Pre-Development Assessment of Geophysical Qualities for the Proposed Long Island – New York City Offshore Wind Project Area

Final Report 10-22
Task 1
October 2010

New York State
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PRE-DEVELOPMENT ASSESSMENT OF GEOPHYSICAL QUALITIES FOR THE PROPOSED LONG ISLAND – NEW YORK CITY OFFSHORE WIND PROJECT AREA

Final Report

Prepared for the

NEW YORK STATE ENERGY RESEARCH AND DEVELOPMENT AUTHORITY

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NOTICE

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DISCLAIMER – The contents within are not meant to serve as a substitute for a full suite of geophysical surveys as required by the Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEM) permitting process and should not be relied on as such. The following report is intended for preliminary and feasibility planning only and not for use in any final permitting, design, and/or construction document(s).

ABSTRACT AND KEY WORDS

This report presents the results of a pre-development assessment study of the geophysical environment in the vicinity of a proposed 700 MW offshore wind energy project in the Atlantic Ocean located approximately 14 nautical miles (16 statute miles) southeast of Rockaway Peninsula, Long Island. The information compiled by this study is intended to provide the Long Island – New York City Offshore Wind Collaborative, which is a coalition of utilities, State and New York City agencies, and other interested parties with a baseline of knowledge to facilitate future project planning, siting and measurement activities. The assessment included a review of geophysical features (bathymetry, benthic sediments, subsurface geology, and seismic activity), the prevalence of submerged obstructions in the study area (shipwrecks, shallow hazards, archaeological resources, munitions and explosives of concern, and chemical warfare material), as well as a brief description of five foundation designs (monopile, tripod, suction caisson, gravity base, and jacket), and potential structural impacts. A review of the existing data indicated that development in the proposed project area appears to be feasible; however, the collection of site specific geophysical and geotechnical field data is required to confidently determine the proposed project's feasibility and to support detailed siting, design, and permitting of project components.

KEY WORDS – offshore wind energy, geophysical study, Long Island – New York City Offshore Wind Collaborative, NYSERDA, AWS Truepower, Geo-Marine.

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LIST OF ACRONYMS AND ABBREVIATIONS

º	Degree
%	Percent
AWOIS	Automated Wreck and Obstruction Information System
AWST	AWS Truepower, LLC
BOEM	Bureau of Ocean Energy Management, Regulation, and Enforcement
CRM	Cultural Resource Management
CWM	Chemical Warfare Material
DoD	Department of Defense
DoT	Department of Transportation
ft	Foot/Feet
GIS	Geographic Information System
in.	Inch(es)
km	Kilometer(s)
Collaborative	Long Island-New York Offshore Wind Collaborative
m	Meter(s)
Ma	Megaannum (Million Years Ago)
MEC	Munition and Explosive of Concern
mi	Mile(s)
mi^2	Square Mile(s)
mm	Millimeter(s)
MW	Megawatt(s)
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NGDC	National Geophysical Data Center
NYSDEC	New York State Department of Environmental Conservation
NYSERDA	New York State Energy Research and Development Authority
NYSHPO	New York State Historic Preservation Office
U.S.	United States
USCGS	United States Coast and Geodetic Survey
USGS	United States Geological Survey
UXB	Unexploded Bombs
UXO	Unexploded Ordinances

SUMMARY

This report presents the results of a pre-development assessment study of the geophysical features in the vicinity of a proposed offshore wind energy project in the Atlantic Ocean southeast of Rockaway Peninsula, Long Island. The information compiled by this study is intended to provide the Long Island – New York City Offshore Wind Collaborative, which is a coalition of utilities, State, and New York City agencies, and other interested parties with a baseline of knowledge to facilitate future project planning, siting, and measurement activities. The offshore wind facility, which would be developed and operated by one or more developers selected as part of a formal solicitation process by the Collaborative, is envisioned to be located within a 65,000 acre (263 km^2) area approximately 14 nautical miles (16 statute miles) southeast of Rockaway Peninsula, Long Island. This area could support up to 700 MW of nameplate wind capacity, although an initial phase could be as small as 350 MW.

This report provides an overview of the following geophysical features that are likely to be relevant to the proposed project area: bathymetry; bottom features and vulnerability to currents, scouring, and sand waves; benthic sediments; subsurface geology; seismicity and side-scan sonar and magnetometer survey data; and obstructions, including wrecks, shallow hazards, unexploded ordinances, and archaeological resources. Additionally, a brief discussion of common foundation types and potential structural impacts is included. The information represented in the report was compiled from literature and database sources, and through consultation with field experts.

The proposed project area lies between southwestern Long Island and northern New Jersey in an area called the New York Bight. The seafloor in the region exhibits a gentle decline seaward and to the southeast. Main features within the vicinity of the proposed project area include the Hudson River Channel, Christiansen Basin, and Cholera Bank. General depth in the project area ranges from 18 to 40 m (59 to 131 ft) with shallowest depths associated over Cholera Bank. Sand ridges found in the region have an average relief of 10 m (33 ft) and extend several miles in length.

The surface sediments found within the project area are approximately 10 m (33 ft) thick and composed mostly of sand. The subsurface geology is composed of various rock layers deposited during multiple geological eras. The basement rock layer consists mainly of crystalline, granitic rock. The mid-section stratum is dominated by sand and gravel composed of glauconite minerals. The subsurface stratal layer consists of quartzose sand and gravel overlying glauconitic silty sand and clay.

At the west end of the project area lies the New York Bight Fault. The fault formed approximately 95 to 30 million years ago and is at least 50 km (31.1 mi) long trending north-northeast. The fault is potentially active with reports possibly linking it to several past earthquake events.

There are 26 documented submerged obstructions in the vicinity of the project area. Of these, 19 are shipwrecks. Additional unidentified or unrecorded vessels could be buried on the seafloor within or adjacent to the project area. Shipwrecks and other shallow hazards may be considered archaeological or biologically sensitive areas and therefore may require specific site surveys and filings with the appropriate agencies.

There are no current listings of munitions or explosives of concern or chemical warfare material (unexploded bombs, bullets, shells, grenades, land mines, naval mines, etc. or materials containing chemical munitions and/or containers of chemical warfare agents) within the proposed project area; however, little is known about the exact quantities, types, and present locations of conventional and chemical weapons that were dumped into the ocean. Sewage sludge and acid waste have previously been dumped within the region. These non-Department of Defense dump locations, lying adjacent to Cholera Bank, include the former 12-mile municipal oceanic sewage sludge and acid waste dump sites.

The foundation design chosen for the proposed project area will depend upon water depth, sediment and subsurface geologic conditions, and dynamic processes such as winds, waves, and currents. Potential structural impacts (i.e., loading and scour) may further influence turbine foundation type. Sandy sediment in the proposed project area may make monopile and jacket foundations more suitable foundation choices than others (i.e., gravity foundation).

A comprehensive analysis of all existing available geophysical data for the project area indicated that offshore wind development in the proposed project area appears to be feasible, and no fatal flaws were identified based on existing data. Still, while the data reviewed and summarized for this report is representative of known conditions in the vicinity of the project area, the collection of site specific field data is required to confidently determine the feasibility of the proposed project area and to support detailed siting, design, and permitting of all components of an offshore wind project. Therefore, in order to better characterize the seafloor, subsurface geology, and known and unknown submerged hazards, further site specific geophysical and geotechnical analyses are recommended to provide a more complete assessment of current conditions of the project area. Suggested surveys include: multibeam and side-scan sonar, magnetometer surveys, sub bottom and seismic reflection profiling, core sampling, and wave and current modeling.

Section 1

1. INTRODUCTION

The Long Island – New York City Offshore Wind Collaborative (the “Collaborative”), a coalition of utilities, State and New York City agencies, is seeking to obtain power from a future offshore wind energy facility located in the Atlantic Ocean. The offshore wind facility, which would be developed and operated by one or more developers selected as part of a formal solicitation process, is envisioned to be located within a 65,000 acre area of approximately 14 nautical miles (16 statute miles) [1] southeast of Rockaway Peninsula, Long Island. The proposed project area could support up to 700 MW of nameplate wind capacity, although an initial phase could be as small as 350 MW.

The New York State Energy Research and Development Authority (NYSERDA) engaged AWS Truepower (AWST) and its subcontractors to conduct pre-development assessment studies of the physical and environmental qualities of the proposed project area and its surroundings. A preliminary review of these qualities is critical in the initial planning stages to determine the existence and nature of any perceived barriers, conflicts, or other fatal flaws that could preclude development of the proposed project. Using existing data, this report characterizes the geophysical environment of this region. This information is intended to provide interested parties with a baseline of knowledge to facilitate future project planning, siting and measurement activities.

This report provides an overview of the following geophysical information likely to be relevant to the proposed project area:

- Bathymetry
- Bottom features and vulnerability to currents, scouring, and sand waves
- Benthic sediments
- Subsurface geology, including geological history overview
- Seismicity and Side-scan sonar and Magnetometer survey data
- Obstructions, including wrecks, shallow hazards, unexploded ordinances, and archaeological resources.

Additionally, common foundation designs are discussed and potential structural impacts are briefly described. These features and concepts are characterized in the following sections.

[1] A nautical mile equals 1.15 statute miles.

Section 2

2. GEOPHYSICAL FEATURES

An offshore wind energy project is composed of wind turbines, foundations, and the electrical collection and transmission systems. In the offshore environment, site-specific conditions, including atmospheric (weather, wind), hydrodynamic (waves, currents), and physical (water depth, seabed geology), can pose limitations for project siting. From a geophysical perspective, water depth and benthic sediment characteristics are significant attributes for foundation design and construction parameters. The foundation is often driven into the seabed for added stability; therefore available present-day and historical seabed stratigraphy provides essential information for planning the location and design of an offshore wind energy project.

