08

APPENDICES

July 2020 Draft

APPENDIX A

Roundtable Discussion Summaries

ROUNDTABLE DISCUSSION SUMMARIES

1. ENVIRONMENTAL

Project: **New Jersey Board of Public Utilities, Offshore Wind Strategic Plan**

Date: March 1, 2019 (10:00 a.m. – 12:30 p.m.)

Location: Rutgers University – Cook Campus, New Brunswick, NJ

Subject: **Environmental Roundtable Discussion Meeting Summary**

Purpose: The purpose of this Roundtable Discussion was to get stakeholder input for the development of the Offshore Wind Strategic Plan (OWSP) being undertaken by the New Jersey Board of Public Utilities (NJBPU) and New Jersey Department of Environmental Protection as directed under Executive Order No. 8. The objective was to provide a forum for stakeholders to discuss their concerns and recommendations relevant to environmental resource protection as the State moves from 1,100 MW to 3,500 MWs of Offshore Wind Capacity. The following is a summary, not a verbatim transcript of the proceedings. Questions, comments and conversations are paraphrased to convey main point/points.

Moderators:

John Crowther, Stantec, Technical Lead to Ramboll

Scott Glenn, Rutgers University, Distinguished Professor, Department of Marine and Coastal Sciences and Co-Director, Center for Ocean Observing Leadership

Facilitator:

Tanya Oznowich, New Jersey Department of Environmental Protection

Participants:

Jim Ferris	NJBPU
Anne Marie McShea	NJBPU
Tony MacDonald	Monmouth University Urban Coast Institute
Tim Dillingham	American Littoral Society
Catherine Bowes	National Wildlife Federation
Doug O'Malley	Environment NJ
Paul Bologna	Montclair University Marine Biology and Coastal Sciences
Brian Hooker	Bureau of Ocean Energy Management
Ursula Howson	National Ocean and Atmospheric Administration/National Marine Fisheries Service/Greater Atlantic Regional Fisheries Office
David Wheeler	Conserve Wildlife Foundation

Brick Wenzel	Point Pleasant Fishermen's Dock Co-Op and Farm Bureau
Patty Cronheim	New Jersey Conservation Foundation and ReThink Energy
Amy Goldsmith	Clean Water Action
Helen Henderson	American Littoral Society
Dan Fatton	Energy Foundation
Paul Eidman	Anglers for Offshore Wind Power
Drew Tompkins	New Jersey Audubon
Steve Evert	Stockton University Marine Field Station
Kevin Wark	Endeavor Fisheries
Martin McHugh	The Dawson Group
Peter Blair	Clean Ocean Action
Debra Coyle	New Jersey Work Environment
David Pringle	Clean Water Action

Welcome and Introductions

NJBPU welcomed attendees and explained that this session was the first in a series of issues-based stakeholder meetings. Invited attendees were encouraged to share their thoughts and knowledge of offshore wind (OSW) and the offshore marine resource so the state can develop a well-informed OWSP.

NJBPU provided an overview of the origin and process of the OWSP, including Governor Murphy's Executive Order No. 8 (EO8) and his directive to achieve 3,500 MW of OSW capacity by 2030. NJBPU noted that the initial solicitation of 1,100 MW of offshore wind capacity was released in 2018 and bids are currently under review by the BPU. The OWSP is intended to serve as a Roadmap of moving from 1.100 MWs to 3.500 MWs. The OWSP will address key components of OSW development, including achieving scale, job growth, economic development, and appropriate siting, while ensuring natural resourced are protected throughout the development and operational stages. A key component of the OWSP process is engaging key stakeholders and soliciting their input. NJBPU noted that they are here to listen to stakeholders concerns and knowledge and allow stakeholders to hear the perspective of the development team and of other stakeholders. Invited attendees were also encouraged to submit written comments.

The Facilitator provided housekeeping notes and roundtable meeting terms of engagement. Asked attendees to be succinct and try to plan ahead in terms of what's important to them. The goal of the meeting was to listen to stakeholders' input, identify problems and concerns, and suggest solutions.

Impromptu Questions:

Can we hear more on the timeline and the opportunities for stakeholder input?

A draft OWSP will be completed by July 2019 and there will be additional opportunities for input and feedback. We'll seek input on the draft OWSP and finalize the OWSP by fall 2019.

How much time will stakeholders have to review and comment?

A minimum of 30 days will be provided for public comment on the DRAFT Offshore Wind Strategic Plan once it is released for comment.

Discussion Summary

New Jersey's Offshore Wind Energy Area – A Brief Overview by Moderator

The Moderators provided a brief overview of the Offshore Wind Strategic Plan. They introduced the Environmental Modeling Analysis (EMA) and Area of Analysis that will be considered within the Offshore Wind Strategic Plan and modeled by the Ramboll Team including Stantec and Rutgers University. The EMA Area of Analysis [shown in Figure I] includes some 10,000 square miles of ocean resources. The OWSP will focus on the existing leases and proposed wind energy areas where offshore wind development is likely to occur and where there may be environmental impacts. The larger area surrounding the leases and secondary nearshore and bay areas will also be considered, but will not be reflected in the modeling [see, Figure 1: EMA Area of Analysis].

Rutgers has been studying the Area of Analysis and the area of the ocean known as the Mid-Atlantic Bight since the establishment of the Rutgers Department of Marine and Coastal Sciences and founding of the RU-COOL Lab in 1990. Rutgers built and operates the world's most advanced ocean observatory. They support weather centers, including hurricane and typhoon centers, and are beginning to consider biologic information and data collection. The Mid-Atlantic Bight has high seasonality between warming and cooling and the difference between top and bottom. This causes a lot of migration of people, and of other species, to the coast.

Environmental protection priorities within the Area of Analysis

Participants were asked for their thoughts on the Area of Analysis and the modeling presented by Stantec. When asked about priorities to be reflected in the modeling, Littoral Society along with a number of other stakeholders posed questions about the modeling itself, data to be used, weights attributed to data layers and the opportunity to review the data. Participants also asked if new data was being collected and if there would be a reference document on the modeling. The source data was a major theme of the initial discussion and pointed to the need to be transparent in the data being used in the EMA modeling, and to provide stakeholders an opportunity to review the modeling and the data layers. BOEM asked for further clarification on how primary and secondary lease areas will be treated and recommended modeling the entire New York Bight area with a single uniform analysis. BOEM also noted that they will soon announce the Wind Energy Areas for the NY Bight.

BPU notes that the New Jersey EMA Area of Analysis includes over 10,000 square miles but does not include the entire NY Bight. However, the RU-COOL Research Lab does collect data and model the New York Bight on a continuing basis, so issues of special interest can be modeled for the entire New York Bight as needed.

Stantec noted that, for the Offshore Wind Strategic Plan, four layers of overlay will be used for the modeling, including: the bio-sensitivity of species and their habitats; resource use—recreational sport fishing; geophysical (topographic, bed formations); industrial use; social areas (recreation, historical); and security (no-go areas determined by the Dept. of Defense).

Species considered the highest priority for protection

Participants were asked to comment on specific species of concern off the coast of New Jersey that should be considered in the modeling and Offshore Wind Strategic Plan. NOAA / NMFA / GARFO and Conserve Wildlife Foundation, NWF and others referenced the ESA listed species and recommended that BPU and NJDEP focus first on the ESA listed species within OWSP and environmental modeling. Conserve Wildlife Foundation noted concerns about avian migratory patterns. Littoral Society noted that ecological considerations are broader than any individual species and must be taken into account. Others noted the need to consider "food security" and not just the high value catches such as scallops. Also consider species that may develop more as a food source in the future, such as jellyfish and seaweed.

NOAA noted that the Ecological Baseline Assessment which was conducted by NJDEP in 2010 is now ten years old and may require an update to be relevant for regulatory purposes. Later in the discussion this point was brought up again noting that "a lot has changed drastically since the 2010 baseline assessment due to Superstorm Sandy in 2012. A new study is needed. Developers, who are the people who benefit most from the project, should be funding these studies."

Avoidance, minimization, and mitigation measures established by BOEM, National Marine Fisheries Service, and Other Agencies

When asked about mitigation measures, participants expressed interest in New Jersey setting clear requirements for environmental protection beyond what is set by BOEM and MFS or other agencies. Some participants recommended requirements for offshore wind developers to identify remediation measures. The spacing between turbines was discussed as a means to ensure fishing access within the turbine array although there was varying distances suggested from 0.7 nm to 2.0 nm. Generally, BPU's requirement for an Environmental Protection Plan as part of its Solicitation Process was seen as a positive. Some participants recommended that the State identify specific remediation and mitigation measures.

Consideration of potential impacts to New Jersey fisheries

Participants responded to the issue of potential impacts and displacement of fisheries with requests for clarification on how impacts will be measured. Littoral Society asked "What is the framework against which you're measuring potential impacts against the goods we are drawing from the ocean? There will be displacement." Others asked if there is an economic analysis regarding what level of activity is necessary to sustain the New Jersey fishing industry. "The fishing industry needs to fish a certain amount to stay in business. There will be a lot of displacement. That needs to be factored into the build out." A number of stakeholders asked about restrictions on fishing. BOEM noted that there are no restrictions on fishing near wind farms. The Coast Guard has jurisdiction over this issue and they do not plan to issue any restrictions. Participants generally agreed that the fishing industry needs to be involved from the beginning of planning and development in order to mitigate impacts.

