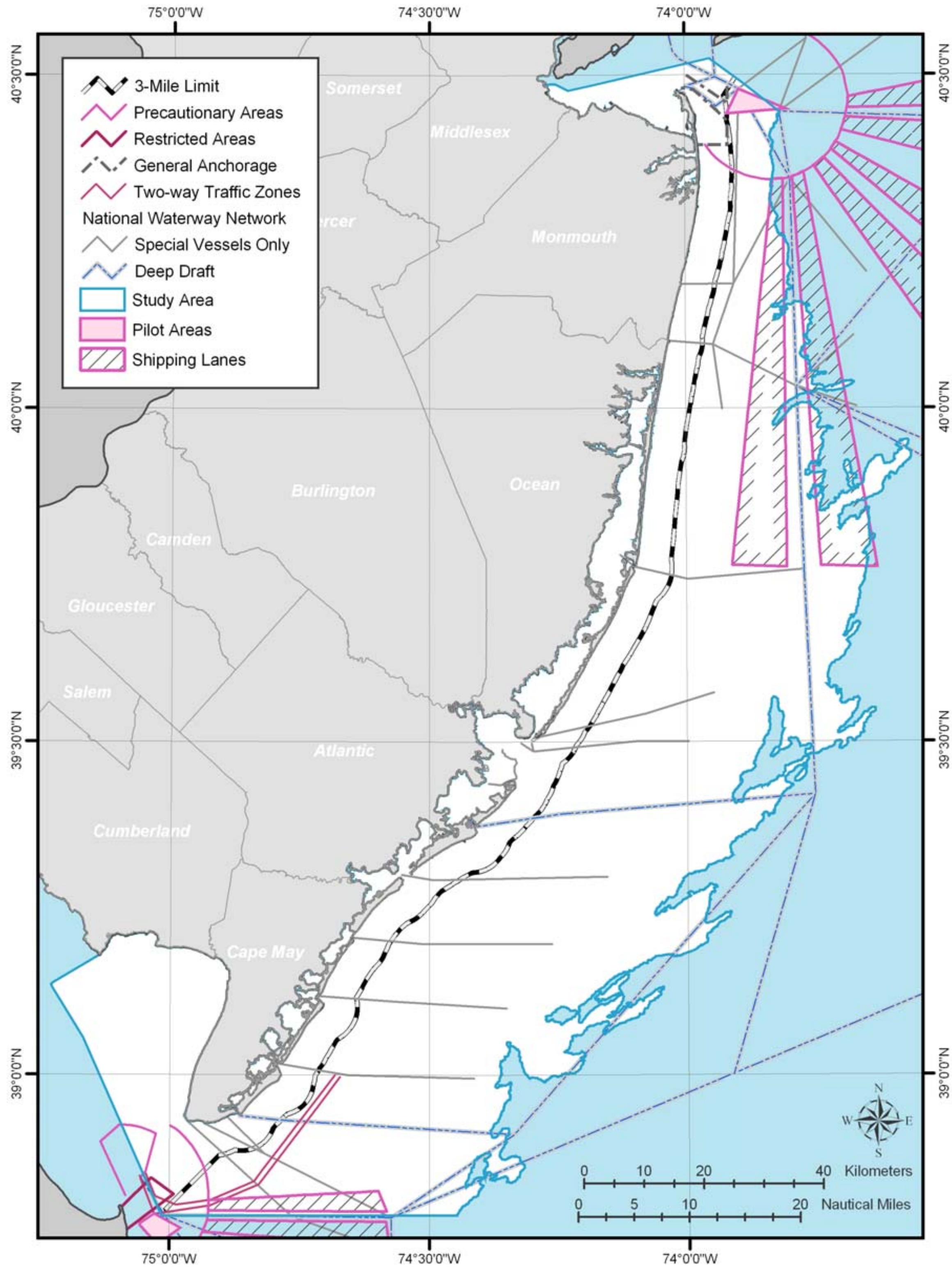
European research on marine mammal sensitivity to offshore wind farm construction and operation is being conducted in parallel with similar studies on fish. Several reports from two of the largest operating wind farms, Horns Rev and Rødsand (both in Denmark), have established a baseline information set for reference and future impact estimates. The available data can be separated into two time-segments, construction effects and operation effects.

The construction phase for the wind farms introduces elevated noise levels resulting from increased boat and helicopter traffic, and foundation pile driving. The mammals native to the study areas, harbor porpoises and seals, are all sensitive to the frequency of sounds generated by construction activities. For these mammals, the expected reaction was avoidance and temporary departure. Prior to construction (particularly pile driving), efforts were made to warn mammals away from the vicinity using an acoustic deterrent (pingers). Observations indicated success with this technique through lower concentrations of these mammals during the construction period.

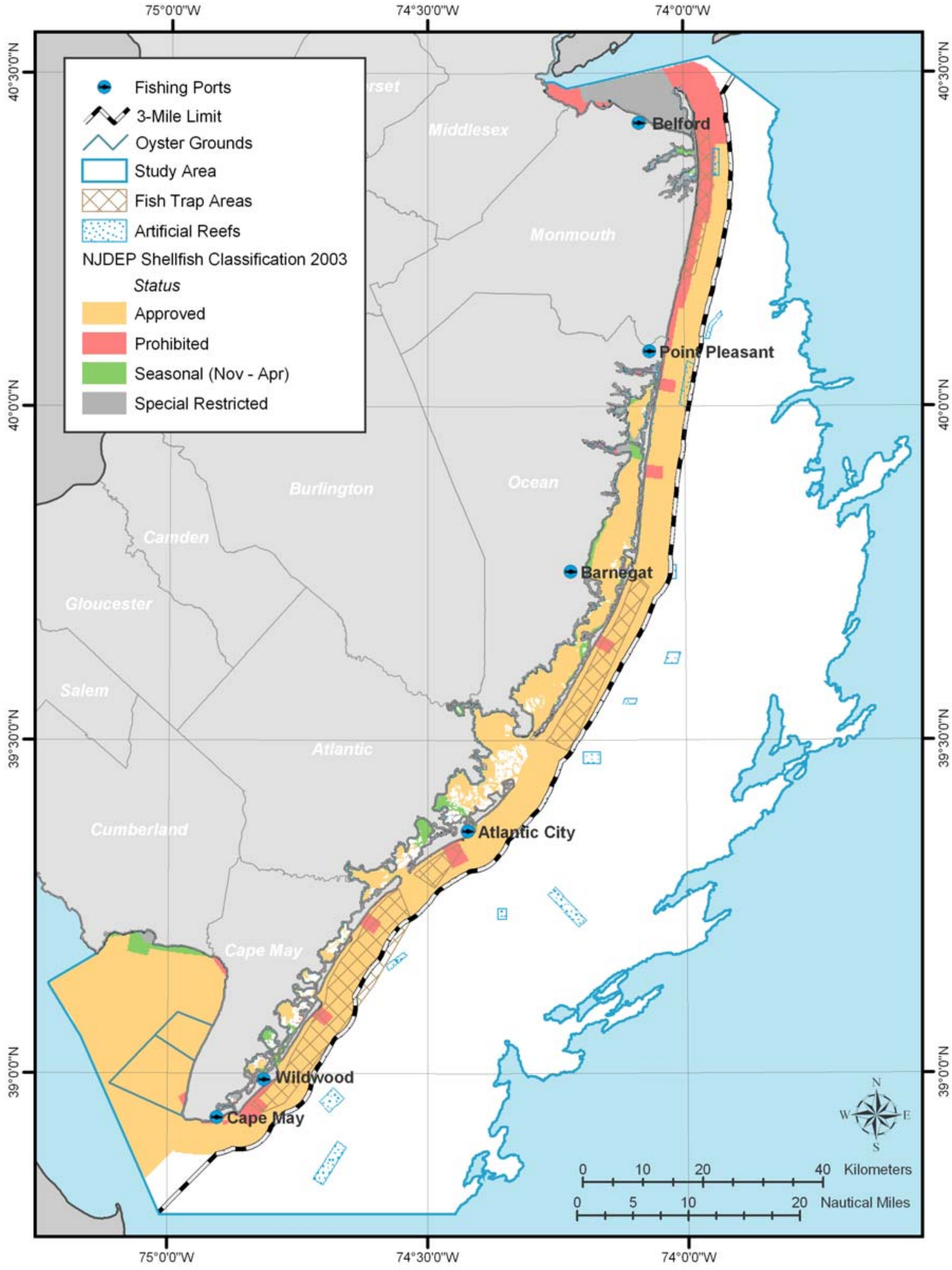
The effects of the parks' operations phase are also being studied. Although the operational noise level of the wind farms is not expected to harm local marine mammals, the studies are designed to verify this. Preliminary findings are that seals and porpoises habituate to the relatively steady, localized noise emissions from a wind farm. Additionally, there is no evidence that the frequencies of the operational sounds interfere with porpoise echolocation The studies also indicate that mammals return to the wind farm sites following the construction period. The magnetic fields in the immediate vicinity of the power cables have not been observed to have an affect on the local mammals. This comprehensive research is ongoing to expand the knowledge base on the effects of offshore wind farms on marine mammals.

Differences in habitat, affected species, and facility design between the European projects referenced here and any facility proposed for the New Jersey Study Area may limit the extrapolation of findings from the European research to the Study Area. Consequently, additional project specific investigation would be warranted for any proposed facility.

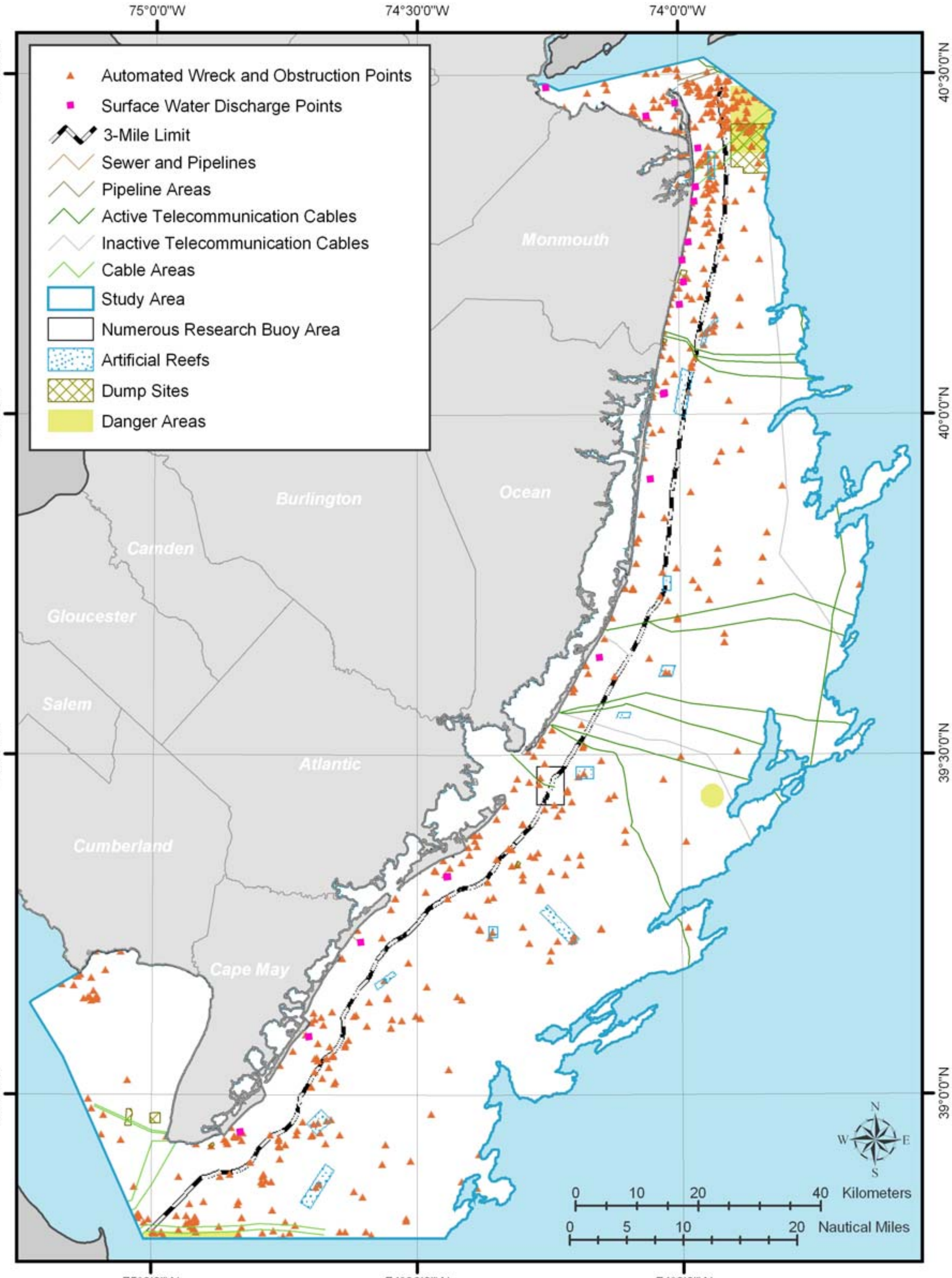
5.5. Maps



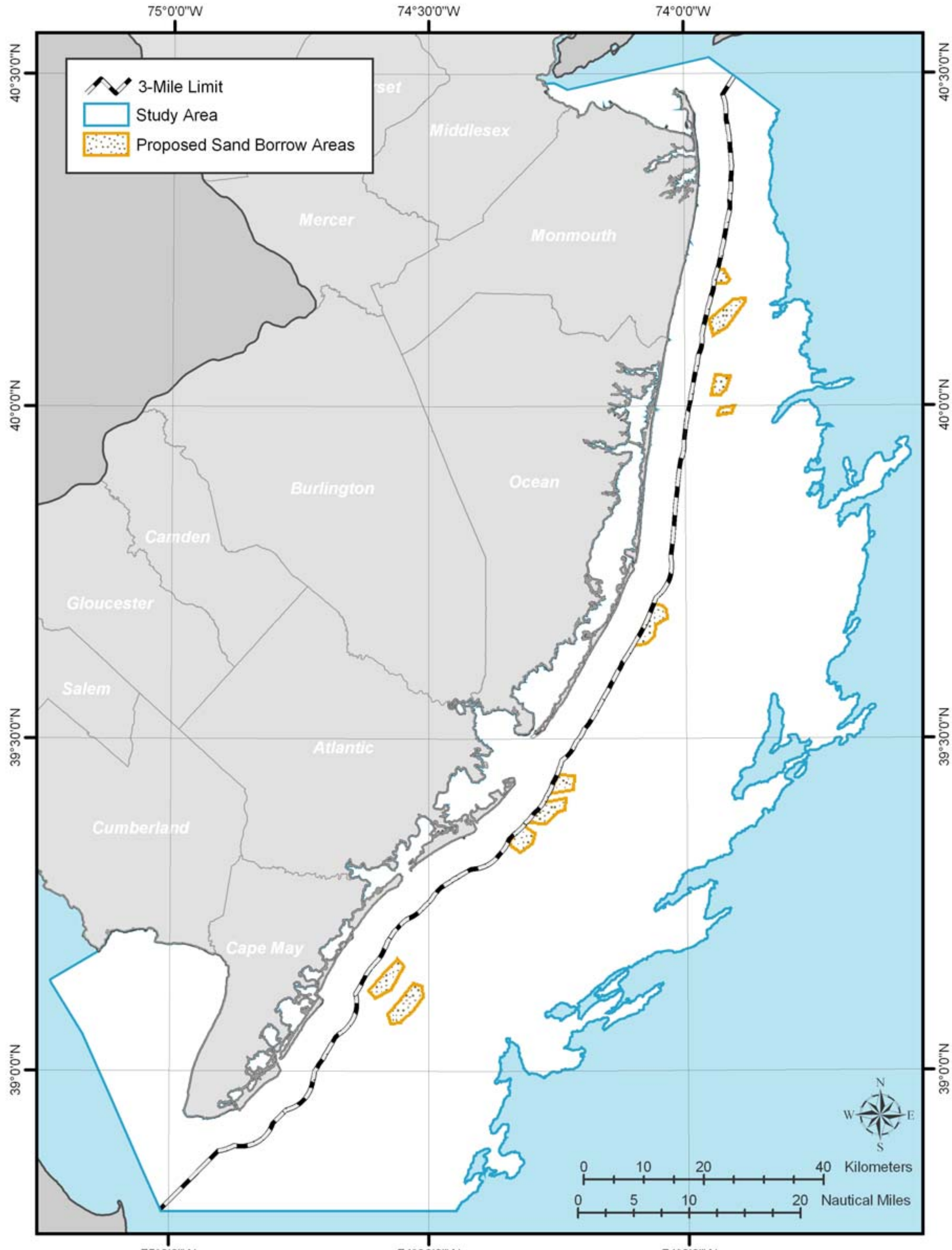
Map 5.1: Vessel Navigation for Offshore New Jersey



Map 5.2: Commercial Shellfish Classification in New Jersey State Waters



Map 5.3: Charted Wrecks and Obstructions



Map 5.4: Proposed Sand Borrow Areas

5.6. Tables

Table 5.1: Major Fishing Ports in New Jersey

Port	Fleet	Target Species	Notes	Fishing Cooperatives / Commercial Village Dock
Belford	Gill Netters		Mixed Trawl Fisherey*	Belford Fisherman's Cooperative
	Lobster Boats	Lobster		
	Purse Seiners	Atlantic Menhaden		
	Otter Trawlers	Silver Hake Red Hake Summer Flounder Winter Flounder Blasck Sea Bass Scup		
Point Pleasant	Gill Netters			Fisherman's Dock Cooperative
	Otter Trawlers	Summer Flounder Squid Silver Hake Red Hake Winter Fklounder Bluefish Monkfish Scallops	Mixed Trawl Fisherey* Primarily Fish Local Waters	
	Clam Dredges	Surf Clams Ocean Quahogs		
Barnegat Light	Longliners	Tuna Swordfish Tilefish	Large Offshore Vessels	Viking Village Commercial Fishing Dock
	Scallopers	Scallops		
	Gill Netters	Weakfish Monkfish Bluefish Shad Dogfish	Small Inshore Vessels	
Atlantic City	Clam Dredges	Surf Clams Ocean Quahogs		
Cape May / Wildwood	Otter Trawlers	Squid Mackerel Summer Flounder Black Sea Bass Scup Lobster Atlantic Mehnaden	Largest NJ Port One of Largest Ports on Coast NJ Center of Fish Processing and Freezing	
	Clam Dredges	Surf Clam Ocean Quahog		

* Mixed Trawl Fisherey - the adjustment of fishing and marketing of fish to annual migrations of several finfish species.

Source: New Jersey Fishing Web Page. http://www.fishingnj.org/dirports.htm

Table 5.2: Major Commercial Finfish and Shellfish Landings by Gear Type 2000 – 2002, New Jersey

Gear Type	Target Species	2000		2001		2002		Total	
		Pounds	Dollars	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
Dredge	Clam	72,882,146	37,888,167	73,921,998	41,274,774	74,013,047	39,952,944	**220,817,191**	**119,115,885**
Purse Seine	Atlantic Menhaden	30,766,603	1,817,864	25,696,684	1,443,250	23,984,590	1,498,501	**80,447,877**	**4,759,615**
Bottom Otter Trawl	Fish	38,143,205	12,435,001	14,666,906	9,136,111	12,964,022	8,989,281	**65,774,133**	**30,560,393**
Midwater Otter Trawl		3,169,324	206,463	25,840,232	1,692,237	8,992,975	736,438	**38,002,531**	**2,635,138**
Sinking Gill Nets		7,716,071	7,233,925	8,495,478	6,976,263	6,868,588	6,290,272	**23,080,137**	**20,500,460**
Dredge	Sea Scallop	4,854,808	21,180,166	7,708,293	26,155,022	8,414,991	30,282,997	**20,978,092**	**77,618,185**
Pots and Traps	Blue Crab	4,745,936	5,167,717	4,107,653	4,306,399	5,343,540	5,963,445	**14,197,129**	**15,437,561**
Paired Midwater Trawl		NR	NR	NR	NR	12,455,028	1,044,539	**12,455,028**	**1,044,539**
Long Lines		1,673,804	3,529,862	1,459,772	2,905,923	1,342,443	2,279,232	**4,476,019**	**8,715,017**
Hand Collection	Other	1,541,978	2,106,422	1,100,672	1,734,291	1,076,668	1,715,912	**3,719,318**	**5,556,625**
Drift Gill Nets	Other Fish	1,543,088	816,581	353,644	103,850	1,789,798	927,018	**3,686,530**	**1,847,449**
Bottom Otter Trawl	Scallop	793,666	3,369,866	1,228,054	4,041,461	892,065	3,122,714	**2,913,785**	**10,534,041**
Dredge	Crab	348,503	323,305	690,071	623,619	1,044,092	1,026,226	**2,082,666**	**1,973,150**
Pots and Traps	Lobster	915,466	3,577,546	604,584	2,426,450	291,777	1,150,995	**1,811,827**	**7,154,991**
Pound Nets	Fish	296,963	84,669	339,095	110,332	528,280	174,982	**1,164,338**	**369,983**
Dredge	Oyster	201,288	943,939	357,820	1,640,255	372,990	1,737,141	**932,098**	**4,321,335**
Pots and Traps	Fish	342,412	554,150	220,829	345,287	262,663	425,475	**825,904**	**1,324,912**
Pots and Traps	Conch	230,094	491,447	184,187	508,599	93,744	200,786	**508,025**	**1,200,832**
Drift Gill Nets	Shad	162,657	84,129	121,171	44,166	72,278	35,776	**356,106**	**164,071**
Hand Lines		141,998	208,623	67,611	113,800	82,701	119,665	**292,310**	**442,088**
Rakes		102,182	430,051	70,832	295,093	64,467	267,702	**237,481**	**992,846**
Pots and Traps	Eel	45,386	56,373	106,134	319,892	64,600	96,630	**216,120**	**472,895**
Pots and Traps	Other Crabs	NR	NR	203,784	199,574	NR	NR	**203,784**	**199,574**
Fyke and Hoop Nets	Fish	31,629	30,570	15,768	15,620	32,841	22,615	**80,238**	**68,805**
Beach Haul Seine		36,218	28,273	15,052	14,706	15,564	11,661	**66,834**	**54,640**
Troll Lines	Tuna	13,969	33,387	14,389	30,805	1,072	1,654	**29,430**	**65,846**
Pots and Traps	Turtle	9,925	4,962	4,049	2,025	1,099	599	**15,073**	**7,586**
Hand Collection	Oyster	1,575	23,264	2,010	33,170	6,294	115,382	**9,879**	**171,816**
Pound Nets	Horseshoe Crab	150	79	8,571	1,714	NR	NR	**8,721**	**1,793**
Tongs and Grabs		3,510	15,520	NR	NR	NR	NR	**3,510**	**15,520**
Dredge	Other	NR	NR	3,100	5,580	NR	NR	**3,100**	**5,580**
Dredge	Conch	951	1,115	957	1,291	NR	NR	**1,908**	**2,406**
Beam Trawls		NR	NR	NR	NR	1,744	682	**1,744**	**682**
Troll Lines	Other	485	959	NR	NR	NR	NR	**485**	**959**
Total		**170,715,990**	**102,644,395**	**167,609,400**	**106,501,559**	**161,073,961**	**108,191,264**	**499,399,351**	**317,337,218**

Source: Annual Commercial Landings by Gear Type. National Marine Fisheries Service Web Page.
http://www.st.nmfs.gov/pls/webpls/MF_GEAR_LANDINGS.RESULTS

Table 5.3: Number of Trips to Commercial Fishing Grounds 2000 – 2003, New Jersey Waters

2000			2001					2002					2003					612	614	615	621	
615	621	Total	612	614	615	621	Total	612	614	615	621	Total	612	614	615	621	Total	Total	Total	Total	Total	Grand Total
145	888	**3851**	2586	36	165	696	**3483**	2836	45	98	965	**3944**	1440	83	71	458	**2052**	**9619**	**225**	**479**	**3007**	**13330**
1125	268	**3150**	1047	778	1064	307	**3196**	1307	721	869	300	**3197**	563	319	401	249	**1532**	**3794**	**2698**	**3459**	**1124**	**11075**
659	274	**1208**	352	10	1119	366	**1847**	380	21	1273	649	**2323**	315	11	1084	680	**2090**	**1308**	**56**	**4135**	**1969**	**7468**
109	86	**1814**	1161	40	196	39	**1436**	1248	46	279	60	**1633**	541	36	132	29	**738**	**4525**	**166**	**716**	**214**	**5621**
42	101	**651**	307	74	20	94	**495**	435	31	28	127	**621**	212	25	14	45	**296**	**1422**	**170**	**104**	**367**	**2063**
49	387	**621**	36	123	32	227	**418**	57	164	11	162	**394**	132	105	25	199	**461**	**258**	**544**	**117**	**975**	**1894**
0	338	**684**	0	176	0	443	**619**	4	85	1	309	**399**	0	41	0	62	**103**	**4**	**648**	**1**	**1152**	**1805**
165	38	**388**	109	115	269	67	**560**	92	70	185	50	**397**	32	18	25	12	**87**	**275**	**346**	**644**	**167**	**1432**
19	1	**320**	0	251	4	7	**262**	5	279	10	7	**301**	0	80	3	0	**83**	**8**	**907**	**36**	**15**	**966**
4	18	**206**	180	1	2	51	**234**	123	1	1	31	**156**	139	0	0	11	**150**	**625**	**3**	**7**	**111**	**746**
0	70	**164**	77	48	11	157	**293**	48	40	8	83	**179**	38	34	0	37	**109**	**215**	**164**	**19**	**347**	**745**
4	59	**70**	0	0	28	75	**103**	2	3	12	135	**152**	0	0	7	244	**251**	**7**	**5**	**51**	**513**	**576**
0	4	**66**	46	0	0	54	**100**	59	0	50	37	**146**	24	0	44	23	**91**	**191**	**0**	**94**	**118**	**403**
0	0	**97**	87	0	1	0	**88**	5	0	2	0	**7**	6	1	0	0	**7**	**195**	**1**	**3**	**0**	**199**
25	0	**46**	0	0	9	0	**9**	6	0	8	1	**15**	4	21	31	17	**73**	**25**	**27**	**73**	**18**	**143**
11	16	**36**	12	0	14	13	**39**	10	0	3	2	**15**	11	0	12	2	**25**	**40**	**2**	**40**	**33**	**115**
0	7	**34**	19	0	0	1	**20**	36	0	0	1	**37**	3	9	0	4	**16**	**83**	**11**	**0**	**13**	**107**
0	1	**32**	3	6	2	21	**32**	18	0	0	3	**21**	1	0	0	4	**5**	**52**	**7**	**2**	**29**	**90**
0	0	**17**	0	53	0	1	**54**	0	0	0	1	**1**	1	0	0	0	**1**	**2**	**69**	**0**	**2**	**73**
0	0	**0**	1	0	0	0	**1**	0	0	11	0	**11**	16	2	24	9	**51**	**17**	**2**	**35**	**9**	**63**
1	2	**51**	4	0	0	0	**4**	0	0	0	0	**0**	0	0	0	0	**0**	**42**	**10**	**1**	**2**	**55**
0	0	**2**	1	0	0	0	**1**	2	27	0	6	**35**	15	0	0	0	**15**	**20**	**27**	**0**	**6**	**53**
0	2	**6**	1	0	2	12	**15**	0	2	0	7	**9**	0	0	0	1	**1**	**4**	**3**	**2**	**22**	**31**
9	0	**9**	1	0	2	1	**4**	6	0	0	0	**6**	5	5	0	0	**10**	**12**	**5**	**11**	**1**	**29**
1	2	**4**	3	0	1	0	**4**	0	0	0	8	**8**	0	0	0	0	**0**	**4**	**0**	**2**	**10**	**16**
0	0	**2**	1	0	0	0	**1**	5	0	2	0	**7**	0	3	0	1	**4**	**8**	**3**	**2**	**1**	**14**
0	2	**4**	0	0	0	1	**1**	0	0	0	2	**2**	1	0	0	2	**3**	**2**	**1**	**0**	**7**	**10**
0	0	**0**	0	0	0	0	**0**	0	0	0	0	**0**	9	0	0	0	**9**	**9**	**0**	**0**	**0**	**9**
0	0	**0**	0	0	0	0	**0**	0	0	0	0	**0**	6	0	0	0	**6**	**6**	**0**	**0**	**0**	**6**
0	2	**5**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0	**0**	**3**	**0**	**0**	**2**	**5**
0	0	**0**	0	0	0	0	**0**	3	0	0	0	**3**	0	0	0	0	**0**	**3**	**0**	**0**	**0**	**3**
0	0	**1**	0	0	0	0	**0**	0	0	0	0	**0**	0	0	0	0	**0**	**0**	**1**	**0**	**0**	**1**
2368	**2566**	**13539**	**6034**	**1711**	**2941**	**2633**	**13319**	**6687**	**1535**	**2851**	**2946**	**14019**	**3514**	**793**	**1873**	**2089**	**8269**	**22778**	**6101**	**10033**	**10234**	**49146**

orts. Preliminary Data 2000 - 2003.

ich correspond to waters fished off New Jersey (see Figure 5).

Table 5.4: Number of Fishing Trips Taken by Party Boats to Fishing Grounds 2000 – 2003, New Jersey Waters

Gear	2000					2001				
	612	614	615	621	**Total**	612	614	615	621	**Total**
OTHER GEAR	1	0	0	0	**1**	0	0	0	0	**0**
DIVING GEAR	28	3	4	0	**35**	22	1	0	6	**29**
HAND LINE/ROD & REEL	4827	728	769	2482	**8806**	4210	887	628	2464	**8189**
Total	**4856**	**731**	**773**	**2482**	**8842**	**4232**	**888**	**628**	**2470**	**8218**

Gear	2002					2003				
	612	614	615	621	**Total**	612	614	615	621	**Total**
OTHER GEAR	0	0	0	0	**0**	0	0	0	0	**0**
DIVING GEAR	2	0	0	0	**2**	5	0	2	0	**7**
HAND LINE/ROD & REEL	4002	592	708	2065	**7367**	1840	406	255	1162	**3663**
Total	**4004**	**592**	**708**	**2065**	**7369**	**1845**	**406**	**257**	**1162**	**3670**

Gear	612 Total	614 Total	615 Total	621 Total	Grand Total
OTHER GEAR	**1**	**0**	**0**	**0**	**1**
DIVING GEAR	**57**	**4**	**6**	**6**	**73**
HAND LINE/ROD & REEL	**14879**	**2613**	**2360**	**8173**	**28025**
Total	**14937**	**2617**	**2366**	**8179**	**28099**

Source: National Marine Fisheries Service. Fishing Vessel Trip Reports. Preliminary Data 2000 - 2003.

* Vessel Trip Reports are for area codes 612, 614, 615, and 621,
which correspond to waters fished off New Jersey (see Figure 5.1).

Table 5.5: Number of Fishing Trips Taken by Charter Boats to Fishing Grounds 2000 – 2003, New Jersey Waters

Gear	2000					2001				
	612	614	615	621	**Total**	612	614	615	621	**Total**
DIVING GEAR	92	30	17	15	**154**	76	16	26	10	**128**
HAND LINE/ROD & REEL	2027	621	613	962	**4223**	2059	572	536	1093	**4260**
Total	**2119**	**651**	**630**	**977**	**4377**	**2135**	**588**	**562**	**1103**	**4388**

Gear	2002					2003				
	612	614	615	621	**Total**	612	614	615	621	**Total**
DIVING GEAR	78	3	24	10	**115**	20	0	6	0	**26**
HAND LINE/ROD & REEL	1817	508	572	745	**3642**	832	204	240	229	**1505**
Total	**1895**	**511**	**596**	**755**	**3757**	**852**	**204**	**246**	**229**	**1531**

Gear	612 Total	614 Total	615 Total	621 Total	Grand Total
DIVING GEAR	**266**	**49**	**73**	**35**	**423**
HAND LINE/ROD & REEL	**6735**	**1905**	**1961**	**3029**	**13630**
Total	**7001**	**1954**	**2034**	**3064**	**14053**

Source: National Marine Fisheries Service. Fishing Vessel Trip Reports. Preliminary Data 2000 - 2003.

* Vessel Trip Reports are for area codes 612, 614, 615, and 621,
which correspond to waters fished off New Jersey (see Figure 5.1).

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6.0. Onshore Considerations

Resources and activities on adjacent land will also have an influence on the viability of offshore wind development. This chapter identifies the predominant coastal land uses that could be impacted directly (e.g., cable landfall) or indirectly (e.g., visually) by an offshore wind project. The location of airports and heliports may also influence height restrictions on turbine structures, depending on their proximity. Offshore wind projects also depend on land-based resources for construction and operational purposes, and also for delivering their power to the existing transmission grid. These onshore considerations are addressed in this chapter as well.

6.1. Land Use

6.1.1. Population Density

A July 2002 population estimate by the U.S. Census Bureau for the five counties bordering the study area (Cumberland, Cape May, Atlantic, Ocean, Monmouth) projected a total of 1,676,105 people living in those counties (an increase of 48,572 from the 2000 Census). Though the average population density of these five counties – approximately 650 persons per square mile – is lower than the state average (1,134 persons per square mile), it is more than eight times the national average. Within those counties, the majority of the residents are located near the shore (see Map 6.1).

Monmouth County, the northern-most county adjacent to the study area, has the highest population (estimated 630,000 persons in 2002) of the bordering counties. Ranked third in size (472 square miles) among the five counties, Monmouth County has a population density of 1304 persons per square mile. Approximately half (51%) of the population lives in municipalities that are within one mile of the coast. Asbury Park and Long Branch are among the seaside population centers.

Ocean County is composed of 636 square miles of land and has an estimated population of 537,000. Its density of 803 persons per square miles is second among the five border counties. Municipalities near the shore account for 66% of the population. The highest density development exists on the barrier islands and near Point Pleasant and Toms River.

Atlantic County has an area of 561 square miles but the least amount of shoreline of the five border counties. This county has an estimated total population of 259,000 and a population density of 450 persons per square mile. Over 60% of the county's residents live in coastal municipalities, especially in the immediate vicinity of Atlantic City.

Cape May County is the southern-most county. As it is a peninsular county, effectively all of its estimated 102,000 residents live in coastal communities. The population is concentrated on the Atlantic shoreline, with Ocean City, Wildwood and Cape May being the most populous communities. This county is the least populated of the five border counties, and is also the smallest. It has an area of about 255 square miles and population density of roughly 400 persons per square mile.

Cumberland County's coastline is entirely on the Delaware Bay. This county is the least densely populated of the five (~300 persons per square mile). In 2002 only about 25,000 of its 148,000 residents lived in communities near the coast. The three population centers – Vineland, Millville, and Bridgeton – are all inland.

6.1.2. State and National Parks

The New Jersey coastline holds numerous state and national parks and wildlife management areas. The New Jersey Coastal Heritage Trail Route, which is managed by the National Park Service, follows the Atlantic and Delaware Bay coastline. This is illustrated in Map 6.2. The trail route begins at Perth Amboy and extends 300 miles south to Cape May Point and around the peninsula along the Delaware Bay up to the Delaware Memorial Bridge. The trail encompasses all of the barrier islands and bays, and in general extends landward just west of the Garden State Parkway, on the Atlantic coast. Just south of Atlantic City the trail extends westward into the Great Egg Harbor River watershed, encompasses the entire Cape May Peninsula, and extends north of the Delaware Bay along the watersheds of the Maurice, Manumuskin, and Cohansey Rivers. Within the trail are several points of interest that include parks, museums, and historical sites.

Map 6.2 also shows the outlines of the major parks and wildlife refuges located within the Heritage Trail. The parks encompass a large portion of the barrier islands and coastal land. The Gateway National Recreation Area is a 1,665 acre national park located on the Sandy Hook peninsula. The park includes seven miles of beach, Sandy Hook Bay, and the surrounding marsh habitats. Island Beach State Park is approximately nine miles of barrier beach located just east of Barnegat Bay and north of Barnegat Inlet. The Edwin B. Forsythe National Wildlife Refuge is the largest park refuge in New Jersey. It extends 25 miles from the southern side of Barnegat Inlet south into Brigantine. The area includes sections of both the barrier islands and the mainland marshes and several smaller wildlife areas including: the Holgate Wildlife Area, the Great Bay Boulevard Wildlife Management Area, and the Brigantine Wilderness Area. Corson's Inlet State Park is a small park located at Corson's Inlet. The Cape May National Wildlife Refuge is made up of several parks located on and around the Cape May peninsula. One section is approximately 6 miles long and the other is 4 miles long. There are several wildlife management areas along the Delaware Bay, including Higbee Beach, Dennis Creek, Heislerville, and Egg Island. Together these areas cover approximately 14 miles of Delaware Bay beach. Approximately 66 miles of coastline in the study area contains wildlife refuge and parkland.

Also depicted in Map 6.2 is New Jersey's designated significant land habitat complex. The land portion of the Significant Habitat Complex was defined by the U.S. Fish and Wildlife Service based upon studies of migration pathways and stopover areas, roosting sites, nursery areas, staging areas, dispersal corridors, core concentration areas, overwintering areas, breeding, nesting, or spawning sites, and major feeding or foraging areas for federal trust (U.S. endangered and threatened species, candidates for listing under the Endangered Species Act, migratory birds, anadromous fish, and marine mammals), state-listed, and regionally rare species found in the watershed. The delineated regions link similar or related habitat types and local species populations for the purpose of ecosystem management.