The Mid-Atlantic Ridge, located near the center of the Atlantic Ocean, represents a spreading zone where new oceanic crust is formed as parallel plates diverge. It is this divergence zone that broke apart the North American and African tectonic plates during the Jurassic period (206 to 142 million years ago), forming the present-day Atlantic Ocean. Initially tectonically active while near the ridge, the North American and African plates grew farther from the spreading center and became passive margins. Passive margins are edges of continental crust that do not experience rifting, subduction, transform faulting, or other large-scale tectonic processes, but instead are zones of sediment accumulation and subsidence.

The east coast of the United States is characteristic of a slowly subsiding, passive continental margin (Hutchinson and Grow 1985; Klitgord et al. 1988; Smith 1996; Byrnes et al. 2004). The offshore region of the northeastern U.S. represents the northernmost component of the Coastal Plain Physiographic Province spanning the U.S. Atlantic and Gulf coasts from Long Island to Mexico (Williams and Duane 1974; Byrnes et al. 2004).

The offshore continental shelf of the eastern U.S. is separated into regions. The northern region, spanning from Massachusetts to North Carolina, is known as the Mid-Atlantic Bight; within this region lies the New York Bight, which extends from Block Island, Rhode Island to Cape May, New Jersey (Buchanan et al. 1988, Vincent et al. 1981). Main features in the region are the Hudson River Channel, which extends southeasterly across the shelf to the Hudson Canyon, the Christiansen Basin, the Cholera Bank (Freeland et al. 1976), and various anthropogenic disposal sites (Butman et al. 1998; Byrnes et al. 2004).

2.1. BATHYMETRY

The project area is located approximately 14 nautical miles (16 statute miles) southeast of Rockaway Peninsula, Long Island in the North Atlantic Ocean (Figure 1). The region encompasses an area of approximately 77 square nautical miles (102 mi^2) and lies between the Ambrose to Nantucket and Hudson Canyon to Ambrose Traffic Lanes.

The continental shelf of the New York Bight slopes gently seaward and to the southeast. Evenly spaced contours (Stumpf and Biggs 1988; Byrnes et al. 2004) from the shoreline to the head of the Christiansen Basin (Byrnes et al. 2004) indicate that the area has a constant slope. East of the Christiansen Basin, shoreface sand ridge-and-swale morphology is common (Stumpf and Biggs 1988; Byrnes et al. 2004). In this region, sand ridges trend northeast-southwest and exhibit a 30 degree (º) to 50º orientation to the Long Island shore (Stumpf and Biggs 1988; Byrnes et al. 2004). The ridges typically occur every 2 km (1.2 mi), have an average relief[2] of 10 m (32.8 ft), and are between 10 km and 50 km (6.2 mi and 31.1 mi) in length (Stumpf and Biggs 1988).

Within the western portion of the project area lies Cholera Bank; a circular, rocky formation with generally low relief (Blunt and Blunt 1863; Muller and Knowlson 1915; USCGS 2010). The bank is centered at 40º23'N 73º36'W (DoT 2009; Schwab 2010). Water depth surrounding the bank ranges from 22 to 25.6 m (72 to 84 ft; Muller and Knowlson 1915); however, water depth over Cholera Bank itself ranges from 18.3 to 22.3 m (60 to 73 ft; Muller and Knowlson 1915; DOT 2009; USCGS 2010). The bank is 1.74 nautical miles (2 mi) long (east to west; Muller and Knowlson 1915; USCGS 2010) with an average width of 0.87 nautical miles (1 mi; Muller and Knowlson 1915).

Throughout the balance of the project area, water depths gradually increase in the seaward direction, reaching a maximum depth of approximately 40 m (130 ft).

[2] i.e., the ridges typically rise 10 m above the level of the ocean floor in the area.

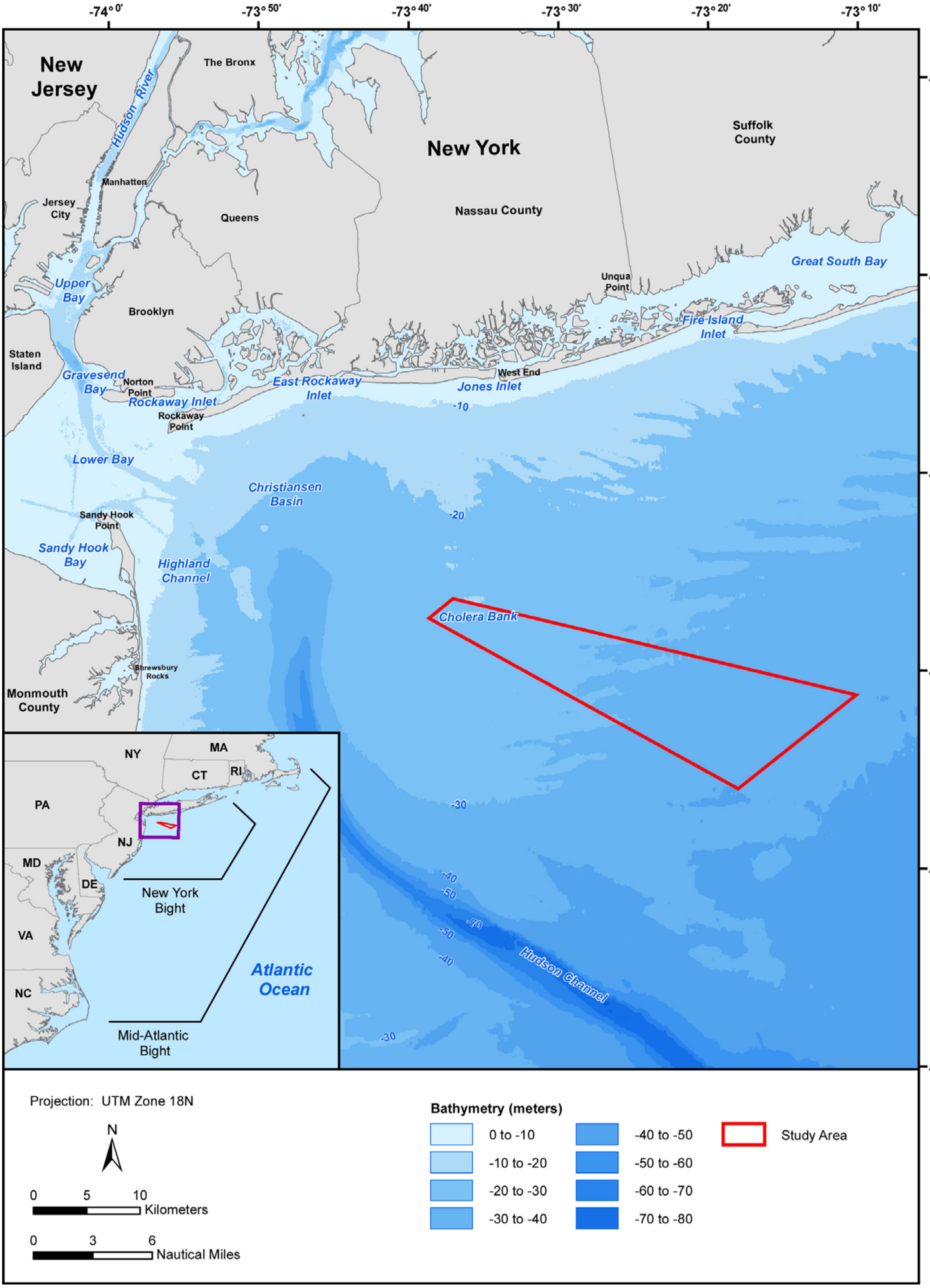

Figure 1. The proposed project area located within the New York Bight.
GIS coordinates for the corners are as follows:
40º24'04"N 73º37'37"W (NW); 40º18'50"N 73º11'02"W (NE);
40º23'06"N 73º39'14"W (SW); and 40º14'13"N 73º18'58"W (SE).

2.2. BENTHIC SEDIMENTS

The New York Bight was created about 20,000 years ago at the end of the last Pleistocene glacial advance (Freeland et al. 1976; Williams et al. 2006), of which Long Island represents the southern terminus (Freeland et al. 1976; Williams 1976; Williams and Meisburger 1987; Byrnes et al. 2004). Dominant surficial deposits on the continental shelf of the New York Bight include fine to medium-grained sand. Additionally, patches of coarse sand and gravel are associated with regions of outcropping coastal plain strata, such as Cholera Bank (Williams and Duane 1974; Williams 1976; Byrnes et al. 2004).

Present-day surficial sediments of the project area (Figure 2) are approximately 10 m (33 ft) thick (Freeland and Swift 1978) and are predominately composed of glacio-fluvial sand and gravel (Schlee 1968, 1973; Freeland et al. 1976; Stumpf and Biggs 1988). The sediments were deposited during the most recent Pleistocene glacial expansion (Schlee 1968, 1973; Freeland et al. 1976; Williams et al. 2006) and modified during the Holocene transgression (Schlee 1968, 1973; Freeland et al. 1976), which resulted in scattered gravel patches partly covered by shoals and sand (Schlee 1968, 1973). The sandy sediments have a median grain size of 0.0625 to 0.25 mm (0.00246 to 0.00984 in) and are composed mostly of quartz (70 to 95% composition) and feldspar (at most 25% composition) with minimal inclusion of heavy minerals (garnet, amphiboles, staurolite, and epidote), less than 3% shell debris (composed primarily of sand dollars [*Echinarchinus parma*] and oyster shells [*Crassostrea virginica*]; Stumpf and Biggs 1988), as well as glauconite (Schlee 1968, 1973). Gravelly sediments, characterized as coarser than 2 mm (0.0787 in. [Schlee 1973; Stumpf and Biggs 1988]), are composed of sub-rounded quartz (Schlee 1968, 1973) and are typically found either interspersed in sands or between sand ripples intermixed with shell debris (Schlee 1968).

The predominately hard-bottom region (i.e., rock) within the project area is Cholera Bank and is composed of outcropping Cretaceous coastal plain strata. Dominant surface sediments of this feature include coarse grey sand and black mud; gravel, large pebbles, and shells are also found throughout the bank (Muller and Knowlson 1915; USCGS 2010).