Mitigation measures to be considered by the State

Given that BOEM requires several mitigation measures be implemented (e.g., time-of-year construction limitations, marine mammal observations, etc.), participants were asked what other types of mitigation measures (e.g., turbine spacing, sizing of individual wind farms, etc.) should be recommended. Right whales, birds, turtles and shipwrecks were all mentioned as issues of consideration for mitigation measures. Right whales were mentioned in context to the need for robust monitoring and mitigation measures within migratory corridors. Consideration of restriction on pile-driving based on the time of year and time of day was also mentioned. To protect whales, there should be restrictions on nighttime pile-driving. Lighting which may impact birds, turtles, and other wildlife was also mentioned. We've found that certain lighting affects migrating birds. Can these be shut off by remote and radar?

Cumulative Impacts resulting from New Jersey offshore wind projects, as well as from multiple state and offshore wind developments within the NY Bight and region

Participants were asked if New Jersey should consider cumulative impacts resulting from New Jersey offshore wind projects as well as from multiple state and offshore wind developments within the NY Bight region. We also asked if BOEM consideration of cumulative impacts is sufficient. Roundtable participants noted that NEPA only requires consideration of impacts resulting from individual projects and recommended that New Jersey consider cumulative impacts in collaboration with other states. Stakeholders also noted the value New Jersey could add in supporting a robust monitoring system. National Wildlife Federation noted that "Cumulative impacts are inherently regional in nature, but New Jersey has a key role to play in doing not just data analysis but data generation—data now and into the future. There should be thoughtful collaboration among all the states committed to OSW and the federal government."

Additional Stakeholder Recommendations

Participants were asked to consider that if offshore wind farms would be built, what recommendations would the environmental groups provide to New Jersey in developing their Strategic Plan. A number of participants recommended that a process be put in place to update and revisit the Plan and to continue the process of stakeholder engagement. NOAA noted the need to update the 2010 Ecological Baseline Assessment and to look at new issues related to habitats and the environmental parameters that influence habitats.

General Questions & Answers

Participants were asked if there are any questions they would like to ask the Offshore Wind Strategic Planning Team or the State Agencies about the future of Offshore Wind in New Jersey. There were a wide range of questions and comments. Some asked for clarification of how the Offshore Wind Strategic Plan aligns with the Energy Master Plan which is much more comprehensive. BPU notes that the two plans will be aligned with each other so that one is a subset of the other. The Dawson Group commented "You've assembled the best experts. We need to set a date, and interact with each other. This is a great start but we have to ramp up and take more time to look at this. OSW is a good source of energy but we don't want to create a new set of problems."

Other stakeholders similarly noted the need for an iterative process and further engagement of local communities. One participant noted the need for a community engagement plan and recommended that BPU should require developers to have a community engagement plan as part of any OSW project award. Others concurred that BPU has the opportunity to think about the requirements on offshore wind developers. BPU was urged to make sure environmental protection is part of those requirements. "Once you've chosen your project, make sure the community is engaged and there is synergy with the Energy Master Plan. We are a strong supporter of OSW development, if it is done responsibly."

Discussion Summary

Stantec summarized the following key points and next steps for the group:

- Engage stakeholders on a continuing basis
- The environmental data used in the modeling is of interest to stakeholders. Ensure Transparency and provide an opportunity to review data and data layers.
- BPU and NJDEP should focus first on the ESA listed species within OWSP and environmental modeling. Reach out to NOAA for existing data
- Ecological Baseline Assessment which was conducted by NJDEP in 2010 is now ten years old, and may require an update to be relevant for regulatory purposes.
- The fishing industry must be involved throughout the process
- Right whales were mentioned in context to the need for robust monitoring and mitigation measures within migratory corridors.
- Assess cumulative impacts of future projects.
- Plan for community engagement.

Next steps:

- Draft of OWSP due to BPU in June, with final OWSP due in the fall
- Draft OWSP will be available for Public Comment
- Meeting Summary to be sent by the end of March/April
- Written comments can be submitted to NJBPU at Offshore.Wind@bpu.nj.gov.

-end-

Note:

The information contained in these notes is assumed to be a complete and correct account of the items discussed, directions given, and conclusions drawn during the meeting. Any clarifications or corrections to this summary should be submitted to InGroup within five calendar days of the receipt of this summary. No response implies that information contained herein is agreed to be correct as written.

Summary prepared by: ***The New Jersey Board of Public Utilities***

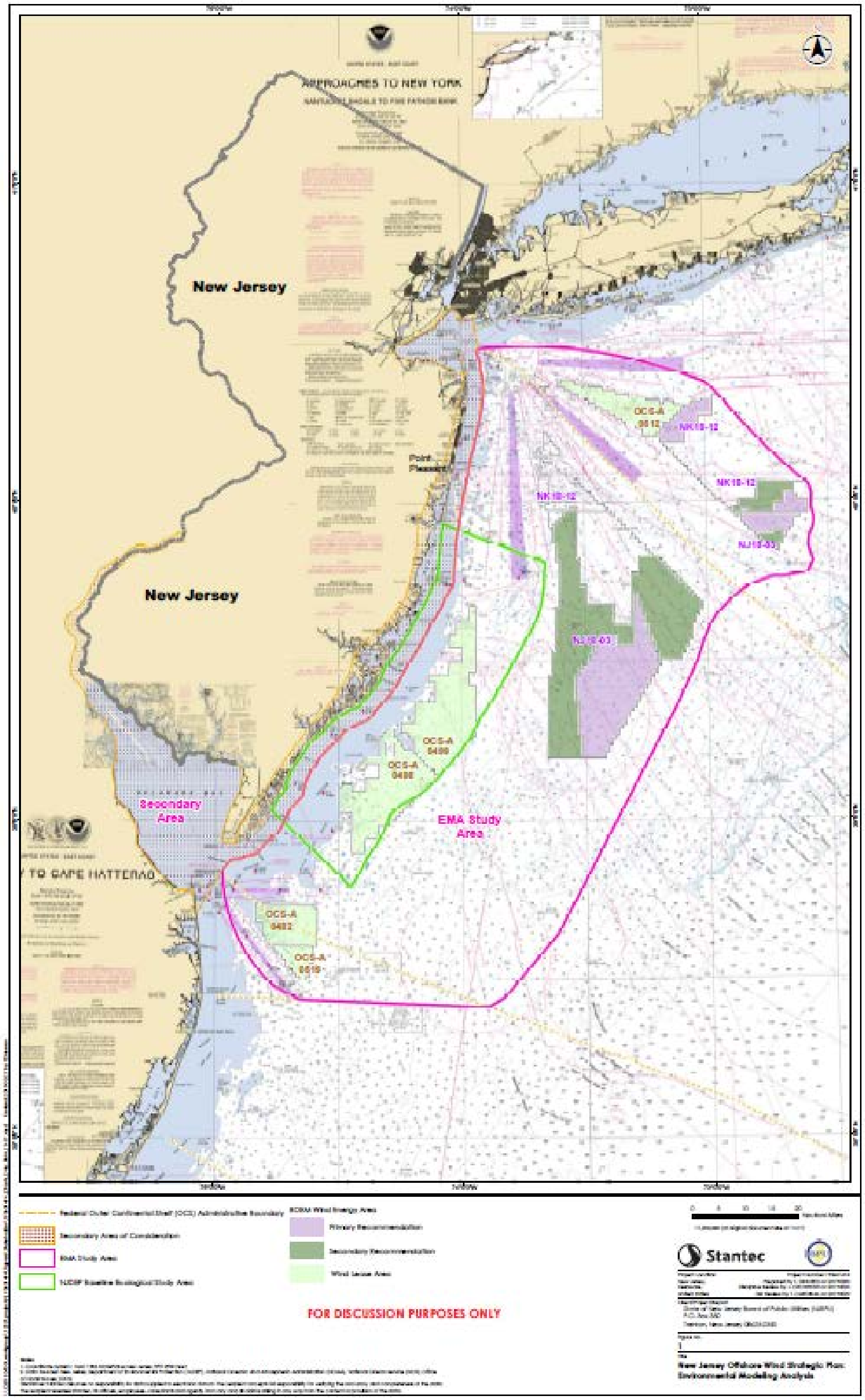

Figure 1: EMA Area of Analysis

2. FISHERIES

Project:	**New Jersey Board of Public Utilities, Offshore Wind Strategic Plan**
Date:	March 1, 2019 (3:00 p.m. – 5:30 p.m.)
Location:	Rutgers University – Cook Campus, New Brunswick, NJ
Subject:	**Commercial/Recreational Fisheries Roundtable Discussion Meeting Summary**

Purpose: The purpose of this Roundtable Discussion was to get stakeholder input for the development of the Offshore Wind Strategic Plan (OWSP) being undertaken by the New Jersey Board of Public Utilities (NJBPU) and New Jersey Department of Environmental Protection as directed under Executive Order No. 8. The objective was to provide a forum for stakeholders to discuss their concerns and recommendations relevant to environmental resource protection and the management of commercial and recreational fisheries as the State moves from 1,100 MW to 3,500 MWs of Offshore Wind Capacity. The following is a summary, not a verbatim transcript of the proceedings. Questions, comments and conversations are paraphrased to convey main point/points.