6.1.3. Industry

Tourism is one of New Jersey's largest industries and a significant component of the coastal counties' economies. The five counties adjacent to the study area represent 57% of the tourism impact in the state. In 2002 New Jersey hosted over 60 million visitors and generated over $26 billion in revenues from tourism. The industry was the state's largest employer in 2002 with 446,000 full-time equivalency jobs providing almost $10 billion in wages. Approximately $2.5 billion in state and local taxes were generated by tourism. Preliminary data from 2003 and future model predictions show a steady growth of the industry. One of the state's largest tourist destinations is the Jersey Shore, with a diverse offering of attractions.. New Jersey has 127 miles of beaches and the coastline has numerous hotels, restaurants and other attractions that cater to visitors. Atlantic City has 13 casinos and Wildwood and Ocean City have large boardwalks that draw tourists.

Several other industries play major roles in the counties bordering the study area. Among the major employers in the area are government and government enterprises, health care and social assistance, construction, real estate, and profession and technical services. In 2001, these industries collectively employed 338,000 full and part time workers and generated $14.5 billion in personal income.

One of the unique industries along the New Jersey coast is commercial fishing. There are five major fishing ports located at Belford, Point Pleasant, Barnegat Light, Atlantic City, and Cape May/Wildwood. In 2002, commercial fishery landings from the Cape May / Wildwood, Atlantic City, and Point Pleasant ports totaled $77.4 million dollars. The Cape May / Wildwood port was ranked 13th in the United States in landings by dollar value, totaling $35.3 million that year.

6.2. Location of Ports and Logistics

An offshore wind project will rely on the existing transportation infrastructure. Map 6.3 depicts the major commercial/industrial port cities near the study area and the transportation network in place throughout the state. A port of sufficient size and facilities is essential to the installation phase of an offshore wind project. Adequate space on land is needed to deliver, store and pre-assemble turbine components prior to loading them onto a transport vessel that delivers them to the construction site. The amount of port space necessary depends on the equipment being used (turbine, blades, transport vessel, cranes, etc.) and the amount of assembly performed onshore (e.g., blades assembled on rotor, tower sections welded together, etc.) prior to loading onto the transport vessel. The proximity of a port to a project during construction also has a bearing on construction costs and schedules due to transit times between the port and the site.

Two major ports exist within or in close proximity to the study area: the Port of New York and New Jersey, and Atlantic City. The Port of New York and New Jersey has over 1,100 waterfront facilities, the majority of these having direct rail and highway connections. Most of the facilities are privately owned and operated, while various government bodies (city, state, or federal) operate the others. Heavy lifting equipment, cranes and lifts up to 500 tons, are available in the harbor. The three major New York area airports also serve the port area. The Atlantic City port serves as a hub for a large fleet of fishing vessels and pleasure craft. The city has highway, railroad and air connections with the mainland. While this port does not have the industrial facilities to support a wind farm installation, its location makes it suitable as base for O&M operations. Details on the facilities and equipment on hand at this port are available through the harbormaster or local port authority.

The southern portion of the study area also has access to other ports via the Delaware Bay and the Delaware River. Several industrial ports are located in Delaware, New Jersey, and Pennsylvania, as shown in Map 6.3. These ports are all served by highway and railroad connections, and offer a variety of facilities for component storage, movement and other logistics.

The equipment, vessel types, and construction techniques chosen for project installation will dramatically affect the construction time. In Europe, at least two different schemes have been recently employed to erect offshore wind parks. The first is a two-vessel system where a dedicated transport ship brings the components to the site. At the site, an erection vessel (typically a jack-up barge) with a heavy crane installs the turbine. This method was used while constructing the North Hoyle farm in the United Kingdom. An additional self-sufficient (transport and installation) vessel worked in parallel with the two-ship team. These three ships installed 30 turbines over a span of six months.

The other installation scheme used one or more specially outfitted vessels to transport the turbines (up to 10 machines at once with the newest design) and perform the installation. This technique was used at the two Danish projects, Horns Rev and Nysted. Horns Rev used a team of these ships and installed 80 turbines in three and a half months. The Nysted project installed 72 turbines in 3 months using a similar technique. This system simplifies logistics by requiring fewer vessels and limiting the trips to port (two to four complete turbines were carried to sea on each vessel).

6.3. Aviation

The height and breadth of an offshore wind project will affect the navigable airspace around it. Current and near-term turbine technology requires planning for structures (including blades) extending up to 450 ft above mean sea level. The Federal Aviation Administration (FAA) regulates the siting of such structures in the proximity of airfields and in certain navigable airspace. Federal Aviation Regulation (FAR) Part 77[24] states that all proposed turbine locations require notice to the FAA. This may also include the development of a lighting scheme for the project as well as other aids to air navigation.

There are a total of twelve public and military air facilities (eight Civil IFR Airports, one Military IFR Airport and two VFR Heliports) located in the proximity of the New Jersey coast. The study area also includes several VOR (Very high frequency Omni-directional Range) Federal Airways and Radar Vectoring Airspace. Summary review of FAA regulations pertaining

[24] FAR Part 77, § 77.13 paragraph (a) (1).

to this study area has yielded three regions limiting offshore wind development. Map 6.4 illustrates the air facilities and the regions with restrictions.

The first region is from Spring Lake Heights south to Seaside Park, extending 10 nautical miles offshore. This area is restricted by the Maximum Obstruction Clearance Altitude (MOCA) rules of Airway V276. This airway has a 1400 ft minimum flight ceiling and minimum obstruction clearance of 1000 ft. The FAA grants structures a 49 ft grace on this restriction, bringing the maximum turbine height to 449 ft above mean sea level in this area.

The second region extends from Brigantine southwest to Strathmere and stretches 2.5 miles offshore. Structures in this area fall under FAR 77[25] glide-slope restrictions for nearby air facilities. The border illustrated in Map 6.4 is an approximation. Development near the Atlantic City area shore would require further analysis of the Atlantic City Municipal Airport, the Steel Pier Heliport and the Ocean City Municipal Airport.

The third region extends 2.5 miles offshore from Wildwood around Cape May into the Delaware Bay. This area is also limited by the FAR 77 glide-slope requirements. Evaluations of the Cape May Municipal Airport and the Coast Guard Heliport will be necessary if development is planned near this area.

Initial inquiries with the U.S. Navy and the U.S. Air Force indicate no concern or objection with the aeronautical aspects of projects within the study area. However, the size of the study area and its air traffic use can only be covered by general responses. Specific offshore wind development will require consultation with the FAA, U.S. Coast Guard, U.S. Navy and U.S. Air Force regarding its impact on aviation.

6.4. Transmission System Assessment

6.4.1 Scope of Required Facilities

An offshore wind facility must transmit power to shore in order to interconnect with existing grid infrastructure. While such facilities have yet to be deployed in the US for the purpose of offshore wind power transmission such facilities would be identical to the submarine power transmission facilities deployed throughout the US and the world. The scope of these transmission facilities would typically include one or more armored cables that would be buried in the seabed to a depth sufficient to ensure they remained covered through natural sediment shift or external aggression from anchors, fishing gear or otherwise. Through the surf zone and across the beach and dune areas it has become common practice to install a directionally bored conduit, through which the transmission cable would be fed, to eliminate the need for surface disturbance of the dune and beach areas. Once onshore the transmission cable would proceed to the interconnection point via direct burial, conduit, or aerially as conditions dictate.

[25] FAR Part 77, § 77.13 paragraph (a) (2).

6.4.2 Interconnection Requirements

To be economically feasible, offshore wind projects generally need to be large in terms of both the number of turbines and total installed capacity (> 100 MW). The thermal capability of existing lines must therefore be sufficient to deliver the power from an offshore wind project to the utility's load centers. The thermal capability of transmission lines rated at 138 kV and higher meet this requirement. Lower voltage lines (69 kV and below) would need to be upgraded to at least 138 kV in order to inject large amounts of wind generation from a single offshore location into the existing bulk power system.[26] Other factors affecting the choice of potential injection points include landfall locations that offer a low-impact route for marine cable, the lack of transmission congestion or the need for costly upgrades, and substation capacity.

The existing transmission grid adjacent to the New Jersey coast consists of a network of 138 kV and 230 kV lines inland feeding loads on the outer banks or barrier islands via a subtransmission and distribution network of 69 kV (Atlantic City) or 12.9-34.5 kV lines.[27] A map showing existing transmission lines and substations rated at 138 kV and above is shown in Map 6.5. A preliminary assessment of the amount of wind generation that could injected into the bulk power system (138 kV and above) at various points (substations) in close proximity (3-9 miles) to the New Jersey coast was performed for this study based on a review of 2002 Series North American Electric Reliability Council (NERC) power flow data for the 2004/05 Winter Case.

Given that peak load, and to a greater degree transmission and generating facilities are likely to change with time, analysis beyond the preliminary stage is location specific and subject to a queuing process administered by PJM, the Regional Transmission Organization for New Jersey. Such analysis, which would confirm available injection capacity and/or define the necessary grid upgrades, would be required for any specific development to proceed but is beyond the scope of this study.

The maximum amount of wind generation that could be injected into the bulk power system at each point was estimated by summing up the normal ratings of all lines connected to each substation plus any local load served by the subtransmission/distribution system less the highest normal line rating of any single circuit connected to the substation of interest to account for local contingencies (or the loss of a single transmission line). The maximum values assume that an equal amount of existing generation can be redispatched (output reduced) in order to maintain the required balance between electricity supply and demand. If redispatch is not possible, the amount of wind generation that could be injected at each location will be lower than the estimates presented in this report.

A lower range estimate on the amount of wind generation that could potentially be injected into the bulk power system at each point was determined by adding 50% of the normal rating of the single lowest rated line connected to each substation to 50% of the local load served by the subtransmission/distribution system. In the case of Sands Point, the lower range estimate is limited to only 50% of the local load served by the subtransmission/distribution system. The

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[26] For example, the normal ratings of the 69 kV lines connected to the Lewis substation range from 72 to 120 MVA. The normal ratings of the 34.5 kV lines connected to the Manitou substation range from 32 to 69 MVA. One MVA is equivalent to 1 MW generated at unity power factor.

[27] The backbone of the existing grid between Lewis and Sands Point is a series of 69 kV lines. A new 230 kV line between Cardiff and Sands Point is currently in the permitting phase.

reason for this is that Sands Point is currently interconnected to the rest of the bulk power system by a single 230 kV line to Oyster Creek. If a fault were to occur on this line, wind generation would be left to serve only the 69 kV loads connected to the Sands Point substation. In the case of Oyster Creek, the nuclear units are assumed to be unavailable for redispatch, and therefore a low range estimate on the amount of wind generation that could be injected into the bulk power system at that location is limited to the normal rating of the one of the Oyster Creek Manitou circuits minus nuclear unit output plus 50% of the local load.

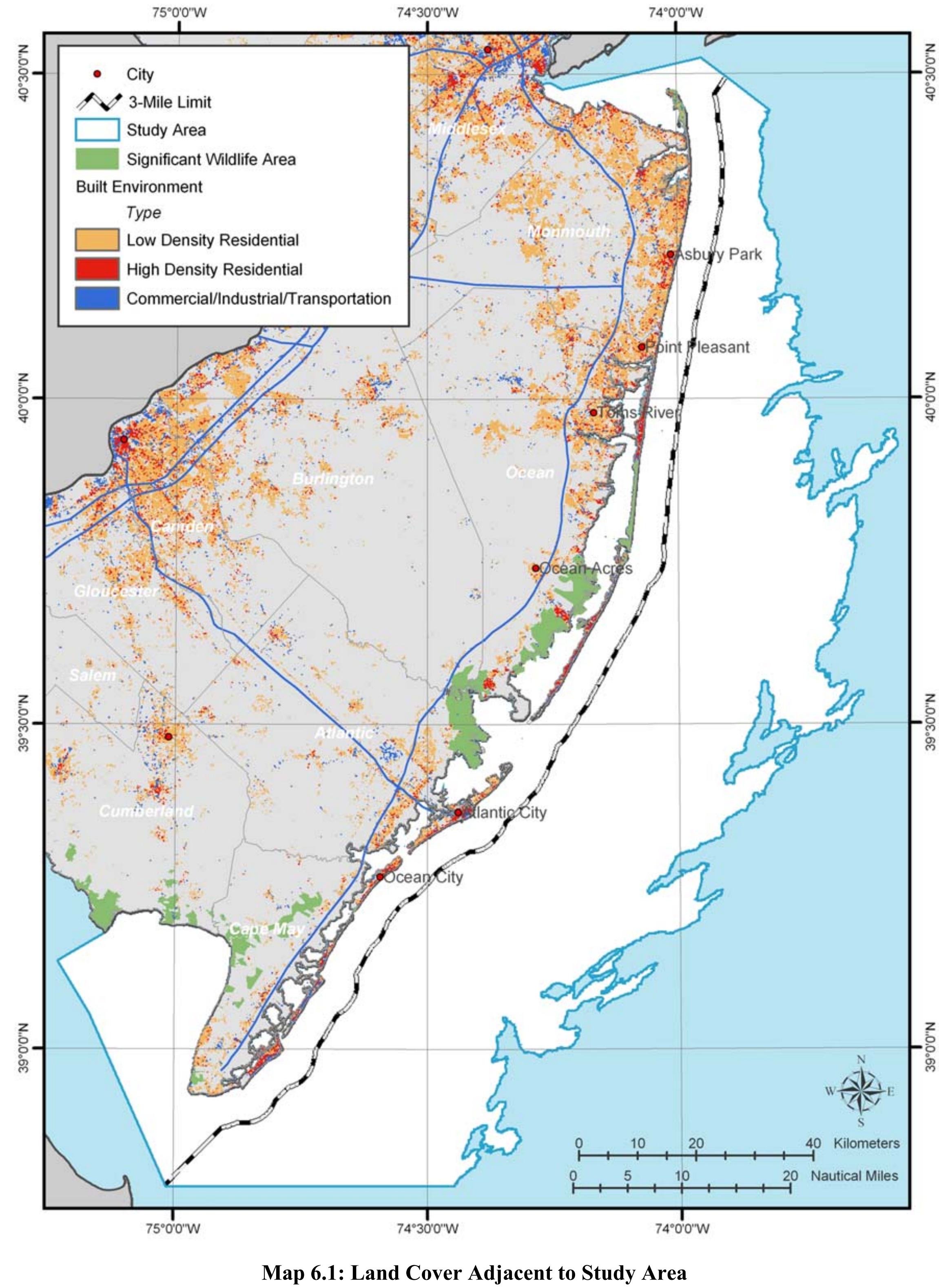
Table 6.1 shows the results of this assessment for each 138 kV and 230 kV substation in close proximity to the New Jersey coast from the south to north. The results indicate that the existing transmission grid in the vicinity of the New Jersey coast is likely capable of accepting significant amounts of wind generation from offshore facilities. These results will need to be further defined based on thermal screening (load flow) studies.[28] The results also indicate that the amount of wind generation that can be injected into the grid varies significantly depending upon the location of the injection point.

Table 6.1: Maximum and Lower Range Estimates of Allowable Wind Penetration for Major Substations along the New Jersey Coast

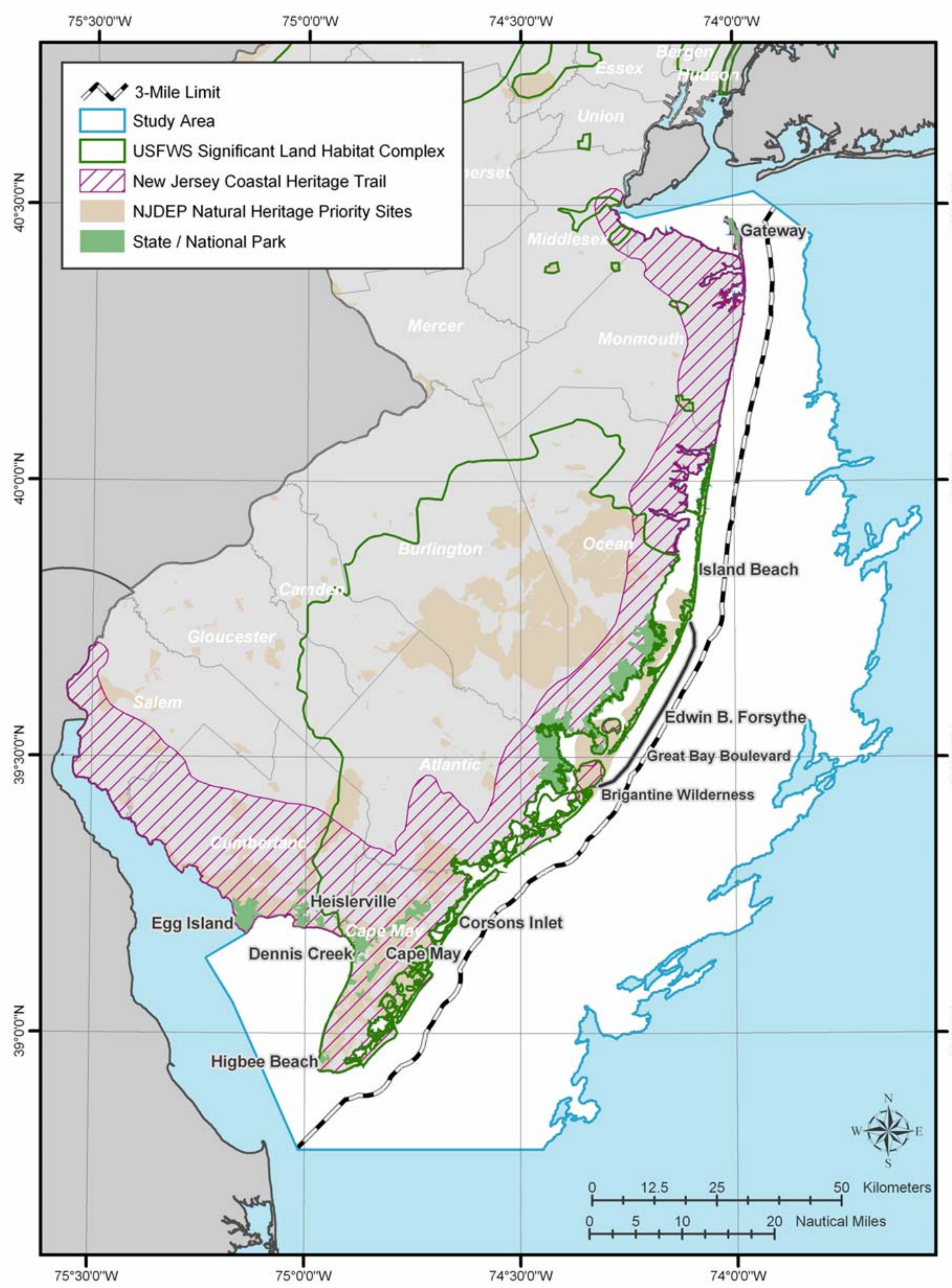
No. of Circuits (Lines) x Line Voltage (kV)	Substation Name	Maximum Wind Penetration at this Location (MW)	Lower Range Estimate of Allowable Wind Penetration at this Location (MW)
2 x 138	Middle	355	178
5 x 138	Corson	789	130
4 x 138	BLEngland	653	112
4 x 138	Scull	669	120
4 x 138	Mill	677	124
4 x 138	Lewis	711	171
3 x 230	Oyster Creek	318	90
1 x 230	Sands Point	138	69
5 x 230	Manitou	1213	448
4 x 230	Leisur	2289	404
4 x 230	LkwdGen	2233	371
6 x 230	Larrabee	3928	482
2 x 230	Oceanview	579	290
8 x 230	Atlantic	3954	276
3 x 230	Red Bank	945	472
3 x 230	Freneau	878	439

[28] Load flow studies are but one of several types of analyses performed by utility engineers to assess power delivery impacts on the transmission system and to ensure that system reliability criteria are met. Lower limits may be imposed based on the results of these detailed analyses. The Pennsylvania-New Jersey-Maryland Interconnection's Process for evaluating generation interconnection requests includes three analytical steps – an *Interconnection Feasibility Study, System Impact Study*, and *Interconnection Facilities Study.*

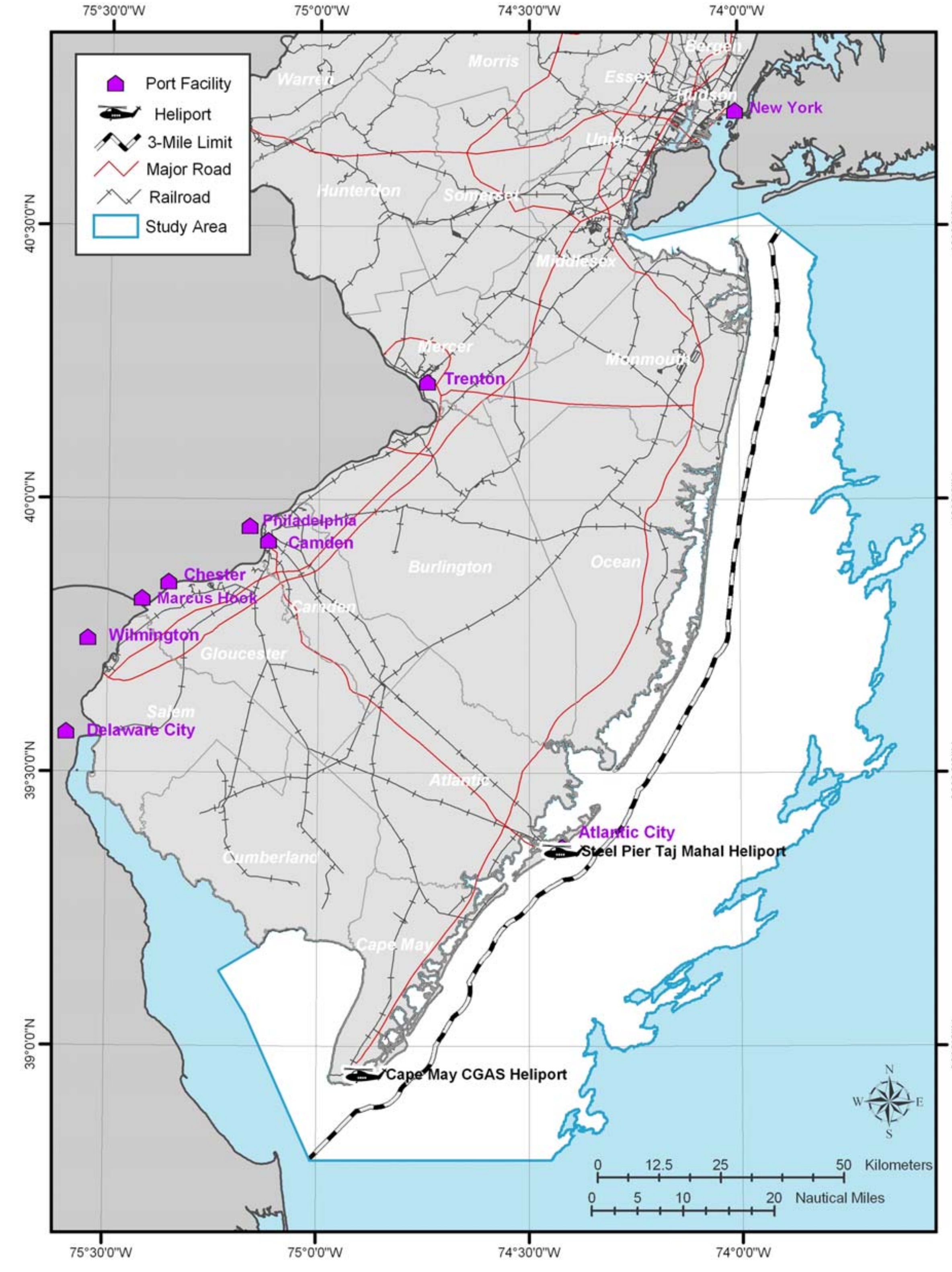
6.5. Maps



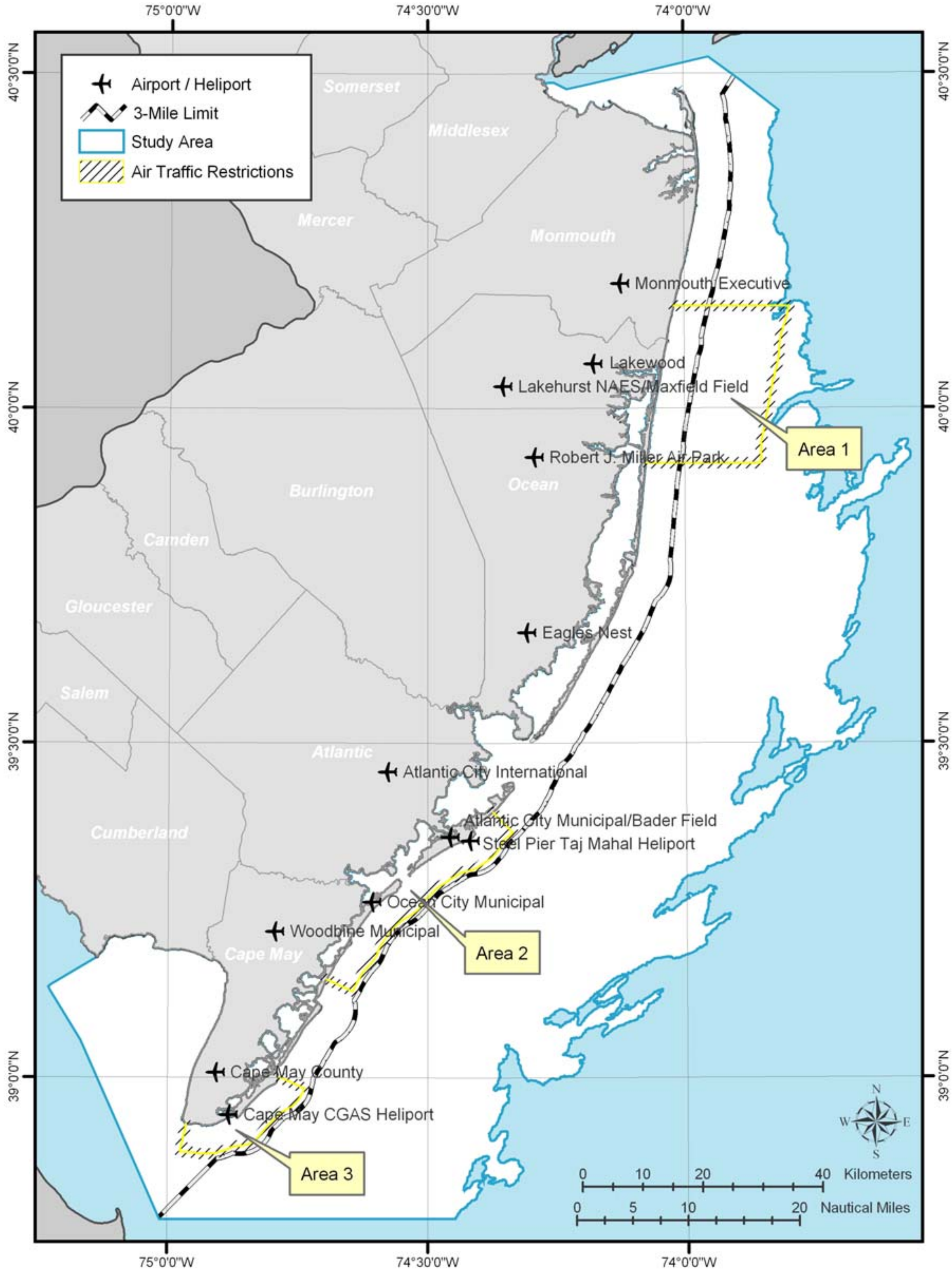
Map 6.1: Land Cover Adjacent to Study Area



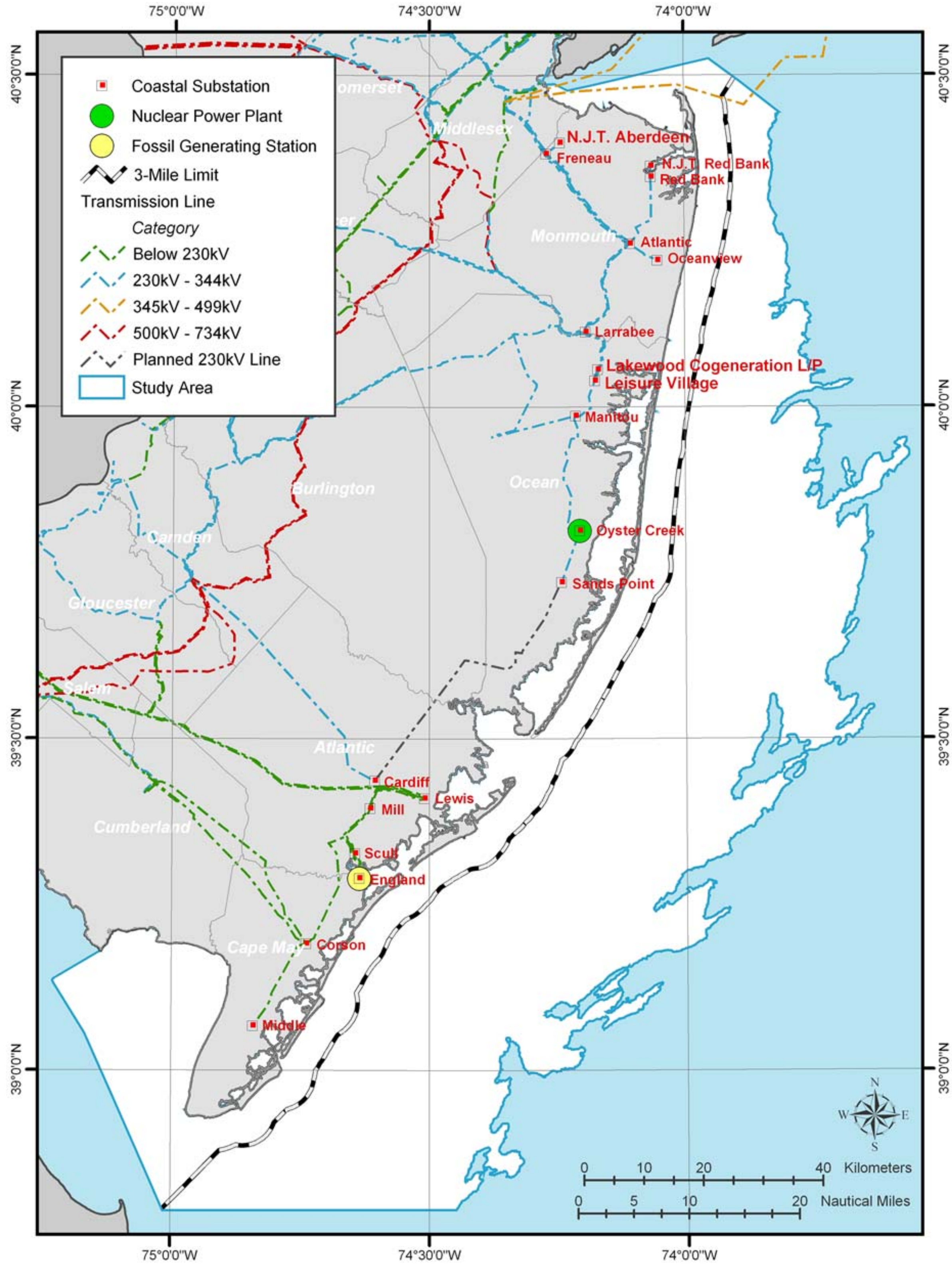
Map 6.2: State and National Parks



Map 6.3: Ports & Transportation Infrastructure



Map 6.4: Aviation Restrictions



Map 6.5: Transmission System Of Coastal New Jersey

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7.0. Siting Analysis

This study has identified a variety of siting factors and considerations for offshore wind energy development in New Jersey's offshore waters. The relative roles that these factors and considerations will play in any future offshore development activity will depend on locale, the size of the project, and economics. In an attempt to evaluate the relative attractiveness of different portions of the study area for offshore wind development, this chapter assesses the net effects of the site screening factors evaluated thus far.

This siting analysis first focuses on three groupings of siting parameters: 1) bathymetry, wind resource and transmission; 2) existing uses and obstructions; and 3) natural resources. Large maps are provided for each grouping of siting parameters, printed individually in sections for the northern, central and southern portions of the New Jersey shoreline. An evaluation is then made of the relative attractiveness of the overall study area, with the most attractive areas identified after eliminating selected siting attributes.

7.1. Northern New Jersey Coast

This portion of the study area, which includes sections of Middlesex, Monmouth and Ocean counties, offers the fewest opportunities for offshore wind development. This is due to the lower wind resource availability compared to the other portions (see Map 7.1), air traffic restrictions, and shipping lanes (see Map 7.2). Average wind speeds for most of this region are less than 8 m/s, with most of the windier areas intersected by designated shipping lanes where wind project development would be excluded. Air traffic safety concerns exist for a large segment of the area as well.

The charted dumpsites and sewer outfalls in this area already lie within areas deemed unattractive for vessel traffic or wind resource reasons. There is a high concentration of shipwrecks and several underwater cables cross the area. Given their relatively small size, however, these obstructions do not pose significant siting constraints. Sand borrow areas do exist here and should be avoided.

Natural resources (see Map 7.3) add additional siting considerations but not to a degree that would necessarily exclude wind project development. The primary gear used by commercial fisheries in area code 612, which constitutes most of this portion of the shoreline, is the otter trawl. Recreational fishers and shellfishers also use this area extensively. Fish trap areas and artificial reefs are mostly within the 3-mile limit, where wind resources are relatively light. There are a few onshore wildlife areas and parks (Gateway National Recreational Area, Sandy Hook National Park) that serve as important habitats for birds and other wildlife.

7.2. Central New Jersey Coast

The central Jersey coast adjacent to Ocean and northern Atlantic counties offers significantly more wind energy development opportunity. Strong wind resources (>8 m/s) prevail beyond 3 miles from shore (see Map 7.4) and exceed 8.5 m/s beginning approximately 12 miles from shore. The 70 ft water depth line extends about 6 miles offshore in northern sections to 10 miles further south; the 100 ft water depth line runs 20 miles offshore. Onshore, the transmission grid runs within four miles from shore in the northern and southern portions of this area; five substations are within two miles of the shore. Access to the main grid system is very limited in the middle portion of this area.

Map 7.5 depicts the primary existing uses and obstructions for the central shore. The Ambrose – Barnegat traffic lanes extend into this area from the north and would exclude wind development there. There is also a charted danger area 16 miles east of Little Egg Inlet should also be avoided. Four large proposed sand borrow areas are designated just outside the 3-mile limit. Air traffic activity in the vicinities of Atlantic City and Ocean City would likely impose near-shore development limitations there.

Offshore of the central coastline there are numerous underwater structures and navigational concerns. Similar to the northern coast, many charted shipwrecks are present together with several groups of cables transit that make landfall in this area. The relatively small size of these obstructions would not significantly limit wind development viability. Another area of note is east of Little Egg Inlet (straddling the 3-mile limit) where an array of oceanographic research buoys is located.

The central coast also has a high concentration of commercial and recreational fishing use (see Map 7.6) as well as boating activity. The Barnegat, Beach Haven, Little Egg, Brigantine and Absecon Inlets all reside in this area. The primary fishing gear used in areas 614 and 615 is the sinking gill net. Extensive fish traps areas exist within the 3-mile limit. Several artificial reefs are located out to a water depth of about 70 ft. The adjacent land area has a high concentration of parks (notably Island Beach State Park), wildlife areas and protected lands. The overlapping of identified coastal water and land habitat essentially forms one homogeneous zone.

7.3. Southern New Jersey Coast

The southern portion of the study area is adjacent to Cumberland, Cape May and southern Atlantic counties and includes a portion of Delaware Bay. Like the central portion, this area possesses strong wind resources (>8 m/s) relatively close to shore (see Map 7.7); average wind speeds above 8.5 m/s are predicted 12-16 miles offshore. Wind in the Delaware prevails between 7.5 and 8.0 m/s. Water depths less than 70 ft extend 8-12 miles from shore; 100 ft depths begin approximately 20 miles offshore. The transmission grid, including several substations, is 3-4 miles from shore for much of the area but is further inland in Cumberland County.

Vessel traffic necessitates excluding portions of the southern study area from development (see Map 7.8). Delaware Bay's precautionary areas and the approaching shipping and traffic lanes are unsuitable for wind project siting. Also excluded is the danger area near this region. Structure height limitations exist in the air traffic restriction zones along most of the coastline (within 3 miles). Shipwrecks are moderately concentrated in this area, and only a few cables are located here. A few proposed sand borrow areas extend 3 to 8 miles offshore.

This area also experiences a high concentration of fishing and shell fishing, in both State and Federal waters, and contains abundant natural resources (see Map7.9). The Cape May/Wildwood port is New Jersey's largest fishing port. Surfclam, quahog and oyster fisheries are numerous through out his area. There is extensive commercial and recreational fishing throughout the area, particularly off of the Atlantic coast. Inlets include Great Egg Harbor, Corson's, Townsend's, Hereford, and Cold Spring. The USFWS significant water habitat in this region extends further from shore around Cape May and into Delaware Bay. Cape May and the inland Significant Land Habitat areas are some of the most important avian use areas in the country.