Sandy sediments are more susceptible to the scouring effects from currents diverging around installed structures than coarser and consolidated sediments. Therefore, some wind turbine foundation designs may be more suitable for the proposed project area than others (i.e., jacket foundation); however sufficient scour protection may mitigate scour effects for other foundation types. Refer to Section 4 for more information.

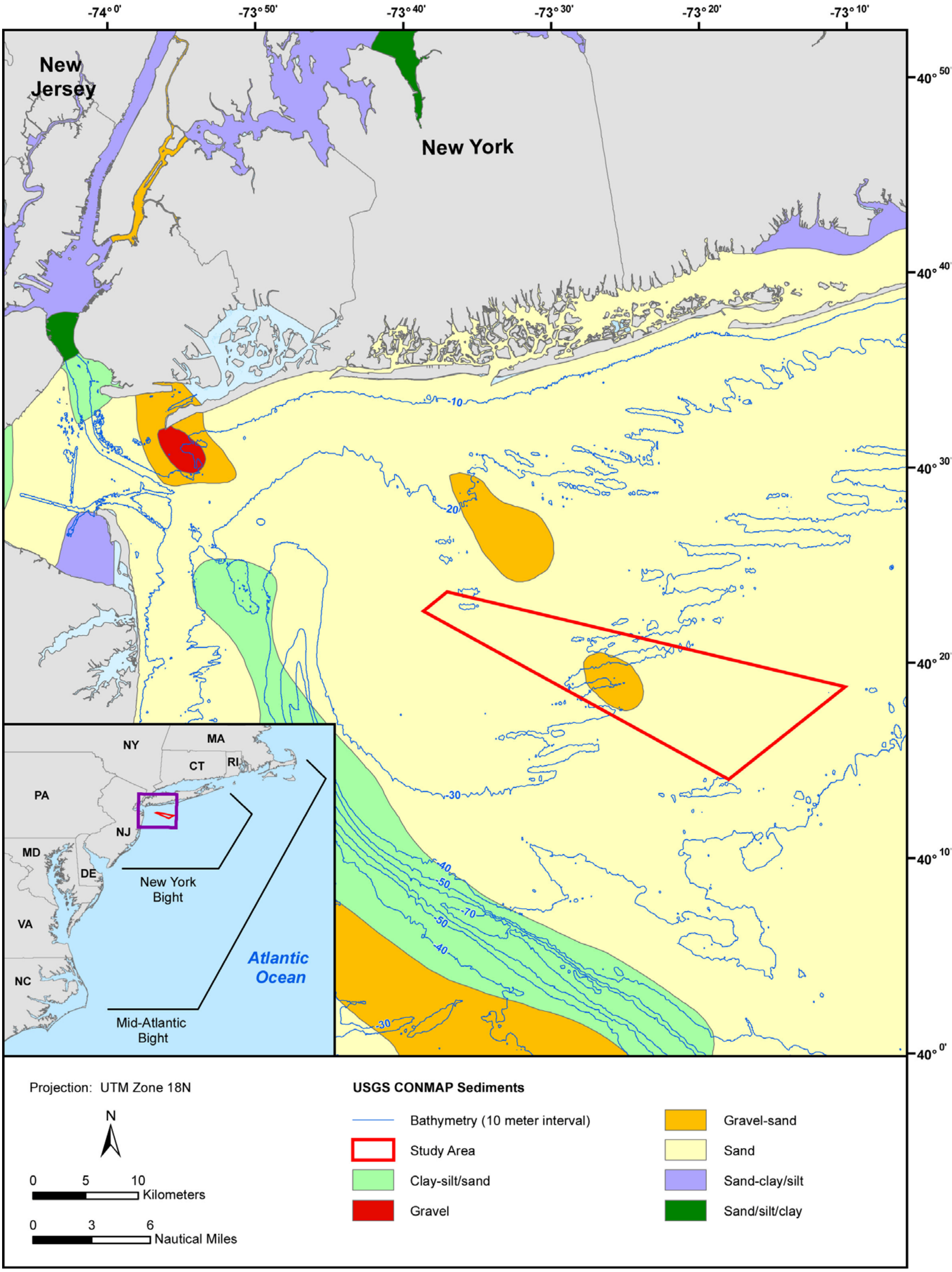

Figure 2. Surficial sediments of the New York Bight.

Data source: Paskevich 2005.

2.3. SUBSURFACE GEOLOGY

Surficial sediment deposits (i.e. benthic sediments) that are approximately 10 meters deep overlie bedrock that was deposited during the Pleistocene and Holocene epochs (Williams 1976; Byrnes et al. 2004). The bedrock, composed of Quaternary sediment deposits, consists of granitic substratum composed of clastic, semi-consolidated quartzose sand and gravel overlying glauconitic silty sand and clay (Figure 4; Williams 1975). Midsection strata are composed of Upper Cretaceous and Tertiary period unconformities (Minard 1969; Fisher et al. 1970; Schlee 1973; Olsson and Miller 1979; Hutchinson and Grow 1985). This layer is approximately 350 m (1,148 ft) thick (Williams 1975) and dominated by glauconitic sand and gravel (Williams 1976).

The basement geology (bottom or oldest rock layer), composed of crystalline, granitic rock, is dominated by Paleozoic and Precambrian stratigraphy, partly or wholly deformed during various orogenies leading to the formation of the Appalachian Mountains (Williams and Hatcher 1983; Hutchinson and Grow 1985). Gravity, magnetic, and drill-hole data indicate Paleozoic crystalline rock stratigraphy, associated with the creation of the Appalachian Mountains, continues beneath the coastal plain and continental shelf deposits (Drake et al. 1959; Woollard and Joesting 1964; Maher 1971; Brown et al. 1972; Grow et al. 1976; Grow et al. 1979; Klitgord and Behrendt 1979; Haworth et al. 1980; Zietz et al. 1980; Hutchinson and Grow 1985).

Subsurface geology will influence wind turbine foundation design. Generally, stronger and thicker strata will provide more stability to driven piles.

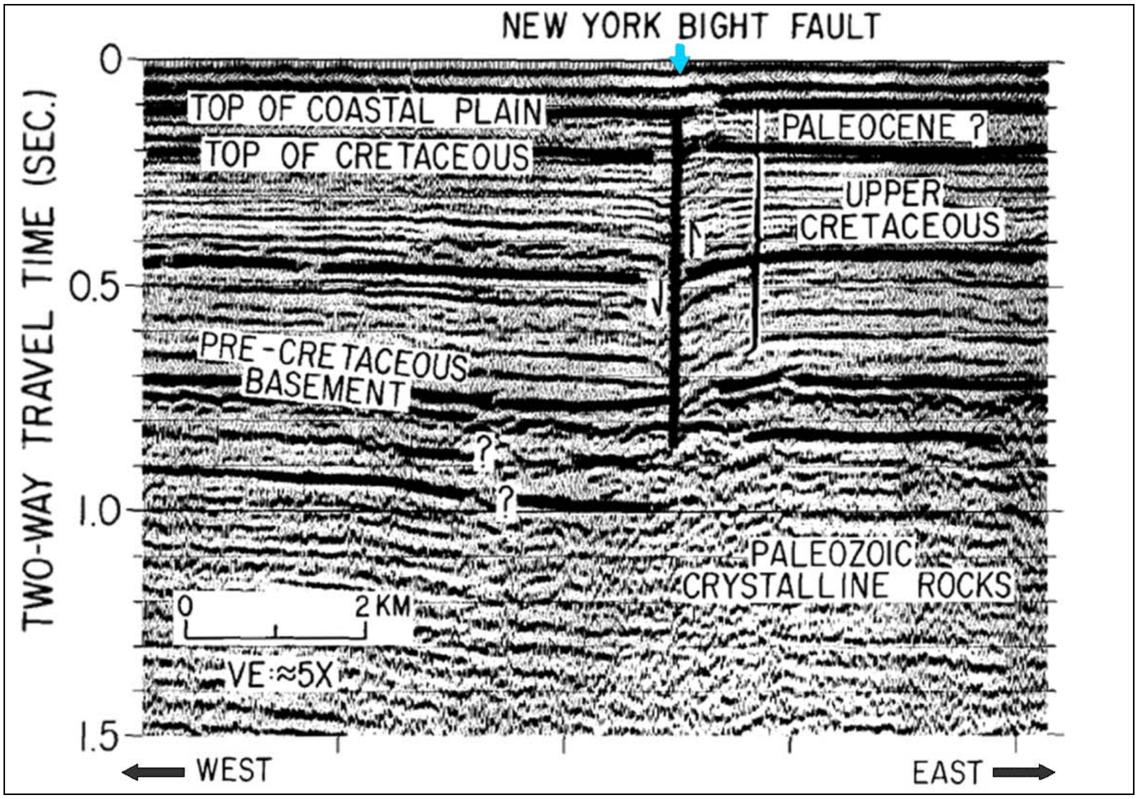

Figure 3. Seismic reflection profile of the New York Bight Fault and surrounding strata.[3]

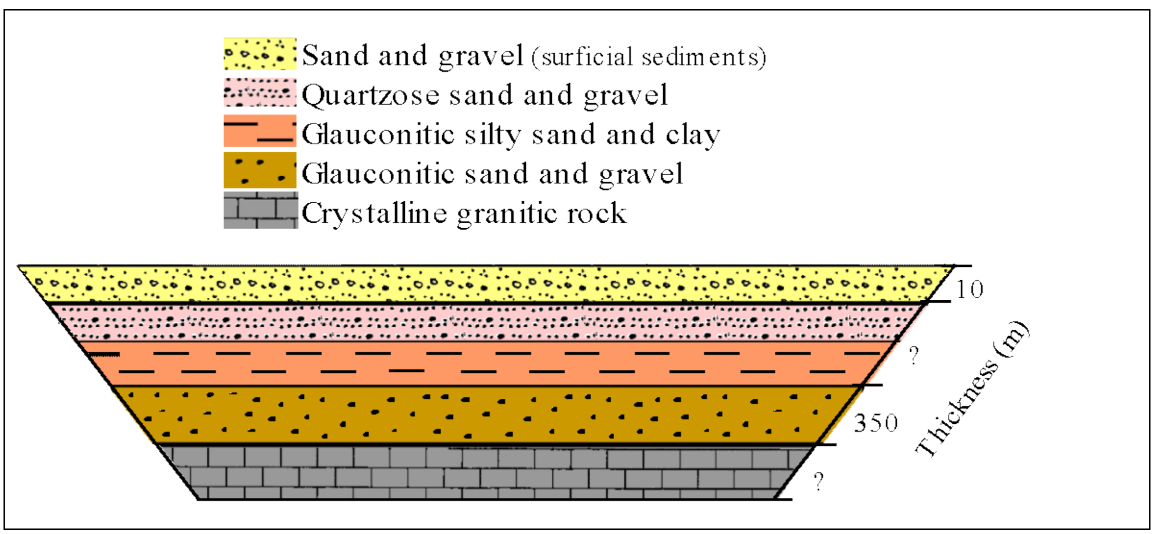

Figure 4. Stratigraphic column of subsurface geology in the region of the proposed project area.