Moderators:
Kevin Wark, Endeavor Fisheries, Fisheries Liaison to Ramboll
Josh Kohut, Rutgers University, Associate Professor, Department of Marine and Coastal Sciences and Co-Founder, Center for Ocean Observing Leadership

Facilitator:
Tanya Oznowich, New Jersey Department of Environmental Protection

Participants:

Jim Ferris	NJBPU
Anne Marie McShea	NJBPU
Brick Wenzel	Point Pleasant Fisherman's Dock Co-op
Tom Dameron	Surfside Foods
Greg DiDimenico	Garden State Seafood Association
Steve Drew	Sea Risk Solutions
Wayne Reichle	Lund's Fisheries
Guy Simmons	Sea Watch International
Dave Wallace	North Atlantic Clam Association

Joe Cimino	New Jersey Marine Fisheries Council (NJDEP)
Jeff Normant	New Jersey Marine Shellfisheries Council (NJDEP)
Scot Mackey	Garden State Seafood Association
Vincent Guida	NOAA Northeast Fisheries Science Center
Peter Hughes	Responsible Offshore Development Alliance
Peter Himchak	LaMonica Fine Foods
Danica Bellini	New Jersey Sea Grant Consortium
Kirk Larson	Viking Village, Inc.
Martin McHugh	The Dawson Group
Drew Minkiewicz	Fisheries Survival Fund
Brian Hooker	Bureau of Ocean Energy Management
Doug Zemeckis	Rutgers University Marine Cooperative Extension

Welcome and Introductions

NJBPU welcomed attendees and explained that this session was the second in a series of issues-based stakeholder meetings. Invited attendees were encouraged to share their thoughts and knowledge of commercial and recreational fisheries and the offshore marine resource so the state can develop a well-informed OWSP.

NJBPU provided an overview of the origin and process of the OWSP, including Governor Murphy's Executive Order No. 8 (EO8) and his directive to achieve 3,500 MW of OSW capacity by 2030. NJBPU noted that the initial solicitation of 1,100 MW of offshore wind capacity was released in 2018 and bids are currently under review by the BPU. The OWSP is intended to serve as a Roadmap of moving from 1,100 MWs to 3.500 MWs. The OWSP will address key components of OSW development, including achieving scale, job growth, economic development, and appropriate siting, while ensuring natural resourced are protected throughout the development and operational stages. A key component of the OWSP process is engaging key stakeholders and soliciting their input. NJBPU noted that they are here to listen to stakeholders concerns and knowledge and allow stakeholders to hear the perspective of the development team and of other stakeholders. Invited attendees were also encouraged to submit written comments. NJBPU noted that a draft plan will be issued by July 2019 with the final plan in September 2019. There will be opportunities to review the draft before the final plan is released. Captain Kevin Wark and Dr. Josh Kohut of Rutgers will serve as moderators of the meeting, with Tanya Oznowich of NJDEP serving as facilitator.

The Facilitator provided housekeeping notes and roundtable meeting terms of engagement. Asked attendees to be succinct and try to plan ahead in terms of what's important to them. The goal of the meeting was to listen to stakeholders' input, identify problems and concerns, and suggest solutions.

Impromptu Questions:

Will we receive notes from other roundtable meetings? Will they be available on a list serve?

Discussion notes from the Offshore Wind Roundtable Discussions will be distributed to Roundtable participants.

How long will we have to review the draft Strategic Plan?

A minimum of 30 days will be provided for public comment on the DRAFT Offshore Wind Strategic Plan once it is released for comment.

Discussion Summary

New Jersey's Offshore Wind Energy Area – A Brief Overview by Moderator

The Moderators provided an overview of the Offshore Wind Strategic Plan (OWSP) as it relates to the environmental protection of the coastline and marine resources off the coast of New Jersey. They introduced the offshore wind lease areas and Environmental Modeling Area (EMA) off the Coast of New Jersey that will be considered within the Offshore Wind Strategic Plan and modeled by the Ramboll Team including Stantec and Rutgers University [see, Figure 1: Map of Area of Analysis]. Environmental analyses will be performed in the study area over a broad area—10,000 square miles to 60 meter depth, including existing lease areas and planning areas under BOEM evaluation. They will identify areas of sensitivity and potential impact and consider expert opinion and feedback from other stakeholders. A series of spatial overlays, intended to identify environmental and fisheries priorities and other resource uses, are being developed. Stakeholder feedback will be incorporated into the model, and will inform development of the Strategic Plan.

Rutgers further noted that they have been studying the Area of Analysis and the area of the ocean known as the Mid Atlantic Bight since the establishment of the Rutgers Department of Marine and Coastal Sciences and founding of the RU-COOL Lab in 1990. Rutgers built and operates the world's most advanced ocean observatory on the planet. They support a wide range of applications including weather centers, including hurricane and typhoon centers and are just beginning to consider biologic information and data collection. They know how changing and dynamic the ocean is and how it can change one season or one day to the next. Rutgers asked participants how they may ensure the OWSP will represent that complexity and all that participants are concerned about.

Protecting Key Fisheries and Fishing Grounds Important to New Jersey Fishing Industry

Participants were asked to identify and comment on the most heavily fished areas for each individual fisheries group. Scallops were noted as being easily identified. There are studies and detailed maps of scallop aggregations in an area as they don't move much. They are where they are, noted one participant. This year approximately 18 million pounds of scallops, worth about $200 million, were harvested. Each day at sea represents one million pounds for the fleet. Scallops become abundant at 120 feet to 30 fathoms. These are generally harvested in the Hudson South draft WEA, and to the south-southwest. A number of participants noted the availability of VMS tracking data and recommended use of the MARCO data portal. This kind of data is readily available in the Mid-Atlantic Data Portal, where you can access the positions and fishing areas of all fleets. Their position is tracked through GPS.

However, it was noted that you see different fishing patterns year after year so you need to look at a 10-15-year swath. What we're harvesting today might not be what we want to harvest 10 to 15 years from now noted one participant. When you collect data, also look at under-utilized species with potential future markets. Other participants noted that all areas on the map are active fishing areas for the industry—flounder, black sea bass, mackerel, herring, scallops. The National Marine Fisheries Services did a fleet program study—and that information is available.

It was also noted that fishing locations are changing because of climate change. Range shifts due to climate change make a big difference where species are living over time. Harvesting of surf clams has moved north. Larval dispersal might be different in the future due to changing temperatures. Surveys and analyses are being done often. They determine our fishing quotas year to year.

Participants also discussed surf clams and ocean quahogs which take approximately 30 years to mature, and can grow up to 200 years. The Clam industry will be moving, because clams are shifting location in response to climate change. The real value is in long-run data sets that can capture some of these shifts and changes. "Clam fisheries, surf clams, ocean quahogs—take years and years before we see there has been a large set of clams in a given area. We don't go to fish until the stock is 30-years old and to 80-90 feet to 150 feet. Ocean quahogs and surf clams are in deeper and deeper water and grow very slowly." Available distribution throughout an area is significant. The clam industry is going to be different than it is today—we'll have difficulty protecting that. If it's disrupted, clams and scallops will be dead because they don't move.

Challenges in conducting surveys within the offshore wind farms were raised as an important issue. National Marine Fisheries Service or NOAA survey vessels conduct annual surveys that inform fishing quotas and thus drive the entire fisheries system across all sectors. The real value of surveys is long-running data sets. The Fishing Industry can't use any information unless it surveys more than five years to see variables. It's problematic. When the build-out occurs, new survey might say there are a different amount of flounder or some other species. The industry is recognizing the problem of time series, surveying and windfarms. They're exploring the possibility of alternate ways of getting time series. Asking for anyone to develop a new way to survey costs money. It's incumbent on developers to alleviate the problem if they want to use the space. They are having a direct negative impact and they need to mitigate it.

Measuring Economic Impact on Fisheries

Participants were asked about the correct mechanism for measuring economic impact on fisheries. The first issue raised was the need to distinguish between value and price. The highest priced fish is not always the one that delivers the broadest value to society or the world as a food source. The value of a lifetime of investment in a business was also noted. We quantify the exclusion from areas of sea bottom. How do you compensate a person who has put sweat equity and real investment into a business for a lifetime?

Other participants quantified the value of species most likely impacted. Ocean quahogs, surf clams and scallops were noted as the most likely to be affected by offshore wind development. The National Marine Fisheries Service (NMFS) on surf clams and ocean quahog estimate 90 to 100 million pounds of finished meat, valued at approximately $60-70 million per year. Ocean quahogs have ~10% yield. Surf clams have ~15% yield. This value has a multiplier effect in the State economy.