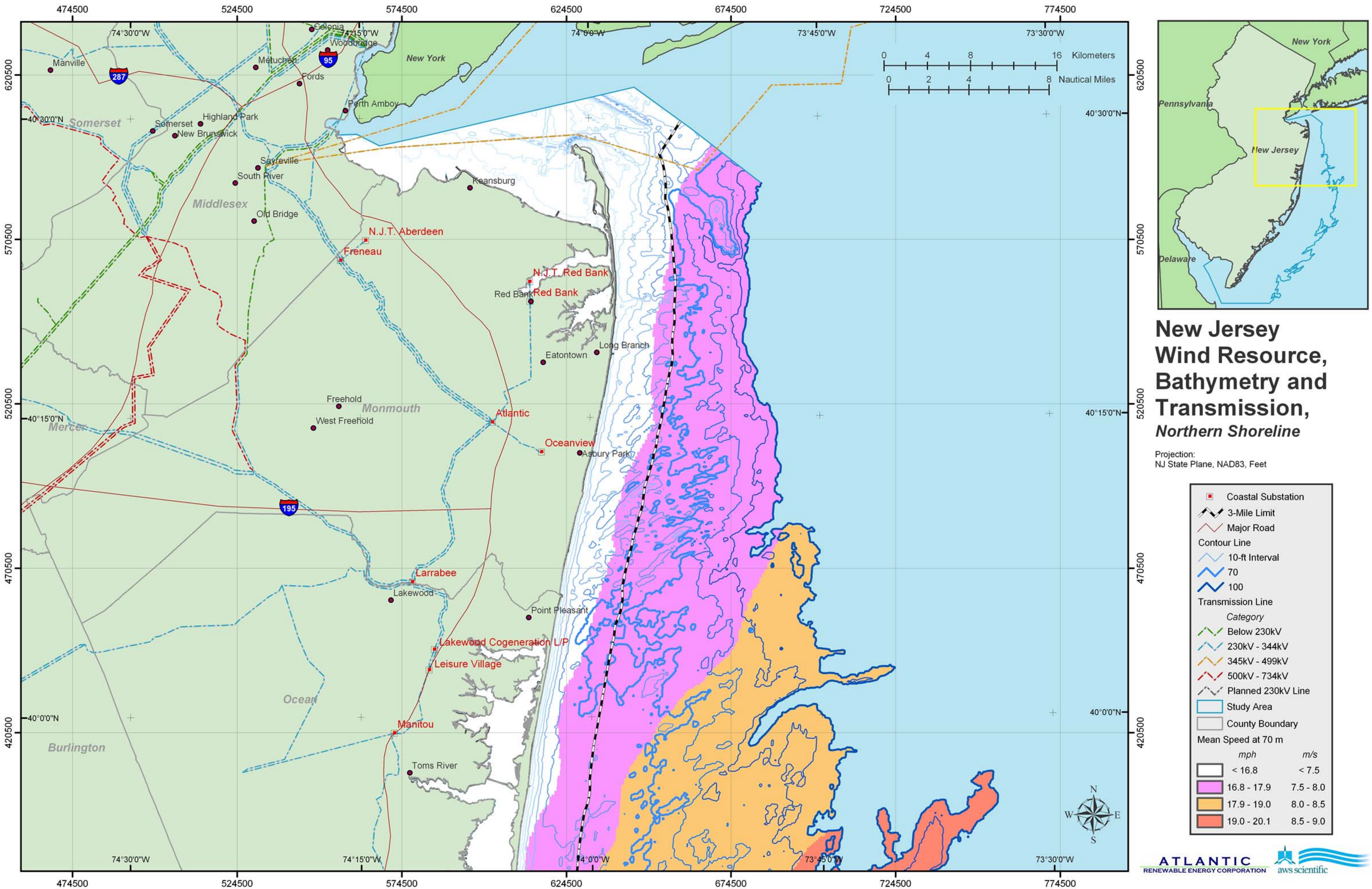
7.4. Summary of Project Siting Viability

Map 7.10 depicts the relative viability of offshore wind project siting for the entire study area. The shaded portions of the study area are designated as "least viable" for development based on one or more of the siting parameters discussed above. The key attributes that placed water areas into this category include: shipping lanes, significant water habitat, average winds below 8 m/s, sand borrow and danger areas, artificial reefs, and structure height restrictions due to air traffic. Some of these attributes overlap most of the shoreline within the 3-mile limit where coastal natural resources, recreational boating, and fishing ports are also concentrated.

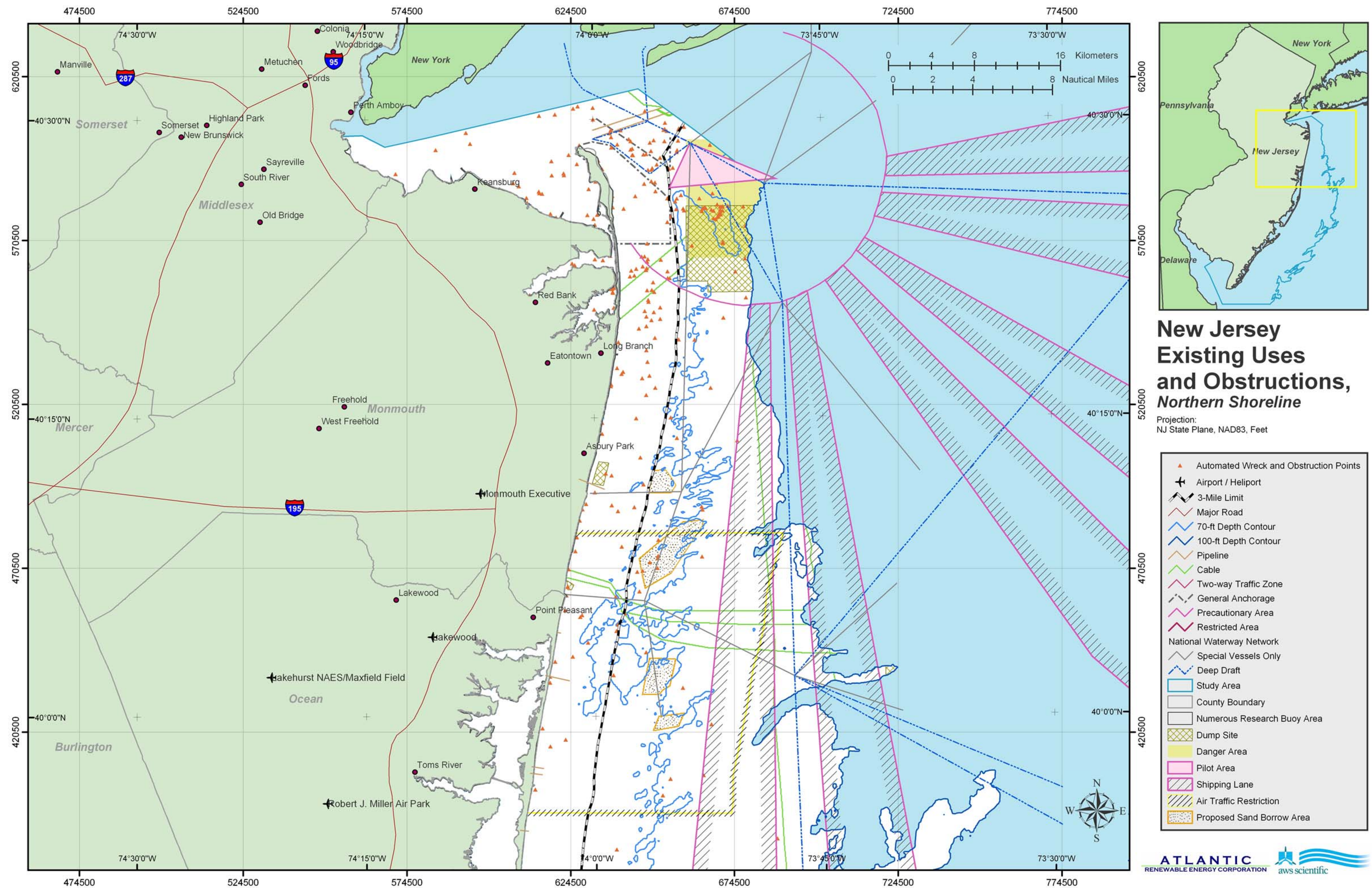
The remaining, unshaded area is considered to be conditionally viable for offshore wind development. This area possesses fewer obvious siting conflicts, but important considerations still exist that must be addressed when conducting future project siting activities. Of the original 2,465 nautical square mile study area, approximately 50% (1,223 sq. mi.) is considered to be conditionally viable for development. Map 7.10 illustrates the wind resource magnitude of this area as well as the location of the 70 ft and 100 ft water depth contours.

The amount of water area occupied by a wind project will depend on the number of turbines and the spacing distance between them. Assuming a 3 MW wind turbine having a 100 m rotor diameter and an average spacing between turbines of seven diameters (or 0.4 nautical miles), a 100 MW wind facility would extend over a 5 sq mile area while occupying less that 1% of the seabed within this area.[29] Different wind turbine sizes would not change this area significantly. Hence, New Jersey's conditionally viable offshore area has a large potential for wind-based energy generation. The utilization of every one percent of this conditionally viable area would mean the addition of 244 MW of wind-based generation capacity to New Jersey's energy mix.

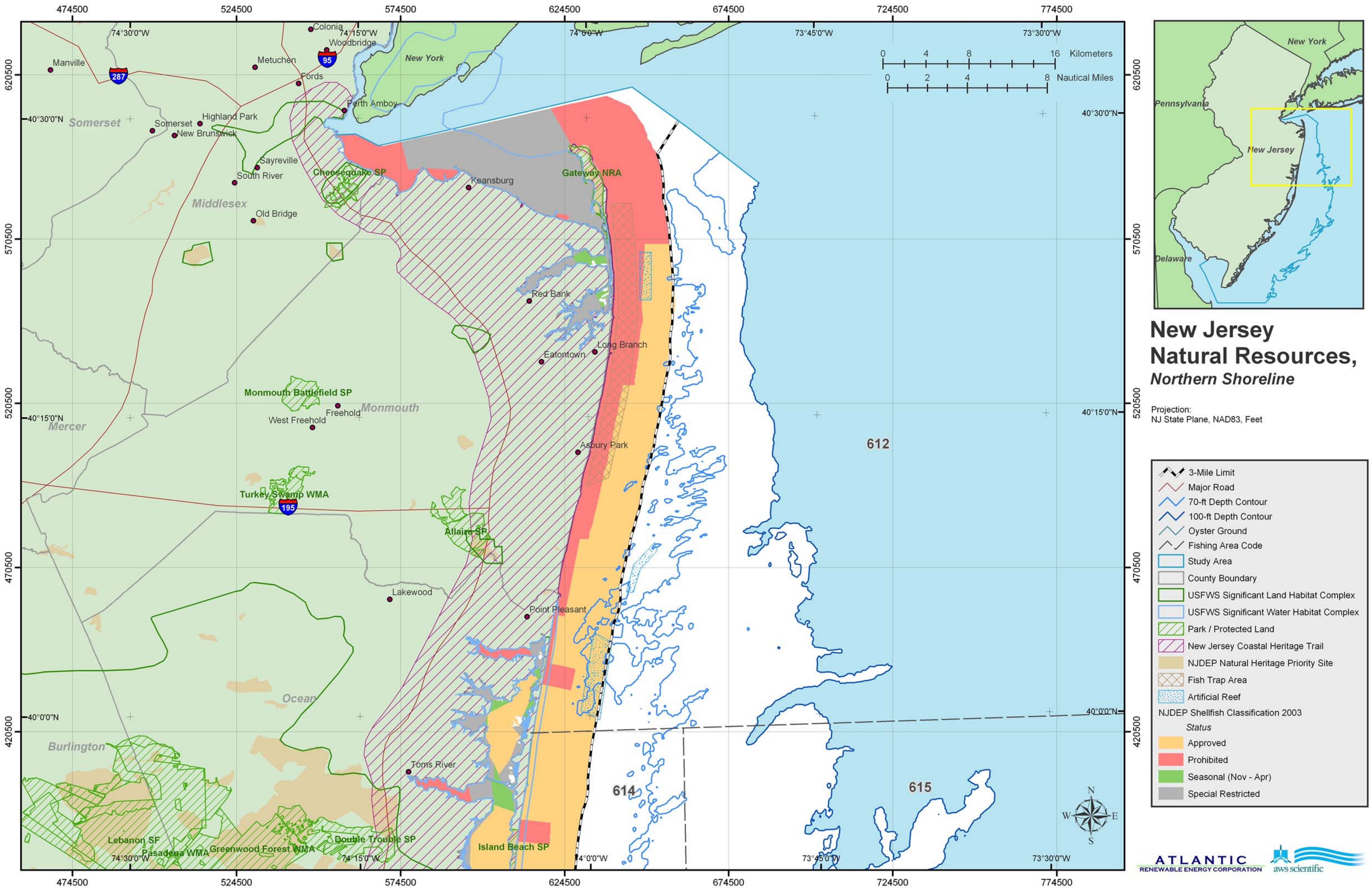
[29] Structures will occupy less than one percent of the project area, allowing for other water uses between turbines.



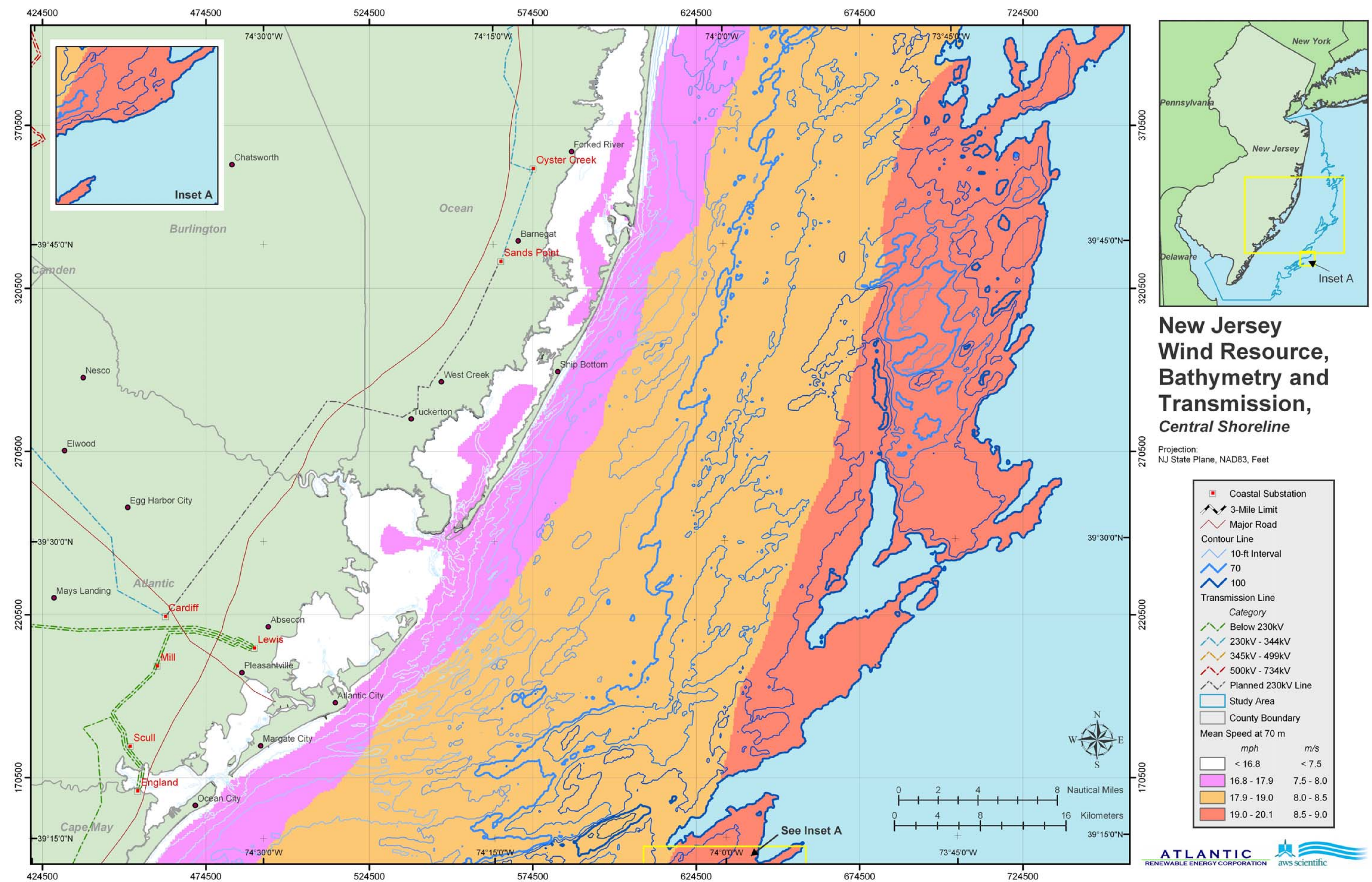
Map 7.1: New Jersey Wind Resource, Bathymetry, and Transmission, Northern Shoreline



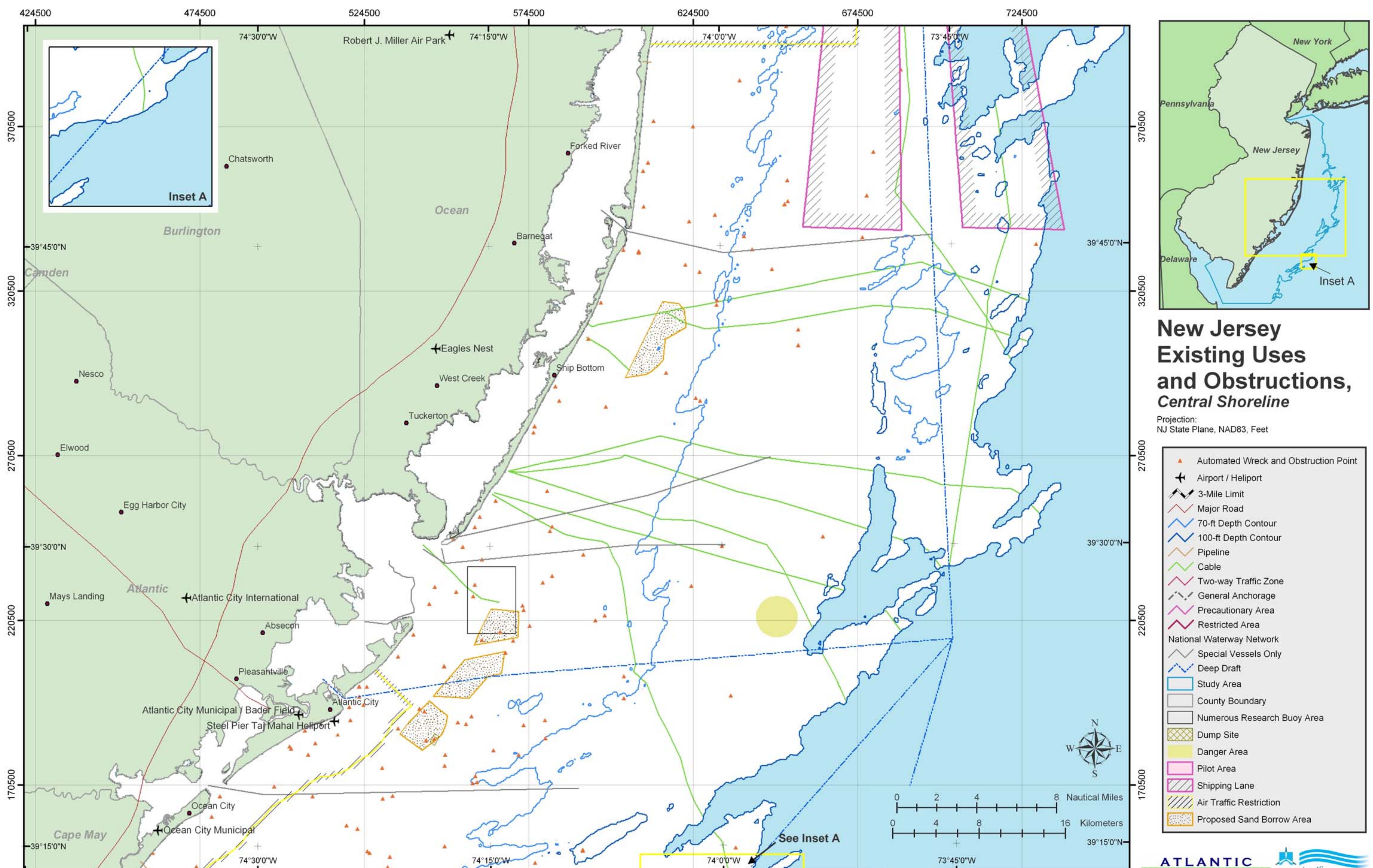
Map 7.2: New Jersey Existing Uses and Obstructions, Northern Shoreline



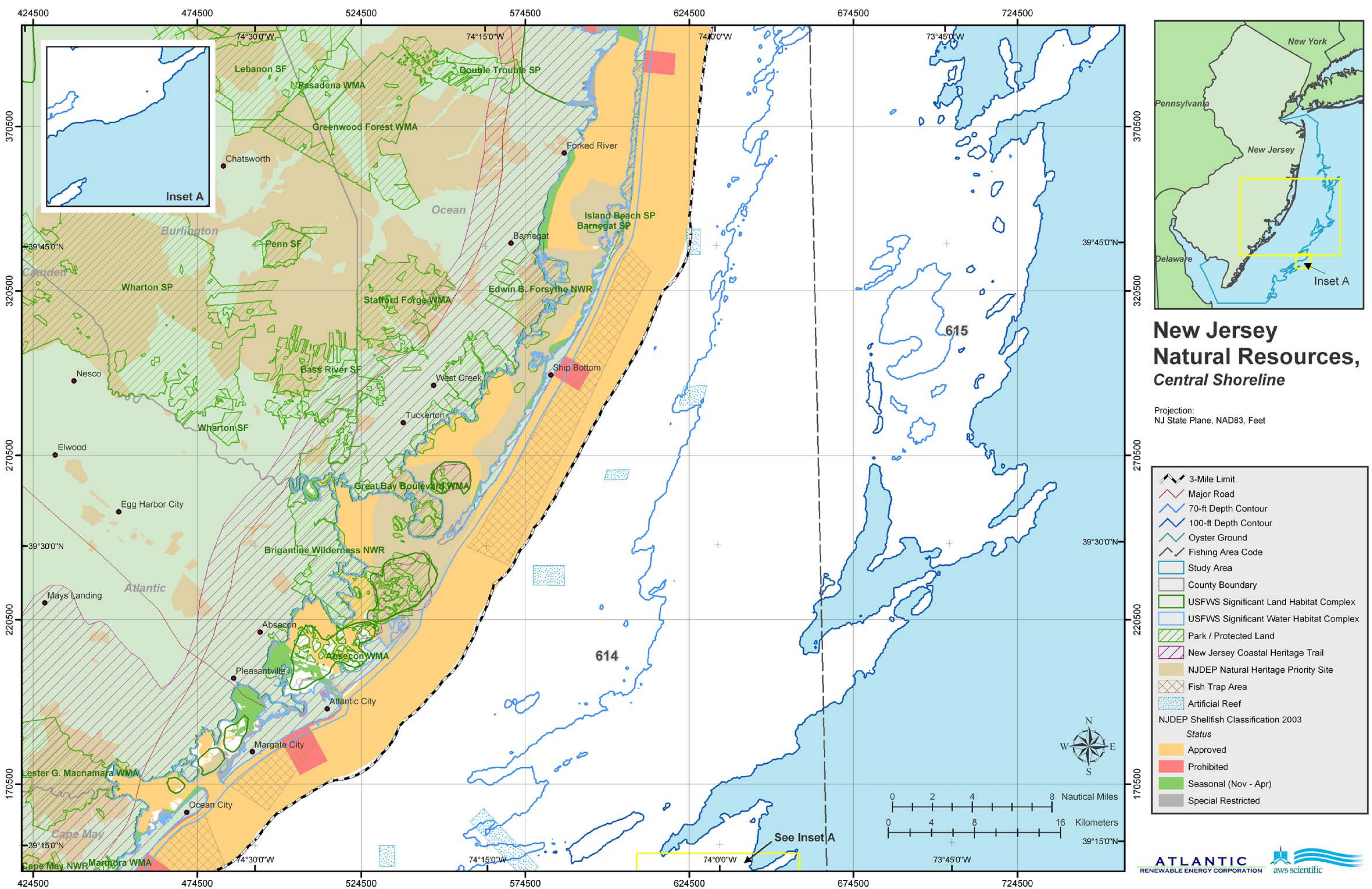
Map 7.3: New Jersey Natural Resources, Northern Shoreline



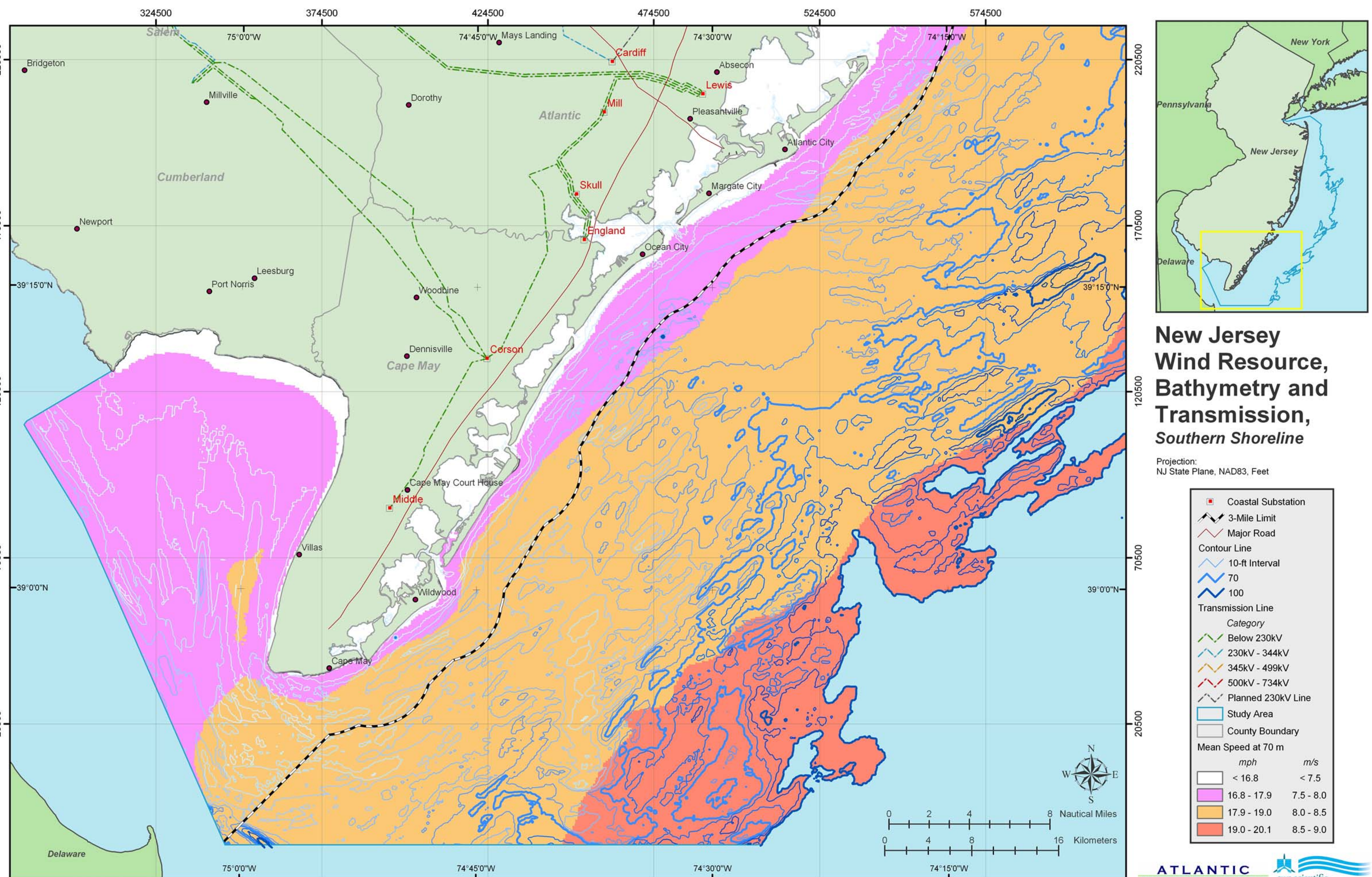
Map 7.4: New Jersey Wind Resource, Bathymetry, and Transmission, Central Shoreline



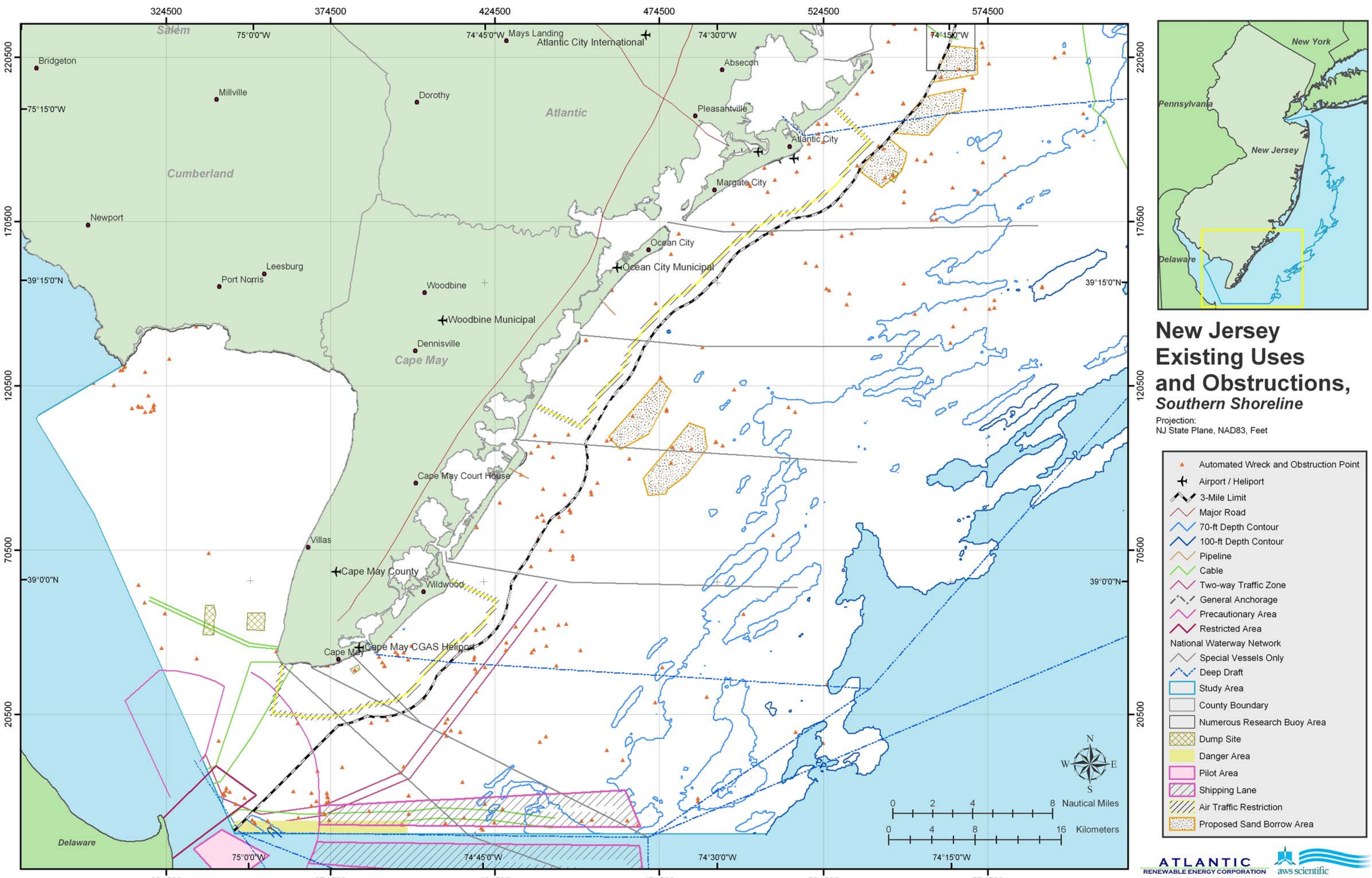
Map 7.5: New Jersey Existing Uses and Obstructions, Central Shoreline



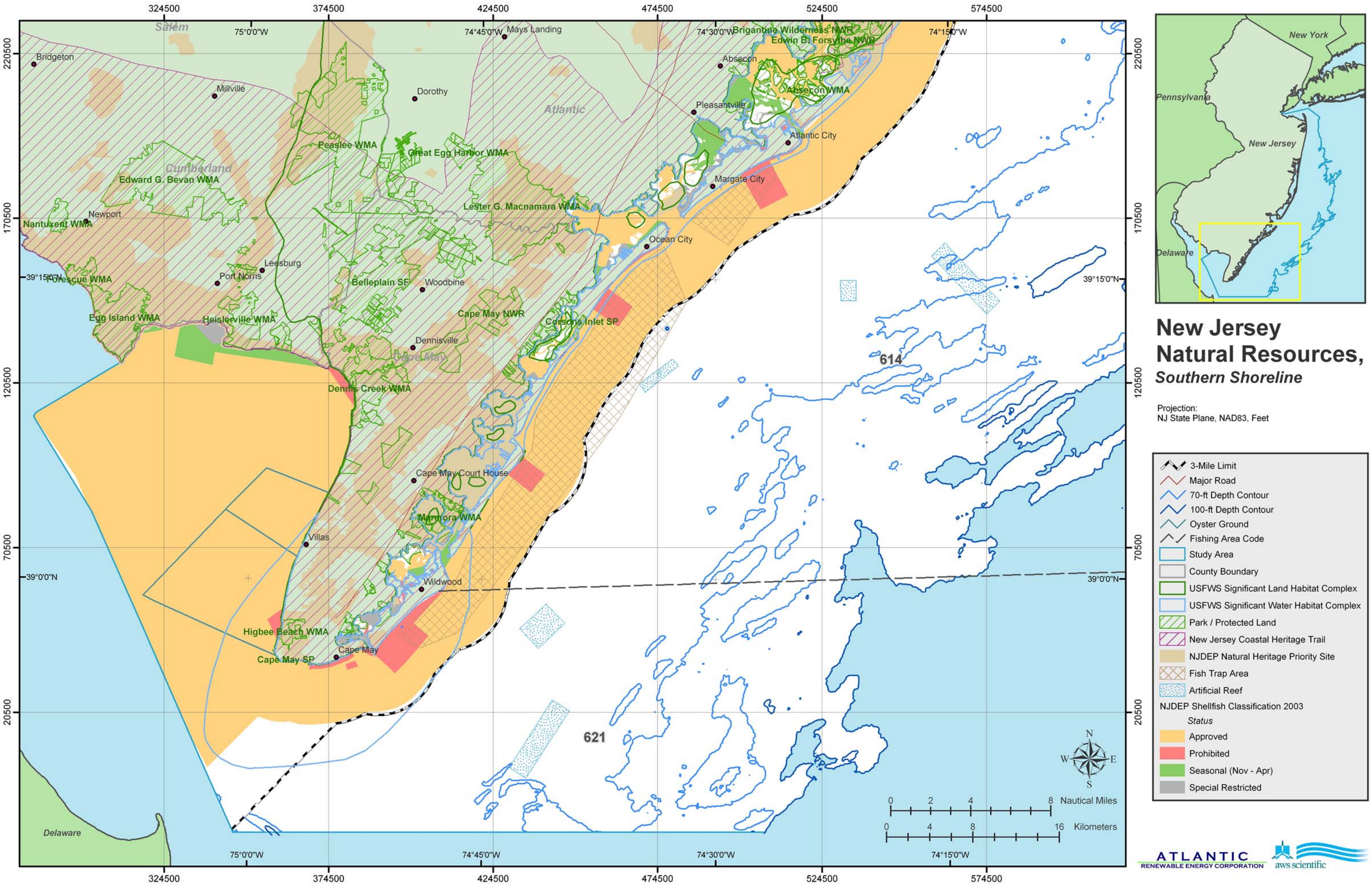
Map 7.6: New Jersey Natural Resources, Central Shoreline



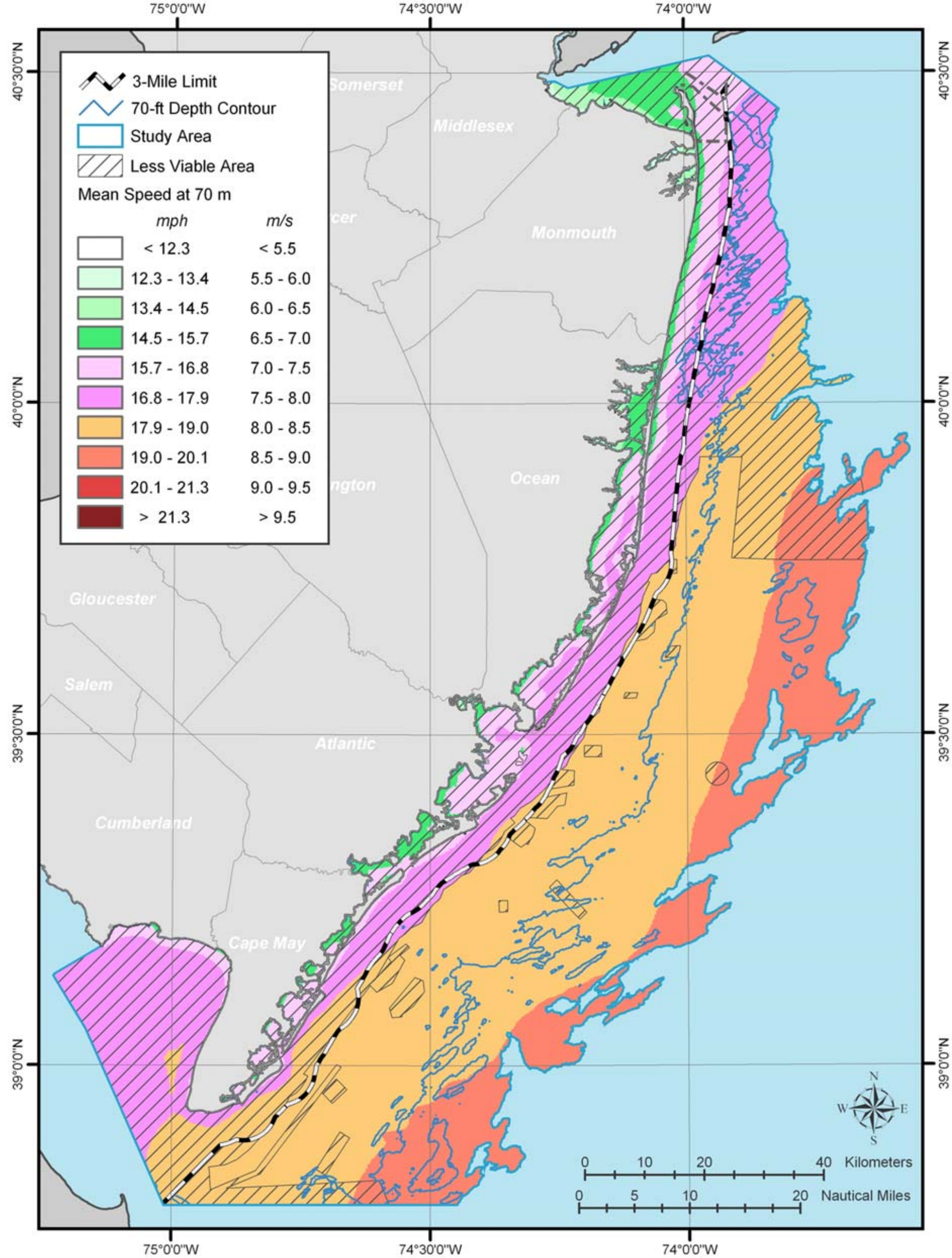
Map 7.7: New Jersey Wind Resource, Bathymetry, and Transmission, Southern Shoreline



Map 7.8: New Jersey Existing Uses and Obstructions, Southern Shoreline



Map 7.9: New Jersey Natural Resources, Southern Shoreline



Map 7.10: Study Area Viability

8.0. Legal and Jurisdictional Evaluation

The purpose of this chapter is to describe the permitting and approval process for an offshore wind energy project located in New Jersey State or adjacent federal waters. Such a project, including both offshore and onshore elements, would encounter Federal, State and Local jurisdiction. To examine the jurisdictional issues in detail, it is useful to examine the elements that make up an offshore wind facility from a geographic perspective (Figure 8.1).