[3] Figure from Hutchinson and Grow 1985 (Figure 6, p. 980). This high-resolution multichannel seismic reflection profile was collected at the point where the fault enters the proposed study area from the south. For location see Figure 2 of Hutchinson and Grow 1985.

2.4. SEISMICITY AND SIDE-SCAN SONAR AND MAGNETOMETER SURVEY DATA

The New York Bight has experienced multiple, low intensity and magnitude (less than 1.0 to 2.7 Richter magnitude) earthquake events (Figure 5; Smith 1966; Yang and Aggarwal 1981; Hutchinson and Grow 1982, 1985). Hutchinson and Grow (1985) cite four events between 1975 and 1981 within 20 km (12.4 mi) of the only apparent fault within the Bight, known as the New York Bight Fault (Hutchinson and Grow 1985). Still, due to limited seismic recording stations at the time, the reported epicenters may in fact have been located much closer to if not along the fault itself, suggesting that the fault may be active (Hutchinson and Grow 1982, 1985).

The age of the fault is approximately 95 to 30 million years before the present (Late Cretaceous to Middle Oligocene). The New York Bight Fault is at least 50 km (31.1 mi) long and represents one of the most continuous post-rift faults along the eastern U.S. From its southern terminus (about 40º15'N 73º34'W), it trends to the north-northeast for about 30 km (18.6 mi) then angles to the northeast (Hutchinson and Grow 1985; Wheeler 2006). It is unknown if the northern terminus lies beneath Long Island. The type of fault (normal, strike/slip, transform) is unknown (Hutchinson and Grow 1985). The hanging wall section of the fault trends to the west. Stratal displacement is a maximum at 190 m (623 ft; basement strata) and decreases to the north and south as well as upsection (i.e., the offset in the youngest fault strata is 12 to 50 m [39 to 164 ft]). These conditions indicate that the fault developed during sedimentation and its motion is continuous (i.e., growth faulting; Hutchinson and Grow 1982, 1985).

Although the New York Bight Fault is the only reported fault offshore in the vicinity of the project area, multiple other faults have been documented underlying southeastern New York (e.g., Ramapo Fault, Mosholu Parkway Fault, and Dyckman Street Fault, as well as several smaller branching faults). It is thought that one of these fault lines was responsible for the most recent large earthquake in the area, which occurred in August 1884 (Table 1). According to recent studies, the 5.2 magnitude earthquake, centered beneath Brooklyn, New York, was felt over an area of at least 181,000 km^2 (70,000 mi^2). The epicenter location for this event coupled with several documented faults within the region, indicating that the quake of 1884 was more likely associated with one of the aforementioned faults rather than the New York Bight Fault (Sykes et al. 2008; Tantala et al. 2008).

For detailed and explanatory information regarding seismic-reflection, side-scan sonar, and multibeam swath bathymetry survey data for the New York Bight, please refer to the following references: Schwab et al. 1997, Schwab et al. 2000a, Schwab et al. 2000b, Butman et al. 2002, and Schwab et al. 2003. Geographic information system (GIS) data for the New York Bight Inner-Continental Shelf region is available from the Coastal and Marine Geology Program.[4] Attempts to identify references regarding magnetometer survey data were not successful.

Forces exerted on wind turbine structures from seismic events may pose limitations in siting location as well as foundation design (Prowell et al. 2010). Seismic events will require further study as the project enters later stages of development.

Table 1. Known earthquakes in NY-NJ Region (magnitude 3.0 or larger, through 1998).[5]

Year	Longitude	Latitude	Magnitude
1783	73º45'00"	41º00'00"	4.9
1848	73º55'12"	41º07'12"	3.3
1871	73º51'36"	40º33'00"	3.0
1872	73º48'00"	40º54'00"	3.0
1874	73º48'00"	40º54'00"	3.4
1884	74º00'00"	40º33'36"	5.2
1893	74º00'00"	40º36'00"	3.3
1895	74º18'00"	40º27'36"	4.3
1916	73º48'00"	41º00'00"	3.3
1926	73º54'00"	40º54'00"	3.0
1927	74º00'00"	40º18'00"	3.9
1933	73º48'00"	41º00'00"	3.0
1937	73º42'00"	40º42'00"	3.1
1938	74º20'24"	40º06'00"	3.7
1938	73º42'00"	41º00'00"	3.6
1953	74º00'00"	41º00'00"	3.1
1976	74º02'51"	40º50'06"	3.1
1979	74º15'49"	40º19'17"	3.5
1980	74º09'13"	40º25'44"	3.1
1980	73º46'48"	41º06'36"	3.2
1985	73º49'48"	40º58'48"	4.0
1992	74º20'28"	40º21'47"	3.1

[4] USGS New York Bight Inner-Continental Shelf: GIS Data Catalog. Accessed 30 March 2010. http://coastalmap.marine.usgs.gov/regional/contusa/eastcoast/midatl/nybight/data.html.
[5] To be used in conjunction with Figure 5. Data source: Wheeler 2001.

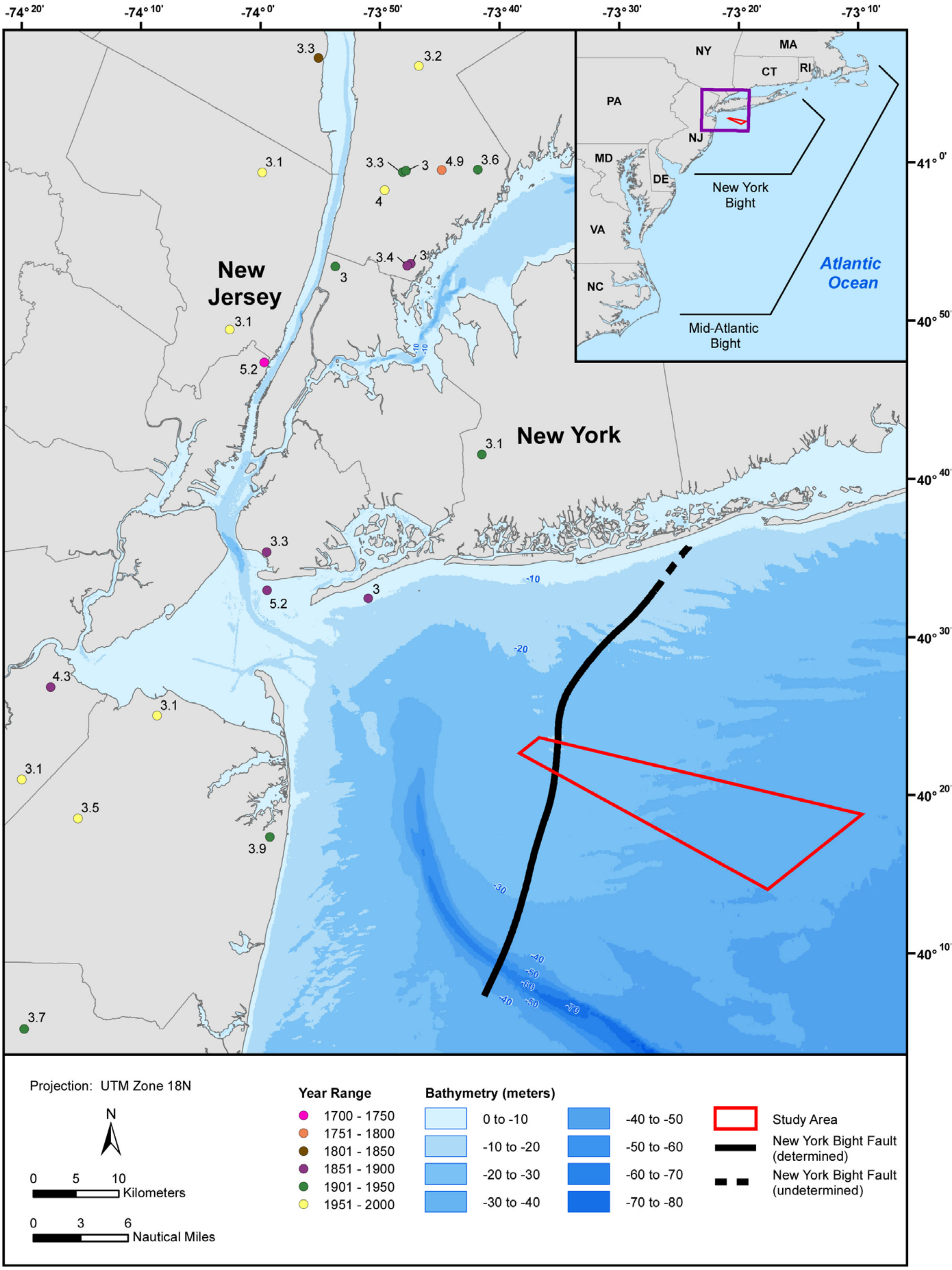

Figure 5. The New York Bight Fault and known nearby earthquakes (magnitude 3.0 or larger, through 1998).