A number of participants shared their perspective on the role of fishing in New Jersey shore communities and the State economy. For example, Lund's Fisheries is a three generation family business. They have a processing facility, and can freeze 500 metric tons of seafood per day. If NMFS or offshore wind limits access, ports like Cape May might close. The processing facility cannot be moved. These are impacts not only to fisherman, but also to coastal communities. One participant noted that New Jersey's Commercial fishing is a $1.3 billion industry based in NJ which ripples through communities as jobs, family support, and sustenance. Fishing and the seafood industry is woven into the family and local shore communities. "My father created a fishing community in Barnegat Light that now employs 250 people who work there. Barnegat Light has already lost all party boats. Schools and county institutions are funded in part by commercial fishing revenues. People come to the Jersey Shore for fresh seafood." Cape May was noted as a top 10 port in the United States. Fisheries are real business engines for NJ coastal communities! This will have an impact on ports and communities beyond summer, seafood, and tourism. In the off season, there is not much going on except commercial fishing—these are real economic engines. Once the fisheries are gone, they'll never come back.

Understanding Fishing Industry Priorities

Participants were asked to prioritize the issues of access; navigation; safety; fishing gear, etc. They were also asked how priorities might vary between Construction and Operations and Maintenance (O&M) phases of development. Participants noted the importance of access and the need to avoid impacts. One participant noted the priorities in the order of "Access, Navigation and Safety." Another participant summarized priorities as "avoid impacts, then mitigate, then compensate." "Only when avoidance can't be accomplished do we mitigate and, when we can't mitigate, compensate. But fishermen don't want other jobs, they want to fish. I'm worried about the long-term impact of an 80-100 turbine windfarm." Construction is temporary, noted a participant, and "we are more concerned about long-term impacts." Another participant recommended that analysis should including modeling of wind farm in the RU-COOL model and consideration of cold pool, wake effects, larval dispersion, and sediment disturbances.

Consideration of Mitigation Measures

Given that BOEM requires several mitigation measures to be implemented (e.g., time-of-year construction limitations, marine mammal observations, etc.), participants were asked about recommended mitigation measures (e.g., turbine spacing, size of individual wind farms, etc.). Layout and spacing were noted as critical. Regarding the layout and spacing of wind turbines:

Clams require you to tow heavy gear with large vessels. There is 0.7 mile allowance for spacing of turbines. However some participants noted that even one nautical mile is not enough. The first time a commercial vessel runs into a wind turbine, if the Coast Guard doesn't shut it down, the insurance company will. Clams are a large-vessel industry, heavy scallop dredge gear must be towed. Large turbines (20 megawatts), spaced 2 miles apart is ideal. Turbines should be laid out in a favorable configuration relative to prevailing tidal flows. Collision of a fishing vessel with a wind turbine will result in problems with insurance. RODA wants to encourage co-existence between fishing industry and offshore wind. A regional approach is favored, because a state-by-state approach results in duplication of efforts. Responsible Offshore Science Alliance (ROSA) is an initiative funded by developers.

The issue of spacing as it relates to the survey vessels was discussed. Surveys are a big issue. Survey vessels say they need more distance between turbines, or they cannot survey. NOAA surveying for stock assessments (which help establish quotas, allocations, rotational closures, etc.) is a critical element of fisheries management for the United States. NOAA biologists stated identical challenges to safe access and navigation stated by fishing industry representatives. The turbine placement also poses significant challenges to survey integrity and the future of the fisheries management paradigm.

Recommendations from New Jersey's Fishing Industry

Participants were asked to consider that "given offshore wind farms will be built" what general and / or specific recommendations would they have for the New Jersey team developing the Offshore Wind Strategic Plan. Participants noted that "spatial operational requirements for all NJ fisheries should be protected." One participant noted that NJ has an obligation to protect fisherman. Some fishing industry representatives noted that "OWSP and design of the wind farms must account for fishing uses. 0.7 mile spacing between turbines is not sufficient. Fisheries want to see draft offshore wind farm configurations from developers." Others noted that wind generated power is expensive. Developers, machines, ships are from Europe. Fisheries are the epicenter of the offshore wind industry. The two industries must coexist.

Participants also questioned if wind farms are consistent with the New Jersey Coastal Zone Management Rules and if offshore wind energy development met the definition of a water-dependent use.

Stakeholders were also asked how they would like to be involved with the offshore wind economy, either directly (permanent employment in O&M, crew-transfer vessels {CTVs}, etc.) or indirectly (vessel assistance for research, construction and O&M). Fishermen responded that they want to keep fishing (implying the employment from OSW may not be appealing). Most agreed, however, that fishermen want to be involved in developing standard operating procedures. Some participants said they would provide written comments/recommendations later. Written comments can be submitted to Offshore.Wind@bpu.nj.gov.

General Questions & Answers

Participants offered a range of final questions and comments, including a suggestion that offshore wind developers should be required to disclose financial withholdings and corporate structure. Some participants expressed interest in attending upcoming ports roundtables. Concern was also expressed about forcing all fishing into shipping lanes (i.e., off the sidewalk and into the highway). Fisheries representatives reiterated importance of MARCO MidAtlantic Ocean Data Portal.

Discussion Summary

Stantec summarized the following key discussion points and next steps for the group:

- Governor Murphy's Executive Order No. 8 (EO8) tasked NJBPU to work with NJDEP and other agencies to fully implement OWEDA and develop an Offshore Wind Strategic Plan (OWSP) for New Jersey.
- BPU was tasked with leading the development of an OWSP to establish a framework. This will be a dynamic rather than static document to support future decision-making.
- The team needs to work to acquire additional fisheries data.
- Fisheries overlap all current and proposed lease areas.
- OSW development may create potential conflicts with surveying.
- It is necessary to understand the cumulative impacts on fisheries including the downstream economic impacts.
- Aggregation of static species is an important consideration.
- Location and layout of wind farms are of prime importance.
- Developers and regulators need to act on the concerns of fisheries.
- There is a need for continued and ongoing two-way conversation

Next Steps:

- A draft OWSP will be forward to BPU in June 2019 and then released for public comment.
- Stakeholders recommended a public comment period of 60 days if possible.
- Written comments can be submitted to Offshore.Wind@bpu.nj.gov.

-end-

<u>Note</u>:

The information contained in these notes is assumed to be a complete and correct account of the items discussed, directions given, and conclusions drawn during the meeting. Any clarifications or corrections to this summary should be submitted to InGroup within five calendar days of the receipt of this summary. No response implies that information contained herein is agreed to be correct as written.

Summary prepared by: ***The New Jersey Board of Public Utilities***

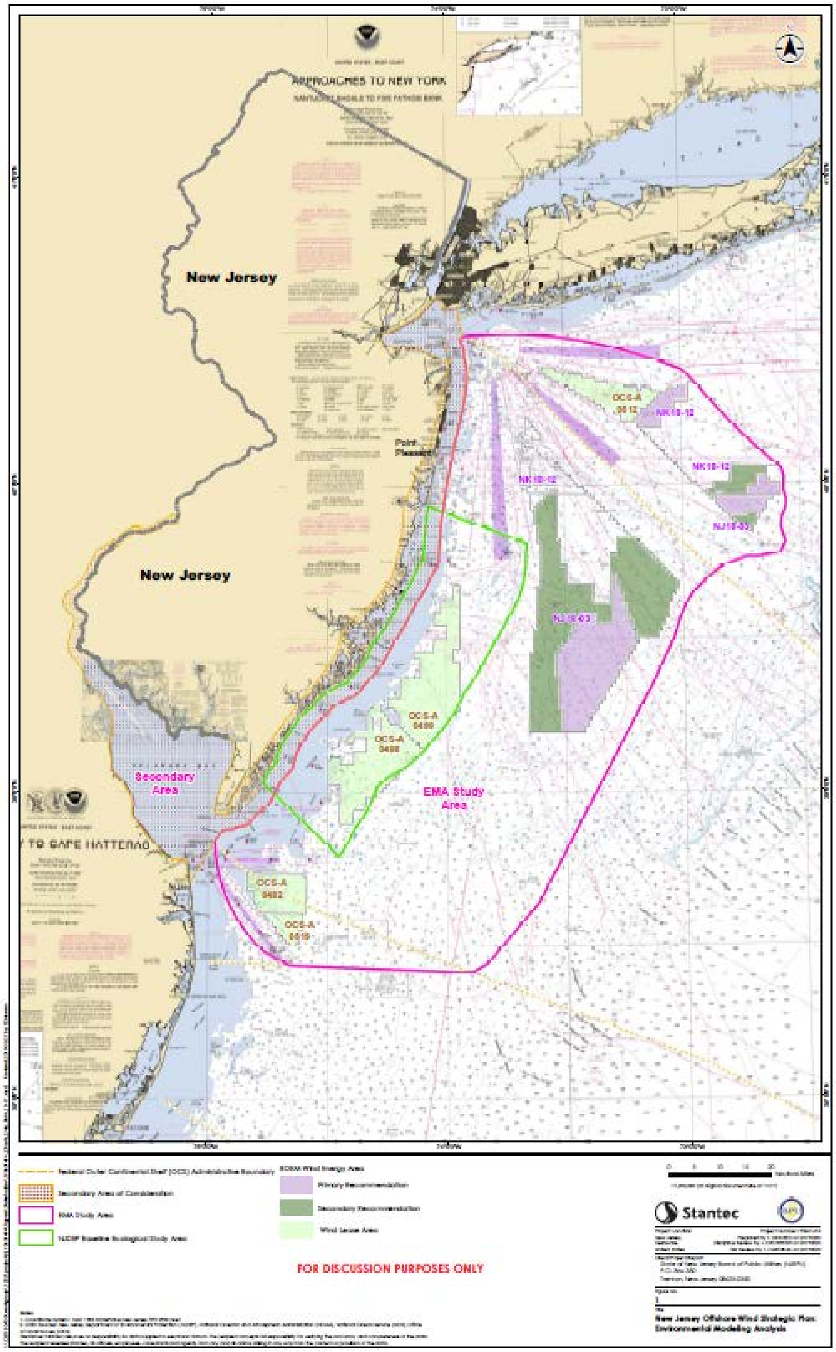

Figure 1: EMA Area of Analysis

3. PORTS AND HARBORS

Project: **New Jersey Board of Public Utilities, Offshore Wind Strategic Plan**

Date: April 5, 2019 (2:00 p.m. – 4:30 p.m.)