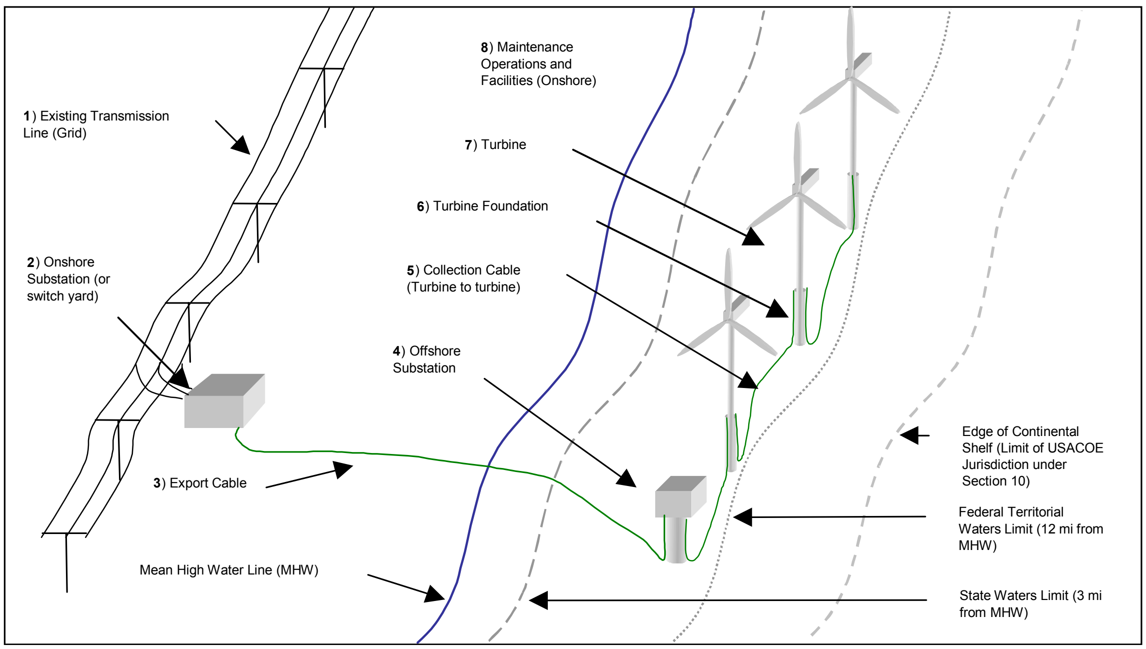


Figure 8.1: Offshore Wind Farm Spatial Representation

8.1. Federal Jurisdiction

8.1.1 US Army Corps of Engineers (USACOE)

The USACOE has authority over navigable water defined as "…those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible for use to transport interstate or foreign commerce." (33 C.F.R. Part 329)

The Rivers and Harbors Act (RHA) of 1899, Section 10 (33 U.S.C. 401 et seq.) provides the US Army Corps of Engineers with permitting authority over projects that include construction, excavation, or deposition of materials in, over, or under such waters, or any work that would affect the course, location, condition, or capacity of navigable waters [to the limit of the continental shelf]. 33 U.S.C. § 403. As shown in Figure 8.1 this authority extends shoreward to the mean high water line. The turbines, offshore substation, other associated infrastructure, and temporary or permanent features related to construction or maintenance (such as port facilities) would be covered under the RHA.

Section 404 of the Clean Water Act (33 U.S.C. 1344) provides the USACOE the authority to issue permits for the discharge of dredged or fill material into the navigable waters. As shown in Figure 8.2, this authority extends shoreward to the Highest Annual Tide line or to the extent of adjacent federal wetlands. Applicability of Section 404 would be dependant on the scope and specific methods of activities associated with the installation of facilities and may be required for an offshore wind facility. Part of the administration of the Section 404 program has been delegated to New Jersey. This is limited to upland sites at least 1000 ft from coastal areas.

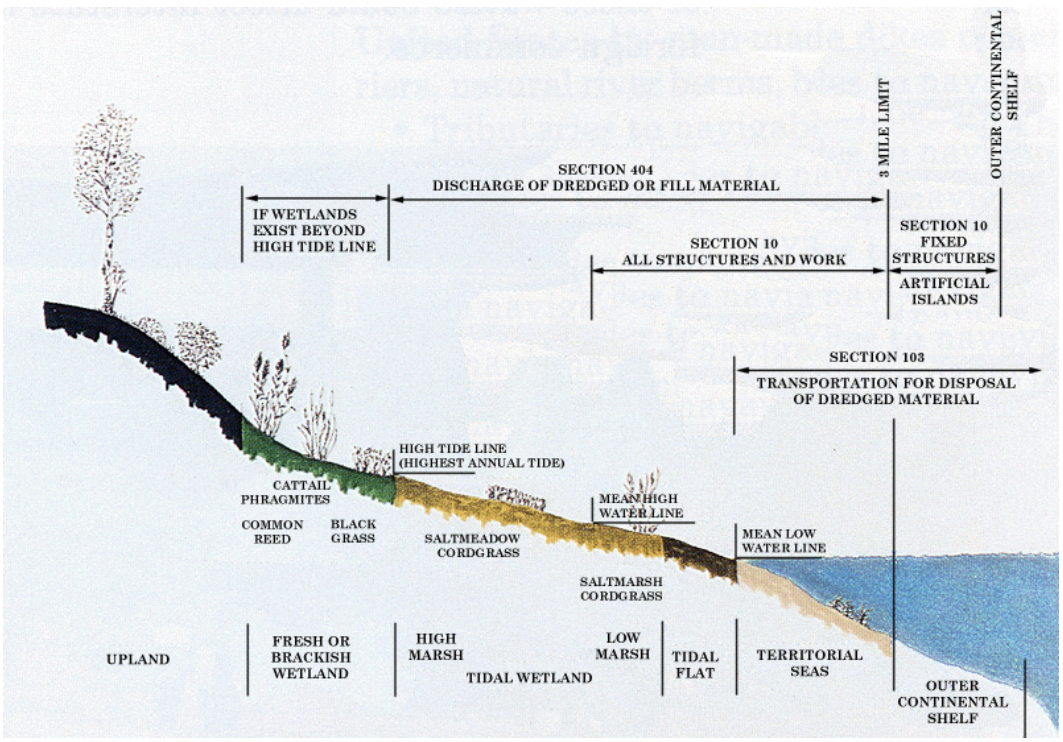


Figure 8.2: U.S. Permitting and Jurisdiction Layout[30]

8.1.2. Coast Guard

Navigation and Navigable Waters (33 C.F.R. Parts 62, 64, 66 et seq.) Marking of Structures, Sunken Vessels and Other Obstructions

The U.S. Coast Guard has jurisdiction and authority to determine appropriate marking requirements for structures to be located in or over waters subject to the jurisdiction of the U.S. Before establishing a structure, the owner or operator shall apply for Coast Guard authorization

[30] Diagram courtesy Philadelphia District of U.S. Army Corp of Engineers.

http://www.nap.usace.army.mil/cenap-op/regulatory/tidewater.gif to mark the structure in accordance with §66.01–5 of this chapter. The appropriate District Commander determines the marking requirements.

8.1.3. Federal Aviation Administration

Objects Affecting Navigable Airspace (14 CFR 77)

This regulation provides the FAA with authority to promote the safe and efficient use of navigable airspace for any proposed structure. By definition any structure greater than 200 ft above ground level requires a Notice of Proposed Construction. To the extent the turbines would exceed 200 feet, notice would need to be made to the FAA. The FAA would likely make recommendations for lighting in response to the notice. While FAA lighting and marking recommendations do not carry the force of law, compliance with them is required in order to obtain a Determination of Non Hazard.

8.1.4. The Federal Energy Regulatory Commission (FERC)

A developer, under current New Jersey Regulations necessarily a Non-Utility Generator, would have to apply to FERC for Exempt Wholesale Generator (EWG) status. Additionally, FERC has promulgated rulemaking that recommend that state utilities adopt one of multiple options for participation with a Regional Transmission Organization (RTO). The four electric utilities in New Jersey have chosen to join the PJM RTO. The RTO is responsible for coordinating interconnection agreements, procedures and requirements. The interconnection of an offshore wind facility would therefore be coordinated through PJM.

8.1.5. Department of Interior

Under the Outer Continental Shelf (OCS) Act the Department of Interior Minerals Management Service (MMS) has certain jurisdiction over the outer continental shelf (from the three-mile limit of state waters to the edge of the continental shelf). Currently this jurisdiction pertains to gas, oil and mineral rights; however pending legislation would amend the OCS Act to grant the Department of Interior (DOI) authority to regulate energy projects on the OCS, including provisions for easements and right of way. Should such an amendment to the OCS Act be passed, the turbines, any offshore substation, collection system, and export cables of a project (to the extent they fell within federal waters) would fall under DOI jurisdiction.

8.2. State Jurisdiction

8.2.1. New Jersey Department of Environmental Protection (DEP)

Coastal Area Facility Review Act (CAFRA) N.J.S.A. 13:19

This Act grants jurisdiction and permitting authority to the New Jersey DEP over development in the "coastal area," defined as bays, harbors, sounds wetlands, inlets, "…and their adjoining upland fastland drainage area nets." The upland coastal area boundary line is depicted in Figure 8.3. Therefore any offshore wind facility with project elements falling within the coastal area would be under New Jersey DEP jurisdiction and would require a CAFRA Permit.

Tidelands Act N.J.S.A. 12:3

New Jersey owns and has jurisdiction over "riparian lands--lands now or formerly flowed by the mean high tide of a natural waterway as well as state waters out a distance of three miles seaward from the mean high water line." A project which entails the use of such lands must get permission from the State in the form of a tidelands license, lease or grant to use these lands.

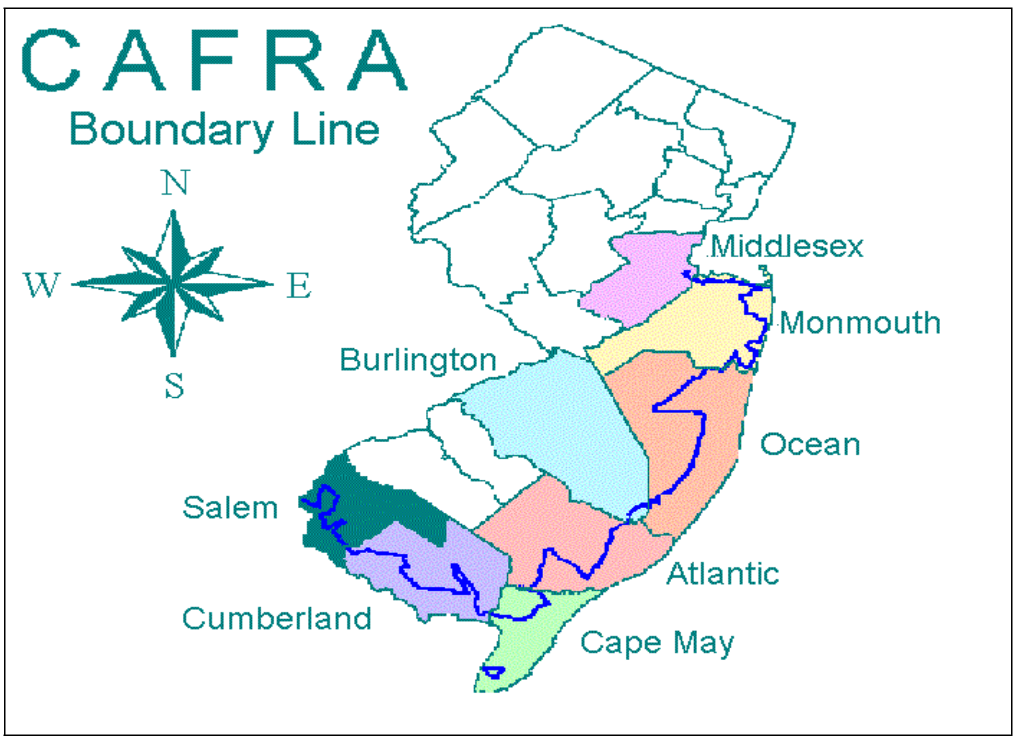


Figure 8.3: Coastal Area Facility Review Area (CAFRA) County Map

The Waterfront Development Law (N.J.S.A. 12:5-3)

The act governs and requires a permit for any development in a "tidally flowed waterway." For development outside of the CAFRA (Figure 8.3), the Waterfront Development Law regulates the area "adjacent to the water, extending from the mean high water line to the first paved public road, railroad or surveyable property line. At a minimum, the zone extends at least 100 feet but no more than 500 feet inland from the tidal water body."[31] Within this zone, the DEP must review construction, reconstruction, alteration, expansion or enlargement of structures, excavation, and filling.

Wetlands Act Of 1970 (N.J.S.A. 13:9A)

The Wetlands Act of 1970 requires the DEP to regulate development in coastal wetlands. The regulated coastal wetlands are delineated on maps prepared by the DEP. These maps are available for public inspection at each county clerk's office. A project including structure excavation, dredging, fill or placement of a structure on any coastal wetland shown on the maps must obtain a coastal wetlands permit.

Water Quality Certificate

All projects requiring a Federal permit for the discharge of dredged or fill material into state waters and/or their adjacent wetlands also require the State Water Quality Certification that ensures consistency with State water quality standards. Part of the Federal 404 program has been delegated to New Jersey.

8.3. Local Jurisdiction

8.3.1. Soil Conservation district

Soil Erosion and Sediment Control Act of 1975

Projects involving more than 5,000 square feet of soil disturbance need to obtain approval of soil erosions and storm water management plans from the local soil conservation district. Generally, the boundaries of these districts conform to county delineation and are administered under county government.

8.3.2 Municipal Land Use Act (N.J.S.A. 40:55D)

The Municipal Land Use Act is the legislative foundation of local Planning Boards and Zoning Boards of Adjustment in the State of New Jersey. It defines the powers and responsibilities of the boards and is essential to their functions and decisions. Upland elements of an offshore wind energy project would need to be designed in compliance with local planning and zoning requirements or seek approval of a variance before such boards.

[31] Paraphrased from material on New Jersey DEP website. http://www.nj.gov/dep/landuse/coast/coast.html.

8.4. Federal Application Process Overview

8.4.1. U.S. Army Corps of Engineers

Application would be made to the U.S. Army Corps of Engineers for a Section 10 permit, which allows for placement of structures in navigable waters, and possibly a Section 404 permit[32], which covers dredging related activity. The necessity of a Section 404 permit would be determined through the course of a pre-application meeting(s) with the Corps (likely to be held jointly with New Jersey State Regulators).

Within fifteen days of application submission to the Corps, the district engineer will either determine that the application is complete and issue a public notice or advise the applicant of the information necessary for a complete application. The district engineer will also evaluate the need for a public hearing pursuant to 33 CFR Part 327. A comment period of between 15 and 30 days, with a possible 30-day extension, will follow after the public notice is issued.

The Corps has 60 days, subsequent to receiving a complete application, to reach a decision on whether to grant or deny a permit. Several exceptions to this time limit are described in 33 CFR §325.2 (d) (3) (i) through (vi). Of these exceptions, §325.2 (d) (3) (i) "precluded as a matter of law or procedure required by law" and §325.2 (d) (3) (vi) "information needed by the district engineer for a decision on the application cannot reasonably be obtained within the 60-day period…" will almost certainly apply. Several laws require procedures including "state and other federal agency certifications, public hearings, environmental impact statements, consultations, special studies, and testing which may prevent district engineers from being able to decide certain applications within 60 days." The laws and associated procedures relevant to an offshore wind energy facility are set forth in the following section.

8.4.2. U.S. Army Corps of Engineers Compliance Requirements

National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321 et seq. (NEPA)

Permitting action by the Corps will trigger procedures required under NEPA. This process starts with lead agency determination. The Corps and other Federal Agencies involved would make a joint determination of the lead agency. Following precedent, the Corps assumes the lead agency responsibility in offshore wind applications. Once established as the lead agency, the Corps would proceed with a decision on the appropriate type of environmental review, ranging from a limited Environmental Assessment (EA) to an Environmental Impact Statement (EIS). Several factors play into this decision including: expected impact on the environment, anticipated controversy, and scope and magnitude of the project. The district engineer can decide 1) that only an EA is necessary; 2) that an EA must be prepared first in order to assess the need for an EIS, or 3) that the need for an EIS is obvious from the start in which case an EA need not be prepared. Concurrent with this assessment the Corps would interact with the state lead agency to confirm the respective agency requirements because state and federal mandates require the environmental review to be performed jointly to avoid duplication of effort.

[32] Recall that for most upland areas the Section 404 program has been delegated to New Jersey.

When an EA is found sufficient then a Finding of No Significant Impact (FONSI) is prepared (see 40 CFR 1508.13) and the NEPA requirements are satisfied. Alternatively, when a determination that an EIS will be required is reached the Corps will contact all appropriate Federal agencies to establish which agency will assume the lead role and what agencies will assume cooperating roles. Given the probable issues and location of the project the Corps likely would be lead agency, as has been the case with the Cape Wind Project in Massachusetts. As noted earlier, pending legislation [omnibus energy bill] would possibly introduce the Minerals Management Service into the lead role for an offshore wind project (discussed in greater detail below). Finally, both State and Federal administrative guidance mandate cooperation between state and federal agencies to avoid duplication of effort (see 40 CFR 1506.2). Accordingly, a NEPA-required EIS would be coordinated with the NJ State lead agency, NJ DEP, to ensure that a joint study addressed respective state and federal requirements.

Assuming the Corps is established as the lead Federal agency, the district engineer will prepare and issue a Notice of Intent to prepare a draft EIS for publication in the Federal Register (see 40 CFR 1501.7) which begins the scoping process. Public concerns on issues, studies needed, alternatives to be examined, procedures, and other related matters would be addressed during scoping.

The Applicant (or the Corps if the applicant so declines) will then prepare a Draft EIS based on input obtained during the scoping process and on information and data collected in support of the EIS. Notice of the Draft EIS will be published in the Federal Register, followed by an additional public comment period and possible public hearings (see 33 CFR part 327). The feedback from the Draft EIS will then be incorporated into a Final EIS, which incorporates a summary of impacts, mitigation measures, and monitoring recommendations (if any).

The Endangered Species Act of 1973 (ESA) (16 USC 1536)

The ESA provides for the conservation of endangered and threatened species of fish, wildlife, and plants. Federal agencies must ensure that proposed actions do not jeopardize the continued existence of any endangered or threatened species or cause the destruction or adverse modification of their habitat. The National Marine Fisheries Services (NMFS) Office of Protected Resources (OPR) is generally charged with the implementation of the ESA for marine species. The U.S. Fish and Wildlife Service (USFWS) generally implements programs and regulations for terrestrial and freshwater species under the ESA. USFWS has jurisdiction over federally protected avian species.

In compliance with the ESA the Corps would issue letters to NMFS and to USFWS initiating consultations, pursuant to Section 7 of the ESA, relating to the project's potential to affect protected species. The consultation process between the Corps and the NMFS and USFWS would lead to a determination of a projects potential to affect the listed species or critical habitat and to provide recommendations to avoid or minimize the taking of species and habitat. Comments will be taken into consideration by the lead agency and may result in project modifications or permit conditions [33 CFR §320.3(i)].

National Historic Preservation Act (NHPA) of 1966, as amended, 16 U.S.C. 470 et seq.

The NHPA requires Federal agencies having direct or indirect jurisdiction over a proposed Federal or federally assisted undertaking to take into account the effect of the undertaking on historic properties (i.e. any district, site, building, structure or object that is included in or eligible for inclusion in the National Register) in accordance with regulations issued by the Advisory Council on Historic Preservation (ACHP) and in consultation with the ACHP and the State Historic Preservation Office (SHPO). [See 33 C.F.R. 320, 325, 325-Appendix C, Processing Department of the Army Permits, Procedures for the Protection of Historic Properties Dredging Guidance]

In compliance with the Act, the Corps would scope and require appropriate historical and archeological studies of the project areas and initiate consultation with ACHP and SHPO. A record of the consultation and any necessary project modification or mitigation would be documented in the Corps Project reports and NEPA documents as applicable.

Fish and Wildlife Coordination Act (FWCA) 16 U.S.C. 661 et seq.

The purpose of this Act is to recognize the contribution of wildlife resources to the nation, the increasing public interest and significance thereof due to expansion of our national economy and other factors, and to provide that wildlife conservation receives equal consideration and be coordinated with other features of water-resources development programs (16 U.S.C. § 661). The terms “wildlife” and “wildlife resources” “include birds, fishes, mammals, and all other classes of wild animals and all types of aquatic and land vegetation upon which wildlife is dependent" (16 U.S.C. § 666(b)).

The Corps consults with the Regional Directors of the USFWS and the NMFS and with the head of the agency responsible for fish and wildlife for the state in which the work is to be performed. This consultation is for the conservation of wildlife resources by preventing their direct or indirect loss and damage due to the activity proposed in a permit application. The District Engineer gives full consideration to these views in evaluating the application [16 U.S.C. § 662(B)].

The Coastal Zone Management Act (CZMA) of 1972 16 U.S.C. §1456 et seq

The CZMA requires that Federal activities affecting land or water resources located in the coastal zone be fully consistent with federally approved State coastal zone management plans. As New Jersey operates under an approved Coastal Zone Management Program (CZMP)[see N.J.A.C. 7:7E] an applicant must submit certification that the proposed activity complies with and will be conducted in a manner that is consistent with New Jersey’s CZMP. This certification will be included in the Corps public notice (associated with the application, not NEPA compliance) and sent to the New Jersey coastal zone agency (NJ DEP) requesting its concurrence or objection. Concurrence is necessary for the Corps to grant a permit.

Once the NEPA review process is complete and other consultation and compliance requirements are met, the Corps can make their determination whether to grant or deny the applicant a permit(s).

Marine Mammal Protection Act of 1972 (16 U.S.C. § 1361 et seq, 1401-1407, 1538, 4107)

This Act establishes a moratorium on the taking and importation of marine mammals and marine mammal products with exceptions for scientific research, allowable incidental taking, exemptions for subsistence activities by Alaskan natives and hardship exemptions (16 U.S.C. § 1371).

The Army Corps guidance states that

> "During preparation of the NEPA document, coordination with U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) will include the discussion of potential impacts to any species covered by this Act. USFWS will provide their comments in the form of a letter or as part of the Fish and Wildlife Coordination Act Report. NMFS will provide their comments in a letter. The concerns and/or recommendations of either agency must be addressed. All practicable efforts will be made to avoid the taking of a marine mammal. If the taking of a marine mammal is unavoidable, then the responsible agency (USFWS or NMFS) will be contacted to begin the process of obtaining a permit for any take." (U.S. ACOE Directorate of Civil Works Planning and Policy Profile of Laws)

Estuary Protection Act (16 U.S.C. § 1221 et seq)

This Act requires all Federal agencies to give consideration to estuaries and their natural resources and to their importance for commercial and industrial developments, in planning for the use or development of water and land resources. Compliance with the act is achieved through coordination with the Department of Interior under the Fish and Wildlife Coordination Act and NEPA.

Historical and Archeological Data - Preservation (16 U.S.C. §§ 469 et seq)

The intent of this Act is to make authorized Federal construction programs, dam construction and specified related activities, and all other Federal projects licensed or assisted by Federal agencies responsive to the damage they will cause to scientific, prehistoric, historical, and archeological resources. The Corps is required to coordinate with the Secretary of the Interior, the National Park Service, and the Regional Consulting Archeologist during NEPA coordination.

Abandoned Shipwreck Act of 1987 (943 U.S.C. §§ 2101- 2106)

This law provides for the U.S. to assert ownership over any abandoned shipwreck in State waters and submerged lands. Submerged lands means lands that are "lands beneath navigable waters" as defined in Section 2 of the Submerged Lands Act (43 U.S.C. 1301). It also provides guidelines for the designation of abandoned shipwrecks as national historic parks, recreation areas and marine biological sanctuaries. The act provides Federal authority to transfer ownership of abandoned shipwrecks to the State on whose submerged lands the wreck is located. The act provides Federal protection to any shipwreck that meets the criteria for eligibility for inclusion in the National Register for Historic Places. Therefore, disposal of dredged or other material on or in the vicinity of such wrecks is prohibited.

Corps reports and NEPA documents must show evidence of consultation with the State Historic Preservation Officers (SHPOs) and, if necessary, the Advisory Council on Historic Preservation (ACHP) for significance and impact determinations and agreements about mitigation stipulations, if required.

The Migratory Bird Treaty Act of 1918 (MBTA), as amended (16 USC 703)

This Act makes it unlawful to attempt to pursue, capture, kill, or possess any migratory bird or any part, nest, or egg of such bird listed in wildlife protection treaties among the U.S., Great Britain, Mexico, Japan, and the countries of the former Soviet Union.

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) (16 U.S.C. § 1855(b)(2))

This Act requires that fishery management plans shall "describe and identify essential fish habitat for the fishery based on the guidelines established by the Secretary under section 305(b)(1)(A), minimize to the extent practicable adverse effects on such habitat caused by fishing, and identify other actions to encourage the conservation and enhancement of such habitat…" Federal agencies must consult with the Secretary of Commerce (NMFS) regarding any action or proposed action authorized, funded, or undertaken by the agency that may adversely affect Essential Fish Habitat.

8.5. State Application Process Overview

8.5.1. New Jersey DEP

A joint application for all required permits (e.g. CAFRA Permit, Waterfront Development Permit, Coastal Wetlands Permit, Water Quality Certificate, and Federal Consistency Certificate) is submitted to the New Jersey DEP's Land Use Regulation Program (LURP). Prior to making an application a proponent may elect to request a pre-application review. This review is recommended for major development and is mandatory for a coast permit application involving the installation of submarine cables in the Atlantic Ocean.

The DEP will schedule a pre-application review meeting within 10 days of receiving a request for such review. Projects involving submarine cables in the Atlantic Ocean have a 15-day advance notice to specified organizations (N.J.A.C. 7:7-3.2 (d)). Within 20 working days of application submission the DEP will either:

1) confirm that the application is complete for public comment and possible hearing and schedule a comment period and possible hearing within 15 days or;
2) advise the applicant of informational deficiencies or;
3) return the application advising why it is unacceptable for filing.

The DEP will provide notice for public comment and may conduct public hearings at their discretion. Coordination with the federal lead agency (likely the US Army Corps) is necessary to avoid duplication of effort.

The DEP shall act on CAFRA applications within 60 days of any public hearing or within 60 days of the close of any public comment period unless additional information is required, in which case the DEP shall act on the application within 90 days of the date it was declared complete for final review. The DEP shall act on all Wetland and Waterfront Development applications within 90 days after the application was declared complete for final review [see N.J.A.C. 7:7-4.4].

Environmental Review – N.J.A.C. § 7:7-6.1 requires either an Environmental Impact Statement (EIS) (major projects) or Compliance Statement (CS) (an abbreviated EIS for minor projects) be completed as part of the review of projects in the DEP's jurisdiction. In uncertain circumstances, guidance as to the necessary form of review (EIS or CS) can be provided through a pre-application review. Again, coordination with the federal lead agency is necessary to streamline the process.

Application for a Tidelands license (Conveyance) is made separately to the Bureau of Tidelands Management. Fees are set by the Tidelands Resource Counsel [see N.J.S.A. 12:3].

8.6. Local Application Process Overview

8.6.1. County Level

Application for approval of storm water management plans is made to county offices where the planned development is to occur.

8.6.2. Local Municipality

Planning, zoning, and building regulations vary by municipality in New Jersey. Application for construction permits for a substation, maintenance facility, and any transmission line would be applied to at the local municipality level and subject to the specific ordinances of the local municipality.

9.0. Economics

Economics plays a critical role when assessing the overall feasibility of offshore wind energy. This chapter identifies the major cost variables comprising a wind project investment and estimates the cost of energy derived from a hypothetical ocean-based project in New Jersey. Financial incentives for wind development are also discussed.

9.1. Offshore Project Costs

The offshore wind industry is gaining momentum in Europe where several countries are promoting offshore installations. According to published figures available from trade journals and web sites for several existing and planned projects, offshore capital costs range between \$1700 and \$2500 per kW, with a mean value of \$1950 per kW (see Figure 9.1). This compares with total installed costs for land-based projects of \$1100 to \$1300 per kW, indicating that offshore installations cost roughly 50 to 100% more than land projects.

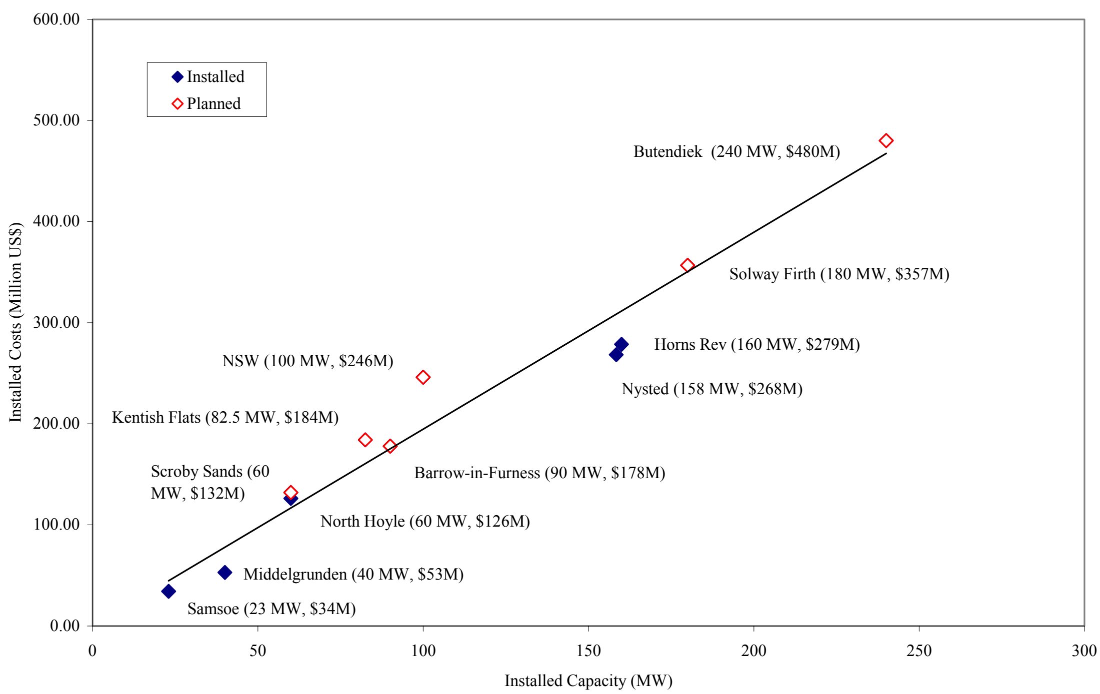


Figure 9.1 Installed Cost of Constructed and Planned Offshore Projects[33]

[33] Data from: www.offshorewindenergy.org, Monetary conversions represent December 2003 dollars. Costs should be treated as approximations.

The graph does not indicate there to be an economy of scale with lower per MW costs for larger projects, as would be expected in a mature industry with all siting factors being equal. This is likely due to the limited number of projects built thus far and the fact that the project characteristics (location, water depth, distance from shore, foundation type) differ significantly from site to site. Customized approaches to materials handling, transport, and installation is a contributing factor. As more projects are built which use standardized practices, economies of scale will become more evident.

Figures 9.2 and 9.3 compare the installed cost components of offshore and land-based projects.[34] The support structure (foundation and tower) and electrical collection and transmission system of an offshore project constitute larger fractions of the capital costs relative to land projects. Wind turbines constitute less than half the cost of an overall offshore project investment.

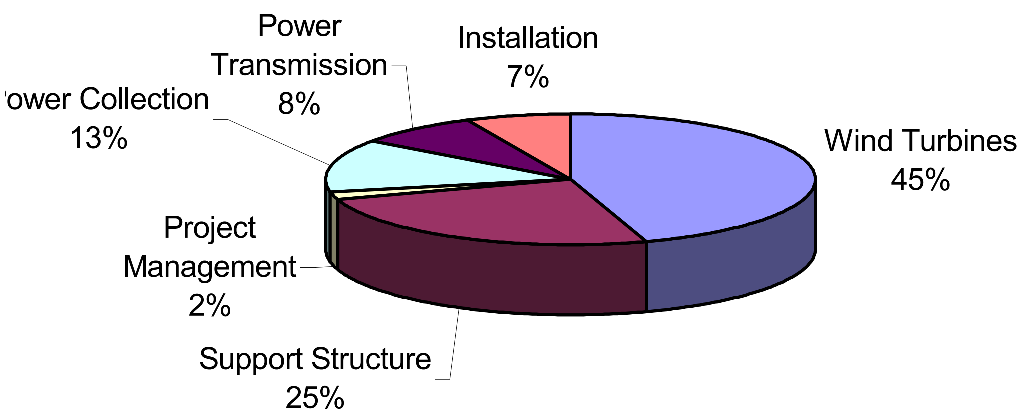


Figure 9.2 Breakdown of Offshore Project Costs

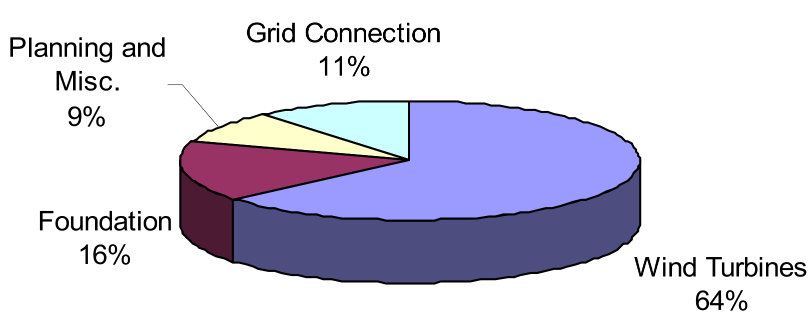


Figure 9.3 Breakdown of Onshore Project Costs

[34] Offshore Wind Energy in Europe-A Review of the State-of-the-Art, Wind Energy, Vol. 6, No. 1, January-March 2003, Wiley, pg. 42.

Table 9.1 lists cost components found within different phases of project development, from permitting to commissioning. Construction costs and schedules are very dependent on weather, waves, geotechnical conditions, foundation types and installation technique, and the availability of specialized vessels. The 160 MW Horns Rev project in Denmark, which uses monopile foundations, took approximately one day to install a foundation, one day for the transition piece, and one day for the turbine (load, transport and erect).