Data sources: Hutchinson and Grow 1985 and Wheeler 2001.

Section 3

3. SUBMERGED OBSTRUCTIONS

3.1. WRECKS AND SHALLOW HAZARDS

The incidence of submerged obstructions in the vicinity of the proposed project area was investigated. A query of the Office of Coast Survey's Automated Wreck and Obstruction Information System (AWOIS) database returned 26 submerged obstructions in the vicinity of the project area. Of these, 19 were identified as shipwrecks (Figure 6 and Appendix A). Identified shipwrecks include early to late twentieth century recreational or commercial vessels (barges, tugboats, tankers), an early nineteenth century shipwreck (Three Sisters), and a late nineteenth century shipwreck (Eureka; Waterproof Charts Inc. 2001; NOAA 2006).[6]

Given the project area's proximity to the port of New York, one of the country's oldest and busiest international sea ports, and the other active historic ports along Long Island's southern shore, the potential exists for unidentified or unrecorded commercial, recreational, mercantile, and exploration vessels dating from the sixteenth through twentieth centuries to lie buried on the seafloor within or adjacent to the project area. Since little archaeological information is known of the early vessels and the people who made and used them, the discovery of the remains of any historic ship or boat located during subsequent archaeological investigations of the project area would have a high potential to be historically significant on a local, regional, national, or even international level.

Aside from historical value, shipwrecks provide important habitat for a variety of benthic marine species and commercial fish species. For these reasons, shipwrecks may be considered biologically sensitive habitats. The Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEM, formerly Minerals Management Service [MMS]) has released a Preliminary Draft Lease Stipulations report, which indicates that for any biologically sensitive habitat located within 100 m (328 ft) of potential seafloor disturbance or 1,000 m (3,281 ft) of sites in which activities have the potential to create turbidity plumes (e.g., excavation), a site survey must be completed before any aforementioned activities commence, including color videography and still photography. Furthermore, survey sites should encompass a range outside the boundary of the biologically sensitive habitat, even if this is outside the lease or grant block, to ensure complete delineation of the habitat. Site surveys must include identification of both substrate type and benthic communities. Surveys completed for a small area must be conducted for the entire site (100%), while larger areas may use transect survey methods with no more than 20 m (65.6 ft) of parallel separation (MMS 2010).

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[6] Scuba Diving-New Jersey and Long Island New York: Dive Sites-Long Island-West. Accessed 25 March 2010. http://njscuba.net/sites/chart_li-1_west.html.

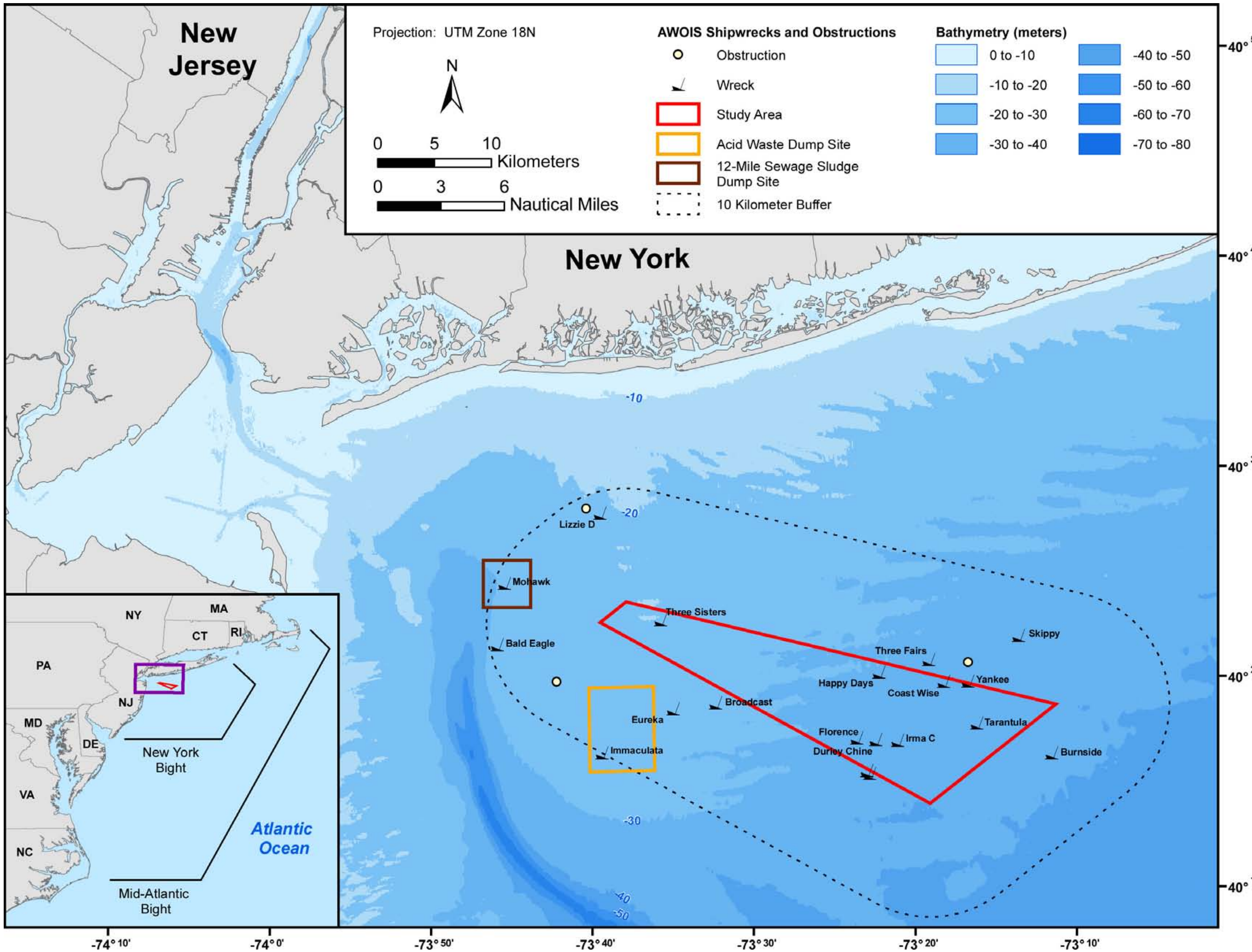

Figure 6. Submerged wrecks and obstructions near the proposed project area.
Refer to Appendix A for additional details.[7]

[7] Data source: AWOIS Download: Region 3. Accessed 25 March 2010. http://www.nauticalcharts.noaa.gov/hsd/ AWOIS.html.

3.2. MUNITIONS AND EXPLOSIVES OF CONCERN AND CHEMICAL WARFARE MATERIAL

Munitions and explosives of concern (MECs) are explosive weapons (bombs, bullets, shells, grenades, land mines, naval mines, etc.) that did not explode when they were employed, whether by malfunction, design, or other cause. MECs are also widely referred to as unexploded ordinances/bombs (UXOs/UXBs); however, MEC is the preferred terminology. In addition to MECs, there are also chemical warfare material (CWM) containing both chemical munitions and/or containers of chemical warfare agents (DoD 2009). Ocean disposal of both conventional and chemical munitions and other waste material was considered appropriate until the enactment of the Ocean Dumping Act of 1972 (U.S. Congress 1972), which prohibited the disposal of wastes into the ocean of the U.S., extending to the contiguous zone (24 nautical miles [27.6 mi] seaward). Both MEC and CWM may continue to pose risks many decades after they were used or discarded.

Carton and Jagusiewicz (2009) state two main risks associated with ocean-disposed munitions: (1) "acute – injury or death caused by either detonation or direct exposure to chemical agents" and (2) "chronic – adverse health impacts resulting from prolonged exposure to munitions constituents". Risk is assessed relative to munitions' specifics (type and configuration), location of disposal, hydrological properties (e.g., depth, current), and activities conducted in the disposal vicinity (e.g., commercial/recreational fishing, construction, dredging; Carton and Jagusiewicz 2009; Greene et al. 2009). The dumping of munitions in the ocean was widespread geographically off the coast of the continental U.S. until the practice was ceased by Department of Defense (DoD) in 1970. Although the U.S. Army disclosed more information than previously available, much remains unknown about the exact quantities, types, and present locations of conventional and chemical weapons that were dumped in the ocean (U.S. Army RDECOM 2001; Bearden 2007). Based on known records, there are no current listings of MEC/CWM sites within the proposed project area. Nevertheless, multiple sites have been documented far outside the study area, beyond the shelf break off the Mid-Atlantic Bight (Brankowitz 1989; Schollmeyer 2006; Ong et al. 2009). Other, non-DoD dump locations, lying adjacent to Cholera Bank, include the former 12-mile municipal oceanic sewage sludge and acid waste dump sites (Pararas-Carayannis 1975; Waterproof Charts Inc. 2001).[8]

3.3. ARCHAEOLOGICAL RESOURCES

The New York State Historic Preservation Office (NYSHPO) maintains a comprehensive inventory of cultural resource management survey reports prepared for projects in New York State. Personal communication with Daniel Bagrow from the NYSHPO indicated that a formal request must be made for any archaeological resource inquiries. The appropriate form for a standard review, included in Appendix

[8] OEMM: Renewable energy program-Current projected uses: Sea surface and bottom map. Accessed 27 July 2010. http://www.boemre.gov/offshore/RenewableEnergy/SeaSurfaceandBottomMap.htm

D,[9] must be completed and returned to the NYSHPO; a response will be received within 30 days. If the NYSHPO's reply indicates no archaeological resources in the proposed project area, the project may proceed. Still, if the NYSHPO's reply indicates archaeological resources in the proposed project area, an archaeological survey will be required.

[9] Environmental Review-NYS Parks, Recreation, and Historic Preservation. Accessed 19 March 2010. http://nysparks.state.ny.us/shpo/environmental-review.

Section 4

4. WIND TURBINE FOUNDATION DESIGNS

The following section briefly introduces wind turbine foundation designs that may be used in the proposed project area. Installation at the current site, however, may require additional engineering strategies not covered here, depending on sediment conditions, such as sand density and depth, as well as the stability of underlying strata. Five different foundation concepts are evaluated below; Monopile, Tripod, Suction Caisson, Gravity Base, and Jacket. Additionally, basic potential structural impacts are discussed.