Location: North Jersey Transportation Planning Authority, Newark, NJ

Subject: **Ports and Harbors Roundtable Discussion Summary**

Purpose: The purpose of this Roundtable Discussion was to secure stakeholder input for the development of the Offshore Wind Strategic Plan (OWSP) which is being undertaken by the New Jersey Board of Public Utilities (NJBPU) and New Jersey Department of Environmental Protection, as directed by Executive Order No. 8. The objective was to provide a forum in which stakeholders could discuss their concerns and provide recommendations relevant to ports and harbors issues as New Jersey moves from 1,100 megawatts to 3,500 megawatts of offshore wind capacity as called for under Executive Order No. 8.

The following is a summary, not a verbatim transcript, of the proceedings. Questions, comments, and dialogue have been paraphrased to convey main point(s).

Moderators:
Andy Geissbuehler, BVG Associates, Consultant to Ramboll
Richard Baldwin, Ramboll Inc.

Facilitator:
Brian Sabina, Senior Vice President of Economic Transformation, New Jersey Economic Development Authority

Roundtable Participants:

Tess Arzu	Port Authority of New York and New Jersey
Dennis Blazak	Naval Weapons Station – Earle
Catherine Bowes	National Wildlife Federation
Jenny Briot	Avangrid
Vicki Clark	Cape May County Chamber of Commerce
Doug Copeland	EDF Renewables
Debra Coyle	New Jersey Work Environment Council
Paul Dengel	Construction & Marine Equipment Co., Inc.
Deniz Ekici	Equinor
Jim Ferris	NJBPU

Sidney Florey	DEME
Robert Freudenberg	Regional Plan Association
Jason Galioto	McAllister Towing and Transportation Co., Inc.
Joshua Gange	Bureau of Ocean Energy Management
Dan Grenier	Stantec (Summary)
Annegrethe Jeppesen	Ørsted
Don Josberger	International Organization of Masters, Mates & Pilots
Ed Kelly	Maritime Association of the Port of New York and New Jersey
EunSu Lee	New Jersey City University
David Morgan	Aries Marine Corporation
William O'Hearn	Business Network for Offshore Wind
Anne Marie McShea	NJBPU
Doug O'Malley	Environment New Jersey
Walid Oulmane	GE Renewable Energy
Timothy Pavilonis	United States Coast Guard
Kevin Pearce	Siemens
James Roussos	Dorchester Shipyard
Jakub Rowinski	North Jersey Transportation Planning Authority
Hady Salloum	Stevens Institute of Technology
Cary Sklar	Prysmian
George Strachan	Gloucester County Improvement Authority
Richard Suarez	International Longshoremen's Association
David Tauro	Belford Seafood Co-Op
Brick Wenzel	Point Pleasant Fishermen's Dock Co-Op and Farm Bureau
Christen Wittman	EnBW North America
Bette Jean Yank	Yank Marine

Welcome and Introductions

NJBPU welcomed attendees, and explained that this session was the fourth in a series of issue-based stakeholder meetings regarding New Jersey's Offshore Wind Strategic Plan (OWSP). Invited attendees were encouraged to share their thoughts and knowledge concerning ports and harbors issues that will impact offshore wind (OSW) development in New Jersey, so that the state can develop a well-informed OWSP.

NJBPU provided an overview of the origin and process of the OWSP, including Governor Murphy's Executive Order No. 8 (EO8), and his directive to achieve 3,500 megawatts of OSW capacity by 2030. NJBPU noted that New Jersey's initial solicitation of 1,100 megawatts was released in 2018, and bids are currently under review by NJBPU. The OWSP is intended to serve as a Roadmap for achieving that goal, and will help guide New Jersey in moving from 1,100 megawatts to 3,500 megawatts of OSW capacity. The OWSP will be structured around six key areas of modeling and analysis: supply chain and workforce development, ports and harbors, environmental protection, commercial and recreational fisheries, wholesale energy markets, and transmission.

A key component of the OSWP process is engaging key stakeholders and soliciting their input. NJBPU convened the roundtables to listen to stakeholders' concerns and knowledge, and to allow stakeholders to hear the perspective of the development team and of other stakeholders. Invited attendees were also encouraged to submit written comments to offshore.wind@bpu.nj.gov following the roundtable discussion.

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Discussion Summary

New Jersey's Offshore Wind Energy Area – A Brief Overview by Moderator

The Moderator provided a brief overview of the Offshore Wind Strategic Plan (OWSP). He introduced the Supply Chain/Workforce Analysis that is being performed by BVG Associates in support of the OWSP. The New York – New Jersey – Maryland cluster area has a 14-gigawatt OSW pipeline, with 500 megawatts of active offtake agreements. See, Figures 1 and 2. By the end of 2019, nearly 2 gigawatts of offtake should be in place. Looking to the future, BVG forecasts 25 gigawatts of installed OSW capacity by 2035, which could translate to approximately $100 billion in capital expenditures.

The Moderator observed that critical questions remain unanswered with respect to where, when, and the order in which these considerable investments should occur. Comprehensive evaluation is needed to appropriately inform those decisions, minimize conflicts, and make New Jersey's OSW industry competitive within the Mid-Atlantic region.

Other considerations include sourcing strategy, timing, ports, and marine logistics. The Moderator also acknowledged that what is best for New Jersey, what is best for the overall U.S. offshore wind industry, and what is best for individual business might not be in perfect alignment.

Ramboll circulated a map of New Jersey port facilities currently being assessed that included over forty port locations (See Figure 1).

Port Development Strategies

Participants were asked for their input regarding New Jersey's ports development strategy. A topic of interest was the extent to which the OSW supply chain strategy and associated marine logistics drive port selection, and vice versa.

The construction of a Jones Act-compliant installation vessel was identified as a top priority, but stakeholders noted that no New Jersey port can presently accommodate such a vessel. One participant stated that he was not aware of any port in the United States north of Virginia that could accommodate an OSW installation vessel. Until ports selections are made, the size of the turbines are defined, and required water depths are known, it will be difficult to secure a commitment to build a Jones Act-compliant installation vessel. In the interim the feeder vessel/barge approach is an innovation that New Jersey could leverage. The development timeline for this approach is significantly shorter than that for a Jones Act-complaint jack up vessel. A participant commented that while the feeder barge concept is pragmatic, it might not be the best approach. The Philadelphia Shipyard was noted as a possible asset for New Jersey and the region in developing its strategic plan. In March 2019, the Philadelphia Shipyard delivered the second of a pair of ships, which are the largest containerships ever built in the U.S.

Another participant indicated that what is needed is a "Paulsboro without bridges and power lines" (i.e. a large port facility, with laydown space, and without air draft restrictions). A signed offtake agreement will lock in OSW turbine size. This will dictate the size of the installation vessel and, in turn, determine vessel berth depth. This certainty will help catalyze investment in installation vessels, and the United States has the capability to build these vessels.

Also discussed was the issue of whether New Jersey's OSW strategy should focus on developing a "superport" – a single, large-scale port handling manufacturing and assembly, marshalling, and load-out – or a distributed network (a "cluster") of ports. Opinions on this issue varied, and at least one stakeholder questioned whether the superport v. distributed network of ports is the correct approach. A network approach could provide a huge opportunity for New Jersey to "go its own way" and develop a unique solution.

New Jersey has a highly urbanized port environment, and existing port facilities in the state are very expensive and highly utilized. For these reasons, preparing waterfront facilities for OSW use is a complex endeavor requiring extensive planning. One question that must be answered is whether these purpose-built facilities will be cooperative or proprietary terminals. Dredging will be needed to prepare ports for offshore wind. Several stakeholders referenced the long timeframes associated with obtaining permits from the New Jersey Department of Environmental Protection needed for dredging activities.