Table 9.1 Project Cost Items

Development	Engineering	Equipment procurement and delivery	Construction
Site permitting	Foundations, scour protection	Meteorological equipment	Foundation piles, transition piece, tower erection
Meteorological studies including Met tower	Electrical facilities	Turbines	Turbine erection
Environmental studies	Operation and maintenance facilities	Tower	Plant start up and commissioning
Geotechnical studies	Site Surveying	Supervisory Control and Data Acquisition (SCADA)	Construction contracting, project management and administration
Public outreach	Preparation of drawings	Electrical cable and collection system	FAA lighting
Power purchase agreement	Inspections/approvals	Offshore substation	Bonding

9.2. Offshore Cost of Energy

The cost of energy from a wind project includes several factors besides those constituting the initial capital costs. In basic terms, the total expenses required to build and operate a project over its effective lifetime, divided by the total energy generated by the project, yields the cost of energy (i.e., $/kWh). Lower energy costs are therefore attainable at windier sites. Cost of energy variables include:

- Debt service
- Return on equity
- Operations and maintenance (O&M)
- Taxes
- Depreciation
- Land leases/royalties
- Insurance
- Energy production.

Approximately 25% of the cost of electricity from an offshore project is due to operation and maintenance. Feedback from European projects indicates that O&M costs are around $0.02/kWh, close to double that for land projects.[35]

In order to gain a better perspective on the potential costs of an offshore wind project in New Jersey, a hypothetical cost of energy analysis was performed. This analysis utilized representative values for the cost variables listed above (e.g., 55% debt @ 6.2% interest rate, 11% discount rate, 2.5% inflation rate). The analysis also estimated the energy production potential from a hypothetical 100 MW offshore project.

Based on the New Jersey wind map and the prevailing wind speeds at a hub height of 70 m above ground, two different annual average wind speeds were considered for an offshore setting: 8.0 and 8.5 m/s. Table 9.2 lists the amount of water area possessing different wind resource values. Average wind speeds greater than or equal to 8.0 m/s exist over a large majority of the study area, whereas speeds exceeding 8.5 m/s cover only 17% of the area.

Table 9.2 New Jersey's Windy Offshore Area

Wind Speed at 70m		Offshore Study Area[36]	
mph	**m/s**	**Area (%)**	**Area (sq. mi.)**
<12.3	<5.5	0	0
12.3-13.4	5.5-6.0	0.2	5
13.4-14.5	6.0-6.5	1	29
14.5-15.7	6.5-7.0	4	114
15.7-16.8	7.0-7.5	8	255
16.8-17.9	7.5-8.0	23	741
17.9-19.0	8.0-8.5	47	1534
19.0-20.1	8.5-9.0	17	562

The capital cost assumed for an offshore project equaled the average value from Figure 9.1, or $1,950/kW. An O&M cost of 2 cents per kWh was assumed. Annual energy production was calculated based upon the designated wind resource characteristics and on state-of-the-art wind turbine power curves. Representative energy losses totaling 16% were applied to account for expected losses resulting from wind plant availability, wake effects, electrical conversion inefficiencies, and other factors.

The results of the cost of energy analysis are presented in Table 9.3. An offshore project would experience a capacity factor of 32 to 35%, with a cost of energy of 8.5 to 8.9 cents per kWh. This cost is similar to that observed in Europe.[37] Depending on incentives available, this cost of energy is at the high end or above the expected market values for power in the Mid-Atlantic region.

[35] Future Offshore, Department of Trade and Industry, England, 2002, pg. 21.

[36] Areas described in square statute miles

[37] Wind Power Monthly, Vol. 19, No.1, Pg. 38, January 2003

Access to financing and interest rates both play an important role in project economics. To date, no known offshore wind project has been financed by lending institutions. Offshore projects are perceived to have higher levels of risk and this perception will likely impact the availability of bank funds (or the cost of borrowing) for offshore investments in the foreseeable future.

Table 9.3 Anticipated Cost of Energy for an Offshore Project in New Jersey

Parameter	Offshore Project (100 MW)	
Average Wind Speed (m/s)	8.0	8.5
Net annual energy (MWh)	286,100	309,100
Capacity Factor (%)	32	35
Levelized Electricity Cost ($/kWh)	0.089	0.085

The availability of long-term power purchase agreements is also an important factor when financing projects. Electric utilities with load serving requirements, the state-mandated Renewable Portfolio Standard, and green electricity retail markets all provide opportunities for establishing power purchase agreements that will facilitate future project development.

The cost of offshore projects is expected to decline as the technology matures, as construction and maintenance firms gain more experience, and as specialized installation and maintenance equipment becomes readily available. The advent of larger turbine sizes should also result in improved project economics. The U.S. Department of Energy's (DOE) Wind Energy Research Program has established a goal of reducing the cost of energy for offshore systems to 5 cents per kWh by 2012. Via funding provided through its Low Wind Speed Technology Program, the DOE is facilitating the development of newer technologies to generate cost competitive electrical energy at lower wind speeds sites.

9.3. Incentives

Various financial incentives for wind energy development are available to wind projects but were not included in the cost of energy analysis. Generally, such incentives would apply to projects regardless of their location.

9.3.1. Production Tax Credit

Utilization of tax benefits, such as the federal Renewable Energy Production Tax Credit, can improve project economics and stimulate development activity. This tax credit, also referred to as the Production Tax Credit (PTC), is a per kilowatt-hour (kWh) corporate tax credit for electricity generated by qualified energy resources, including wind. The PTC is available for the first ten years of operation and provides 1.5 cents per kWh credit, which is adjusted annually for inflation. The adjusted credit amount for 2003 was 1.8 cents per kWh.

The PTC was originally enacted as part of the Energy Policy Act of 1992 and was set to expire at the end of 2001. In March 2002, the PTC was extended until December 31, 2003 as part of the H.R. 3090, Job Creation and Worker Assistance Act of 2002. As of Spring 2004, there is no PTC available because a multi-year extension has not yet been passed by Congress. The PTC extension is part of the wide-ranging energy policy bill (S. 1637) being debated. The House and Senate versions of the bill both include a three-year PTC extension.

9.3.2. Tradable Renewable Certificates and the Renewable Portfolio Standard

Tradable Renewable Certificates (TRCs) represent the separable bundle of non-energy attributes (environmental, economic and social) associated with the generation of renewable power. TRCs are sometimes also referred to as green tags, green tickets, renewable certificates, and renewable energy certificates or credits. TRCs are generally sold separately from their associated energy in wholesale markets. In retail markets they may be sold separately as an independent product or may be combined with electrical energy at the point of sale to create a renewable electricity offering.

The diversity of suppliers now offering TRC products reflects the growth of the green power market and acceptance of 'green tags' as an innovative and cost effective way to serve both residential and commercial customers. In 2002, the first year that TRCs were offered in the marketplace, Green-e certified and verified 144 million kilowatt hours of TRC transactions. The number of Green-e certified TRC products nearly tripled in 2003, and exponential growth is predicted in TRC transactions as this new market gains momentum.

Currently, there is no state-sanctioned system for certificate trading in the Pennsylvainia, New Jersey, Maryland (PJM) electricity trading region. New Jersey has approved a Renewable Portfolio Standard (RPS) and is exploring the implementation of a certificate tracking system. Under the current RPS, generation located within the PJM qualifies for RPS compliance, but environmental attributes cannot be unbundled from the energy, thus inhibiting participants from participating in the market for TRCs. The RPS does not contain provisions for the banking of TRCs. New Jersey may move toward pure attribute trading and the establishment of a market for certificates.

9.4. Load Matching of Offshore Wind

The value of wind energy to electricity markets is a function of the time of day and year it is generated. Unlike conventional generation technologies, wind energy production is dependent on weather conditions and therefore cannot be controlled; it can be forecast one to two days in advance, however. The output from an offshore New Jersey wind project will vary throughout the year in tandem with weather patterns, as discussed in Section 3.3.3. Seasonally, average electricity delivery will reach a maximum in late fall and winter and a minimum in summer.

Due to air conditioning loads, summer is the season of highest electricity demand in New Jersey. Market energy prices are higher when electricity demand is greater, meaning the value of wind energy is heightened if production occurs during periods of strongest demand. Although the average wind energy output in summer will be lower than the other seasons, relatively high output levels can still be achieved on hot summer days during peak demand periods due to the influences of the sea breeze.

Figure 9.4 illustrates this point. The measured wind conditions at the Ambrose Light Station (located 8 miles off the northern New Jersey coast) were compared with hourly electric load data for the two utility service territories (Atlantic Electric and Jersey Central Power) during the top-ten peak load days in each year from 1999 to 2003. The Ambrose wind speed data were converted to net energy production and capacity factor estimates for an offshore wind plant using the same approach in Section 9.2. It was found that average wind plant output increases sharply beginning near noon, peaking in the late afternoon and early evening when the electric demand also peaks. Average peak capacity factors exceed 40% in this case.

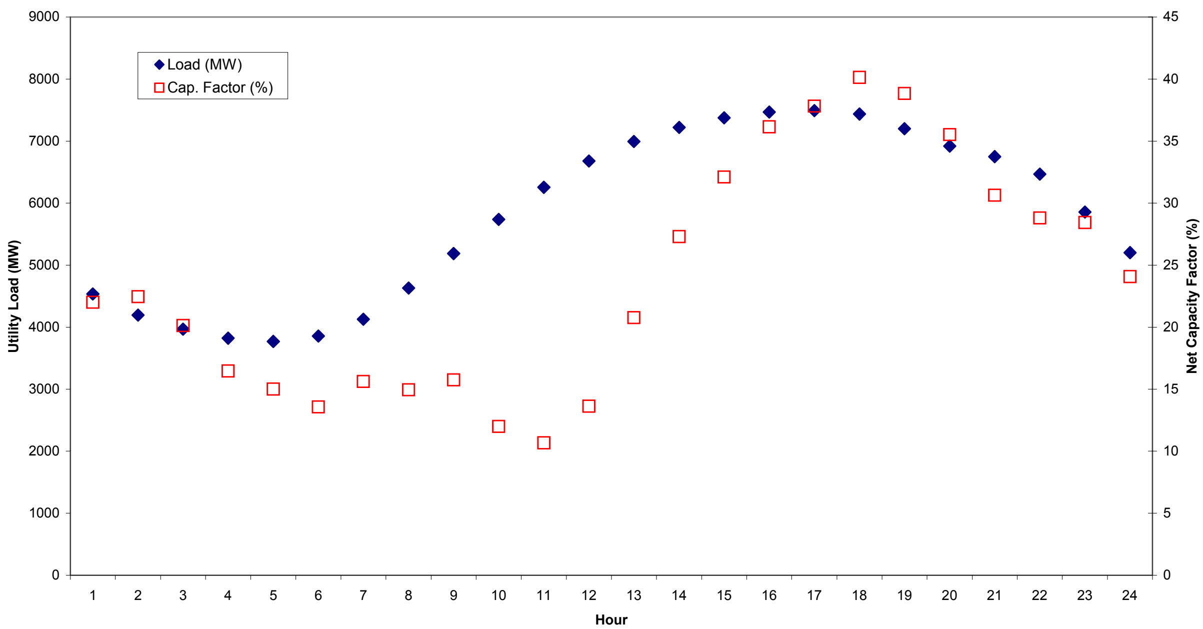


Figure 9.4: Average Peak Load Day (1999-2003), Coastal Utility Load and Plant Net Capacity Factor

These results indicate that offshore wind energy can have good load matching value, particularly on peak load days in summer. The load matching qualities of any particular project will depend on its location, the distance from shore, and the intensity of the sea breeze at that location during hot, peak load days. These qualities can be evaluated by a meteorological measurement program, as described in Section 2.3.3.

10.0. Conclusions

This study has evaluated the feasibility of offshore wind energy development in New Jersey based on a substantial body of existing siting resource data and wind technology experience. This investigation was conducted to provide potential stakeholders with a better understanding of the nature of offshore wind technology and of the technical, environmental and commercial suitability of the state's offshore waters for wind development. This study does not constitute an environmental review that a particular project would have to undergo as part of its permitting process. Rather, it addresses the general feasibility of offshore wind development for a large study area.

Several key conclusions can be drawn from this study:

- Approximately half of the original study area (1,223 sq. nautical miles) is deemed to be conditionally viable for offshore wind development after excluding areas with conflicting water and air space concerns, or because of marginal wind resources (less than 8 m/s annually) or water depth over 100 feet. The conditionally viable areas still contain important siting considerations that must be investigated in greater detail if specific projects are contemplated. It is likely that more in-depth study of environmental constraints would exclude additional offshore areas from considerations for development.
- The conditionally viable area lies mostly beyond the 3-mile limit and stretches roughly 75 miles from the Seaside Height/Seaside Park area south to Cape May.
- Offshore wind development could provide a significant contribution to New Jersey's renewable portfolio. Offshore wind would produce approximately 3,000 MWh/yr for each installed MW of facility. Power densities of approximately 20 MW per square mile could be harvested while occupying less than 0.01% of the seabed within a project area.
- Current projections on cost of energy produced by a hypothetical facility within the study area are at the high end or above what the market will bear. Incentives may play a key role in the near term. Over time, capital costs are expected to decrease with advances in design and experience base for developers and constructors as well as financing and insurance participants.
- The existing transmission system along the coastline has sufficient capacity to accept significant amounts of new wind-based generation, with the amount of this capacity dependent on the locations where wind projects are interconnected.
- Historical data suggest a high and favorable correlation between offshore wind speed and electricity demand during the peak hours of high demand summer days. This suggests a higher potential for offshore wind generation during peak summer demand hours than may be implied by summer monthly average wind speeds, which are lower than the balance of the year.
- The study area is actively used by commercial and recreational fishing, boating and shipping interests, and by wildlife (fish, shellfish, mammals, birds). It is within the

viewshed of beach users and includes sand borrow areas. These uses will be relevant considerations in evaluations of offshore project proposals.

- Several major ports exist within or near the study area that are suitable to support the shipping, installation, or O&M requirements of an offshore wind project. These ports include the Port of New York and New Jersey, Atlantic City, and industrial ports accessible via the Delaware Bay and Delaware River in New Jersey, Delaware, and Pennsylvania.
- A state and federal regulatory structure exists that can ensure all siting issues and stakeholder concerns are considered during the permit evaluation process.

Countries in northern Europe are continuing to develop offshore wind projects and conduct related environmental research; these activities should continue to be monitored. Meanwhile, the opportunities and issues associated with offshore wind development in New Jersey should be investigated further. The State's coastal and offshore region contains an abundance of highly valued environmental and commercial resources. As this study has shown, an abundance of attractive wind resources exist within this region as well. Through ongoing collaborations with state, federal and coastal stakeholders, the co-utilization of all these resources may be attainable to the benefit of everyone.

11.0. ANNEX 1

ASSESSMENT OF AVIAN ISSUES FOR OFFSHORE
WIND POWER DEVELOPMENT IN NEW JERSEY

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Annex Table of Contents

Executive Summary

This report details a desktop avian feasibility study for the potential development of wind power in waters of: Raritan Bay from Conaskonk Point to Sandy Hook, the Atlantic Ocean from Sandy Hook to Cape May Point, and Delaware Bay from Cape May Point to Egg Island. The purpose of the study was to provide a first step for developing a framework for assessing potential risk to birds from wind power development in coastal waters of New Jersey. The report is organized in the following chapters.

Chapter 1. Introduction – A summary of the issues is given surrounding wind power development and risk to birds. This chapter identifies sources of information used for the review, agencies and environmental organizations contacted for information, and the type of hardware/equipment that is used or being proposed for offshore wind power projects.

Chapter 2. Avian Legal and Ecological Issues – A brief overview is given of legal issues regarding bird protection that must be considered during the development process. These include the Endangered Species Act, the Bald and Golden Eagle Protection Act, and the Migratory Bird Treaty Act, the National Environmental Policy Act, and the Coastal Areas Facility Review Act. In addition, a summary of the ecological issues, direct collision fatality and indirect impacts to habitat via disturbance and displacement/avoidance are reviewed.

Chapter 3. Review of Avian Risk at Wind Plants in North America and Europe – A detailed literature review of quantitative studies of avian impacts due to wind power projects is presented. The studies include numbers of fatalities, species impacted, the degree of habitat impacts as they relate to disturbance and displacement of birds, as well as the significance of those impacts.

Chapter 4. Birds of the New Jersey Offshore Wind Power Study Area – The literature regarding avian presence, abundance, seasonal presence, distribution, and behavior while in New Jersey waters is summarized. Areas with large concentrations of birds are identified along with information regarding their behavior there. A separate section addresses issues relating to foraging, migrating, staging, wintering, roosting, and listed (endangered and threatened) species present in New Jersey waters.

Chapter 5. Prevention and Mitigation of Risk in Wind Plants – A summary of what is known about prevention of risk at wind plants is provided along with a discussion of potential mitigation of impacts.

Chapter 6. Information Gaps, Research Needs, and Potential Research Methodologies – Based on what was presented in Chapter 4, gaps in our knowledge of avian abundance and behavior are discussed along with specific research needs and the methodologies needed to fill in the gaps.

The information reviewed in this report revealed that a diverse assemblage of species uses the coastal waters of New Jersey. Birds are present year round, although the species change from season to season, along with abundance and behavior. Some areas were identified to have very high seasonal use suggesting the need for in-depth studies of risk.

A1. Introduction

Offshore wind power development is being considered for waters off the coast of New Jersey and with that prospect has come a concern about environmental impacts. Wind power development in the United States and Europe has progressed rapidly since the 1980s when commercial facilities were first developed in California. Commercial wind power facilities spread eastward from California to Minnesota in the mid-1990s and by the late 1990s there were commercial wind power facilities in more than a dozen states eastward to Vermont and Massachusetts. Today, there somewhere in the range of 18,000 commercial sized turbines in the United States and more than 20,000 turbines in Europe (estimate for late 2002; American Wind Energy Association and European Wind Energy Association). Early discoveries of dead eagles and other raptors at wind sites in California in the 1980s made bird impacts an issue at many proposed wind projects. Simultaneously, the growing awareness of bird collisions with tall communication towers (www.towerkill.com) also elevated scrutiny of wind turbines.

Avian fatalities at wind turbines in the United States were first recognized as a potential issue at the Altamont Pass Wind Resource Area (APWRA), 40 miles (64 km) east of San Francisco, California. At that site there were nearly 7,000 turbines in an area of 150 km^2 (80 square miles; California Energy Commission 1989). Because this project was one of the first in the United States and the largest in the world, avian issues became well known among environmentalists, animal rights groups, and government agencies, among others.

With offshore wind power projects being proposed, wildlife agencies and environmentalists have expressed concern about bird impacts at these very different facilities. Both collision fatality and disturbance/displacement studies conducted in terrestrial situations are applicable to some extent in offshore situations, but because these types of facilities are so new and different in marine environments, generalizing is not always possible. At the present time we know relatively little about impacts of wind turbines in marine environments. In Europe, where there are now several offshore wind power projects, some impact studies have been conducted or are being conducted, but there are few published reports. There are, however, a few studies that have been conducted at coastal wind power sites in Europe that provide some information regarding impacts in marine environments. These studies, however, only include some of the species that are found in offshore situations in the United States and New Jersey. Some of the studies conducted in offshore projects in Europe relate to behavior of birds flying around turbines, but these have been done at facilities where there are limited numbers of turbines and the species composition is not entirely comparable to the Atlantic Coast of the United States including New Jersey. Thus, collision and disturbance risk to birds at offshore wind power facilities has yet to be thoroughly investigated and more studies are needed. However, without having such facilities operating, empirical or post-construction impact studies cannot be done.

This report is an assessment of the avian issues associated with potential wind power development in the nearshore and offshore waters of New Jersey. Hereafter referred to as the New Jersey Offshore Study Area (NJOSA), the boundaries are provided in Figure 1.1. The study area extends from the waters off Raritan Bay near Conaskonk Point to the Atlantic Ocean, along the Atlantic Coast to Cape May and into Delaware Bay to a point near Egg Island in Cumberland County. The NJOSA include state and federal waters out to 8-10 miles from the Jersey Shore. This report is an effort to assemble existing information and information sources that will be used to commence avian risk assessment studies for wind projects that may be proposed for the offshore waters of New Jersey. The sources of information include published and unpublished reports, papers from the peer reviewed literature, newsletters of environmental organizations, public databases such as the National Audubon Christmas Bird Count, state databases, federal data, and personal knowledge of the two authors (more than 50 years of experience on and near the waters of New Jersey). The report is divided into chapters on legal and ecological issues (Chapter 2); a review of avian impacts at wind power facilities at both terrestrial and offshore facilities in the United States and Europe (Chapter 3); a summary of what is known about the types of birds (taxonomic composition, endangered and threatened, migrants, etc.), abundance, seasonal presence and use; and a concluding chapter on information gaps and potential research that needs to be done to assess risk once specific projects and sites are identified by developers or by the New Jersey Board of Public Utilities (Chapter 5). Appendix I summarizes collision fatalities at wind power facilities in the United States and Appendix II summarizes impacts at facilities in Europe.

A1.1 Specifications of Offshore Wind Power Facilities

For permitting agencies, wind power developers, wildlife agencies, conservation organizations, and other stakeholders to understand the potential risks to birds at offshore wind power facilities, a rudimentary knowledge is needed of the potential hardware that might be deployed as well as the types of activities that will occur during project construction and operation. The following paragraphs provide a description of the type of wind turbine that is now being proposed for development at a site in Nantucket Sound in Massachusetts and are being used at sites in Europe. In addition, information is presented about other infrastructure, as well as construction activities that are likely at such developments in coastal waters. The infrastructure described below is currently what is available. Whereas the construction process is not likely to change significantly, turbine design is likely to change in the coming decade. The trend has been toward fewer, larger turbines.

An offshore wind power project generally consists of turbines, electrical collector cables, a transmission line that brings the generated electricity to shore, and, in some cases, an offshore substation.

Modern turbines have three rotors located on a nacelle atop a tubular tower, which is embedded in the ocean floor. The type of foundation varies and can include an extension of the tubular tower that is above water or a multi-piling type foundation (perhaps 3 legs in a pyramidal shape) upon which the tubular tower is affixed. Turbines are generally aligned in rows, spaced by at least 600 m (1,968 feet) and rows are generally spaced by at least 1,000 m (3,280 feet). Turbine rows (also called strings) are generally aligned perpendicular to prevailing winds. Turbines now being proposed at other offshore sites in the United States have a nameplate generating capacity of between 2 and nearly 4 megawatts. Turbine tower diameter is about 4-6 m (~13-20 ft) and the height is about 80 m (261 ft) above the mean high tide level and rotors that are roughly 50 m (164 feet) in radius. Taller towers are sometimes considered, upwards of 100 m. The rotor swept area would be in the range of 100 m (328 feet) or more in diameter and rotors extend down to about 22 m (72 feet) above the water when in the 6 o'clock position and up to about 150+ m (492 feet). These are ranges and are subject to change in the coming years. The total height of turbine rotors when in the 12 o'clock position may be nearly 153 m (500 feet) above mean sea level. Each rotor would turn at about 10-20 rpm or less, depending on wind speed, and tip speed would be variable up to more possibly more than 85 m/sec (~190 mph). Each tubular tower would likely have a landing/docking platform, complete with handrails and an entrance into the turbine tower, along with some other equipment.

Wind turbines in offshore environments are likely to have two types of lighting. FAA lighting of turbines to date has mostly been with L-864 medium intensity red strobe-like lights at night and L-865 medium intensity white strobes in daytime. The exact lighting and number of turbines could be changed by FAA if their 2000 obstruction marking circular is changed. Recently, FAA has agreed that not all turbines in onshore situations need to be lit, but there is no precedent for turbines in marine environments. At the Nantucket Sound facility, the FAA is considering the use of L-864 medium intensity (2,000 candelas) red strobe-like lights for night on turbines at the outer edge of the facility and L-810 low intensity (200 candelas) red blinking lights for interior turbines. The L-810 lights normally do not blink, but they can be modified. Their normal intensity is greater. (See FAA 2000 Advisory Circular AC 70/7460-1K Obstruction Marking and Lighting, U.S. Department of Transportation). The FAA is considering simultaneous flashing of all turbines. FAA lights are generally mounted on top of the nacelle, which would be at a height of slightly greater than 80 to 100 m, depending on the height of the tower used.

Coast Guard navigation obstruction safety lighting to warn watercraft will undoubtedly be required. Two flashing amber navigation lights would likely be affixed to tower structures a few feet above the high waterline.

Electrical lines connecting the turbines are run turbine to turbine (daisy-chained), and buried up to about 6 feet (2 m) into the sea floor, usually via hydrojetting. The cables are entirely insulated. Offshore substations are being proposed for some projects, which are actually large platforms, perhaps 30 feet (~10 m) above the water on which there are switching facilities, transformers, and other structures, most all of which are entirely within walls and under a roof for total protection against the elements. That station is where the collector cables from the turbines are gathered and electricity is stepped up in voltage for transmission onshore. A substation of this sort may be upwards of an acre in size. This facility, if constructed, would have to have Coast Guard navigation lights and could have other types of lighting, which would be relevant to avian safety issues. Electricity from offshore wind power facilities is brought ashore via a transmission line embedded in the seafloor via hydrojetting. The transmission line is linked to the grid onshore, usually after being hydrojetted or directionally drilled beneath the beach or through an inlet. The location and impacts of this portion of wind power development is beyond the scope of this feasibility study.

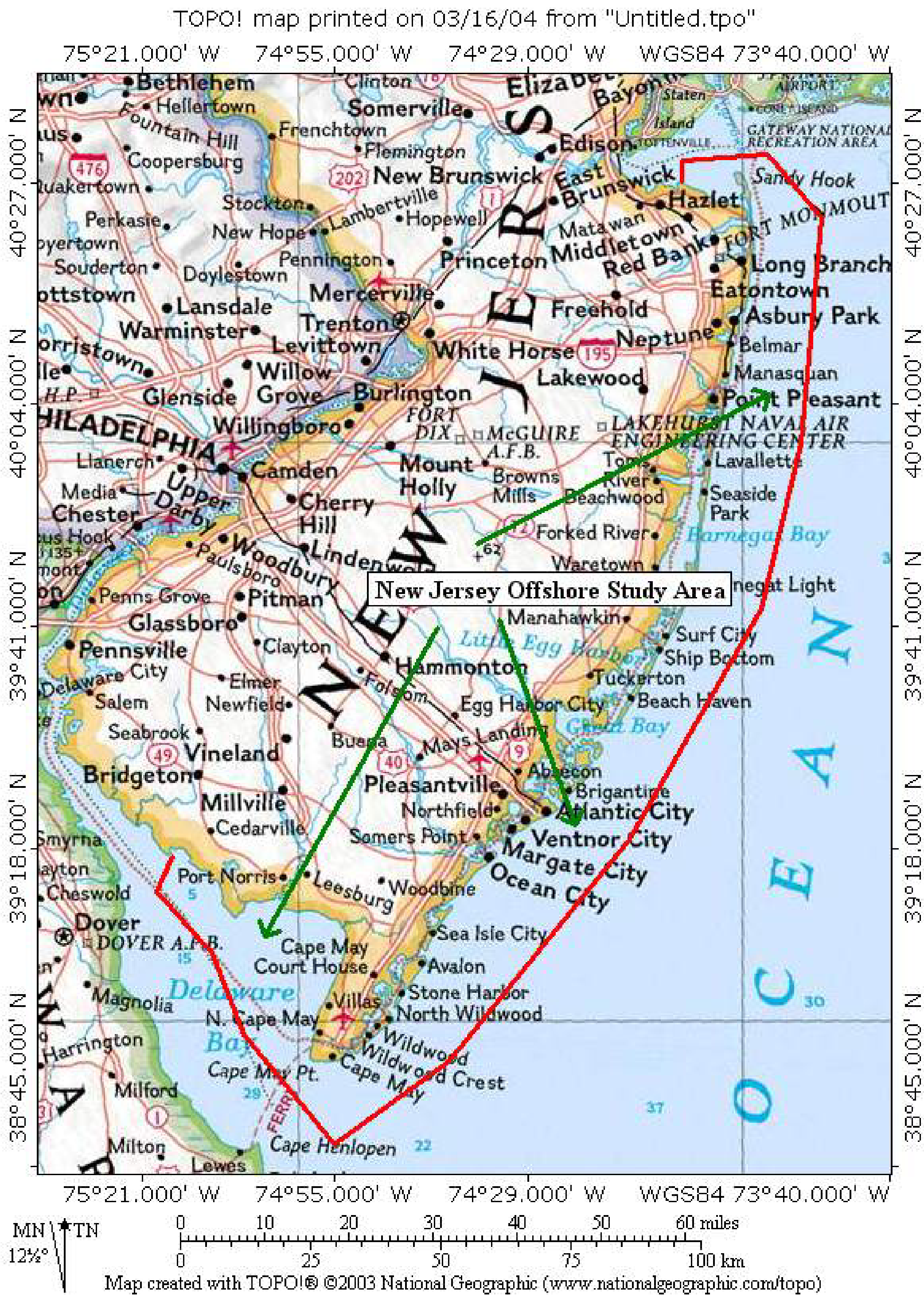
A1.2 Government Agency and Environmental Organization Information Requests

As part of the information gathering portion of this project, biologists from the New Jersey Department of Environmental Protection, Division of Fish, Game, and Wildlife (Endangered and Nongame Species Program), the U. S. Fish and Wildlife Service (Pleasantville, NJ and Annapolis, MD, offices), and the New Jersey Audubon Society (Cape May Court House and Bernardsville, NJ) were contacted.

The following bullets summarize interactions with the above listed agencies and New Jersey Audubon Society, and consultant requests for information regarding avian activity in the marine waters of Delaware Bay, Raritan Bay, and the Atlantic Ocean.

- New Jersey Division of Fish, Game, and Wildlife – Endangered and Nongame Species Program
  - Telephone Call to Larry Niles, Chief – Endangered and Nongame Species Program – Niles assigned David Golden to be point of contact on this project. Golden is the primary biologist working for the Division on wind power projects
  - David Golden – face to face meeting in January 2004, request for relevant avian information made in January 2004, no response until telephone conversation in early March 2004
  - Golden provided an oral account of the relevant information from the Division and was requested by the consultant to provide said information in writing
- U. S. Fish and Wildlife Service
  - Wendy Walsh – Pleasantville, NJ office was contacted by telephone autumn 2003; Walsh stated that they had little information and deferred to Doug Forsell at the Annapolis office. Walsh stated that their office did not conduct research of the sort that was relevant to the feasibility study
  - Doug Forsell, one of the lead Service biologists working on wind power issues, was contacted November 18, 2003; Forsell provided important information regarding federal studies in nearshore waters of the Atlantic Ocean, Delaware Bay, and Chesapeake Bay with respect to wintering sea ducks, loons, and some other species. In addition, several research reports and publications were sent by Forsell, which proved invaluable to the feasibility study
- New Jersey Audubon Society (NJAS)
  - Face to face meeting in September 2003 with Eric Stiles and David Mizrahi at the Cape May Bird Observatory during which an information request was made. The project was discussed at length
  - Information request made via letter in November 2003
  - In early March 2004, the NJAS requested entering into an MOU prior to divulging information. Legal documents were reviewed and revised by AREC and consultants, and sent back to NJAS. As of April 30, 2004, no information from NJAS has been received. The report that follows used only published information from NJAS.

Figure 1.1. Map showing the New Jersey coastal area including the area within which wind power development may be considered. The area within the red lines is the approximate study area for this report.



A2. Avian Legal and Ecological Issues

This chapter identifies legal and ecological issues that need to be addressed, with respect to birds, as part of the development process (site screening, site selection, permitting, etc.) for offshore wind power development in New Jersey. Specifically, this chapter addresses those issues for the waters of New Jersey designated in Figure 1, including portions of Raritan Bay, Delaware Bay, and the Atlantic Ocean. These waters include areas with both state and federal jurisdiction. The legal issues outlined below are specific to birds. The permitting process, both federal and state, could focus on these issues as part of NEPA, CAFRA, or other permitting processes. The intent of this section is to inform the reader regarding the underlying laws that protect birds rather than how those laws may be implemented in the permitting process. How such laws are used varies from jurisdiction to jurisdiction and describing their use is beyond the scope of this section.

Issues Considered in Risk Assessment at Wind Power Projects

Both legal and ecological issues must be considered when assessing risk at proposed wind power projects. The legal issues include federal and state laws protecting birds, as well as the regulatory and permitting processes that take avian impacts into consideration.

<u>Regulatory/Legal Issues</u>[38]

- <u>Migratory Bird Treaty Act</u> (federal) – MBTA - The Migratory Bird Treaty Act is a federal law that protects virtually all birds. The MBTA is a strict liability statute that stipulates birds cannot be taken (killed) without a federal permit ("take" permit, scientific permit, hunting license, or other permit). Although officials at the U.S. Fish & Wildlife Service and other federal agencies have stated that bird collisions with wind turbines could be subject to prosecution under the MBTA, no enforcement action has occurred to date for incidents at wind power facilities, nor have actions been initiated at such facilities (at least publicly). The U. S. Justice Department seems to be exercising prosecutorial discretion with respect to the MBTA and the wind power industry, as well as with most federal and corporate activities. There is no provision under MBTA for incidental take permits and they have generally not been granted for accidental takings. The MBTA does not take into account whether a taking is intentional or unintentional, nor does it take into account whether takings are likely to result in biologically significant issues. Recent letters to wind power developers from the U.S. Fish and Wildlife Service have mentioned the specter of potential prosecution with respect to MBTA.

- <u>Endangered Species Act</u> (federal and state) – ESA - The Endangered Species Act is a federal law that provides for criminal prosecution of those who kill, harm, or harass species listed by the U. S. government as Endangered or Threatened. The penalties include fines and/or

[38] *<u>Caveat/Disclaimer.</u> The above should not be construed as legal interpretation or advice. It should be noted that various U.S. Fish & Wildlife officials have stated publicly that even one fatality resulting from wind turbines is illegal and could be the subject of prosecution under the MBTA. The applicability of the laws and acts protecting wildlife provided above should undergo legal review.*

imprisonment. The primary agency entrusted with responsibility of this law is the U. S. Fish and Wildlife Service. The Act is most often invoked when listed (endangered or threatened) species are killed or harassed. The Act also includes the protection of habitats of listed species. There are also state counterparts to the ESA and lists of endangered, threatened, and candidate species. The New Jersey Department of Environmental Protection maintains a list of endangered and threatened species, although the state law affords a different level of protection for these species. That list may be changed in the near future. Recent letters from the U. S. Fish and Wildlife Service to wind power developers have mentioned the potential for prosecution under this law.

- Bald & Golden Eagle Protection Act (federal) - B&GEPA - This law protects these species from killing, harming, and harassment. It provides for penalties (fine and/or imprisonment) that are greater than those provided by the MBTA, and similar to those provided by the ESA. It has been used to prosecute people who shoot eagles as well as companies whose power lines have electrocuted these birds. The latter has only occurred a few times; in instances where utilities have not diligently sought to remedy or mitigate a recognized problem (e.g. no insulation added to wires to prevent electrocution) when recommended by the U. S. Fish & Wildlife Service.

- Species of Special Concern (state and federal) - SSC – The federal government and New Jersey Department of Environmental Protection have lists of species of special concern. These species are believed to be declining and in some cases are candidates for official listing. With respect to federal authority and jurisdiction, the birds on these lists are legally protected by either the MBTA or the B&GEPA.

- National Environmental Policy Act – NEPA – Projects involving federal dollars, federal agencies, federal licensing or permitting, or federal lands are subject to NEPA review, usually in the form of a Biological Assessment, Environmental Assessment, or Environmental Impact Study, depending on the size and type of project and the potential degree of impact. Strict adherence to the ESA (and B&GEPA) is the norm, although attention to the MBTA has rarely been brought up as an issue by federal agencies (see Caveat below). The U. S. Fish and Wildlife Service has the authority to review or comment on many NEPA applications and they also comment on issues relating to the three federal laws listed above.

- New Jersey – Coastal Areas Facility Review Act. – CAFRA – This law is specific to coastal areas of New Jersey. It covers various types of developments including projects in some marine or tidal waters of New Jersey. There is a strong component of the CAFRA rules that addresses impacts to endangered and threatened species, as well as significant migration concentration areas. The CAFRA rules and regulations are complex and the reader is referred to the actual documents.

Ecological Issues

There are two ecological impact issues considered by most avian biologists and conservationists to be most important with respect to wind power development: fatalities resulting from collisions with turbines, and disturbance/avoidance of an area resulting from the presence of turbines and other infrastructure. Both operate at the individual level, although population and community level impacts are a possibility.

Fatalities resulting from collisions with turbines may result in population impacts at the global, regional, or local level if sufficient numbers of birds are involved. Thus, it is not the total number of birds killed at a given facility, but the numbers of birds of a particular species that are important from a biological or ecological perspective. If the number of fatalities of a particular species that are incurred are great enough, they could result in a decline of a local or larger scale population of that species. The number of individual fatalities that can be incurred without population impacts is a function of where the birds that collide with turbines originate (local or migrating populations), the total number of birds in the population from which those individuals come from, and several other ecological and demographic factors. The potential for population impact, also called "biologically significant impact," is greatest when fatalities occur in small populations that are localized at or near a particular project site and, or populations with small numbers of individuals in their global, regional, or local populations. The latter could include endangered, threatened, species of special concern, or rare species.

To date, population impacts have not been demonstrated to have resulted from collisions with wind turbines, although there are some suspected local impacts that may be biologically significant. The case of Golden Eagle mortality in the APWRA may be an exception, although a long-term population study revealed that the regional population of this species was not declining despite regular fatalities among local nesters and dispersing subadults (Hunt 2002). The probable reason these eagles were not impacted significantly is that some of the fatalities were from migrating populations that come from a very large geographic area, thereby diffusing the impacts over a large population. Other potential local population impacts are suspected (Smallwood et al. 2003).