4.1. FOUNDATION DESIGNS

4.1.1. Monopile

Common design philosophy for offshore wind turbines in water depth less than 30 m (98 ft) is based on the monopile foundation (Figure 7a; Byrne 2003; Wang and Bai 2010). This foundation scheme consists of a steel pile/tube 2 to 6 m in diameter driven into the seabed to a depth ranging from 20 to 40 m (66 to 131 ft; HKOW 2009). Installation methods (driving and/or drilling) are contingent upon sediment composition and water depth (Byrne 2003). While the monopile design is the most common foundation for offshore wind installations, it may not be suitable in all cases, such as sites containing large boulders and/or other geohazards (Thomsen et al. 2007).

4.1.2. Tripod

This foundation design uses three steel piles approximately a meter (3.3 ft) in diameter, driven into the seafloor (Figure 7b; den Boon et al. 2004). This structure is generally more stable and less susceptible to loading impacts than a monopile design. Tripod foundations are common for installations in waters greater than 20 m (66 ft) deep (Johansen et al. 2008; Wang and Bai 2010).

4.1.3. Suction Cassion

This design resembles an upside-down steel or concrete bucket, 12 to 15 m (39 to 49 ft) in diameter, sunk into the seabed to a depth of approximately 12 m (39 ft; Figure 7c; Irvine et al. 2003; HKOW 2009). The caisson foundation is placed on the seafloor and the rim creates a seal against the sediment. Water and air are then pumped from the internal space, creating a pressure difference. This difference in pressure creates a suction force that pulls the foundation into the sediment and locks it in place (Irvine et al. 2003).

4.1.4. Gravity Base

These foundation types use gravity and mass as sources of dead load to stabilize the turbine against overturning load effect and are composed of a large, heavy steel or concrete base filled with heavy ballast material (Figure 7d; Irvine et al. 2003; HKOW 2009). Unlike pile-based foundations, gravity base foundations are not driven into the seabed, but rather rest on the seafloor. Due to this foundation relying only on ballast and gravity for support and not containing stabilization through anchorage into the underlying strata, this design is not suitable in soft-sediment conditions such as unconsolidated clays. Furthermore, this foundation may be more susceptible to scour processes (Feld 2004). The earliest gravity base foundations were installed in water depths of less than 10 m (33 ft) (Wang and Bai 2010); however, more recent gravity-base foundations have been installed in waters as deep as 28 m (92 ft), such as installed by COWI at the Thornton Bank project in 2008 (Renewable Energy World, 2 July, 2009).

4.1.5. Jacket

The jacket foundation style consists of three or four steel piles or tubes, each a meter or two in diameter, held together in a lattice design and driven into the seabed (Figure 7e; HKOW 2009). This structure design has been successfully implemented in the oil and gas industry for deep water platforms and has been installed in water depths of over 40 m (131 ft) (i.e., Beatrice offshore wind project, Scotland; Loman 2009; Wang and Bai 2010).

The most optimal foundation design is site-specific and contingent upon various conditions, including, but not limited to sediment characteristics, seabed strength and structure, environmental loading, and scour processes and effects. Refer to Table 2 for more information regarding benefits and drawbacks for each foundation design previously discussed.

Table 2. Comparison of common offshore wind turbine foundations.[10]

Foundation Type	Suitable Water Depth	Benefits	Drawbacks	Example Wind Projects
Monopile	< 30 m (98 ft)	-Little to no site preparation before installation	-Generally not recommended for water deeper than 30 m -Not recommended for sites containing boulders or other geohazards -Greatest noise impact from drilling and/or hammering	Horns Rev (Denmark)
Tripod	> 20 m (66 ft)	-Generally more stable than Monopile -Generally less susceptible to loading impacts than Monopile	-Not suitable for highly coarse or stony sediments	Hooksiel (Germany)
Suction Caisson	< 30 m (98 ft)	-Little to no site preparation, drilling, or dredging -Easiest to decommission -Least overall impact	-Unknown*	Frederikshaven (Denmark)
Gravity Base	< 30 m (98 ft)	-Complete structure can be assembled onshore and towed to site -No drilling/driving required	-Requires significant site preparation -Requires strong and stable seabed -Imposes large footprint -Highest water quality impact from dredging and other preparation	Lillgrund (Sweden)
Jacket	> 30 m (98 ft)	-Acceptable for deep water sites -Proven use in oil and gas industry -Most or all assembly can be conducted onshore -Reportedly decreased wave load -Can be installed in a broader range of sediment types than the monopile	-Unknown*	Beatrice (Scotland)

[10] Sources: dena Energy 2009, Loman 2009, Snyder and Kaiser 2009, and Wang and Bai 2010.
* indicates information was not found; however, drawbacks for those foundation types may exist.

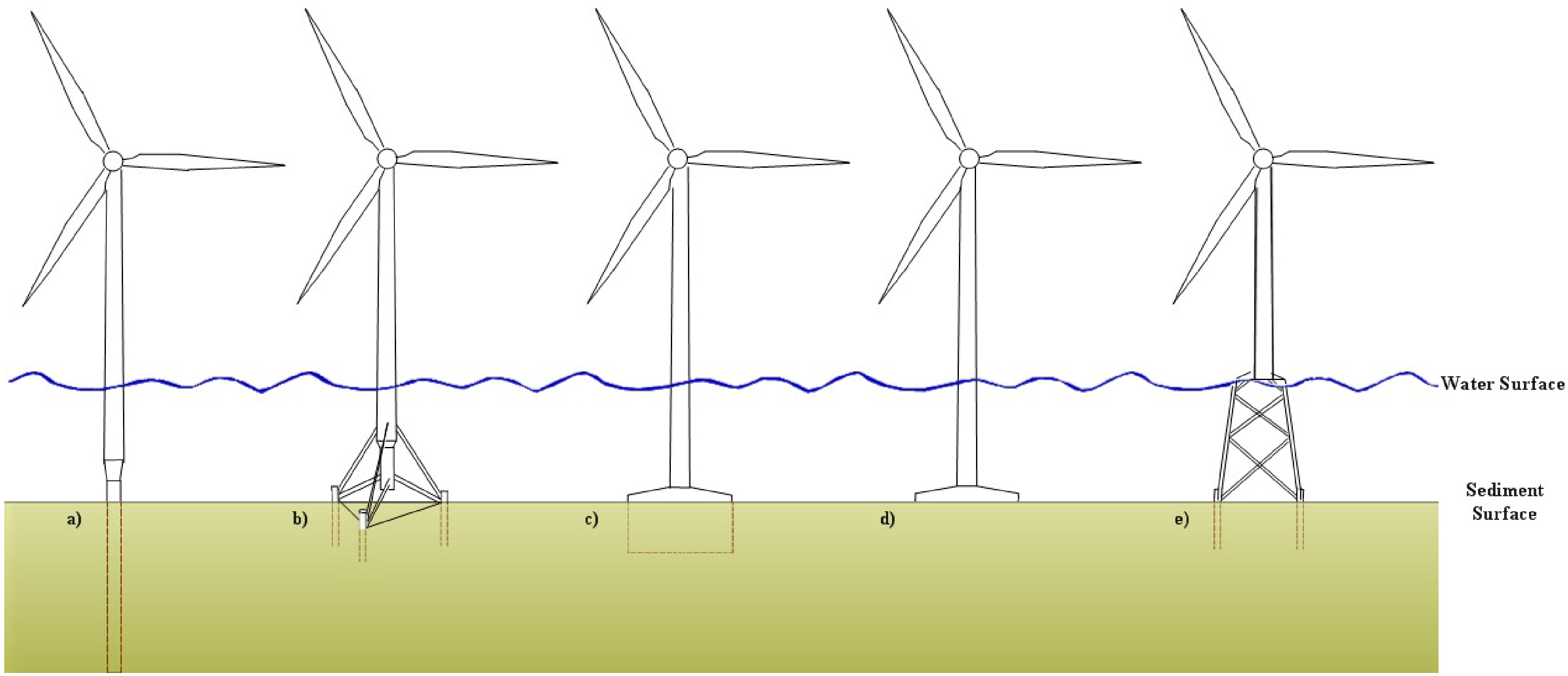

Figure 7. Basic wind turbine foundation designs.

a) monopile; b) tripod; c) suction caisson; d) gravity base; and e) jacket.

Dotted lines indicate pile installation into the seabed.

4.2. POTENTIAL STRUCTURAL IMPACTS OF GEOPHYSICAL ENVIRONMENT

Both vertical and overturning loads require consideration when selecting a foundation type. Vertical loading occurs from the weight of the turbine structure itself while overturning loads result from wind and wave forces exerted on the foundation structure. The magnitude of the load will vary with local environmental conditions, and are expected to be greatest when high winds occur concurrently with increased sea states (Byrne and Houlsby 2003).

Scour is another significant factor to consider when selecting a foundation type. Scour is the erosion of sediment immediately surrounding a structure and is the result of altered wave and/or current flow around a structure. Foundations employing pile-schemes may experience a loss of sediment on one side of the pile due to turbulent eddies. The depth of the scour hole is typically one and a half to two times the diameter of the pile, leading to a decline in the structure's natural resonant frequency, which can result in decreased lifetime and/or increased bending forces upon the structure, effectively weakening the foundation (Watson 2000; Johansen et al. 2008). Additionally, scour can cause free-spanning of and damage to transmission cables (Johansen et al. 2008).

The proposed project area is dominated by medium-grained sandy sediments. Sands are more susceptible to scour (the erosion of sediment immediately surrounding a structure resulting from altered wave and/or current flow around the structure) than more cohesive sediments such as mud, silt, and clay. Therefore, scour protection may be required for installations within the proposed project area. Various methods of scour protection for pile-designs exist and include diversion fences composed of seaweed mats surrounding the pile-base and boulder or rock layers around the base of the pile. Gravity base foundations experience scour effects beneath the structure that may lead to instability in sandy environments (Watson 2000).