One stakeholder noted that New Jersey lacks a 100+ acre undeveloped waterfront parcel that is currently available to serve as a superport site. By contrast, clustering of smaller ports "spreads the wealth," and could confer a broader benefit. One participant pointed out that a multi-state cluster approach lessens risk, increases participation, and provides more flexibility. New Jersey could then participate in, and benefit from, the regional ports ecosystem that will be mobilized to support Mid-Atlantic OSW projects. A network of ports could also accommodate varying OSW turbine sizes, permitting adaption to future technological evolution. Although this clustered approach has its advantages, bringing jobs to New Jersey is still a priority.

Other stakeholders suggested that a superport is a pragmatic long-term goal for New Jersey, but it will require careful planning. Regional coordination with New York and other states would be necessary to making that determination. It was suggested that an in-state superport capable of both manufacturing and staging will ultimately be well-positioned to send components to OSW projects in other states. However, even if the superport strategy is pursued, interim workarounds (i.e. use of feeder barges) will be required in the short-term. This is because no superport will be operational by the time the first tranche of New Jersey offshore wind projects are anticipated to begin construction. To achieve 3,500 megawatts of OSW capacity by 2030, a superport and multiple staging ports will likely be required.

Notwithstanding its air draft restrictions, Paulsboro – which has already made significant investments – is a port site that is ready to begin development to serve OSW projects. Naval Weapons Station Earle stated its interest in supporting New Jersey OSW development, and is ready to work with the State. Pier 2 is available. NWS Earle recently dredged to 45 feet, with 2 feet of overdredge. NWS Earle also has plenty of laydown space.

One stakeholder commented that, regardless what port site(s) are used to support OSW, we must ensure that OSW does not interfere with and/or have an undue impact upon the American cargo shipping industry. The ocean and inland waterway areas being discussed "are not blank areas." The maritime shipping sector contributes more than $100 billion, and 400,000 jobs, to the New York/New Jersey area, and is a major driver of the national economy. There is a concern about OSW farms forcing vessels into increasingly constrained transit lanes. Impacts on New Jersey's tourism industry and potential for shipping accidents must also be considered. If the Exxon Valdez spill happened off of U.S. East Coast it would have stretched from approximately Cape Cod to Cape Hatteras.

Assessment of Currently Available Port Assets

The Moderator asked participants to assess currently available port assets in New Jersey, and which locations have the potential to support New Jersey OSW development. One participant stated that New Jersey's commercial fishing industry generates $3.2 billion per year, and that commercial fishermen use all of New Jersey's seven ports. This stakeholder opined that Belford will be most heavily impacted, due to restrictions on landings, constraints on areas in which fisherman can operate, and because vessels in Belford – which tend to be smaller and made of wood – have a limited operational range. Point Pleasant has multiple commercial docks, and the U.S. Army Corps of Engineers uses Point Pleasant to store vessels that are involved in beach replenishment activities currently taking place along New Jersey's coast. Point Pleasant has a train to Northern New Jersey/New York City, and is concerned about OSW's impacts to tourism and commercial fishing. The stakeholder believes that Atlantic City "will and should be a big winner." The stakeholder posited that mitigation funds from offshore wind developers should flow to ports.

A potential OSW port site at North Avenue and McLester Street in Elizabeth, New Jersey, near the APM Terminal, was identified by another stakeholder. This site is approximately 70 percent freshwater wetlands. A question was raised as to whether the

Cape May Ferry Terminal could be utilized to support New Jersey OSW activities. Dorchester Shipyard, a "well-kept secret on the Maurice River," also stands ready to support New Jersey's OSW initiatives.

Approaches to port infrastructure investment were then discussed. One option would see port operators investing in redevelopment to attract new customers. One developer noted that ideally, ports would invest in redevelopment to attract new customers. Then, an offshore wind developer could lease that already-developed space. In the early days in Europe, Ørsted developed the port infrastructure itself. But in New Jersey, state support would be helpful. Others agreed that these investments should be driven by port developers, but state support would enhance the likelihood of success. This might vary for each unique site. Several stakeholders indicated that state support, public-private partnerships, and/or alternative innovative partnership frameworks would enhance the likelihood of success, though this might vary for each unique port location. Alternatively, as was done for some early European projects, OSW developers would themselves be responsible for port infrastructure redevelopment, though this was not a favored approach.

Potential Infrastructure Improvements

One stakeholder noted that New Jersey has created a regulatory framework and has the physical infrastructure to support OSW development. However, "it is not government's job to do everything." It is now incumbent upon the private sector to leverage available assets and execute within the framework the State has created. New Jersey has a coast "perfect for pounding piles" into the sand, and New Jersey OSW projects will be strategically situated to serve electricity to millions of people. A suggestion was made that offshore wind developers should directly engage with county governments in Atlantic, Cape May, and Ocean Counties.

It was also observed that the electricity distribution companies (EDCs) that serve southern New Jersey have been reinforcing and upgrading transmission infrastructure. New York is "handing out $200 million" for port development, and New Jersey must consider New York's port strategy, as well as clustering port assets between the two states. Available land was noted as a major obstacle.

Jones Act Compliant Vessels

"Ports and vessels go hand in hand," pointed out one participant. Turbine selection drives vessel selection, which, in turn, will determine port usage. Ultimately, it is the size of the port that will dictate whether it can accommodate a Jones Act-compliant jack-up vessel. "Futureproofing" is very difficult to achieve.

Unification of stakeholders in the development of New Jersey's ports strategy, potentially through the use of a decision-making matrix, was recommended.

One participant observed that there appears to be an assumption that all OSW developers will be working together. Another stakeholder responded, saying that, once ORECs have been awarded, increased coordination between developers will be necessary and very likely in terms of colocation and use of ports. However, OSW developers are not port operators, and these responsibilities should be undertaken by a third party. The U.S. Navy identified itself as having extensive experience in ports operation and a potential strategic partner and ally for the State.

Yank Marine has been building boats for 50 years, has made millions of dollars in investments, and is ready to build whatever vessels OSW developers want.

Recommendations

The Moderator asked stakeholders for recommendations. The most common recommendation was that collaboration will be necessary if OSW is to succeed in New Jersey. This includes collaboration with stakeholders within New Jersey, as well as interstate cooperation with states to the north and south. A regional clustered approach will spread the wealth and maximize synergies without diluting opportunities. Additionally, diversification of port assets will provide options for shorter vessel routes to offshore construction sites; this might prove more cost effective than being locked into one superport location serving all of New Jersey's current and future OSW lease areas.

It was recommended that developers awarded ORECs should consider making some investment into each of New Jersey's ports. This is because OSW is not a "winner-take-all" scenario. This distributed investment might increase buy-in to OSW across the state. However, it was noted that recent polling revealed high levels of support for OSW among New Jerseyans. Because New Jersey needs facilities for both operations & maintenance and marshalling, a network of ports will likely be required. New Jersey has many ports, and this strategy requires a holistic approach. The Port of Paulsboro stands ready and is excited about offshore wind as an opportunity to bring good-paying, living wage jobs to New Jersey Cape May County, a sophisticated marine community, is also well-positioned to be competitive.

Feeder barges may be an acceptable short-term solution. However, an effective long-term ports strategy must include Jones Act compliant jack-up vessels. Dissemination of information about the dimensions of offshore wind turbines will help New Jersey better prepare. This is because the size of cargo dictates which port facilities can handle it. Situating supply chain elements as close as possible to ports will reduce carbon emissions. An examination of land-side transportation infrastructure was also recommended.

Port development does have environmental impacts which must not be overlooked. For that reason, the New Jersey Department of Environmental Protection has a crucial role. Stakeholders requested sufficient time for review of these environmental issues.

Several stakeholders committed to supporting OSW development in New Jersey. Yank Marine and Dorchester Shipyard stand ready to build Offshore Service Vessels and Crew Transfer Vessels. Naval Weapons Station Earle wants to work with OSW developers. The International Longshoremen's Association provides its full support. The Port Authority of New York and New Jersey supports New Jersey's OSW agenda. The United States Coast Guard is involved with marine safety on a national level, and is working with both Congress and the Bureau of Ocean Energy Management to preserve navigational safety while enabling continuing progress on OSW development.

Offshore wind is "too big to get it wrong." The safety and security of existing maritime transportation must be maintained.

One stakeholder asked "how is Belford is going to survive?"

Discussion Summary

Stantec summarized the following key discussion points and next steps for the group:

- Forecasts currently project roughly 25 GW of energy to be developed in the East Coast region by 2035 and 3.5 GW in New Jersey.
- Producing 25 GW is estimated to generate $100 billion for the economy.
- To construct 100 turbines will create 3,500 full-time equivalent (FTE) job positions.
- New Jersey has a long maritime port history with many resources, but they will have to be updated to meet industry needs.
- Ports, vessels and bridges are all important components of industry development, involving alignment by many stakeholders.
- Superports can provide one stop shopping but are expensive and create investment risk.
- Using multiple ports provides flexibility but may be difficult to coordinate.
- Building a port requires coordination of design, permitting and construction.
- It's important to consider long term regional and cluster approaches.
- Waterways are currently used by many stakeholders, and potential impacts on those stakeholders needs to be considered.
- Port funding and investment approaches must be settled.
- Create a matrix around port development requirements to build scopes of work around port components.
- Developers have knowledge of the industry and can work with port developers to

meet industry goals.