The other type of ecological impact is from disturbance that leads to displacement of birds from a feeding, roosting, lekking (courtship), or nesting area. Such disturbance to birds or habitat could lead to population declines. If birds are excluded from areas necessary for a species' successful reproduction or survival, population impacts may result. With respect to offshore wind power development, nesting areas would not be impacted. However, birds could be excluded from areas in which they traditionally feed. Whether this will impact a population depends on whether birds avoid turbine areas, how large an area they avoid, and whether the areas they avoid are critical foraging sites or migration staging areas. These are species and site-specific questions that may be addressed prior to construction. There is also a possibility that migrating birds will deviate from their migration pathways, especially birds that fly at low altitudes above the water. Such deviations could include flying a mile or several miles around a facility or flying to higher altitudes over a facility. The degree of impact is dependent upon the extra distance a migrant would be forced to fly to avoid flying near wind turbines. Such diversions would likely only divert birds a few miles, the equivalent of only a very small proportion of the overall distance most species migrate. This would translate to a small amount of extra energy needed for migration.

A3. Review of Avian Risk at Wind Plants in North America and Europe

The impacts of wind turbines on birds have been studied since the mid-late 1980s at dozen of locations in Europe, the United States, and, to a lesser extent, Canada. There has not been a comprehensive review of the European research, although partial reviews of the North American literature (Erickson et al.2001, Erickson et al. 2002) are available. With a few exceptions in Europe, bird impact studies have been conducted onshore, so our knowledge is limited primarily to terrestrial situations. In the United States, virtually all studies have been conducted in terrestrial situations, although a few have been near rivers or marshes. Studies of wind turbines have been done on tilled agricultural land, grazing land, desert, forest, lakes along the sea coast, lowlands near the sea, jetties along sea coasts, lakes adjacent to the sea, and short distances offshore. These studies represent a diverse array of habitats and geographic locations, such that robust generalizations about risk to birds posed by wind power developments can be made for terrestrial habitats. However, fewer generalizations can be made for offshore or marine habitats and for those made the degree of uncertainty is much greater than in terrestrial situations.

The few studies conducted in marine environments include offshore waters, lands immediately adjacent to shorelines, harbors, and bodies of water adjacent to the sea. These studies have examined small to moderate sized wind plants (1-50+ turbines) in the United Kingdom, Denmark, the Netherlands, Belgium, and Canada. The turbines examined in these studies were relatively modern models with nameplate outputs in the 300-500 kilowatt range, each on a tubular tower, although some 1 megawatt sized turbines extending to more than 100 m (328 feet) have been studied more recently or are currently being studied. Most of the studies, however, were of turbines on shorter towers, with smaller rotor swept areas than the turbines being proposed for North American offshore areas.

There are two basic types of impacts to bird populations that occur at wind turbine facilities. These impacts range from ephemeral and not significant, to long-lasting and potentially biologically significant impacts. Biological significance is defined as impacts that cause a decline in the population of a species at the local, regional, or global level. The types of impacts are:

- Disturbance and displacement/avoidance
  - Short term/ephemeral impacts during plant construction
  - Long-term resulting from the presence of turbines and other infrastructure on site (including habitat fragmentation) and human activity (boats, helicopters, people)

- Fatalities resulting from collision with turbine rotors or turbine tower (and guyed meteorology towers)

(Small numbers of birds have been electrocuted at older wind power plants, but these have been virtually eliminated because collection lines are today located underground within most modern wind plants. This issue will not be considered further because the engineering of offshore wind plants precludes electrocution.)

The following sections provide a brief review of what is known about impacts to birds at terrestrial and marine wind power facilities. The review is not meant to be exhaustive, but it does cover most of the literature. Because European research groups are not as organized as those in the United States, there are few reviews available from Europe and the literature is written in several languages and difficult to find. The review provided below examines terrestrial facilities primarily because of structural similarities among turbines in these habitats and because there are some taxonomic similarities as well. The constellation of species in marine habitats is very different than from terrestrial habitats and generalization is difficult. However, providing the following review may assist researchers in developing risk assessments in marine habitats and by providing an introduction into avian risk at turbine facilities.

Disturbance and Displacement (Avoidance) During Plant Construction

The initiation of wind plant construction almost always results in some form of disturbance and subsequent displacement (avoidance behavior) of birds in the area where activities occur. There are parallels and similarities between onshore and offshore facility construction. The similarities include equipment arrival, ground (ocean floor) breaking resulting in habitat alteration, presence of people, noise, erection of turbines. These activities can exclude terrestrial or marine birds from a construction area and the surrounding habitat.

Construction activity associated with offshore wind plants includes boat traffic, barge moorings for weeks or months, presence of cranes, helicopter traffic, and the presence of people on a daily basis for several months. Similarly, the ocean bottom will be disturbed and some sediment will be released into the water. Because so few offshore plants have been constructed, we know little about how this process will impact birds. Disturbance during the construction of wind plants is ephemeral and limited to several months to, perhaps, more than a year. Few, if any, studies of this type of disturbance have been conducted. Disturbance to nesting birds at offshore wind projects is nil, because the birds nest so far away. Foraging and wintering birds may be disturbed and displaced during the construction process. With respect to migrants, low flying birds such as scoters and loons may simply fly around a plant as they fly around other objects such as transport ships. Night migrants generally fly above surface based activities. The fact that there may be bright lights associated with construction equipment is an important factor because many land-based and marine birds are attracted to bright lights. It is also possible that some construction activity may attract birds in a fashion similar to fisheries activities (clamming, trawling, etc.) by providing foraging opportunities. Overall, the construction activities associated with wind plant development have not been studied, although some impacts are likely to be ephemeral.

Disturbance and Displacement (Avoidance) by Infrastructure and Habitat Alteration

The construction of a wind power facility results in changes to habitat and the landscape, which alters the suitability of habitat for some birds, as well as the organisms they eat. Although the infrastructure footprint itself covers a very small percentage of the area of most project sites, wind turbines have been demonstrated to disturb and displace some species of birds over greater areas. The responses of birds to wind turbines varies greatly in both terrestrial and marine habitats (Appendix I). In general, birds have graded responses to turbines such that avoidance is nonexistent or avoidance can be hundreds of meters, depending on species and the habitat in which the turbines are situated. Results have not always been consistent among species and sites. Projects in different locations have even reported different results for the same types of birds. Habituation may explain this variation. Most species of birds do habituate, to some extent, to the presence of human structures. Birds may avoid turbines when first erected and approach more closely over time. Resident birds at or adjacent to wind turbines may respond differently than transient migrants that have never encountered a wind turbine.

Raptors and Soaring Birds. Most raptors habituate to turbines, but anecdotal accounts suggest that they sometimes avoid turbine areas and that they may habituate over time to the presence of turbines. Richard Curry (former chair of the Kenetech Avian Task Force) reported complete avoidance by a naïve Red-tailed Hawk trained for falconry. When first confronted by a turbine within several hundred feet, it would not fly. Within days the bird flew closer to turbines and behaved like local hawks. Red-tailed Hawks, Golden Eagles, kestrels and other raptors (Prairie Falcons, Ferruginous Hawks, etc.) do habituate to turbines. They perch on various parts of turbines in the Altamont (Orloff and Flannery 1992, 1996). Many raptors and vultures in the Altamont fly close to turbines (Kerlinger personal observations) and Griffon Vultures in Tarifa, Spain soar within 20-30 feet (6-10 m) of operating turbines (Kerlinger personal observations). Ravens, Barn Owls, and some other species habituate to turbines and nest within turbine nacelles in the APWRA.

One European study reported that Red Kite, Peregrine Falcon, Kestrel, Common Buzzard, and Common Ravens in Wales were reluctant to occupy habitat close to turbines. These results were confounded by the fact that a feeding area for endangered Red Kites had been established in the vicinity of the wind project, which served to attract these birds away from the project (Lowther 2000). Migrating hawks that had undoubtedly never seen a wind turbine seemed to avoid flying near turbines on hilltops in Vermont (Kerlinger 2000a, 2002a).

Raptors like Bald Eagles, Peregrine Falcons, Merlins, and Ospreys that forage over water, are known to perch on human structures both on and offshore. They are regularly reported to perch on ships at sea, oil platforms, communication towers, buoys, and other structures. This suggests that raptors that migrate or forage in the vicinity of the NJOSA habituate to and use large structures in the ocean.

Songbirds and Shorebirds. Forest nesting songbirds such as White-throated Sparrow, Blackpoll, Dark-eyed Junco, and some others apparently habituated to turbines in Vermont, whereas others (Swainson's Thrush) did not (Kerlinger 2000a, 2002a). The thrush's seeming avoidance of the area near the turbines may have resulted from the forest canopy being opened for the turbines or from the presence of the tower and moving rotor. The fact that forest birds are accustomed to having trees overhead and thus are not threatened by the tall turbines may explain their ability to habituate.

Studies of grassland and other open habitat birds in both the United States and Europe have reported strong avoidance patterns in some cases. In Conservation Reserve Program grasslands (prairie-like habitats) in southwestern Minnesota (Leddy et al. 2000) fewer Eastern Meadowlarks and other ground nesting species were present close to turbines as opposed to farther away. They used impact gradient methods to study the magnitude of impacts along transects. Avoidance distance for meadowlarks were less than about 100 m, making the area within this range unsuitable for this species. This means that birds avoided using areas of about three-quarters of an acre surrounding turbines. A study from Wyoming (Johnson et al. 2000) suggested that Mountain Plovers were disturbed by wind turbines and showed reduced activity and nesting in the immediate vicinity of wind turbines. These birds did nest successfully within 200 m of operating wind turbines. Because impact gradient studies were not conducted, it is difficult to know what the actual area of avoidance was for this species.

The area of disturbance and avoidance may actually be larger when turbines are arrayed in rows, such that some species may not venture between rows. However, in the APWRA of California, Western Meadowlarks, Horned Larks, and Loggerhead Shrikes perch on turbine latticework and fly amongst the turbines (Kerlinger, personal observations). These turbines are spaced at 100 feet (31 m) hub to hub, so birds flying between the turbines must fly through a space of about 80 feet (24 m) between the actual towers and only 30 feet (~10 m) between rotors. The turbines have been in place there for 15-20 years, so the birds have had time to habituate. It would seem that because these birds have habituated, disturbance impacts have not been considered to be important.

European studies have also examined grassland and other open country (including farmland) birds in both nesting and feeding situations. As in the U. S., results varied (Appendix I). Lapwings investigated in Germany showed avoidance distances of about 100 m) of turbines (Ihde and Vauk-Hentzelt 1999). Other studies of this species, as well as Golden Plover, Skylark, Meadow Pipit, and other songbirds and shorebirds, did not demonstrate a large-scale displacement (Ihde and Vauk-Hentzelt 1999). Instead, they report slight reductions in numbers of some grassland birds near turbines.

Rigorous studies conducted along gradients will provide critical information to answer the question of habituation to wind turbines by ground nesting songbirds and other open country and open-water/pelagic birds.

<u>Waterfowl and Waterbirds</u>. Studies of waterfowl and other waterbirds have been conducted at several localities in Europe with varied results both pre (Noer et al. 2000) and post-construction. At the Oosterbierum Wind Park in the Netherlands, in low-lying lands near the shore, disturbance to shorebirds and waterfowl was minimal (Winkelman 1995). For diving ducks, Winkelman found an avoidance distance of approximately 150 m. At another location in the Netherlands diving ducks avoided the areas within 300 m of new turbines and in another study showed avoidance behavior at a distance of about 100 m. The same species would not fly between turbines 200 m apart (Winkelman 1995). Eiders studied at a 10-turbine offshore wind power site in the Kattegat of Denmark would not feed within 100 m of turbines. This avoidance was not deemed to be significant by the authors of the study and was subsequently revealed to be a result of greater food availability nearby (Guillemette et al.1998).

At Blyth Harbour, where 9 wind turbines were constructed on a sea wall/jetty, species like Purple Sandpipers and Sanderlings were not impacted by the turbines and continued to feed on the jetty (Still et al. 2000). Cormorants, gulls, and eiders did not seem to avoid the turbines at Blyth.

Guillemette and Larsen (2002) reported "little evidence for negative impacts" to Common Eiders at a ten turbine offshore wind park at Tuno Knob off the Danish coast. They cautiously concluded that further study, including impact gradient studies, were needed to clarify and quantify impacts. The same species, along with Common Scoters (Black Scoters in the U. S.) were studied at the same wind park using radar (Tulp et al. 1999). Large flights at night were dramatically reduced by mist and poor visibility. Fewer birds flew near the turbines as opposed to farther away from the turbines, with some avoidance flight being demonstrated at 1,000 to 1,500 m from the turbines. Avoidance was greatest on moonlit nights. Eiders were reluctant to fly through the windpark, but they preferred to fly between turbines spaced by more than 400 m as opposed to 200 m. Thus, there was active avoidance among flying eiders and scoters.

A study of three different wind farms near Zeebruge harbor was revealing (Joris Everaert, Institute of Nature Conservation, undated preliminary report). Although disturbance and avoidance were not studied directly, the fact that terns, gulls, and some other waterbirds were killed by turbines suggests that they were not displaced by them. This does not mean that the terns and other birds would forage near the turbines, however. It may be that they are willing to fly near the turbines when passing between different foraging areas, but they will not rest, nest, or forage near those same turbines.

Studies of wind turbine displacement of geese show varying distances of avoidance that seem to be species specific. Pink-footed Goose in farm fields in Denmark were less common within about 200 m of turbines and would not enter areas within turbine clusters, so they completely avoided the interior of the wind farm (Larsen and Madsen 2000). This species also avoided using fields less than 500 m across, which would mean that wind turbines placed in larger fields would likely preclude use by Pink-footed Geese. Barnacle Geese were less impacted and would approach within 25 m, whereas White-fronted Geese avoided turbines by up to 400-600 m. Swans avoided turbines by about 200 m. The researchers seem to show that there may be innate differences in avoidance behavior among similar species. Impact gradient studies of this sort are critical to furthering our understanding of avoidance and displacement impacts.

<u>Displacement, Avoidance and Habituation – Summary</u>. From the studies summarized above, no simple conclusions emerge regarding avian disturbance and displacement by wind turbines. The number and type of species for which information is available regarding disturbance and displacement by wind turbines is limited to the groups examined. The species groups summarized are limited to a small subset of species likely to be present at new wind power facilities. There has been little or no research on these types of impacts to other species. The species likely to be found in the NJOSA are likely to be very different from the species mentioned above, so the results reported above may not be applicable. For example, none of the studies cited include significant information on avoidance by gulls, terns, gannets, storm-petrels, sea ducks, loons and non-waterfowl divers, and other waterbirds have not been studied.

A determination of disturbance and displacement will only be possible after turbines have been erected in marine habitats and studies conducted. Most needed are impact gradient studies that can quantify the actual area of avoidance around a wind turbine or a group of wind turbines. In addition to more and better studies of avoidance distance, long-term habituation studies are needed to resolve some of the inconsistencies described above. Habituation studies should be conducted over periods of years following the construction of a wind plant.

Collision Fatalities

Fatalities resulting from collisions with wind turbine rotors have been studied extensively in both the United States and Europe. The literature on avian fatalities at wind turbines is largely in unpublished reports, company reports, government publications, and a few peer reviewed journals. The following review includes studies done at wind turbines now operating in Europe (Appendix I) and in the United States.

Although collision fatalities have been studied at a variety of turbine and habitat types, and in several countries, most of our knowledge about avian fatality at wind plants comes from terrestrial wind plants. Only a few studies have been conducted at sites on or adjacent to coasts or in open water. Virtually no studies of avian fatalities at offshore wind plants are now available. Such studies may be done as new offshore wind plants come online in Europe. It is not likely that information from the European sites will be available until 2004 or later. Therefore, this review summarizes collision fatality studies conducted at terrestrial facilities and wind plants located adjacent to coastlines, harbors, wetlands, and in shallow bodies of water.

At onshore wind power sites, fatality rates and absolute numbers of dead birds have, on average, been low. Erickson et al. (2001) reviewed studies done in the United States and concluded that, on average, about 2 birds are killed per turbine per year (with a range of <1 to more than 4). Since 2001, several other studies have been completed. Fatality rates at some turbine sites in the eastern United States have revealed fatality rates of 4-7+ birds per turbine per year at sites in West Virginia (Kerns and Kerlinger 2004) and Tennessee (Nicholson 2001, 2002), and Erickson et al.'s extrapolations to 1-2 birds killed per turbine per year and the higher eastern U. S. rates are based on extrapolations of the actual number of dead birds found using correction factors for the rate at which carcasses are removed by scavengers and the rate at which carcasses are overlooked (not seen) by searchers. Scavenging and observer efficiency are an integral part of studies that detect fatalities at wind plants and are done routinely at studies of larger wind plants. At smaller wind plants where very few carcasses have been located, use of extrapolation techniques is statistically risky because of small sample sizes.

The studies summarized herein come from more than 20 wind power sites in about a dozen states. The studies vary in intensity and with respect to what they focused on. Some studies merely attempted to determine if there were large fatality events, while others focused mostly on raptors. Fatalities reported in these field studies range from none documented at small wind plants to hundreds in a few of the studies where turbines number in the thousands. The largest overall number of fatalities that has been reported is from the APWRA (Appendix I), although the greatest per turbine per year rates have been reported from Tennessee, West Virginia, and Minnesota.

It should be noted that formal studies have not been conducted at all wind power facilities and studies are lacking from plants in Texas, Iowa, Alberta, and some other locations.

Raptors and Soaring Birds. It is believed that eagles, hawks, falcons, and other diurnal raptors may be more susceptible to colliding with wind turbines than other types of birds (Anderson et al. 2000). This has been demonstrated for the APWRA of California (Howell and DiDonato 1991, Orloff and Flannery 1992, 1995) and the Tehachapi Mountains of California (Anderson et al. 2000). Several hundred Golden Eagles, Red-tailed Hawks, and American Kestrels, along with smaller numbers of other species have collided with turbines in the APWRA. That the APWRA is an anomalous situation is agreed upon. It is believed that the large numbers of raptors present year round, combined with several risk factors explains the degree of mortality there. Those risk factors include 5,400 operating turbines, an enormous prey base that attracts raptors, close spacing of turbines, and placement of turbines on steep terrain. Other groups of birds have not been demonstrated to be susceptible to collisions. Perhaps three to four dozen raptor fatalities occur per year in North America outside of California (Appendix I).

At European wind power sites, raptor fatalities have been limited mostly to the Tarifa wind power area in southern Spain. Kestrels and Griffon Vultures were the most common fatalities with 0.34 medium-sized (the size of kestrels) bird fatalities per turbine per year (Marti Montes and Barrios Jaque 1995). These numbers were "unacceptably high, and far higher than indicated in any other European studies" (Lowther 1998), but they included power line collisions. Another study at Tarifa reported two raptor fatalities (Janss 1998) at 66 wind turbines or 0.03 bird fatalities per turbine per year. Yet another study found fatality rates from Tarifa to be 0.05 to 0.45 birds per turbine per year (Barrios and Aguilar 1995). At several wind plants in Navarre, northern Spain, larger numbers of raptors were reported to be killed than at Tarifa (newspaper reports, no publications or study reports available). Two White-tailed Sea Eagles were killed in Northern Germany (Krone and Scharnweber 2003), although several others were reported recently without details on where they were killed or about turbine specifications (Joris Everaert, personal communication soon to be published).

Raptors apparently collide with wind turbines most often while foraging. The APWRA is not a migration pathway and raptors such as Golden Eagles, Red-tailed Hawks, and others in large numbers forage in the APWRA year round. At sites such as Tarifa, Spain, where more than 100,000 diurnal raptors and other soaring birds migrate annually, there are few fatalities. At the Mountaineer Wind Energy Facility in West Virginia, located on a long, narrow ridge, a single Red-tailed Hawk and two Turkey Vultures were the only raptors killed in one year of study. Several hundred of these and other raptors migrate along this ridge during autumn and spring. At virtually all other wind power facilities, the numbers of raptors killed has been very small. Most experts agree that foraging near turbines by raptors puts them at risk.

Songbirds and Night Migrants. The greatest numbers of bird fatalities at wind turbines have been songbirds, including night migrants and birds active during daytime. The numbers, however, have been small in relation to populations (local, regional, and global). That night migrating birds collide with tall communication towers, sometimes in very large numbers, has led to a belief that wind turbines will potentially impact these species. Several million night migrating birds (mostly songbirds) are reported to collide with the communication towers each year (U. S. Fish & Wildlife Service website, Kerlinger 2000b). In comparison, wind turbines kill relatively few of these birds, probably because turbines are shorter than the communication towers that have been demonstrated to kill birds and turbines do not have guy wires. It is the guy wires that have been demonstrated to kill most, if not all, of the birds that collide with communication towers. Reviews of literature on communication tower collisions reveal high risk factors to be a combination of tower height in excess of 500-600 feet (152-183 m; Crawford and Engstrom 2001), the presence of guy wires, and the presence of multiple FAA obstruction lighting on the towers (Trapp 1998, Kerlinger 2000b, Avery et al. 1980, U. S. Fish and Wildlife Service Guidelines for Communication Towers 2000). Almost no large-scale, single night, mortality events involving dozens or hundreds of birds have been documented at towers less than 500-600 feet (152-183 m) in height that are lit with standard FAA lighting and guy wires. At towers without guy wires, regardless of height, virtually no birds seemed to be killed.

Eastern wind power sites appear to have greater fatality rates than western turbines, a result of greater numbers of night migrating birds. For example, per turbine fatality rates at sites in Tennessee, West Virginia, and Minnesota (Appendix I) are larger than those at sites in Colorado, Wyoming, California, Oregon, and Washington. The reason for this disparity is likely to be a result of fewer night migrating birds or lower densities of these birds. A majority of birds killed at turbines in Minnesota (Johnson et al. 2002), West Virginia (Kerns and Kerlinger 2004), and Tennessee (Nicholson 2001, 2002) were night migrating song and similar birds, whereas a larger proportion of the birds at western sites are raptors and daytime active songbirds (Horned Larks in particular).

It is important to note, however, that there have not been any large-scale fatality events involving night migrating birds at wind power facilities, with the possible exception of a fatality event involving about 30 night migrants at the West Virginia site. That event occurred during thick fog on May 22-23, 2003, and was concluded to be a result of attraction to the turbines and a substation that was lit by four sodium vapor lights. Those types of lights have been repeatedly implicated in fatality events, often involving hundreds of individuals, at communication towers, natural gas pumping stations, ski lifts, and the Washington Monument. It is important to note that there was no difference between the numbers of birds killed at wind turbines in West Virginia (and elsewhere, Kerlinger and Kerns 2003) that were lit and those that were not lit with FAA lights. Wind turbines are almost always equipped with FAA L-864 red-flashing (strobe-like) lights and rarely have L-810 steady burning red lights. It is likely that the attraction of night migrants to tall, guyed communication towers is caused by multiple sets of red, steady burning, L-810 lights. It is also important to note that the birds are almost all killed via collisions with the guy wires as they fly around the lit towers. (An event involving 14 night migrating bird fatalities occurred at two turbines in Minnesota on a single night, which has yet to be explained fully.)

The European literature reveals little in the way of fatalities of night migrating songbirds, except from coastal wind farms in the Netherlands. It is likely that the birds involved in collisions reported by Winkelman (1992 and other papers by Winkelman) were a variety of birds, including some songbirds and some waterbirds/shorebirds (see next section). There is almost no mention of night migrating song or other birds being involved in collisions with wind turbines in Belgium or elsewhere in Europe (Appendix II).

Waterfowl and Waterbirds. Turbines situated in lakes or low-lying coastal areas of the Netherlands on the Wadden Sea had higher rates of fatalities than turbines in upland habitats (Winkelman 1995). The large numbers of migrant and wintering waterfowl, shorebirds, and songbirds in that area, likely explain the higher fatality rates. The fatalities do not appear to be strictly birds engaged in migratory flight, but are birds making low altitude flights among feeding locations (Winkelman 1995) during migratory stopovers. Winkelman (1995) reported 0.04-0.14 dead birds per turbine per day during the migration season. Turbines situated in coastal areas probably are a greater risk to migrants than turbines found inland.

Twenty-five turbines located in a "lake" in the Netherlands killed about five-dozen diving and other ducks (Winkelman 1995). This water body hosted large numbers of migrating and wintering diving ducks near the Wadden Sea. Small numbers of fatalities were noted at 9 turbines located on a jetty at Blyth Harbor, consisting primarily of eiders (Lowther 2000). No information on fatalities is available from the offshore turbines at Tuno Knob (Tulp et al. 1999) or elsewhere within Denmark. The amount of information on fatalities at terrestrial sites is fairly well documented, but for offshore facilities the information is limited, at best. Radar studies by van der Winden et al. (1999, 2000) in "semi-offshore" wind farms suggest that species like Pochard, eiders, and Tufted Ducks seem to recognize wind turbines and avoid them during day and night.

The Erickson et al. (2001) review listed very few waterfowl being killed at wind power facilities in terrestrial habitats in the United States. In fact, fewer than about a dozen waterfowl have been noted to collide with wind turbines in the United States. A review of lists of fatalities published by Shire et al. (2000) for tall communication towers (all but one tower >500 feet [152 m]) revealed few fatalities of waterfowl. Together, these sources of information suggest that waterfowl are less likely than most birds to collide with tall structures. It should further be noted that, unlike night migrating songbirds, waterfowl have not been involved in large-scale collisions with tall, guyed, communication towers equipped with FAA lights, so they do not seem to be attracted to those types of lights.

Shorebirds. To date, the numbers of shorebirds killed by wind turbines has been extremely small. The appendices in Erickson et al. (2001; and the original reports summarized therein) listed very few shorebirds and studies conducted since that review have also failed to demonstrate large numbers of shorebird fatalities (Nicholson2001, 2002, Kerns and Kerlinger 2004, Johnson et al. 2002, Erickson et al. 2003) despite intensive study. It appears that shorebirds are not highly susceptible to colliding with wind turbines. Further corroboration of this comes from the lists of birds killed in collisions with tall communication towers. Shire et al. (2000) analyzed lists of birds killed at 47 different tall communication towers and reported very few shorebirds colliding with even 1,500 foot tall towers. A review of the literature by this author (including shorter towers and towers with partial lists, those not used by Shire et al. 2000), revealed almost no shorebirds colliding with communication towers. A two migration season study at two 380-foot communication towers (1 guyed and 1 unguyed) on an island in the marshes of South Jersey, revealed not a single shorebird fatalitydespite regular use of the area by these birds (P. Kerlinger, 2003 unpublished report to Community Energy and NJ DEP – CAFRA). The island was only 4 miles (6 .4 km) from the Forsythe National Wildlife Refuge where perhaps 100,000 or more shorebirds gather each year during migration. Shorebirds, unlike night migrating songbirds, have not been involved in large-scale collisions with tall, guyed, communication towers equipped with FAA lights. This strongly suggests that they are not attracted to those types of lights. Overall, it appears that shorebirds are less likely to collide with structures than other types of birds.

Known and Suspected Factors Associated With Collision Risk

Several factors are now suspected or known to be associated with risk to birds at wind turbines. These risks have not all been studied in experimental or field trial situations, and some of the factors listed below are logical, generally accepted, or, in some cases, hotly debated. It should be noted that the risk factors that follow were developed almost entirely from terrestrial or shore-based wind turbine facilities. Some are likely to be applicable in marine situations and others are not likely to be applicable. Many of the risk factors that follow should be considered primarily hypothetical and need to be tested in situations and at places other than where the risk was suspected or demonstrated originally. Risk factors apparently can act alone, or in concert with other risk factors such that when there are several high risk factors collision fatalities are likely to occur more often than when there is only a single or fewer risk factors.

Avian Use/Species Specific Behavior - Flight and Foraging Behavior. The most widely accepted risk factor is avian use of a wind turbine area. "Use" is a construct that includes the abundance, types of species, phenology (seasonal presence), and behavior of individuals when present at a site. If birds are not present, there is no risk. At sites where collisions are common, such as in the APWRA, there have always been large numbers of Golden Eagles and Red-tailed Hawks, which are present year round and in large numbers. They hunt near turbines and even perch on the turbines, which constitutes high use and increased risk. High use patterns do not always constitute high risk because some species, such as gulls, ravens, crows, some waterfowl, and others exhibit high use but generally avoid collisions. Thus, species behavior and physiological abilities also seem to be related to collision risk. For offshore wind power facilities, it is likely that areas where there is a great deal of aerial foraging (high use) will be riskier than areas where there is less aerial foraging. It is also likely that migratory corridors constitute high seasonal use situations and, therefore, are more risky than areas where there are few migrants.

Turbine Design and Specifications

- Height – Although turbine height has not been demonstrated to be a risk factor, it is likely that shorter turbines, such as those on 60-ft towers, are riskier to hunting raptors and taller towers (250+ ft towers) are riskier to night migrating birds. Communication towers taller than 500 ft (152 m) are more risky to night migrating birds than those less than this height (Kerlinger 2000b). This factor is dependent on the species of birds that use an area and how they use the turbine area.
- Tower Structure (perchability) – Towers that lack perch sites for raptors and other birds may be less risky than towers on which perching is possible. Perching is both a direct and indirect risk. The direct risk is through collision while attempting to perch or take off from a turbine that is operating. The indirect risk is likely to be through habituation. Turbines that permit perching allow birds to spend time in very close

proximity to turbines, thereby promoting habituation. They are then more likely to approach operating turbines and collide with rotors. Perching on the nacelles of larger turbines may be possible, but this rarely occurs at modern wind plants. In offshore situations, the actual turbines will not offer perching opportunities, although the work/docking platforms are likely to attract birds.

- Turbine Spacing – Turbines in the APWRA spaced by 80-100 feet (<30 m; rotor to rotor distance is only ~30 feet [10 m]) cause more fatalities than more widely spaced turbines. Raptors fly between these turbines while hunting ground squirrels at which time they are at risk. Wider spacing of turbines is likely to pose less risk, although this has not yet been demonstrated empirically. It is important to note that this and other risk factors are related such that closely spaced turbines may not constitute a risk in areas where there are few birds and low use.
- Rotor RPM and Tip Speed – Larger, slower rotating turbines seem to be no more risky on a rotor-swept-area basis than smaller and faster rotating turbines, but only one empirical (Howell 1997) study and one theoretical (Tucker 1996) study have been done. Hodos et al. (2001) has reported that tip speed is what matters most, although larger rotors may be more visible than smaller rotors that travel at the same speed. These hypotheses need more testing, although at the modern wind plants with turbines that rotate at slower speeds, fatalities have been less numerous.
- Lighting – FAA lights on communication towers have been demonstrated to attract night migrating song and other birds, putting them at risk of colliding with tower guy wires (Avery et al. 1980). White strobes on communication towers are believed to be less attractive than red lights (U. S. Fish and Wildlife Service 2000, S. Gauthreaux, 1999 address to the Communication Tower Working Group), but this has not been demonstrated via a completely controlled test. Because wind turbines are lit differently than communication towers (FAA 2000 Obstruction Marking Circular), there appears to be less risk. The reason is likely to be the absence of steady burning red L-810 lights on communication towers that are lacking on wind turbines, which are equipped with only red L-864 strobe-like lights. Communication towers involved in large-scale fatality events are equipped with 4 to more than a dozen steady burning red lights as well as several blinking red lights. Kerlinger and Kerns (2003) and Kerns and Kerlinger (2004) working at a 44 turbine site in West Virginia, as well as studies from sites in Wisconsin, Minnesota, and elsewhere have never demonstrated large-scale fatality events involving night migrating birds. Moreover, turbines with red strobes do not have greater fatality rates than unlit turbines, suggesting that the red strobes do not attract night migrants. There is a growing consensus among researchers that red strobes are not as attractive to birds as steady burning red lights and that there is not likely to be a difference in attraction between white and red strobes (Communication Tower Working Group, February 11, 2004 meeting).

Numbers of Turbines and Density. – The shear number and density of turbines in places like the APWRA are likely to be a risk factor. In the APWRA there are now 5,400 turbines, down from a maximum of 7,000 in about 1990. The density there is about 67.5 turbines (obstacles) per square mile. Sites with fewer turbines of similar dimensions and design are likely to experience fewer fatalities. With respect to offshore wind turbines, they are likely to be larger and the design somewhat different so individual turbines may experience different fatality rates such that the actual number of turbines is not a strict risk factor.

Topography. – In the APWRA fatalities of Golden Eagles and Red-tailed Hawks are two to three times more likely to occur at end of row turbines that are situated on steep hills or canyon walls or at turbines that are in the middle of strings that are at the bottom of a canyon or steep valley – notch or dip in a ridge (Kerlinger and Curry in prep.). This factor was so well documented that it has been incorporated in the Alameda and Contra Costa County, California, recommended practices for siting new or repowered wind turbines. Keeping turbines on level ground in the APRWA, and perhaps other sites, is likely to reduce risk of collision. In marine environments, the surface is flat, except for waves and the sea bottom, so this relationship may not apply. However, shorelines, inlets, and islands often concentrate both land and seabirds into flight lines within restricted areas, thereby increasing risk of collision. Also, it is possible that shoals, banks, and "lumps" and other discontinuities in the ocean floor where fish can concentrate will likely be areas where more birdlife is present.

Visibility. – Visibility has been demonstrated to be an important risk factor for predicting collisions at lit communication towers (Avery et al. 1980). On nights with poor visibility (fog, rain, snow, or low cloud cover) night migrating song and other birds are attracted to communication tower lights and often collide with the guy wires. At turbines, the risk of collision may be greater at night or at dawn or dusk because moving rotors may not be detectable. Fog and other conditions that make seeing towers difficult have been associated with fatalities at terrestrial communication tower sites (Trapp 1998). Eiders and scoters have been shown to detect and avoid offshore turbines at night in both the Netherlands (Winkelman 1995) and at offshore towers at Tuno Knob in Denmark (Tulp et al. 1999).

Summary

Impacts to birds at wind plants in North America and Europe have been studied for more than fifteen years. Disturbance associated with turbine presence has resulted in the displacement of several species in both terrestrial (grassland, low-lying agricultural land, farm fields, and forest) and marine habitats. The impacts are generally localized, with some birds being reluctant to forage or nest beneath or within 100-200+ m of turbines. In the most sensitive of species, avoidance involves not entering into areas where turbines are clustered or not flying between turbines. Thus, disturbance impacts can amount to areas larger than the actual project footprint, excluding birds from valuable resting, nesting, and feeding areas. However, some species apparently habituate to turbines resulting in minimal disturbance. In those species where habituation has occurred, impacts have been minimal. Lessons from terrestrial facilities are extremely valuable, especially for designing post-construction studies to determine magnitude of impacts. The crucial question regarding this type of impact is which species are capable of habituating to the presence of turbines and which are not. For the latter group, the question of relevance is the size of the disturbance or avoidance area and whether that area is ecologically significant. Studies in marine habitats have been few and limited to only a subset of the species that occur in these environments.

Collision fatalities have been studied at nearly thirty sites in several countries. Fatalities do occur at most, if not all, wind turbine installations, but the numbers of birds involved have usually been small and spread among several species. A few studies have revealed greater numbers of fatalities, especially at sites in Spain, Netherlands, and California, primarily involving raptors and some other species. However, the studies done to date and summarized above are mostly at terrestrial facilities well away from the ocean or marine habitats. A few of the studies were done adjacent to marine habitats or coastal areas. Most importantly, offshore wind turbines will be taller than the majority of wind turbines studied in terrestrial or coastal habitats, the topography will be different, and the amount and type of bird use will be different. Because of these differences generalizing from onshore facilities to offshore facilities should be tentative. Unique methods will need to be devised to conduct post-construction fatality studies at offshore wind plants.

Several factors are not believed or shown to be related to risk. These factors apparently may work independently, but are most likely to work in concert with others such that combinations of high risk factors may present disproportionate amounts of risk. Future studies of risk factors will provide better means of assessing risk at both onshore and offshore wind power facilities.

A4. Birds of the New Jersey Offshore Wind Power Study Area

This chapter summarizes much of what is known about birdlife in the NJOSA as it relates to potential risk to those species should wind power be developed. The information that follows is not meant to be used to assess risk, but instead is meant to be a starting point for researchers tasked with assessing risk at specific projects when they are proposed or screening potential wind power development sites.

There is an enormous body of anecdotal information about bird abundance in the NJOSA, mostly resulting from birder accounts. With respect to quantitative information, a significant amount of study has been devoted to the Jersey Shore, with most studies being onshore and fewer studies focusing out to about one mile (1.6 km) from shore. This information is mostly abundance and seasonal occurrence information. Little is known about the behavior or about avian abundance, use, and seasonal occurrence in the waters between 1 and about 8-10 miles offshore, the areas where wind power projects will, likely, be proposed.

The information that is available suggests that the NJOSA is a high abundance bird area. New Jersey has been called the "Crossroads of Migration" in the title of a book by Dunne, Kane, and Kerlinger (1989, published by New Jersey Audubon Society). The waters off Delaware Bay, Raritan Bay, and the Atlantic Ocean off New Jersey are used by enormous numbers of waterbirds and pelagic species of various types, as well as some shorebirds, songbirds and raptors. There is also evidence that small numbers of owls are transients in the NJOSA at times, and in some places the numbers may be substantial.

Information from the literature, personal knowledge, various databases, and interviews with biologists with the U. S. Fish and Wildlife Service and NJ DEP – Endangered and Nongame Species Program was used to determine the abundance and seasonal presence of birds. Behavioral information about foraging methods, migration flight, and height of foraging flights was gathered from such texts as Ehrlich et al. (1988), Nelson (1979), Bellrose (1976), Johnsgard (1975), Kerlinger (1989, 1995), Kerlinger and Moore (1989) and other sources. In addition, personal experience (of both authors) with many of these species was used. Both authors have studied and published extensively on the birds of New Jersey.