Detailed information regarding scour is available for further reading. Den Boon et al. (2004) and Johansen et al. (2008) detail the physical processes that lead to scour as well as various methods of scour protection (e.g., fins, diversion fence, surrounding rock/boulder layer).

To further determine the likelihood and impact of scour within the specific proposed project area, further research and field studies may be necessary.

Section 5

5. RECOMMENDATIONS FOR FURTHER STUDY

Geophysical site-specific conditions (bathymetry and sediment and subsurface geology composition and thickness) are significant factors to be examined for project siting, foundation design, and construction effort.[11] As the next step in further assessing the feasibility of offshore wind development within the proposed project area, technical site surveys are recommended to better understand sediment characteristics, stratification beneath the seabed, and locations of submerged obstructions or hazards.

Sediment, subsurface, and obstruction/hazard surveys may include, but are not limited to:

- Sonar (multibeam and side-scan)
- Sub bottom profiling
- Seismic reflection profiling
- Core sampling
- Magnetometer surveys
- Wave/Current modeling

Each geological survey listed above is useful to obtain specific data relevant to offshore wind project development. While both side-scan and multibeam sonar surveys provide image-based data regarding seabed shape and geologic composition, only multibeam sonar surveys will also indicate bathymetric differences. Sub bottom profiling and seismic reflection surveys are used to identify and measure stratification beneath the seafloor via assessment of structural geology and sedimentation patterns. Core samples are useful to determine sediment/geologic composition representative of the area of intent. Magnetometer surveys detect anomalies in the earth's magnetic field caused by obstructions and hazards composed of, or consisting of, ferrous metals (steel and iron) that may be partly or wholly buried beneath the sediment. Lastly, waves and currents are dynamic physical processes constantly causing changes at the water-sediment interface. Wave/Current modeling may provide information on sediment movement and re-distribution.

[11] For example, some turbine foundations are driven into the seabed; therefore, thicker sediments may require longer or multiple monopiles to increase structural stability.

Section 6

6. CONCLUSIONS

A pre-development review of the geophysical characteristics of the New York Bight was conducted on behalf of the Collaborative to assess the feasibility of the development of an offshore wind energy project in a proposed area southeast of Rockaway Peninsula, Long Island. The review relied on multiple literature and database sources and on consultation with field experts. It did not identify any fatal flaws that are likely to preclude development of an offshore wind farm.

The geology of the New York Bight consists of mostly sandy surface sediment with an average thickness of approximately 10 m (33 ft) overlying subsurface rock layers from multiple geological eras. The basement geology is composed mainly of crystalline granitic rock. It is not anticipated that the subsurface geology would impose a significant obstacle to the construction of a wind project.

Water depths in the project area range from 18 to 40 m (59 to 131 ft), with the shallowest depths in the Cholera Bank region. This range is shallow enough for the installation of current wind turbine foundation technologies.

There may be seismic activity in the area. The New York Bight Fault runs approximately north to south along the west end of the study area. This fault is potentially active, and has been linked to seismic events within 20 km (12 mi) of the fault. The possibility of a seismic event occurring during the project's operation should be further investigated and may be considered in the design of turbine foundations and other system components.

Obstructions (shipwrecks and other shallow hazards) are not likely to materially interfere with development in the project area. Shipwrecks may be considered either archaeologically or biologically sensitive areas, and require additional site surveys. The NYSHPO will determine if an archaeological survey will be required. MECs and CWMs are not expected to preclude development in the project area; however, little is known about the exact quantities, types, and locations of these materials within the New York Bight. Other biohazards (i.e., sewage sludge and acid waste) may also exist in the area, particularly at the 12-mile dump site adjacent to Cholera Bank, which should be avoided.

It should be noted that a Liquid Natural Gas (LNG) port facility, known as the Safe Harbor Energy Project, has been proposed by the Atlantic Sea Island Group in the Cholera Bank area (DoT 2009). The draft environmental impact statement for this facility is being processed by the New York State Department of Environmental Conservation and the U.S. Coast Guard (USCG); no determination has been made. It is not clear what impact this potential facility would have on the siting of wind turbines in the western portion of the Collaborative's proposed project area.

The type of foundation used for the proposed project should be determined by site specific engineering studies of physical environment conditions (sediment and subsurface geologic composition and depth) and processes (winds, waves, and currents). Structural and environmental constraints will ultimately determine which foundation is best suited for the project area.

A comprehensive analysis of all existing available geophysical data for the project area indicated that offshore wind development in the proposed project area appears to be feasible, and no fatal flaws were identified based on existing data. Nevertheless, while the data reviewed and summarized for this report is representative of known conditions in the vicinity of the project area, the collection of site specific field data is required to confidently determine the feasibility of the proposed project area and to support detailed siting, design, and permitting of all components of an offshore wind project. The need for recent site specific geophysical data is further supported by the fact that several factors can contribute to changes, sometimes quickly, in the marine environment (i.e., storms, river runoff, and dredging), and historical data may not be reflective of current conditions. Therefore, in order to better characterize the seafloor, subsurface geology, and known and unknown submerged hazards, further site specific geophysical and geotechnical analyses are recommended to provide a more complete assessment of current conditions of the project area. Suggested surveys include: multibeam and side-scan sonar, magnetometer surveys, sub bottom and seismic reflection profiling, core sampling, and wave and current modeling.

Section 7

7. REFERENCES

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APPENDIX A

SUBMERGED OBSTRUCTIONS

Table A1. Query results from the Office of Coast Survey's AWOIS database, regarding wrecks and obstructions within study area vicinity; to be used in conjunction with Figure 6. All points included in the table are from AWOIS Region 3.4 * indicates information from Ocean Surveys Inc. 2002.

Figure Label	RECRD	VESSLTERMS	CHART	CARTOCODE	Depth (ft)	LATDEC (N)	LONDEC (W)	LAT-DMS (N)	LONG-DMS (W)	Classification	Comments*
1	1622	Unknown	12300	370	60	40.46843889	73.65123889	40º28'06"	73º39'04"	Sounding	40 ft crane barge
2	1624	Lizzie D	12326	370	59	40.47193889	73.65290556	40º28'19"	73º39'10"	Sounding	85 ft tug; built in 1907 and sank on October 19, 1922
3	749	Relief Lightship	12326	100	22.81	40.45239444	73.81783889	40º27'09"	73º49'04"	Wreck	-
4	1548	Yankee	12300	102	0	40.33343889	73.27456111	40º20'00"	73º16'28"	Wreck	-
5	1549	Coast Wise	12300	999	0	40.33343889	73.29956111	40º20'00"	73º17'58"	Unknown	-
6	1551	Obstruction	12300	67	0	40.33844167	73.69957222	40º20'18"	73º41'58"	Obstruction	360 ft L-shaped object
7	1554	Asfalto	12326	102	95*	40.35010833	73.76624167	40º21'00"	73º45'58"	Wreck	300 ft schooner barge; sank on either March 12, 1932 or 1942
8	1559	Continent	12326	102	99	40.3622	73.81785	40º21'44"	73º49'04"	Wreck	-
9	1583	Unknown	12300	999	0	40.41677222	73.77596389	40º25'00"	73º46'33"	Unknown	-
10	1586	Mohawk	12326	100	78	40.41707778	73.75262778	40º25'01"	73º45'09"	Wreck	-
11	1607	Dryland	12326	100	87	40.45434444	73.80802778	40º27'16"	73º48'29"	Wreck	-
12	1611	Unknown	12300	999	0	40.45843611	73.44956944	40º27'30"	73º26'58"	Unknown	Barge; sank Nov.10, 1910

Figure Label	RECRD	VESSLTERMS	CHART	CARTOCODE	Depth (ft)	LATDEC (N)	LONDEC (W)	LAT-DMS (N)	LONG-DMS (W)	Classification	Comments*
13	7704	Bald Eagle	12326	102	85*	40.36843889	73.76113056	40º22'06"	73º45'40"	Wreck	Wooden hull
14	7706	Three Sisters	12326	102	75*	40.38640278	73.59159722	40º23'11"	73º35'30"	Wreck	Possible early 19th century tug
15	7721	Durley Chine	12326	102	185*	40.28831389	73.37114444	40º17'18"	73º22'16"	Wreck	279 ft tanker; sank in 1917
16	7730	Eureka	12326	102	110*	40.31563333	73.58008333	40º18'56"	73º34'48"	Wreck	128 ft tug; built in 1898
17	7731	Ba Wreck	12326	102	120*	40.32808056	73.79775833	40º19'41"	73º47'52"	Wreck	-
18	7740	Three Fairs	12326	102	0	40.35115833	73.31465278	40º21'04"	73º18'53"	Wreck	-
19	7741	Obstruction	12326	102	0	40.34811667	73.27378056	40º20'53"	73º16'26"	Wreck	-
20	7774	Happy Days	12326	102	0	40.34198333	73.36639722	40º20'31"	73º21'59"	Wreck	-
21	7790	Immaculata	12326	102	100*	40.28155556	73.65443056	40º16'54"	73º39'16"	Wreck	Barge; sank in 1920s
22	7791	Irma C	12326	102	0	40.28750556	73.348475	40º17'15"	73º20'55"	Wreck	-
23	7792	Broadcast	12326	102	0	40.31998611	73.53608889	40º19'12"	73º32'10"	Wreck	-
24	7815	Florence	12326	102	0	40.28992778	73.39083056	40º17'24"	73º23'27"	Wreck	-
25	7817	Unknown	12326	102	0	40.38329444	73.807475	40º23'00"	73º48'27"	Wreck	-
26	13252	Obstruction	12326	67		40.47560556	73.666575	40º28'32"	73º40'00"	Obstruction	-

COLUMN HEADER EXPLANATIONS OF TABLE A1
FROM THE AWOIS USER'S GUIDE (NOAA 2006; PP 4-6)

RECRD – Unique five-digit AWOIS number. AWOIS numbers are assigned by the Hydrographic Surveys Division, Operations Branch.