Next Steps:

- A draft OSWP will be forwarded to BPU by July 2019, and will be thereafter released for public comment.
- Written comments can be submitted to offshore.wind@bpu.nj.gov.

-end-

Note:

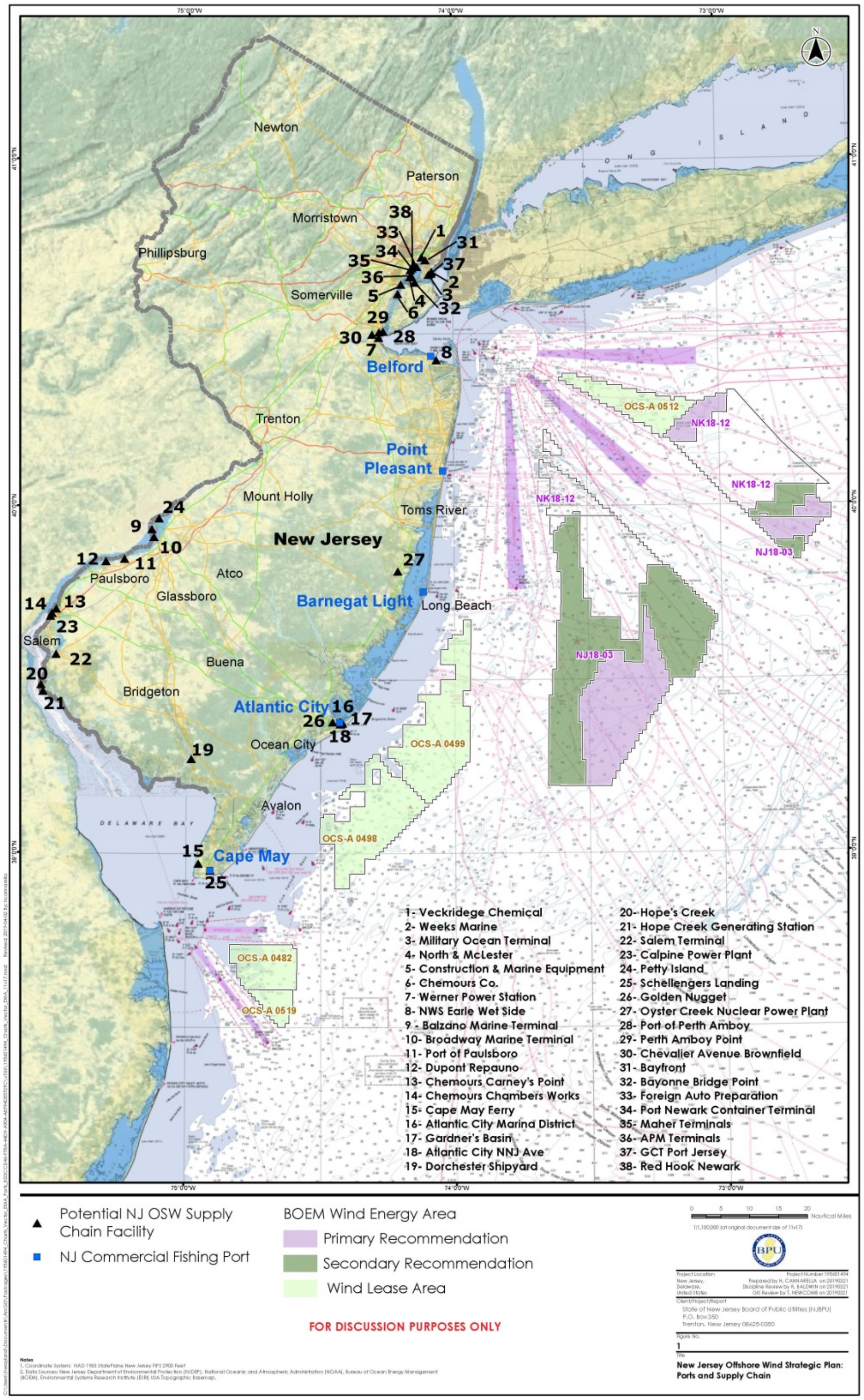
The information contained in these notes is assumed to be a complete and correct account of the items discussed, directions given, and conclusions drawn during the meeting. Any clarifications or corrections to this summary should be submitted to InGroup within five calendar days of the receipt of this summary. No response implies that information contained herein is agreed to be correct as written.

Disclaimer:

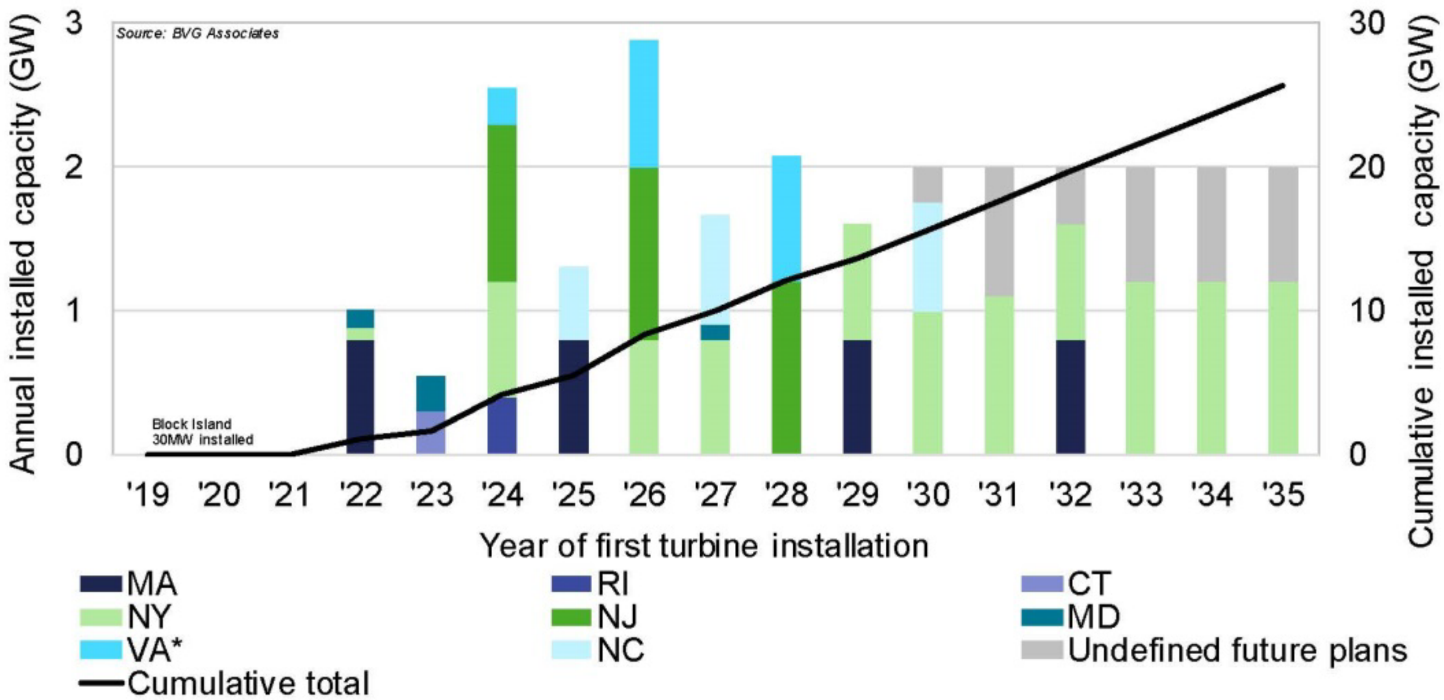
The information contained herein, and any related documents, transcripts and materials, does not reflect any official position of the New Jersey Board of Public Utilities (BPU). This information is a result of a Roundtable Discussion which served to secure stakeholder input for the development of the Offshore Wind Strategic Plan (OWSP). The Roundtable Discussion produced varying views, approaches, suggestions and proposals that in no way reflect the BPU's current nor future position. The BPU may consider this information in its future deliberations related to the OWSP, however, the BPU is in no way bound by this information.