Quantitative estimates of bird numbers from the NJOSA are available for only some species. For others, rough approximations were made by season, time of day, weather, marine conditions, etc., although the numbers are likely to be rough. The accounts that follow are mostly based on observations from shore and some observations from boats. Few systematic surveys have been conducted in the project study area. For winter birds, several Christmas Bird Counts (Audubon Society) supply good information, but these are primarily land-based and count birds visible from shore. A few CBCs include observations from boats. These counts have not been conducted consistently, nor do they cover the entire study area. They do provide an idea as to the species present in early to mid-winter, as well as relative numbers of each species.

In the following accounts of bird use (abundance, seasonal occurrence, and types of behaviors while in the project study area), species are combined into a few groups with similar attributes in relation to their use of the area. These groupings are, in part, taxonomic and, in part, functional. Birds that are taxonomically related are combined, sometimes with unrelated species that are functionally similar, particularly in the ways they fly and forage. The foraging method is also related to the type of food they consume. Prior to the group by group reviews, a description of the major types of bird movements that occur in the NJOSA is presented.

High Bird Use Areas within the New Jersey Offshore Study Area

Within the NJOSA not all waters support the same number or types of birds. It was obvious from the investigations made for this feasibility study that some portions of the study area experience much greater bird use and, therefore, are likely to be higher risk locations for proposed wind projects. The area between southernmost New Jersey and Delaware seems to be one of the highest bird use areas in the NJOSA. The waters between Cape May and Cape Henlopen support an enormous number of wintering and migrating birds, as well as birds making offshore foraging flights between these land masses. These waters are food rich and likely attract more birds than the waters anywhere else off the Jersey Shore. There are other bird rich areas, including much of Delaware Bayto north of Cape May and Cape Henlopen, and the waters within about 1.5 miles (1 km) of the entire Jersey Shore. Also, the waters off Sandy Hook and in the mouth of Raritan Bay are rich in bird life. Inlets and estuaries up and down the Jersey Shore also support a greater abundance of bird life than adjacent waters, and should be considered potential “high use” areas, as has been done elsewhere (Kerlinger and Curry 2002).

Types of Use: Patterns of Movement

There are several types or classes of bird movements known to occur in the NJOSA. The type of bird movement, in conjunction with weather conditions, may influence collision risk. The types of movements described below are not mutually exclusive. The behaviors of birds in the vicinity of wind turbines may differ from the behavior of birds flying around terrestrial wind turbines or locations where there are no wind turbines. Their behavior may also be modified in the presence of turbines in marine environments, increasing or decreasing risk. As has been shown at most wind plants, behavior of birds is modified by the presence of wind turbines.

<u>Seasonal (Day/Night) Migration</u>. The majority of birds, numbering in the millions, likely to be present in the NJOSA are migrants engaged in day and night flights. Species that migrate at night include songbirds, owls, rails, shorebirds, long-legged waders (e.g., herons, egrets) and some waterfowl. A majority of bird migration occurs at night, usually at altitudes above 500 ft. How much proceeds over the ocean or over coastal bays is not entirely known, although it is likely to be substantial. Night migration commences about 45 minutes after the sun sets and continues almost unabated until dawn. On some nights migration ends shortly after or a few hours after takeoff, depending on weather. Most migration occurs during clear weather, although at times, birds are forced to fly in inclement weather (fog, rain, adverse winds), which can influence their altitude, flight direction, speed, and other behaviors.

There is also a significant migration by day near the shore and out over the water, including raptors, cormorants, loons, seaducks, other waterfowl, some songbirds (swallows, morning flight), herons and egrets, shorebirds, etc. Several species migrate by day or by night. There are also many unknowns. For example, do loons, seaducks, and some others, known mostly to migrate in daylight, also make flights during darkness?

At least three patterns of migration are known to occur in the NJOSA and are of interest to biologists who are assessing potential risk to birds from wind power facilities. They are not entirely distinct and it is likely that there is overlap. However, the patterns are constructs that will help us understand the migration phenomena that occur in the NJOSA.

- Birds flying over land continue out over the ocean for short distances, only to return to land to rest and feed or return to nearshore waters to rest and feed. These species include many night migrants that "mistakenly" fly out over the ocean.
- Birds flying over the ocean on a track parallel to shore. These include seaducks, true pelagics such as shearwaters and petrels, gannets, cormorants, alcids, loons, and some others. Some of these birds, including some songbirds, shorebirds, and others, may originate flights farther up the coast from New Jersey and make "landfall" somewhere along the New Jersey Shore.
- Birds that are initiating long-distance flights over water to the southern United States or even tropical landmasses. These include some songbirds and shorebirds, perhaps including a few raptors, loons, and waterbirds.

Specific migration seasons are defined below in the section about major bird groups.

<u>Feeding Movements.</u> Many of the birds that use the NJOSA are seeking food. Species like Common Terns, Ospreys, scoters engage in daily or nightly foraging flights, during which they fly from shore out into the ocean or bays or fly between locations on the water. Most of these species seek food rich areas that can change from day to day, week to week, or year to year. Species like scoters visit familiar mussel beds or in the case of loons, visit fish refuges such as rips and lumps on the sea bottom, inlets, or channels. Studies at Danish offshore windfarms in winter demonstrated that Common Eider and scoters flew frequently at night (Tulp et al. 1999), especially during clear conditions. Others, like terns and gannets, explore opportunistically, wandering over large areas in search of fish or squid. Knowing where and when these flights occur is useful to determining risk to the species involved.

<u>Nightly Roosting Flights.</u> These flights generally occur around sunset and sunrise among scoters, eiders, and other species. They sometimes involve flocks moving in times of poor visibility. These flights are noted for terns in late summer, wintering seaducks, loons, and some others. The height of these movements has not been measured.

Major Groups of Birds that Occur In and Use New Jersey Offshore Waters

Oceanic/pelagic seabirds. Large numbers of Sooty, Greater, and Cory's shearwater and very small numbers of other shearwater species migrate through and forage NJOSA during May-November (peak late May-August/September, Walsh et al. 1999, Sibley and Elia 1997). These species infrequently approach within a mile of shore and the largest concentrations are generally more than several miles from shore. Most fly very low, almost exclusively within about 10-20 m (33-66 ft) of the waves. Birders on boats see them regularly, far offshore, and occasionally small numbers are seen from shore. Their daily presence in the NJOSA during late spring and summer may number in the thousands during the peak season.

Jaegers, mostly Parasitic and fewer Pomarine, migrate through New Jersey coastal waters and the NJOSA regularly. Hundreds are counted at the Avalon Seawatch between October and November/December (Ward 1980, Ward and Sutton 2001, data provided in Peregrine Observer, publication of the Cape May Bird Observatory). They can be seen close to shore at times, but there are likely to be more individuals farther offshore. Their behavior is relatively unknown during migration and their distribution in relation to the Atlantic shoreline is also imperfectly known. They are infrequently reported from Delaware or Raritan Bays.

Northern Gannets are abundant over the continental shelf during autumn and early spring, and to a lesser extent winter (Stone 1937, Sutton 1985, Walsh et al. 1999). They migrate through the NJOSA in large numbers, and a majority of the North American population (perhaps 75,000 passing within sight of land) passes through New Jersey waters each year. Some pass farther from shore and may pass beyond the limit of the NJOSA. They are regularly observed from shore and excellent records of their passage have been gathered since the 1970s by the Cape May Bird Observatory (Ward and Sutton 2001) at the Avalon seawatch. It is not known how much of the New Jersey coast they follow, although in autumn they can commonly be seen along much of the shore. They are present in varying numbers within the NJOSA between mid-October and late April, although stragglers are present earlier and later in migration. Offshore surveys by the U. S. Fish and Wildlife Service (Forsell and Koneff 2002, Forsell undated report) show somewhat clumped distributions of gannets in winter. Most birds were found mostly within the waters <76 ft (23 m) within about 10 miles of shore. Numbers decline after migration because most gannets move southward. Migration in spring seems to involve fewer individuals and is less evident from shore. Gannets often dive for fish, frequently from heights that would bring them into the lower portion of the rotor area. Although their migratory flight usually is below rotor height, during strong winds they use dynamic soaring, which brings them into the lower portion of the rotor swept area.

Storm-petrels (Wilson's, mixed with occasional Leach's) can at times be the most abundant of pelagic birds in the NJOSA project study area (Levine 1998, Walsh et al. 1999), especially during summer. They spend mid-May-September (peak – late May-August) in the area, and number in the thousands. The largest numbers are reported well offshore (more than 1-2 miles), although they do venture within sight of land along the Atlantic Coast and into Delaware Bay. At night they approach the lights of fishing boats and by day they can be seen as they feed at the water's surface. Altitude of foraging flight when feeding on zooplankton is virtually always below 10 m (33 feet) above the water. Migration altitude is unknown.

Smaller numbers of these pelagic species are seen in Delaware and Raritan Bays, although all of these species do venture into these areas at times. They can be numerous in the area between Sandy Hook and Long Island, and probably even more numerous in the area between Cape May and Cape Henlopen, Delaware. Other pelagic species have been noted by birders in NJOSA waters and waters farther out (Sibley 1993, Levine 1998, etc.), but their numbers are small and they sometimes are not seen on a yearly basis.

There are very few quantitative studies of these birds in New Jersey waters. It is not known how many individuals of these species migrate through or forage within the NJOSA. Whereas seasonal distributions of most species and approximations of daily numbers are somewhat known, flight behavior and distribution of individuals in relation to the shoreline are not known.

Cormorants. Both Double-crested (mostly March-November) and Great Cormorant (mostly November-March) occur within the NJOSA (Walsh et al. 1999). Both catch fish by swimming underwater relatively close, usually within one mile of shore. Roughly 200,000 Double-crested Cormorants (Cape May Bird Observatory statistic) pass along the south Jersey shore at Avalon in autumn mostly in September through mid-November. Migration has been studied along the New Jersey shore and seems to be mostly within one or two miles of the beach. Migration height over water is usually less than 1,000 ft (310 m) above the shoreline, although it is not infrequently within 100 ft (31 m) of the water. From our observations, many cormorants migrating along the coast of New Jersey fly within the height of the rotor swept zone of turbines. Their return in spring is less noticeable. Although these birds probably migrate along most of the New Jersey coast, it is not known where they arrive at the coast from farther north (from inland and from Long Island), although large numbers are seen off Long Island, which suggests a large coastal migration.

Most of the Double-crested Cormorants observed during migration in New Jersey winter to the south of New Jersey. Although they can occur far from shore, most observations are of birds within about 1-1.5 miles of shore, except during migration when these birds cross from Long Island to New Jersey and from Cape May to Delaware, sometimes “cutting the corner” and moving several miles offshore. Many stop over in New Jersey waters, although very few nest within the state. About 1,100 pairs nest in the New York City portions of the New York/New Jersey Harbor (Kerlinger 2003, Levine 1998), only a few miles from the NJOSA. The colony at Swinburne Island (about 200 pairs), off southern Staten Island, is the closest. Foraging flights are usually within about 20-50 m (66-164 ft) of the water. Smaller numbers of Double-crested Cormorants are present through the spring and summer, into early fall, in the waters of New Jersey. They may be nesting, foraging, or pre-reproductive birds from New York nesting colonies. Probably only a few hundred Great Cormorants are found in the NJOSA during winter.

Both species readily perch/roost on any suitable structure and will probably attempt to use turbines and associated structures if available.

Whereas there is a large body of information regarding the numbers and seasonal timing of fall migration along the New Jersey shore, in addition to anecdotal information on migration altitude, there have not been quantitative studies of flight behavior or distances that these birds migrate and forage from the New Jersey shoreline.

Seaducks. The waters of the New Jersey shore host an immense migration of scoters and some other seaducks each year (U.S. Fish and Wildlife Service 1993). The most common of these birds are Black and Surf Scoters, which together number more than 200,000 during migration each year, and smaller numbers of White-winged scoters (<5,000) (Ward and Sutton 2001, Mizrahi et al. 2000, Peregrine Observer several years data). In addition, there are smaller numbers of Long-tailed Ducks, Red-breasted Merganser, Greater Scaup, scaup sp., Bufflehead, and some others in smaller numbers (Harlequin Duck). The migration of the scoters commences in October and continues into December. The other species are also present in that time period. All of these species will be present during winter, but in much lower numbers than during migration. The spring migration commences in March and continues into mid-April. In northern New Jersey, migration is less well known, although anecdotes show that large numbers of ducks can use Raritan Bay and be present off Sandy Hook. R. Kane (personal communication) witnessed about 15,000 scaup arriving in Raritan Bay in mid-October. These birds arrived from the northwest, which is the direction of their nesting areas. They arrived high and landed on the waters of Raritan Bay. Numbers like these are not reported regularly in New Jersey, but these birds may simply takeoff and fly unnoticed (either at high altitudes or at night) and fly south of the NJOSA.

Migration flight behavior of most seaducks during over water flights usually parallels the shoreline. Most birds fly at very low altitudes (<100 feet, 31 m ASL) when flying over water and at high altitudes over land (>500m, 1,640 ft). Many of these flights are seen by day, but some are nocturnal (Goudie et al. 2000). A Danish study showed that <10% of migrating eiders were at >50 m (Kahlert et al. 2000). Scoters and Long-tailed Ducks studied with radar in southern Finland flew above 500 m, and above 100m over the Baltic Sea (Bergman and Donner 1964). From the seawatch at Avalon, New Jersey, most migrating scoters are reported within a mile or two of shore and fly at less than about 20 m (66 feet).

During winter, scoters, and some other seaducks can be densely concentrated in the waters off Cape May and elsewhere in southern New Jersey, including Delaware Bay. The concentrations of these ducks can be immense where there are significant mussel and/or clam beds. Most of these ducks forage within about 1-3 miles of shore in this area (from what can be seen from boats and from shore), where depths are appropriate and where food is abundant. Roosting movements and roost sites of scoters have been noted in New Jersey waters during winter. U. S. Fish and Wildlife Service studies (Forsell 1999, Forsell and Koneff 2002, Forsell undated) have revealed significant numbers of these birds during winter. It is likely that the numbers add to more than 100,000 of these birds each year spend all or part of the winter in the NJOSA study area. Maps produced via aerial surveys reveal that these birds are distributed throughout the offshore waters of New Jersey and that their locations and concentrations vary from year to year. The Service database also includes information on Red-breasted Mergansers, Common Goldeneye, scaup, Bufflehead, Ruddy Duck, and Long-tailed Duck. In February-March of 2004, perhaps 100,000 to 150,000 Black and Surf scoters were present in enormous rafts off Cape May Point, feeding in the rips formed by the confluence of the Atlantic Ocean and Delaware Bay.

Small numbers of dabbling ducks, such as Green-winged Teal, and fresh water species (Wood Duck), and divers are also present among the seaducks during migration, as evidenced from data collected at Avalon by the Cape May Bird Observatory and published in their newsletters. Their numbers are small in comparison to scoters and in comparison to aggregations in places like the Maurice River and other estuaries during winter. Most of the individuals of these species do not fly out over the Atlantic Ocean so they will infrequently be found in those waters. However, they do frequent the waters adjacent to Delaware Bay and migrate over those waters, as well as the waters of Raritan Bay (based on distribution reports of these species).

Although much is known about seaducks and other species of waterfowl found in the NJOSA, little quantitative information on flight height or distribution during migration or winter is available. We do not know what percentage of the migration is beyond view from land and therefore goes uncounted by land-based observers.

<u>Other divers – including loons, mergansers, grebes, alcids.</u> Loons (Common and Red-throated), grebes (mostly Horned), and alcids (mostly Razorbills) are migrant and, to a lesser extent, winter residents in the NJOSA. They feed principally on fish and small invertebrates in the water column. They fly mostly near the water surface and some species do fly within the rotor height-range. Overland, Common Loons migrate at altitudes up to more than 1,525 m (5,000 ft) (Kerlinger 1982, 1998). Along the New Jersey shore, these birds generally fly below 10-25 m (33-107 ft), although when flying over the shoreline/beach, they fly at more than 30-50 m (98-164 ft) (personal observations, Kerlinger and Sutton). Migrants usually fly in loose, widely spaced flocks that sometimes exceed a dozen birds (up to about 100 for Red-throated Loons). The flight behavior of grebes, mostly Horned Grebes, is similar to that of loons and seaducks.

Migrant loons arrive in September and continue into December. Loons are present through the winter and migrate north in March through early May. The autumn peak is late October through mid-November (Ward and Sutton 2001, Walsh et al. 1999, dates from the Cape May Bird Observatory Seawatch at Avalon, Mizrahi et al. 2000). Annual counts of migrating birds at the Cape May Seawatch total roughly 60,000 for Red-throated and less than 5,000 for Common Loons. Most migrate through the NJOSA, stopping to feed for hours to days at a time. Some end their migration in New Jersey waters with winter numbers being much lower than migration numbers. Their distribution during migration from the coast outward is not known, although anecdotal information from the authors suggests most of the birds are within 2 miles of shore in the Avalon area. Farther from shore, they are far less densely aggregated than are the migration streams that are close to shore.

The numbers of Common Loons wintering off New Jersey are likely in the range of about 1,000 individuals according to Audubon CBCs and anecdotal information. Red-throated Loons seem to be less common in winter, although they commence to stage near Cape May in February and March, reaching thousands in the mouth of Delaware Bay and nearby waters by late March and April.

Horned Grebes migrate at the Avalon Seawatch in autumn, when hundreds are observed (Ward and Sutton 2001, Walsh et al. 1999). Because these birds are night migrants, little is known about their flight behavior. They are present during the winter, as evidenced from CBCs. Their distribution from the shoreline out into the ocean is unknown.

Alcids are rarely seen from the Jersey Shore, although pelagic trips (offshore boat trips by birders to see birds that seldom come near land) can yield small numbers on a regular basis, mostly several miles offshore. Razorbills are the most commonly reported alcids, although small numbers of Dovekies are also present, and Atlantic Puffin observations are sometimes made very far offshore in late winter/early spring. The flight behavior of alcids in migration or when making foraging flights has not been studied, although they seem to always fly within a few meters of the waves.

Geese and non-sea ducks. Large numbers of geese and ducks are present in the coastal wetlands, estuaries, ponds and lakes, as well as back bays, principally in autumn through spring (September-April; Stone 1937). Most do not use the NJOSA except during some migratory flights. Those that do fly out over the Atlantic Ocean generally do not venture far from shore. These species include Geese (Canada, Brant), bay ducks (eg. Goldeneye, scaup) and freshwater ducks (eg. Hooded Merganser, and various dabblers). These species will definitely be found in some nearshore portions of the NJOSA. Some of these species, such as Brant, Tundra Swans, and Snow Geese migrate parallel to the Atlantic Coast for varying distances. Goose movements may be in day or night. Their presence more than 1-2 miles from shore is unknown and their flight behavior has not been studied in the NJOSA. They are rarely seen more than one mile from the beach.

Gulls, Terns, and Skimmers. Species from these three groups nest in colonies along the Jersey Shore, mostly in the back bays and on islands in inlets, at the edge of the NJOSA. A majority of gulls that nest in New Jersey are Laughing Gulls, although some Herring and Great Black-backed Gulls do nest in the state. Some of these birds feed within or immediately adjacent to the NJOSA. They also have concentration points along the shore near nesting sites and roosts after the nesting season.

Four tern species regularly nest in New Jersey: Common, Forsters, Least, and Gull-billed, although other species that do not breed here (Roseate, Black, Arctic, Sandwich, Royal and Caspian) can be found at the tern colonies in New Jersey (Walsh et al. 1999). There are many thousands of terns in colonies along the coast. The location and numbers of pairs have been recorded by the NJ DEP biologists who conduct regular nesting surveys.

Most gulls and terns feed near shore, but they may concentrate anywhere out to several miles offshore where forage is plentiful. The locations are not predictable, except over short periods. Most flight occurs below 30-50 m, but this has not been investigated systematically and gulls and terns regularly fly more than 100 ft above the ground or water. Some nocturnal migration (of terns) entails initial climbing to altitudes of 1000 m, or more among some terns, although little is known about their migration behavior.

Skimmers nest on islands and other protected locations in the back bays and inlets of New Jersey. See below in listed species section for more information on this species.

Gulls, terns, and skimmers migrate along the New Jersey shore and numbers have been summarized as a result of the Cape May Bird Observatory Seawatch at Avalon. However, the numbers are certainly underestimates, because the counters focus most of their attention on loons, seaducks, etc. and because it is difficult to separate the thousands of feeding and resting gulls from migrants. The distribution of these birds in relation to the shoreline is not known, so it is not possible to conclude what proportion of the migrants and wintering gulls, or even nesting gulls in New Jersey spend time in the NJOSA or what they are doing when they are in that area.

Wintering gulls in New Jersey are spread along the entire coast, including Herring, Ring-billed, Great Black-backed, and to a lesser extent some Bonaparte's Gulls (National Audubon Christmas Bird Counts; Walsh et al. 1999). The latter doesn't winter in large numbers in New Jersey waters. Little is known about their distribution, although except within 1-2 miles such as in the rips of Cape May, where large aggregations of these birds can be seen mixed with scoters, loons, and other birds during late winter and early spring. Bonaparte's Gulls can be very pelagic in winter and are not infrequently found more than 3-4 miles from shore (Sutton personal observations). Very small numbers of other gull species can be found in New Jersey at almost any time of the year, but mostly during late fall through winter.

<u>Shorebirds.</u> Millions of shorebirds frequent coastal New Jersey during spring and fall migration. Southbound shorebirds begin arriving from arctic nesting areas in late June and July and remain until October/November. Most leave during August and September into October, taking off after dark and heading out over the western Atlantic or paralleling the Atlantic Coast on their way to the tropics. Thousands of Sanderling, Dunlin, and Ruddy Turnstone remain in New Jersey for the winter, spending their time on the beaches and tidal flats of the back bays and inlets. Smaller numbers of other Purple Sandpipers also spend the winter on the New Jersey coast, mostly on jetties. During fall migration, shorebirds probably arrive both from inland to the north and west, as well as from over the ocean (up the coast). In spring these birds arrive in late April through mid-May and depart by the first week of June.

Although not studied in the NJOSA, the altitude of shorebird migration over the western Atlantic and over coastal areas is generally quite high, even higher than the songbirds (Kerlinger and Moore 1989). Radar studies by Richardson (1979) and others show migration to be mostly above 2,000 ft (610 m) when the birds are over the ocean. However, birds making shorter flights along the coast (foraging or short migratory flights) may fly only at or lower than a few hundred feet above the waves. Those birds migrating, especially at night, over the waters of the NJOSA are undoubtedly flying at relatively high altitudes because they are engaged in longer distance flights. Virtually all of these birds will be above 1,000 ft (305 m), except while ascending after takeoff or landing after longer flights. Less is known about the return migration, although several million shorebirds likely descend on coastal New Jersey from the south, perhaps even from over the ocean.

Other than flights in and around Delaware and Raritan Bays (as well as the nearby Atlantic Ocean), shorebirds are not likely to make short foraging flights within the NJOSA because there are no foraging areas offshore in the Atlantic Ocean. Phalaropes are also present, but totally unknown with respect to numbers and distribution.

The spring concentrations of shorebirds on the Delaware Bayshore of New Jersey and Delaware are one of the wonders of the avian world (Dunne et al. 1982, 1982b, 1983, L. Niles personal communication, Pettigrew 1998). As many as one million individuals of at least five principal species (Red Knot, Sanderling, Ruddy Turnstone, Semipalmated Sandpiper, and Dunlin) may have at one time gathered to forage on horseshoe crab eggs and other items to deposit fat before their final flight to arctic nesting areas. This phenomenon is critically important to the survival of these species and has been well studied by groups from the Cape May Bird Observatory, Manomet Observatory, the NJ ENSP, and several universities since the late 1970s. Studies show these birds arrive in early May and depart during the last week of May or first days of June. Recent research using radiotelemetry and color leg bands have shown that thousands of these birds fly back and forth over the Delaware Bay between New Jersey and Delaware. Little is known about flight height or regular pathways, although it is likely that these birds are spread over a broad front. This suggests that portions of Delaware Bay are high use areas.

Long-legged Wading Birds. Herons, egrets, and Glossy Ibis nest in significant numbers in coastal areas of New Jersey (Kane and Farrar 1978, Galli and Kane 1979, Walsh et al. 1999). Colonial waterbird surveys conducted by the NJ DEP Endangered and Nongame Species Program and the New Jersey Breeding Bird Atlas provide accurate information on the whereabouts of most nesting areas, along with the numbers of nesting pairs of each species. There are several thousand nests of these birds in New Jersey and nearby waters of New York Harbor (Hoffman Island, Kerlinger 2003). Most nesting areas are within forested patches of islands in back bays or larger bays. These birds forage in shallow waters of marshes, lakes, bays, and, sometimes, in rare instances, the surf zone. They do not fly offshore, except during migration, or perhaps during longer foraging flights that traverse Delaware or Raritan bays. They are not likely to be found, except in very rare circumstances, out over the Atlantic Ocean. Those circumstances may include migrants flying between Long Island or New England to the Jersey Shore or farther south, at which time they will pass through Atlantic Ocean waters of the NJOSA. Thousands of these birds are likely to migrate through the NJOSA, between landmasses at Sandy Hook-Long Island/New York and Cape May-Cape Henlopen.

It is known that these birds make foraging flights that traverse the waters of Raritan Bay (Kane and Kerlinger 1994), presumablycoming from Hoffman Island and the Arthur Kill islands in New York or colonies farther south in New Jersey. Long-legged waders also make foraging flights across Delaware Bay and can be seen regularly crossing the Bay in summer. Flight behavior during migration and foraging flights has not been studied thoroughly, so it is not known how high these birds fly at these times. Anecdotal observations reveal that these birds do fly up to several hundred feet above the water during these flights, but accurate altitude measurements are lacking.

Raptors. New Jersey hosts some of the largest migrations of raptors in the eastern United States. Each year, more than about 50,000 hawks, eagles, harriers, and falcons of about 16 species are usually counted at places like Cape May Point (Stone 1937, Sutton and Dunne 1986), and in spring up to about 5,000 hawks are counted at Sandy Hook (Peregrine Observer; Heintzelman 1975, 1986). Lesser numbers migrate through Cape May during spring (Sutton 1984), some of which may cross from Cape Henlopen to Cape May. These sites are located at the northern and southern ends of the Jersey Shore. For nearly 30 years, the Cape May Bird Observatory has conducted hawk counts at Cape May and for a lesser number of years at Sandy Hook. There is also a significant flight of hawks up the Delaware Bayshore (Sutton et al. 1991, Sutton and Kerlinger 1997). Zalles and Bildstein (2000) suggest that the migrations in Cape May are of global importance.

The migration of hawks is, for the most part, a terrestrial phenomenon because many raptor species are reluctant to venture out over water. With respect to which raptor species migrate offshore in the NJOSA, studies by Kerlinger (1984, 1985, 1989) and Kerlinger, Cherry, and Powers (1983) found that even species that are sometimes reluctant, do make crossings from Cape May to Cape Henlopen if the weather conditions permit such a flight. It is likely that the same species make crossings from Sandy Hook to Long Island or Staten Island. The species most likely to be found migrating in the NJOSA include Peregrine Falcons (arctic/tundra population, which is not listed), Osprey (northern populations and New Jersey listed populations), Northern Harriers (northern populations and New Jersey listed populations), Merlin, and to a lesser extent American Kestrel, Sharp-shinned Hawk, Bald Eagle, and a few other species. The latter species are more reluctant to cross water, so they are less likely than the former species to be found more than a mile from shore. Most of the latter species that are likely to be found in the NJOSA will be making crossings from Sandy Hook to Long Island and from Cape May to Cape Henlopen. The former group will be found both making those crossings and over the waters of the Atlantic Ocean.

A flight path of Peregrine Falcons from mid-Long Island and farther northeast to the Jersey Shore has been identified (reviewed in Kerlinger 1989). These birds are seen leaving the shoreline of Long Island flying toward the southwest, which would bring them ashore on Island Beach, Long Beach Island or farther south. Peregrines, Merlins, Osprey, and Northern Harriers are seen regularly offshore (Kerlinger, Cherry, and Powers 1983) and from the Cape May Hawk Watch and Avalon Sea Watch these species are frequently seen well out over the Atlantic Ocean, suggesting they are jumping from the New Jersey shore north of Cape May to the Delaware shore or farther south.

Kerlinger (1982, 1985) examined flight behavior of these birds, finding that crossings from Cape May to Cape Henlopen were done at various altitudes and with varying weather conditions. Species like Peregrine Falcon, Merlin, Northern Harrier, and Osprey crossed under all weather conditions and crossed mostly at fairly low altitudes (<30 m), although some were hundreds of meters above the water. Sharp-shinned Hawks and American Kestrels, on the other hand, chose specific conditions during which to make the crossing. They preferred to initiate the crossing at much higher altitudes, generally above 200 m, although some came back at very low altitudes (<20 m). Bald Eagles make the crossing, but less is known about their behavior.

Foraging by raptors offshore occurs, but is limited to a few species. Peregrine Falcons and Merlins hunt small birds offshore during migration. Bald Eagles will venture out from shore to fish, but they do so only on rare occasions. Both New Jersey nesting and migrating Ospreys forage in the ocean and over both Delaware and Raritan Bays. Hundreds of Ospreys nest in New Jersey, mostly in the coastal marshes behind the barrier islands. These birds forage in shallower waters of back bays, but are frequently observed heading out over the ocean or out over Delaware and Raritan Bays. They are less likely to be seen more than a mile from shore as opposed to within a mile of shore. Very little is known, however, about this type of foraging behavior, with respect to how far these birds venture offshore in search of fish. Altitude of hunting behavior among Ospreys varies from <10 m to 50 or more meters above the water.

Passerines (Songbirds) and Other Landbirds. Although songbirds and other small landbirds do not forage over the ocean, there are likely to be large numbers of migrants that fly over the waters of the project study area. Millions of these birds migrate through New Jersey in autumn and fewer migrate through the state in spring. Most of these birds are engaged in long or middle distance nocturnal flights at relatively high altitudes. In autumn these birds take off from forests and fields just after sunset and head southeast, south, and southwest. In addition, birds taking off from Rhode Island, Massachusetts, and Long Island/southern New York may pass over the NJOSA in autumn and a similar, though smaller flight, probably occurs in spring. The altitude of most nocturnal migrants is within the 300-2000 ft (91-610 m) range (Kerlinger 1995, Kerlinger and Moore 1989, Able 1970). Overwater flight over the Gulf of Mexico was found to be between 1,900 and 8,200 ft (580-2,500 m), although most of the birds were in the lower portion of this range (S. A. Gauthreaux in Able 1999). Over the western Atlantic, Williams and others have tracked songbird-sized migrants at 3,500 to 7,000 ft (1,067-2,134 m) during their long flight over water (in Able1999). These radar studies suggest that in autumn songbirds migrating over the NJOSA will be predominantly above 1,000 ft (305 m). Studies by Drury and Nisbet (1964) in coastal Massachusetts demonstrated that many songbirds migrate over low-lying fog and show well oriented migration even under overcast skies.

Some of the birds that will occur in the NJOSA have been drifted offshore by winds and will then attempt to regain land. They do this by flying directly toward shore as the sun rises and into midday. These birds, if they are fighting headwinds (the same winds that drifted them offshore) are almost exclusively below 100 feet (30 m) above the waves. Many never make it to shore because of exhaustion and predation by gulls. At these times, migrants will fly within the range of the rotor swept zone or below it. We know that these birds arrive at shore from casual observations and from a study of migrant songbirds in Cape May (Wiedner et al. 1992) that showed tens of thousands of Neotropical songbirds move northward out of Cape May (onshore) after dawn. Many of these birds likely were over the ocean or near the ocean when they terminated their night migration several hours earlier than they were observed by Wiedner et al. (1992).

Some diurnal migrants (for example, swallows and late season finches), do fly at lower elevations and some of these birds will be found crossing between Long Island/New York and Sandy Hook and between Cape May and Cape Henlopen. Their altitudes are unknown, but they are seen coming ashore at altitudes of less than 100 ft.

The New Jersey Audubon Society research program has an ongoing radar study of night migration in some parts of New Jersey. Those studies promise to provide an abundance of information regarding the offshore migration of these birds. Any risk assessment that is done for offshore wind power projects in New Jersey should examine these studies (if available) and use them to assess risk.

Endangered, Threatened, and Species of Special Concern

Bird species listed by the U.S. Fish & Wildlife Service as endangered or threatened in New Jersey waters and species listed by the New Jersey Department of Environmental Protection as endangered, threatened, and, or species of special concern are provided in Table 4.1. The state list refers to those populations of each species that both breed or spend other time within New Jersey. The state nesting populations may involve different individuals than those that frequent the waters off the New Jersey shore.

Table 4.1 contains three species on the federal list: Roseate Tern, which is globally endangered, as well as Piping Plover, for which the Atlantic population is threatened and Bald Eagle, which is federally threatened (proposed for delisting in 2000). Of these three species, Roseate Tern is the only pelagic species.

Any of the species listed in Table 4.1 may, at times, be found in the offshore waters of New Jersey. A majority of these species use terrestrial habitats, although during spring and fall migration, some individuals of most of these species can be found several miles out over the Atlantic Ocean. The terrestrial species on the list are likely to be found most often migrating over the waters of Delaware Bay and, or Raritan Bay. These bays are, with a fair degree of certainty, regularly crossed by most species on the lists. The songbirds on the list will not be found foraging at sea, although many regularly can be found at sea when making crossings from New England or Long Island to New Jersey or farther south. They may also be found several miles out over the Atlantic Ocean after being blown offshore, sometimes in large numbers. Wiedner et al. (1992) identified tens of thousands of Neotropical songbird migrants, including some on in Table 4.1, engaged in morning flight at Cape May, New Jersey, following night migration. These and more common songbirds can be seen coming ashore from dawn into midday at almost any location along the shore. There do not seem to be regular migration routes or pathways offshore.

A few species forage irregularly out to a mile or more from shore in both the Atlantic Ocean and Delaware and Raritan bays. Details for these species are provided below. Other species in Table 4.1 do engage in regular foraging flights over Delaware and Raritan Bays. Red Knots forage on both sides of Delaware Bay in very large numbers and are known to commute across the Bay regularly (L. Niles, NJ DEP personal communication). Radiotelemetry studies and color band marking of thousands of these birds have shown that these birds cross Delaware Bay. From this research, it is likely that thousands of these birds (and many other shorebird species) fly between places like Reed's Beach on the New Jersey side of the Delaware Bay to places like Slaughter Beach on the Delaware side of the bay. Such crossings to Delaware and back originate or end in across a wide geographic area of Cape May and Cumberland County on the New Jersey side.

Table 4.1. Birds listed as endangered, threatened, candidate, or species of special concern by the New Jersey Department of Environmental Protection, Endangered and Nongame Species Program and the U. S. Fish and Wildlife Service (federally listed species designated as follows - US-T = Threatened, US-E = Endangered). Species with an asterisk are known to forage regularly beyond 1 mile from shore.

Species	Breeding Status	Non-breeding Status
Pied-billed Grebe	Endangered	Special Concern
American Bittern	Endangered	
Least Bittern	Special Concern	
American Bittern	Endangered	Special Concern
Tricolor Heron	Special Concern	
Little Blue Heron	Special Concern	Special Concern
Great Blue Heron	Special Concern	
Black-crowned Night-heron	Threatened	
Yellow-crowned Night-heron	Threatened	
King Rail	Special Concern	
Black Rail	Threatened	
Whimbrel		Special Concern
Spotted Sandpiper	Special Concern	
Piping Plover – US-E	Endangered	Endangered
Upland Sandpiper	Endangered	
Sanderling		Special Concern
Red Knot	Threatened	
Common Tern*	Special Concern	
Roseate Tern* - US-E	Endangered	Endangered
Black Tern*(?)		Special Concern
Least Tern	Endangered	
Caspian Tern *	Special Concern	
Black Skimmer	Endangered	Threatened
Osprey	Threatened	
Bald Eagle – US-T	Endangered	Threatened
Northern Harrier	Endangered	Special Concern
Sharp-shinned Hawk	Special Concern	Special Concern
Cooper's Hawk	Threatened	
Broad-winged Hawk	Special Concern	
Red-shouldered Hawk	Endangered	Threatened
Peregrine Falcon	Endangered	
American Kestrel	Special Concern	
Common Barn Owl	Special Concern	Special Concern
Short-eared Owl	Endangered	Special Concern
Long-eared Owl	Threatened	
Barred Owl	Threatened	
Red-headed Woodpecker	Threatened	

Common Nighthawk	Special Concern	
Least Flycatcher	Special Concern	
Loggerhead Shrike	Endangered	
Horned Lark	Special Concern	
Cliff Swallow	Special Concern	
Winter Wren	Special Concern	
Sedge Wren	Endangered	
Veery	Special Concern	
Gray-cheeked Thrush		Special Concern
Blue-headed Vireo	Special Concern	
Golden-winged Warbler	Special Concern	Special Concern
Northern Parula	Special Concern	
Cerulean Warbler	Special Concern	Special Concern
Black-throated Green Warbler	Special Concern	
Kentucky Warbler	Special Concern	Special Concern
Canada Warbler	Special Concern	
Yellow-breasted Chat	Special Concern	Special Concern
Vesper Sparrow	Endangered	Threatened
Savannah Sparrow	Threatened	
Henslow's Sparrow	Endangered	Endangered
Grasshopper Sparrow	Threatened	Special Concern
Eastern Meadowlark	Special Concern	
Bobolink	Threatened	

Piping Plover. This federally threatened and New Jersey endangered beach-nesting shorebird nests on New Jersey beaches from Sandy Hook to Cape May from April to October (arriving in late March). These birds feed entirely on the shore and are confined to the vicinity of their nests during that season. During the migration season, some individuals flying to nesting areas farther north along the coast undoubtedly fly along the New Jersey coast and may cross from Sandy Hook to Long Island. They undoubtedly cross from Cape Henlopen, Delaware, to Cape May or even farther north along the Jersey shore before they reach land. It is not known if any of these birds fly directly over water from Delaware to New York, thereby flying through New Jersey offshore waters. Little is known about their migration flight behavior.