VESSLTERMS – A vessel name or the terms UNKNOWN, OBSTRUCTION, and SOUNDING.

CHART – The chart number entered here is that of either a National Ocean Service (NOS) chart or a Defense Mapping Agency chart and is the largest scale chart on which the wreck, obstruction, or sounding is located.

CARTOCODE – This three-digit cartographic code with leading zero identifies the characteristic of the item. A list of the CARTO Codes used in AWOIS is contained in Appendix B.

DEPTH – Actual least depth or wire drag cleared depth over a feature that has been determined by hydrographic or wire drag survey methods. This depth will not be a reported or unverified depth. These depths originate primarily from NOS hydrographic surveys.

LATDEC and **LONGDEC** – Geographical position expressed in decimal degrees. The geographic position represents the most accurate position available found in documents at NOS.

LATDMS and **LONGDMS** – Geographical position expressed in degrees, minutes, seconds.

APPENDIX B

AWOIS CARTOGRAPHIC CODES

CODE	SYMBOL	DESCRIPTION
		<u>Wrecks</u>
098		Visible
100		Submerged, dangerous to surface navigation
102		Submerged, nondangerous
		<u>Obstructions</u>
085	o	Visible at high water
284	o	Covers/uncovers (awash)
067		Submerged
		<u>Rocks</u>
094	*	Awash
104	+	Covered at low water
		<u>Soundings</u>
127		Feet and tenths
130		Fathoms and tenths
711		Meters and tenths
370		Wire-drag clearance, feet
372		Wire-drag clearance, fathoms

APPENDIX C

GLOSSARY

GLOSSARY

Active margin—the border of a continent along which subduction occurs, producing igneous activity and deformation zone where tectonic spreading occurs and new crust is formed.

Asthenosphere—the uppermost layer of the mantle, located below the lithosphere.

Basement geology—bottom, or oldest rock layer.

Bathymetry—spatial variability in the bottom of a body of water.

Benthic zone—the ecological region at the lowest level of a body of water such as an ocean or a lake, including the sediment surface and some sub-surface layers

Clastic—of or belonging to or being a rock composed of fragments of older rocks (e.g., conglomerates or sandstone).

Coastal plain—Flat low-lying land along the ocean's coast.

Cretaceous—a geologic period and system from circa 145.5 ± 4 to 65.5 ± 0.3 million years ago.

Epoch—a unit of geological time that is a subdivision of a period and is itself divided into ages.

Fault—a crack in the earth's crust resulting from the displacement of one side with respect to the other.

Glacio-fluvial – deposits distributed by rivers that helped drain melting glaciers.

Glauconite—a phyllosilicate (mica group) mineral.

Growth fault—a particular type of shovel-shaped, normal fault that develops during ongoing sedimentation, so the strata on the hanging wall side of the fault tend to be thicker than those on the foot wall side.

Hanging wall—the upper wall of an inclined fault.

Holocene—a geological epoch that began approximately 12,000 years ago.

Lithosphere—Earth's outer rigid shell, situated above the asthenosphere and consisting of the crust and upper mantle. The lithosphere is divided into plates.

Magnetometer—a scientific instrument used to detect disturbances and irregularities in the earth's magnetic field caused by the presence of metal, excavated areas, burned areas, or other disturbances in the soil.

Magnetometer survey—a survey using magnetic detection sensors to locate known and unknown wrecks or objects that are constructed of steel or iron and/or contain components that are constructed of steel or iron.

Morphology—form or structure.

Multibeam swath bathymetry—an acoustic technique used for the production of bathymetric and sediment classification maps.

Munition—often defined as a synonym for ammunition. A slightly broader definition would include bombs, missiles, warheads, and mines.

Oligocene—a geologic epoch of the Paleogene Period and extends from about 34 million to 23 million years before the present (33.9 ± 0.1 to 23.03 ± 0.05 million years ago).

Orogeny—process by which mountain ranges are formed, i.e., the process of rock thrusting, folding and faulting in association with deeper plastic deformation, metamorphism and plutonism.

Paleozoic—the earliest of three geologic eras of the Phanerozoic Eon; it spanned from roughly 542 to 251 million years ago.

Passive margin—continental margin that is not affected by rifting, subduction, transform faulting, or other large-scale tectonic processes, but instead forms a shelf that accumulates sediments

Pleistocene—the epoch from 2.588 million to 12,000 years before present covering the world's recent period of repeated glaciations.

Precambrian – a geologic period from the formation of Earth around 4,500 million years ago to the beginning of the Cambrian Period, when macroscopic hard-shelled animals first appeared in abundance about 542 million years ago.

Quartzose—sandstones (also known as 'beach sand'), which have a high (greater than 90 percent) quartz content.

Quaternary – a geologic period spanning 2.588 ± 0.005 million years ago to the present. This period includes the Pleistocene and Holocene Epochs.

Richter magnitude—also known as the local magnitude (M_L) scale, assigns a single number to quantify the amount of seismic energy released by an earthquake.

Rift—a juncture between to plates where lithosphere forms and the plates diverge.

Scour—the erosion of sediment in the vicinity of a structure, leading to a lowering of the seabed directly surrounding the structure.

Sediment—mud, sand, silt, clay, shell debris, and other particles that settle on the bottom of rivers, lakes, estuaries, and oceans.

Seismicity—the study of the location, frequency, and magnitude of earthquakes.

Seismic reflection—a method of geophysical exploration using acoustic waves and interpretation of their reflection from submarine layers.

Shoal—sandbar (or just bar in context), or gravebar is a somewhat linear landform within or extending into a body of water, typically composed of sand, silt or small pebbles.

Shoreface—the sloped portion of the seabed between the shoreline to the horizontal seabed surface.

Side-scan Sonar—a geophysical instrument that uses sound waves reflected off the seafloor to image the areal extent of different bottom types.

Stratigraphy—the study of rock layers and layering.

Stratum (pl: strata)—is a layer of rock or soil with internally consistent characteristics that distinguishes it from contiguous layers. Each layer is generally one of a number of parallel layers that lie one upon another, laid down by natural forces.

Stratal displacement – the vertical offset of layers of rock or soil.

Stratigraphy—the branch of geology that studies the arrangement and succession of strata.

Subduction—descent of a slab of lithosphere into the asthenosphere along a deep-sea trench.

Subsidence—a gradual sinking of land with respect to its previous level (usually sea level).

Surficial—of or pertaining to the surface.

Swale—a low area (especially a marshy area between ridges).

Tectonic—pertaining to the structure or movement of the earth's crust; "tectonic plates"; "tectonic valleys"

Tertiary—a geologic period 65 million to 1.8 million years ago.

Transform fault—a strike-slip fault along which two segments of lithosphere move in relation to each other. Many transform faults offset mid-ocean ridges.

Upsection—the upper portion, i.e., the geologically youngest stratigraphic layer.

Wave/Current modeling—a type of hydrodynamic mathematical process that assesses how waves and currents affect sediment transport and re-suspension.

APPENDIX D

ARCHAEOLOGICAL RESOURCES SUBMISSION FORM

New York State Office of Parks, Recreation and Historic Preservation
Historic Preservation Field Services Bureau
Peebles Island Resource Center, PO Box 189, Waterford, NY 12188-0189 (Mail)
Delaware Avenue, Cohoes 12047 (Delivery) (518) 237-8643

PROJECT REVIEW COVER FORM

Rev. 5-05

*Please complete this form and attach it to the top of **any and all information submitted to this office** for review.*
Accurate and complete forms will assist this office in the timely processing and response to your request.

This information relates to a previously submitted project. ☐ If you have checked this box and noted the previous Project Review (PR) number assigned by this office you do not need to continue unless any of the required information below has changed.

PROJECT NUMBER ____PR_______

COUNTY ______________________

2. This is a new project. ☐ If you have checked this box you will need to complete ALL of the following information.

Project Name ____

Location ____
You MUST include street number, street name and/or County, State or Interstate route number if applicable

City/Town/Village ____
List the correct municipality in which your project is being undertaken. If in a hamlet you must also provide the name of the town.

County ____
If your undertaking* covers multiple communities/counties please attach a list defining all municipalities/counties included.

TYPE OF REVIEW REQUIRED/REQUESTED (Please answer both questions)

A. Does this action involve a permit approval or funding, now or ultimately from any other governmental agency?

☐ No ☐ Yes

If Yes, list agency name(s) and permit(s)/approval(s)

Agency involved	Type of permit/approval	State	Federal
________	________	☐	☐
________	________	☐	☐
________	________	☐	☐

B. Have you consulted the NYSHPO web site at **http://nysparks.state.ny.us
to determine the preliminary presence or absence of previously identified cultural resources within or adjacent to the project area? If yes: ☐ Yes ☐ No

Was the project site wholly or partially included within an identified archeologically sensitive area? ☐ Yes ☐ No

Does the project site involve or is it substantially contiguous to a property listed or recommended for listing in the NY State or National Registers of Historic Places? ☐ Yes ☐ No

CONTACT PERSON FOR PROJECT

Name ____________________ Title ____________________

Firm/Agency ____

Address ____________________ City __________ STATE _____ Zip _______

Phone (____)__________ Fax (_____)__________ E-Mail ____________

**http://nysparks.state.ny.us then select HISTORIC PRESERVATION then select On Line Resources

Figure D1. NYSHPO project review cover form for acquiring offshore archaeological resources information.

Environmental Review-NYS Parks, Recreation, and Historic Preservation. Accessed 19 March 2010.

http://nysparks.state.ny.us/shpo/environmental-review.

For information on other
NYSERDA reports, contact:

New York State Energy Research
and Development Authority
17 Columbia Circle
Albany, New York 12203-6399

toll free: 1 (866) NYSERDA
local: (518) 862-1090
fax: (518) 862-1091

info@nyserda.org
www.nyserda.org

Pre-Development Assessment of Geophysical Qualities for the Proposed Long Island – New York City Offshore Wind Project Area

Final Report 10-22 Task 1