Roseate Tern. This species is listed as federally endangered because its population has declined dramatically and because these birds nest in a few, dense colonies making them potentially vulnerable to impacts (USFWS 1989). No Roseate Terns are known to nest in New Jersey, although in the summer of 2003, several individuals frequented the tern colony at Stone Harbor Point for several weeks. In addition, several Roseate Terns frequented the tern colonies at the Rockaways and Breezy Point area of Long Island during June and July (New York City Parks and Recreation biologist, personal communication), only a few miles from the New Jersey offshore study area. Although the species used to nest on western Long Island's South Shore and in the 1920s and 1930s in southern New Jersey, they no longer do so. Roseate Terns are regular, although infrequent visitors to the Jersey Shore, mostly represented by a few individuals in May through August (Sibley 1987). Their status offshore is not entirely known, but this species is mostly pelagic and could be found anywhere in the New Jersey Offshore study area.

<u>Other Terns.</u> Least Terns nest in several locations along the New Jersey shore (Walsh et al. 1999). They are not found regularly more than about a few hundred yards from shore, except in more protected waters like those of Delaware Bay and, to a lesser extent Raritan Bay. They likely migrate to and from Delaware and New York via the shortest crossing routes which would be from Cape May to Cape Henlopen. They probably also migrate from the vicinity of Sandy Hook to Long Island. Either of these crossings would bring them into the NJOSA. Black Terns are more restricted to freshwater, although at times during migration they can be found foraging in numbers exceeding 100 individuals in locations such as the rips off Cape May Point (Sibley 1987). Common Terns nest in several colonies along the New Jersey shore, as well as in large colonies on western Long Island. They are known to forage up to 10-15 miles from nesting colonies and can be seen offshore at almost any time. These terns will mostly be present in New Jersey waters between April and October, migrating southward out of the state. During autumn and spring migration, Common, Black, and Least Terns from other colonies to the north and west of New Jersey will likely pass through the NJOSA waters. The proportions of resident vs. nonresident individuals are not known. Also, little is known about the flight dynamics and behavior of these birds during migration.

<u>Diurnal Raptors.</u> Of the raptors in Table 4.1 that may occur in the NJOSA area during migration, Peregrine Falcon, Northern Harrier, Osprey, and Bald Eagle are the most likely candidates to be seen. Bald Eagles are rarely reported off the Jersey Shore, although they do fly from Cape May Point to Delaware regularly. They sometimes forage offshore, out to about a mile, infrequently during autumn migration period. Ospreys regularly forage within the NJOSA, from March through October. Ospreys present will be a combination of locally nesting individuals and migrants from farther north. They normally forage within about 1 mile of the shoreline of the Atlantic Ocean, although they less frequently forage farther from shore. In the Delaware and Raritan Bays, they are likely to forage farther from shore than in the ocean, a result of a greater abundance of food and shallower water in which to forage. The Peregrine Falcon is the species most likely to be seen in the NJOSA. That species is not reluctant to cross water (Kerlinger 1989) and frequently fly from Long Island to the Jersey Shore. They are commonly seen from boats during migration, sometimes many miles from shore. New Jersey nesting birds are not as likely to be seen offshore because foraging is best onshore. Northern Harriers are not reluctant to make long-distance water crossings (Kerlinger 1989) and may cross between Long Island and the New Jersey shore during fall migration and make return flights in the spring. During other seasons it is highly unlikely that these species will be seen in the NJOSA.

Species such as Sharp-shinned Hawk, Cooper's Hawk, and American Kestrel all make crossings from Cape May Point to Cape Henlopen, Delaware (Kerlinger 1984, Kerlinger 1985), but they are generally reluctant to make long distance water crossings. These same species may also make crossings from Sandy Hook to New York. Red-shouldered Hawks may also cross from Cape May to Delaware during autumn, in small numbers. Sharp-shinned Hawks and Cooper's Hawks are not infrequently observed several miles out in the Atlantic (Kerlinger et al. 1983). Broad-winged Hawks rarely make water crossings between Cape May and Delaware, which is likely the case for Sandy Hook to New York as well.

Owls. Three species of owls that appear in Table 4.1 may be found within the NJOSA, primarily during the migration season. Barn Owls, Short-eared Owls, and Long-eared Owls are regularly captured and banded in Cape May in autumn (although few Short-eared Owls are now captured; Duffy and Kerlinger 1992). Long-eared and Short-eared owls have been seen taking off and circling up to several hundred feet near the Cape May Point lighthouse prior to flying toward Delaware. Short-eared Owls are infrequently seen migrating several miles offshore, as well as closer to shore from the Avalon Sea Watch. That Barn Owls and Short-eared Owls are reported offshore suggests that they regularly make water crossings through portions of the NJOSA. Russell et al. (1991) report owls migrating southward from Cape May Point, providing additional evidence that the above listed and other owl species do cross the mouth of Delaware Bay.

Other Species. The other species that appear in Table 4.1 rarely fly out over the Atlantic Ocean or Delaware or Raritan Bays. Instead, they are restricted to land, except during migration. Black Skimmers nest in several places in New Jersey and forage mostly along the edges of the ocean, but they are rarely found farther from shore.

A5. Prevention and Mitigation of Risk in Wind Plants

Currently, there are few “best industry practices” for preventing and/or mitigating impacts to birds at wind plants. Without a doubt, the best means of preventing or reducing risk of displacement or collision is to construct wind plants where there is minimal or low bird use and where listed or rare species or species known to be susceptible to colliding with wind turbines do not occur or occur in very small numbers. The design of turbines and wind power facilities for minimizing avian collisions should be monitored. Although some of the information available is tentative, based on weight of evidence arguments, some conclusions may be made regarding prevention of fatalities. Studies designed to test specific hypotheses regarding prevention and mitigation of impacts need to be conducted.

Conducting prevention and mitigation studies is extremely difficult for collision fatality issues. The reason is because the rate of fatalities at single turbines or groups of turbines is so low on a per turbine and per year basis. For example, even where raptor collision rates are deemed to be highest in the APWRA, the rate is only about 0.1 birds of a species per turbine per year (Howell and DiDonato 1991, Orloff and Flannery 1992, 1996, Thelander and Rugge 2000). This means that, on average, only one collision of a given species would occur at a given turbine every 10 years. If, however, several night migrating bird species are involved with several fatalities per turbine per year, studies may be easier to conduct. This has made development of best industry practices difficult. The following paragraphs summarize what is known or believed to be important for minimizing and mitigating risk at wind power facilities onshore. Some may be applicable at offshore wind power facilities.

Turbine Tower Design. Modern turbines, particularly those that have tubular towers without external ladders or work platforms, are suspected to be less risky than are older turbines with lattice towers or tubular towers with external ladders and work platforms, because birds cannot land or perch on them (Orloff and Flannery 1992, personal observations of Kerlinger in Altamont Pass). Although any wind turbines proposed for New Jersey waters will have tubular towers, they will also have a docking and landing platform (and possibly the nacelle) that could provide perch sites for cormorants, gulls, terns, raptors, migrating songbirds, and other species. In May and June, terns attracted to perching sites may engage in high courtship flights (to 100 m) and other behaviors that bring them near the rotors. It is recommended that the turbines and landing platforms provide no perching opportunities.

Lighting. The FAA obstruction marking lights on communication towers, bright lights on offshore oil platforms, as well as bright lights (spotlights and sodium vapor lamps) on buildings, in parking lots, and on other structures are known to attract birds, thereby increasing their risk of collision. With respect to communication towers, FAA lighting guidelines are now recognized as being one of the most significant risk factor to night migrating birds (together with guy wires; Avery et al. 1980, Trapp 1998, Kerlinger 2000b). As detailed in Chapter 2, only flashing lights (red strobe-like lights [L-864 lights] or white strobes) should be used on wind turbines, with as few as possible being lit and with blink rate set as close to 20 blinks per minute as possible. Steady burning red lights, like the L-810 lights on communication towers, should not be used. Also, lights on landing platforms should be off at night, except in emergency situations. Bright spotlights (or mercury vapor lamps), as are used for worker safety, will attract several types of birds, including waterfowl, storm-petrels, and other pelagic species (Montevecchi et al. 2001). Lights on substations should be minimal and on only in emergencies. All windows should be shielded so that lighted windows are not visible to birds.

Standard ship navigation beacons (flashing amber lights near water level) have not been demonstrated to attract birds, although that has never really been investigated. Tests of these lights are needed to determine if pelagic or other birds are attracted to them.

Height of turbines (in relation to avian flight). Because guyed communication towers in excess of 500-600 ft (152-183 m) are known to kill migrating songbirds, offshore turbines may be kept below this height until more is known about this risk factor. Many waterbirds (pelagic species, loons, and seaducks) frequently fly within 20 m or the water, so turbine rotors should not come within this range. The current specifications for offshore turbines fall within this range and may be a compromise between these two height levels and the species of birds mentioned above. However, more information regarding this risk factor is needed.

Rotor Marking/Painting. Early on in studies of avian collisions with wind turbines it was recognized that painting patterns on rotors could make them more visible to birds, thereby reducing potential collisions. Rotors were painted with concentric circles on some turbines in the Altamont, but tests were never completed. Hodos et al. (2001) theorize that it is the tip of the rotors that cannot be seen when they are turning. This phenomenon is called tip smear, such that the bird literally cannot distinguish the tip of the rotor. Hodos et al. conducted simulations of various patterns in laboratory conditions (using kestrels) to determine if painting rotors made them more visible to birds. They found that painting one of the three rotors a dark color and leaving the others unpainted (white or light gray) made them more conspicuous and recognizable by these birds. In a conversation with Hodos, the senior author (P. Kerlinger) learned that it is likely that only the distal (portion farthest from the hub) one-third or one-quarter of a rotor need be painted to make it more conspicuous. Rotor painting has not been field tested, but it promises to reduce risk, at least during daylight. Other researchers have found that painting rotors with ultraviolet (UV) reflecting paint makes them more visible to birds, but that such paint does not resolve the tip smear issue. A test of rotor tip painting is needed.

Audio Deterrents. It has been suggested that birds may be deterred from the area close to wind turbines or hazardous structures via audio stimuli. The Electric Power Research Institute is currently underwriting experiments with acoustical or audio devices. In addition, Breco Buoys, which emit various types of noises, are sometimes used at oil platforms off the northern coast of Alaska to deter seaducks from flying too closely (Ted Swem, U. S. Fish & Wildlife Service, pers. comm.).

Guy Wires and Cables. Because guy wires on meteorology towers and communication towers, as well as transmission lines, have been demonstrated to kill birds via collision impacts, no guy wires or narrow wires should span any areas at the turbines or at the substation. If such wires or cables are needed, they should be clearly marked. Marking has been shown to prevent collisions during daytime, but have not been tested for effectiveness in preventing collisions at night.

A6. Information Gaps, Research Needs, and Potential Research Methodologies

Avian impact studies at wind turbines have been conducted primarily at terrestrial sites. Although these studies provide a considerable amount of information on the magnitude and probability of impacts, they are not entirely useful for assessing risk at proposed offshore wind power sites. Whereas some of the birds that may be found at offshore wind power facilities are the same as those at onshore facilities, there are overall taxonomic differences between terrestrial and offshore bird communities, and these birds display different behaviors. The NJOSA is used by a large diversity and enormous number of individuals of both common and rare species, some of which are not seen onshore or at terrestrial wind power sites. Thus, it is not known if these species are susceptible to impacts or if they are like most species found at terrestrial wind power facilities that generally avoid collisions. The birds that frequent the NJOSA vary in seasonal use and geographic distribution, with some areas experiencing extensive use and others experiencing less use by migrating and foraging birds.

The presence of large numbers of birds throughout the year in portions of the project study area suggests the potential for some risk to these species. These risks include disturbance/ displacement and avoidance resulting from the presence of large, moving structures (turbines) and collisions with turbine rotors and towers. Risk of collision is more difficult to assess because little is known about the susceptibility of collision of several species that are known to migrate, feed, and rest within the NJOSA. Studies from Europe provide some insight regarding potential collision impacts, although this insight can only be used after more thorough investigations in specific project areas are done. Those studies should focus on determining avian use of a particular site. Because there are vast gaps in our knowledge of bird use in the NJOSA several types of studies are listed below that will help to fill in those gaps, once project areas are proposed. Research will also provide information needed to screen alternative sites so that choices can be made well prior to permitting of individual sites.

- The daily (diel) movement patterns of hundreds of thousands of seaducks, primarily scoters, along with smaller numbers of mergansers, Long-tailed Ducks, and others within the NJOSA during migration and winter suggests the need for further study (October-March). Whether significant movements occur during night, as well as day, needs to be resolved along with the numbers passing in relation to distance from the shoreline. Radar studies (marine), boat transect surveys, night vision, and, or aerial transect surveys will resolve the temporal and spatial patterns during migration and winter. Another possible study method would include direct visual observations from fixed points (anchored boats or platforms).

- Common and Red-throated loons, grebes, and alcids are present in the NJOSA during migration and winter. A study that provides information about numerical and geographic presence, as well as behavior (flight height, direction, etc.) will be needed. These birds may be studied using similar methods to those outlined above for seaducks and may be done simultaneous to those studies (when seasonally appropriate). Distance from shore should also be studied.

- Night migrating song and shorebirds are present during both spring and autumn (including summer). Little is known regarding how far offshore these birds fly, how often, and how high they fly. Radar (perhaps NEXRAD and marine surveillance radar) would be helpful for studying these birds. NEXRAD used from land may provide resolution over large areas, whereas marine radar may be used at specific sites to determine numbers of birds and height of flight in relation to potential wind turbines.

- Raptor migration, particularly of those species that are known to fly offshore, may be explored via direct visual studies from boats or from offshore platforms at proposed wind power sites (as well as in conjunction with other studies).

- Little is known about the presence and movements of the more pelagic seabirds (Northern Gannet, shearwaters, and storm-petrels) in the NJOSA. A study that provides a more complete picture of the seasonal and numerical presence, as well as behavior of these species (height above the water, activity at night vs. day, etc.) and distance from shore would be needed to assess risk at potential project sites.

- Roseate and other terns are present in NJOSA, thereby raising the specter of Endangered Species Act incidental takings. Studies should be designed to examine the numbers of birds that forage within the NJOSA, the behavior of the birds when foraging in this area, and the likelihood of impacts to these species during spring through early autumn (April-October). Terns are primarily diurnal, with some exceptions, so direct visual observations from boats (transects), aircraft (transects), or fixed point counts from anchored boats or platforms will be useful.

- Disturbance/Avoidance Studies. Because we do not know if species that frequent the NJOSA waters will avoid the area near turbines, studies will be needed. It is suggested that if wind power facilities are constructed in New Jersey, they not be sited in locations determined to be important feeding areas. Studies of benthic invertebrates and other organisms will reveal if a prospective area is likely to be a good feeding area for birds. Such areas should be avoided as locations for wind turbines. In addition, impact gradient studies should be done at newly constructed wind turbines to see how large an area is avoided, along with studies that will determine if the same birds that avoid turbines after they are built will habituate to their presence over several years.

Methodologies for studying these birds and avian phenomena include aerial, boat, and, perhaps, radar (day and night) surveys. These methods have been used at European sites, as well as in Nantucket Sound, where they are being used for preconstruction risk assessment. Their use will result in detailed information about the distribution and behavior of the species and types of birds listed above, as well as the significant ornithological phenomena listed above.

In addition to the studies mentioned above, offshore wind projects in Denmark, United Kingdom, Germany, Sweden, the Netherlands, and elsewhere should be monitored closely because studies from those projects will provide critical information about displacement and collision risk for some of the same (and similar) species present in the NJOSA.

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Appendix I. Review of avian fatality studies in the United States, Canada, and Europe.

UNITED STATES

- **Vermont** – Searsburg near Green Mountain National Forest, 11 modern turbines in forest on hill/mountain top, nesting and migration season, 0 fatalities, Kerlinger 2000a, 2002a
- **New York** - Tug Hill Plateau, 2 modern turbines on farmland, 2 migration seasons, 0 fatalities, Cooper et al.1995
- **New York –** Madison, 7 modern turbines on farmland, 1 year, 4 fatalities (2 songbirds, 1 woodpecker, 1 owl), Kerlinger 2002b
- **Pennsylvania** – Garrett (Somerset County), 8 modern turbines, farm fields, 12 months, 0 fatalities, Kerlinger 2001
- **West Virginia** – Mountaineer Wind Energy Center, 44 modern turbines in forested mountaintop, 1 year, ~4 fatalities per turbine per year, Kerns and Kerlinger 2004
- **Tennessee** – Buffalo Mountain, 3 modern wind turbines in forested mountaintop, 2 years, 7.7 fatalities per turbine per year (mostly songbirds), Nicholson 2001, 2002
- **Massachusetts** – Princeton, 8 older turbines - type unknown, forest (hardwood) and brush, autumn & winter, 0 fatalities, Jacobs 1995
- **Minnesota** – Buffalo Ridge near Lake Benton, 100s of modern turbines in farm and grassland, several years, 55 fatalities (mostly songbirds and 1 hawk), ~1-4+ birds per turbine per year, Johnson et al. 2002, Higgins et al. 1996
- **Kansas** – St. Mary's, 2 modern turbines in grassland prairie, 2 migration seasons; 33 surveys, 0 fatalities, E. Young personal communication
- **Wisconsin** – Kewaunee County Peninsula, 31 modern turbines in farmland, 1+ year, 18 fatalities (3 waterfowl, 14 songbirds, some night migrants), Howe et al. 2002
- **Wisconsin** – Shirley, 2 modern turbines in farmland, 54 surveys, 1 fatality (night migrating songbird), report to Wisconsin Department of Natural Resources Bureau of Integrated Science Services and Richter Museum of Natural History Special Report
- **Iowa** – Algona, 3 modern turbines in farmland, three seasons, 0 fatalities, Demastes & Trainer (2000)
- **Colorado** – Ponnequin, 29 (later 44) modern turbines in rangeland, 5 years - 1999-2003, several dozen found per year, Kerlinger, Curry, and Ryder unpublished
- **Wyoming** – Foote Creek Rim, 69 modern turbines in rangeland, 2 years, fatalities (songbirds - one-half were night migrants - and 3 raptors), Johnson et al.2000, Strickland et al. 2000
- **Oregon** – Vansycle, 38 modern turbines in farm and rangeland, 1 year, 11 birds (7 songbirds [~ 4 night migrants], 4 gamebirds, Erickson et al. 2000
- **Washington-Oregon** – Stateline, ~400 modern turbines in farm and rangeland, 18 months, (mostly songbirds, some raptors), 106 individuals (1.7 birds per turbine per year) of >20 species (Horned Larks = 43%), Erickson et al. 2003
- **California** - Altamont Pass Wind Resource Area (APWRA), 5,400 older turbines mostly on lattice towers in grazing and tilled land, many years, large numbers of raptor fatalities (>400

reported) and some other birds, Howell and DiDonato,1991, Howell 1997, Orloff and Flannery 1992, 1996, Thelander and Rugge 2000

- **California** – Montezuma Hills, 237 older turbines, 11 modern turbines in farmland, 2+ years, 30+ fatalities (10 raptors, 2 songbirds, 1 duck), Howell and Noone 1991, Howell 1997
  California - San Gorgonio Pass Wind Resource Area, thousands of older turbines, 120 studied in desert, 2 years, 30 fatalities (9 waterfowl, 2 raptors, 4 songbirds, etc.), Anderson et al. 2000
- **California** - Tehachapi Pass Wind Resource Area, thousands of turbines, 100s of mostly older turbines studied, in Mojave Desert mountains (grazing grassland and scrub), 2+ years, 84 fatalities (raptors, songbirds), Orloff 1992, Anderson et al. 2000

CANADA

- **Quebec** - Le Nordais, Gaspe, 2 projects, 133 modern turbines in forest, 26 studied, two seasons, no fatalities, Province of Quebec Ministry of Environment 2000
- **Ontario** – Pickering and Toronto Waterfront, 2 projects, 2 turbines studied, two migration seasons, ~3+ night migrant songbird fatalities per turbine per year (James 2003, James and Coady 2003)
- **Prince Edward Island** – 8 modern wind turbines along the coast, 2 season study, 1 fatality reported (Prince Edward Island Energy Corporation 2002)

Appendix II. Review of Avian Studies from Europe.

The list of avian studies at wind parks in Europe that follows is not complete and represents a work in progress. The literature in Europe is more diffuse and difficult to locate.

United Kingdom

- **Llandinam, Wales** – Behavioral and fatality studies were done at this farmland site where there are 103 turbines (30.9 megawatts) revealed minimal impact
- **Mynydd Cemmaes, Wales** – Same types of studies, 24 turbines in farmland, 2 dead birds (1 snipe and 1 Black-headed Gull)
- **Blyth Harbour, Northumberland** – 9 modern turbines on seawall adjacent to the sea, no apparent displacement of shorebirds (Purple Sandpiper, Sanderling) on the jetty or sea and waterbirds (eiders, gulls, cormorants), weekly searches revealed 20 carcasses in 1 year (34 in 2.5 years,12 eiders in first 2.5 years) then numbers declined and no fatalities were found 1996-1997, no significant impacts
- **Blyth Offshore, Northumberland** – 2 modern wind turbines 1.5 km offshore – erected in 2000, no studies yet available
- **Bryn Titli, Wales** – 22 relatively modern wind turbines in sheep-grazing and heather moorlands, behavioral studies of wintering raptors (Red Kite, Peregrine Falcon, Kestrel, and Common Buzzard) and ravens; no fatalities reported.

Spain

- **Tarifa, Andalucia** - about 1,000 turbines ranging from older commercial grade turbines to modern turbines, lattice and tubular towers on steep hillside grazing land. Morocco is visible in the distance and the wind park is situated at one of the world's largest migratory concentration points of raptors (more than 100,000 pass per autumn), storks and cranes (more than 50,000 pass per autumn), song, and other birds. Several studies have been conducted. The numbers of migrating birds found has been minimal. It should be noted that Griffon Vultures (2+ m wingspan) have been impacted as have Kestrels.

In one study where rigorous searches were made at 87 turbines, an estimated 30 vultures and 49 Kestrels were killed (Marti Montes and Barrios Jaque 1995). The vultures are permanent residents with a population of about 400+ pairs that frequent the general area of the wind plant. Kestrels are resident nesters, wintering birds, and migrants. The behavior of the vultures constant soaring at low altitudes looking for dead livestock) and the steep terrain on which the turbines are situated combine to make the wind park risky to this species. This is analogous to Golden Eagle and Red-tailed Hawk mortality in the Altamont where birds hunt at low altitudes amidst a large number of turbines that are on steep hills.

In a second study, only 1 Griffon Vulture and 1 Short-toed Eagle were found dead during 14 months of study. Fatality rate per turbine was estimated to be 0.03 birds per turbine per year.

More than 45,000 vultures and 2,500 Short-toed Eagles flew over the site during the study period. Very few migrants were impacted. Researchers feel that migrants fly well above the wind turbines and that it is residents that have greater potential for impact. Tarifa seems to be the only place in Europe where raptor fatalities may be high, but study results have been inconsistent and vary dramatically. It is unlikely that raptor populations are or have been impacted by the turbines at Tarifa.

[Observations of migrating raptors made by this author during spring 1996 at Tarifa and radar observations made by researchers during the same spring confirm that migrating raptors, storks, cranes and other birds fly around or above the turbines. Black Kites, a numerous species, simply flew around the ends of turbine rows, before continuing their northward migration. They did not fly within 50 m of the turbines, except on rare occasions. It was obvious that these birds deviated so as to avoid the turbines.]

- Navarre – Although no technical reports of avian fatality studies could be located, news reports reveal that each year there are hundreds of fatalities at modern wind power facilities in Navarre, including fatalities of raptors. Some reports suggest large numbers of raptors and have compared Navarre to the APWRA of California. Efforts should be made to locate technical reports if they exist.

- Galicia. Large-scale wind plants in Galicia, northwestern Spain, have been online for several years and development is ongoing there. Technical reports were not readily located and an effort should be made to locate any that may exist.

There are other wind plants now operating in Spain, although there is little information regarding avian impacts from them. There are no offshore wind facilities in Spain and, none seem to be planned for the near future.

Netherlands

- **Oosterbierum Wind Park** – 18 mid-sized wind turbines (300 kilowatts per turbine) in farmland adjacent to Wadden Sea, birds (waders and songbirds) changed flight paths at 100+ m when approaching turbines, disturbance was found to be minimal.

- **Urk Wind Park, Lake Ijsselmeer** – 25 mid-sized wind turbines (300 kilowatts per turbine) situated along 3-kilometer dike at edge of Lake Ijsselmeer, mortality and behavior of mostly wintering sea ducks were studied, <63 fatalities documented (mostly diving ducks and a few dabblers) during autumn and winter when wintering waterfowl were present in peak numbers, disturbance occurred within 300 m of the turbines - diving ducks avoided these areas

- **Lake Ijsselmeer** – a "lake" inland a short distance from the sea, 4 wind turbines (200 m between turbines), wintering diving duck (hundreds on the lake) behavior, risk documented to be low, at night ducks "can cope rather well with wind turbines in semi-offshore situations," On moonless nights, ducks turned away at closer distances than on brighter nights. It is possible that long strings of turbines create barrier effects because ducks were reluctant to fly between turbines. No fatalities were reported and no fatality data were included. In 1996-1997, 28 600-kilowatt turbines were installed in Lake Ijsselmeer. Studies of that site were not found.

Other Wind Plant Studies in Netherlands

- Early-mid 1980s – 7 small wind turbines at a coastal site – no collisions or fatalities documented
- 1987 - 75 small wind turbines at several sites were studied – 21 fatalities reported

The fatalities at the wind plant at Oosterbierum adjacent to the Wadden Sea were more numerous than at most wind plants in the world. In general, the wind power facilities located in coastal marsh and lowland areas of the Netherlands appear to pose a higher risk to birds than inland sites. The numbers of migrants in these areas is very high and turbines are located among migration stopover and resting sites, which together may account for the risk.

Summary of 108 European wind power study sites by Winkelman in 1995 revealed 303 fatalities, of which 124 were proven to collide with turbines. It is likely that the actual number was larger. No rare or threatened species were involved.

Belgium

There are a few wind parks now operating in Belgium. Everaert et al. (2002) reported on three different wind turbine facilities in and around the port of Zeebrugge. Turbines were located on rivers or on the harbor. They concluded that between 0 and 125 birds killed per turbine per year, with a mean of 23. Those turbines closest to the sea revealed 39 birds killed per turbine per year. Size of the turbine mattered less than the amount of bird activity/use in the vicinity of the turbines. Fatalities included terns, songbirds, kittiwake, and some hawks (sparrowhawk, kestrel, and Peregrine Falcon), with gulls being the most common birds among the fatalities. Gulls and terns, during the nesting season, simply flew through the wind turbines, rather than avoiding the area within which turbines were located. Other species would not fly within 150-300 m of turbines, so there was avoidance demonstrated.

The numbers of birds killed by turbines at the port of Zeebrugge exceed, in some ways, the fatalities found at other wind power facilities. That terns, raptors and some other species were killed suggest a potential for biologically significant impacts to some rarer species.

Denmark

- **Tuno Knob, Kaategat** – A behavioral study was conducted at 10 modern, 500-kilowatt turbines located several kilometers off the Danish coast in the sheltered waters of the Kaategat. The turbines were erected in 1995 and intensively studied via radar and direct visual methods. The area is a prime feeding area for thousands of wintering eiders and some scoters (also gulls and some other waterbirds present). The study showed that birds did fly in the height range of the rotors, but demonstrated avoidance. There was little in the way of significant disturbance effects, although eiders were reluctant to feed with in about 100 m of the turbines. No fatalities were reported, although the study was not designed to assess mortality.

- **Rodsand Offshore Wind Farm** – This large windplant (about 90 turbines, ~200 megawatts) is planned for an area 10 km southwest of Gedser on the west coast of Denmark. Bird studies are now being conducted to examine potential impacts. Several hundred thousand waterfowl, 15,000 raptors, and 200,000 songbirds move through the area. Results of a preliminary study are available.

- **Esbjerb** – Reference to this study was found, but the original was not. Five turbines of varying sizes were examined. Reduction in breeding birds beneath the turbines was documented and 7 fatalities were located.

To date, significant impacts to birds from wind turbines have not been reported from Denmark, despite the proliferation of wind power in this country.

Germany

- **Drochtersen Wind Plant, Saxony** – 7 older turbines in a grassland/meadow site were investigated to determine the impact of turbines on these songbirds and waders. Although lapwings "avoid close proximity to the wind power generators" other birds did not seem to be impacted by the turbines and were distributed evenly in the area.

- **Summary of Studies at 13 wind parks in Lower Saxony** – Study in 1997 suggested that birds are less sensitive to the presence of wind turbines than previously thought. (Habituation was not investigated or suggested, but it is likely that after wind turbines are on the land for several years, birds are not deterred by them to the degree as when they were first constructed.)

- **Jade Wind Park and Dewi Test Field, Wilhelmshaven** – Several species of shorebirds (golden plover, lapwing) and songbirds (skylark, Meadow Pipit) were examined in these German wind parks. They did not seem to be as sensitive as was suggested earlier and did not maintain large distances from the wind turbines.

- **Cuxhaven Wind Farm, Nordholz** – Several small wind turbines in open, grassy fields and farmland. Twelve species of breeding and resting birds including shorebirds and songbirds were examined in relation to wind turbine locations. A slight, but insignificant reduction in numbers of birds occurred after the wind turbines were constructed. Some birds, like Syklarks, reached their highest densities within 250 m of turbines.

- **Northwestern German Wind Plants -Lower Saxony** – Six wind power facilities were examined to determine the presence of wind turbines on nesting birds. Studies resulted in similar findings with respect to nesting and resting grassland birds in northwest German wind plants.

(A study that is about to be published summarizes fatality studies at several wind plants in Germany, fide Joris Everaert from the Institute of Nature Conservation [a scientific institute of the Flemish government]. The report lists fatalities of raptors [including several sea eagles among other raptor species] and other birds at 10 wind power facilities. The results of those studies are extremely important for evaluating the impacts of turbines in Germany. It is not known whether any of these projects is offshore, although at least one alcid was reported dead, suggesting that some of the turbines may have been in offshore settings.)

The above information was assembled from abstracts. The original papers are being sought to provide greater detail.

Sweden

There are currently hundreds of commercial wind turbines operating in Sweden. More wind power is planned for the future. There were no studies of avian impacts readily available and there have been no reports of large-scale fatalities or impacts from wind plants, which are mostly near the coast in Gotland, Oland, and along the west coast. Some of these coastal areas are known for major concentrations of a diverse assemblage of migrating birds.

12.0. ANNEX 2

RESPONSE TO COMMENTS

The following is a response to comments received by Atlantic Renewable Energy Corporation (AREC) from the Office of Clean Energy within the New Jersey Board of Public Utilities (BPU) regarding the final report for the New Jersey Offshore Wind Energy Feasibility Study funded by the NJ BPU.

1. Consistency of Power Density: Page 8 cites power densities of 20 MW per square mile. Page 121 cites an example of a 100 MW facility covering 5 square miles. Dividing through, this reduces to 20 MW per square mile. Also on page 121 it is stated that one percent of the "conditionally viable area" would support 244 MW. One percent of the area, 1,223 square miles would be 12.23 square miles. At 20 MW per square mile this one percent area would yield 244 MW. These different references do appear to be consistent and based on a power density of 20 MW per square mile. Actual array design requires detailed analysis of wind speeds and directions, but the power densities described in the report are representative and sufficiently accurate for planning purposes.
2. NJ Historical Peak Load Profile: some question was raised on the shape of the load profile for the NJ peak load. This has been checked and confirmed. The data file and a graph of the constituent years are attached.
3. Known Fishing Grounds: Commercial and recreational fishing is permitted and practiced throughout the entirety of the offshore wind study area, with limited exceptions. Some catch data exists and has been presented for commercial operations, which shows some concentration of harvest. However, from a habitat perspective, species such as the surf clam would be found throughout the entirety of the study area. Spatial catch records for recreational fishing were not found to be available; however, anecdotal information suggests that there is a higher concentration of activity closure to shore and nearer to inlets, commensurate with the limitations and relative abundance of smaller vessels. In addition anecdotal information suggests that target species tend to congregate in the vicinity of bottom relief, so-called "lumps", and that fishing intensity will be higher in these areas. The general conclusion that can be drawn is that wholesale avoidance of areas, which are - or could be fished - is not feasible.
4. Transmission Congestion: Clarification as to what extent congestion was considered in the determination of power insertion capacities found in section 6.4 (Table 6.1) was requested. In response to this question, AREC confirms that power flows and congestion were not analyzed or considered in the assessment. Such analysis requires a discrete interconnect point and capacity. While any future project would undergo such assessment, it was beyond the scope of this study. The thermal capacity assessment that was performed in the creation of Table 6.1 provides a useful first order indication of injection capacities.

5. Comparison of Onshore and Offshore Economics: An observation was made comparing the economics of onshore and offshore facilities, citing a reference to energy production found on page 10 (50-75% increase for offshore) and a reference to capital expense found on page 143 (50-100% increase for offshore), advancing the question: Would higher costs would be encountered possibly negate the benefit of the higher wind? AREC agrees that offshore wind and offshore construction and operation costs do work to offset one another and that, at this juncture, offshore wind energy is not "in general" cheaper than onshore wind energy. What can be said is that meaningful comparisons need to be site and timeframe specific and that feasibility incorporates factors including transmission, load, environmental impact, availability of land, compatibility of land use, as well as other factors. Indications are that offshore wind can be very competitive and in some cases superior to onshore opportunities.

   For a number of reasons including the wind resource and land use patterns, onshore opportunities within NJ for utility scale wind facilities appear to be limited.

6. Job Intensity Citation: A citation for the statement "Wind energy provides more jobs per dollar invested than most other energy technologies", found on page 9, was requested. In response: An NWCC fact sheet from 1997 cites a NY study finding that wind energy would create 27 percent more jobs than coal and 66 percent more than a natural gas plant per kilowatt hour generated. A link to this sheet can be found at: http://www.nationalwind.org/pubs/wes/ibrief05.htm. Another reference is found in a Union of Concerned Scientists report (1999): http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?pageID=98. The specific reference to the jobs issue apparently originally came from the reference: A.K. Sanghi., Economic Impacts of Electricity Supply Options, New York State Energy Office, July 1992.

Top Ten Peak Load day averages for Atlantic Electric and Jersey Coast zones (1994 - 2003)

	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	Hour 8	Hour 9	Hour 10	Hour 11	Hour 12
2003	4570	4207	3963	3809	3749	3833	4108	4627	5212	5790	6332	6775
2002	4887	4497	4260	4090	4030	4123	4391	4943	5547	6166	6746	7255
2001	4680	4333	4115	3974	3920	4020	4303	4804	5366	5921	6447	6866
2000	4093	3812	3608	3500	3480	3586	3869	4329	4814	5288	5728	6083
1999	4451	4119	3886	3744	3666	3722	3961	4451	4997	5520	6021	6416
1998	4043	3759	3562	3452	3424	3545	3839	4291	4787	5269	5713	6010
1997	4015	3741	3547	3417	3379	3444	3691	4190	4701	5195	5627	5912
1996	3472	3206	3049	2960	2935	3050	3354	3797	4247	4614	4935	5187
1995	4143	3819	3637	3501	3451	3518	3733	4189	4729	5237	5632	5922
1994	3785	3496	3312	3204	3162	3230	3486	3948	4413	4846	5209	5491
Average	4214	3899	3694	3565	3520	3607	3873	4357	4881	5385	5839	6192

	Hour 13	Hour 14	Hour 15	Hour 16	Hour 17	Hour 18	Hour 19	Hour 20	Hour 21	Hour 22	Hour 23	Hour 24
2003	7088	7329	7539	7659	7668	7613	7336	7027	6812	6523	5902	5224
2002	7624	7880	8047	8166	8195	8119	7860	7510	7304	6929	6246	5538
2001	7156	7370	7476	7521	7522	7449	7249	7025	6896	6605	6017	5393
2000	6371	6598	6766	6838	6914	6865	6628	6371	6214	5950	5348	4717
1999	6721	6922	7042	7148	7150	7129	6924	6654	6511	6330	5771	5140
1998	6215	6420	6519	6533	6506	6432	6257	6042	5993	5716	5192	4568
1997	6151	6340	6465	6538	6552	6437	6204	5955	5827	5603	5061	4461
1996	5377	5552	5675	5769	5831	5762	5510	5254	5156	4946	4448	3880
1995	6113	6279	6390	6452	6518	6497	6328	6115	6023	5881	5390	4851
1994	5692	5843	5925	5961	5990	5962	5793	5611	5529	5382	4875	4355
Average	6451	6653	6784	6858	6885	6826	6609	6356	6226	5986	5425	4813