Summary prepared by: ***The New Jersey Board of Public Utilities***

Figure 1: New Jersey Ports and Harbors



US EAST COAST PIPELINE: CAPACITY BY ANNUAL INSTALLATION (MW)



- State driven offshore wind commitments have reached 19 GW for 2035
- Additional commitments anticipated, currently estimated at 6 GW
- By the end of 2019, offtake agreements expected to approach 5 GW

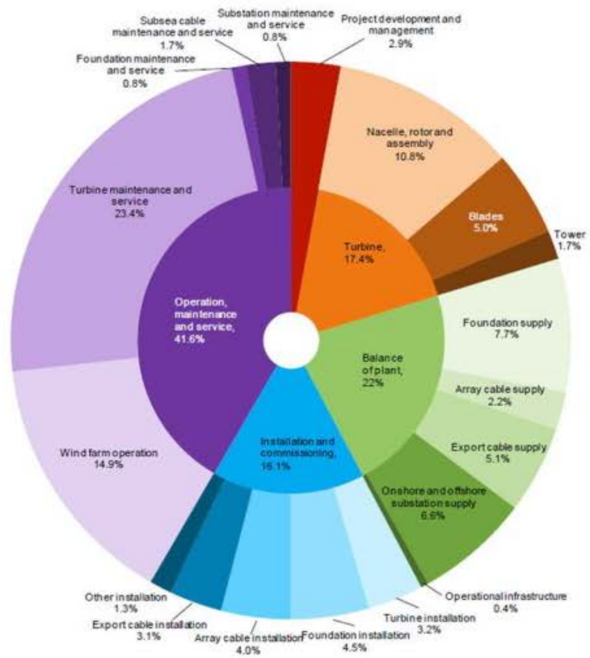
**North Carolina anticipated but not communicated

BVGassociates

Figure 2: U.S. East Coast Offshore Wind Pipeline through 2035

DIRECT FTP JOB REQUIREMENTS
(100 TURBINE PA INSTALLATION SCENARIO)

Element	Trade Workers	Assemblers	Managers	Engineers	Support Staff	Total
Project management & development	10	0	60	50	80	200
Blade manufacturing	100	430	30	10	30	600
Nacelle assembly	35	300	20	25	20	400
Tower manufacturing	120	50	10	5	15	200
Jacket manufacturing	580	20	25	10	15	650
Subsea cable manufacturing	25	320	15	15	25	400
Construction staging*	90	90	5	5	10	200
Substation manufacturing	200	240	20	15	25	500
Operations & maintenance**	400		35	20	45	500
Total	1,560	1,450	220	155	265	3,650



CAPEX and OPEX breakdown of an offshore wind farm

BVGassociates

Figure 3: Job Creation associated with Offshore Wind (left) / Offshore Wind CAPEX and OPEX Breakdown (right)

4. SUPPLY CHAIN/WORKFORCE

Project: **New Jersey Board of Public Utilities, Offshore Wind Strategic Plan**

Date: April 5, 2019 (10:00 a.m. – 12:30 p.m.)

Location: North Jersey Transportation Planning Authority, Newark, NJ

Subject: **Supply Chain/Workforce Development Roundtable Discussion Summary**

Purpose: The purpose of this Roundtable Discussion was to secure stakeholder input for the development of the Offshore Wind Strategic Plan (OWSP) which is being undertaken by the New Jersey Board of Public Utilities (NJBPU) and New Jersey Department of Environmental Protection, as directed by Executive Order No. 8. The objective was to provide a forum for stakeholders to discuss their concerns and provide recommendations relevant to supply chain and workforce development issues as New Jersey moves from 1,100 megawatts to 3,500 megawatts of offshore wind (OSW) capacity as required under Executive Order No. 8.

The following is a summary, not a verbatim transcript, of the proceedings. Questions, comments, and dialogue have been paraphrased to convey main point(s).

Moderator:
Andy Geissbuehler, BVG Associates, Consultant to Ramboll

Facilitator:
Hugh Bailey, Assistant Commissioner, New Jersey Dept. of Labor and Workforce Development

Roundtable Participants:

Sivaraman Anbarasan	New Jersey Community College Consortium
Timothy Axelsson	Ocean Tech Services, LLC
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Kevin Pearce	Siemens
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Ciro Scalera	New Jersey Laborers' Union
Josh Skubal	GE Renewable Energy
Michael Telesco	Marine Power Technologies, LLC
Arturo Villegas	XPEED Turbine Technology
Bill Wall	LS Cable America
Thomas Walsh	Jersey Wind Farm Boats
Christen Wittman	EnBW North America

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Other considerations include sourcing strategy, timing, ports, and marine logistics. The Moderator also acknowledged that what is best for New Jersey, what is best for the overall U.S. offshore wind industry, and what is best for individual businesses might not be perfect alignment.

Supply Chain Development Strategy

Participants were asked for their input regarding New Jersey's current positioning in the OSW supply chain, and how New Jersey should structure its supply chain strategy going forward. Stakeholders noted that OSW is a "just-in-time" industry, and is therefore sensitive to supply chain bottlenecks. These "choke points" must be identified to avoid a domino effect that could hinder continued growth of this large, capital-intensive industry. Other stakeholders observed that these bottlenecks can be identified by mapping the entire New Jersey offshore wind supply chain, including tiers and lead times. This will help New Jersey identify gaps, better understand its positioning to serve the OSW industry, and develop mitigation measures.

Several stakeholders identified greater interstate collaboration on OSW development as important. It is not productive for "every state to be an island." Cooperation and coordination between states with respect to timing of OSW solicitations was particularly urged. The Moderator reiterated the benefit of a "cluster view" encompassing the U.S. East Coast.

One participant noted that the impact of OSW development on tourism must be considered and addressed effectively. Tourism is the biggest industry in many of the State's southern coastline communities. OSW has tremendous potential for Cape May County, in terms of job creation and helping resolve the problem of seasonal unemployment patterns, but it must be executed in a manner that cohesively integrates with the tourism industry.

Another stakeholder pointed out that the OSW supply chain can be subdivided into three segments. The first segment is comprised of activities that automatically occur when an OSW facility is being developed (staging/marshalling, cable landfall, O&M). The second segment includes businesses that require attraction by way of incentive. New Jersey's current incentives are primarily aimed at large manufacturers. For this segment, targeted incentives that are designed to facilitate smaller suppliers finding their pathway into the OSW industry are required. The third segment requires an OSW developer with a large (multi-gigawatt) pipeline, which will trigger investment by large OSW component suppliers (foundations, towers, blades, etc.). Offtake agreements need to be in hand before these large investments will take place.

OSW technology is also developing at a rapid pace. Technology decisions made by large developers will drive the makeup of the supply chain. NJBPU should be considering these technologies, as they help lower costs, which is an important consideration, particularly for New Jersey's ratepayers.

One stakeholder noted that collaboration between states is unlikely for the first 6 gigawatts of OSW capacity. The structure of the Offshore Renewable Energy Credit (OREC) subsidy can be constraining, as it essentially requires the developer to keep work within the state awarding the subsidy. This stakeholder also commented on the lack of industrial areas directly along New Jersey's coastline.

The Jones Act is not going away, and New Jersey has opportunities to manufacture some smaller vessels to serve the OSW industry. For larger vessels, interstate collaboration could result in mobilization of the Philadelphia shipyard. There is a precedent of New Jersey's workforce participating in projects located in the Philadelphia Shipyard and/or Pennsylvania. Because OSW is a new workforce development opportunity, preparatory dialogue to establish the groundwork for workforce development mechanisms, and to foster engagement with industry experts and colleagues, must commence as soon as possible.

Atlantic City is seeking ways to expand the uses of the significant amount of land in the area of the airport.

Stakeholders were asked how OSW solicitations should be timed and sized to best attract OSW component manufacturers to the East Coast, and New Jersey more specifically. Greater coordination with other states regarding solicitation timing was urged. This careful planning is crucial, because the "worst nightmare" for any manufacturer is not having anything happening in its plant.

One participant commented that New Jersey's OSW solicitation schedule provides the certainty necessary to encourage suppliers to make investments. By bringing large suppliers on board, Tier 2 suppliers should follow. There was also encouragement for New Jersey to stagger its future OSW solicitations so as to permit participation by developers who do not currently hold a federal OSW lease.

Developers have a responsibility to conduct outreach in New Jersey, and educate the supply chain. Developers need to make their terms, conditions, and requirements clear to suppliers. This will help ensure that suppliers can be as competitive as possible.

Offshore Wind Manufacturing

OSW is essentially an immense logistics puzzle. Many project components (turbines, export cables, etc.) have long lead times. Additionally, suppliers may be reluctant to make considerable investments until an OSW developer has secured offtake. The first question from suppliers to developers is almost always – "do you have a PPA?"
Next-generation manufacturing was identified as one avenue for leveraging the deep connections between New Jersey's educational institutions and suppliers. This may help facilitate future pathways for research efforts to be translated into commercial applications. Rutgers noted that it has developed cements that perform well in marine environments.

New Jersey's status as a logistics and distribution hub was highlighted as a potential asset to serve the logistics needs of the local and regional OSW industry. Potential redevelopment of the Atlantic City Airport was referenced. Another stakeholder had a different view, suggesting that New Jersey needs to capitalize upon OSW-related manufacturing opportunities.

The Moderator asked participants – by show of hands - to vote on which OSW component(s) should be manufactured in New Jersey. Attendees could vote more than once. Polling results as follows: foundations (10); towers (7); blades (0); substations (7).

One participant noted that, due to the QA/QC requirements of high voltage cables, an assembly plant would be more feasible than a manufacturing facility in New Jersey in the near-term.

It was observed that the primary goal of developers building New Jersey OSW projects should be to leverage New Jersey's local supply chain, from manufacturing to workforce development. However, another stakeholder pointed out that many OSW developers and OEMs already have preferred suppliers in place. This could render it difficult to integrate New Jersey or regional suppliers. The need for an offshore wind supply chain portal/database was reiterated. Massachusetts Clean Energy Center's Offshore Wind Supply Chain Directory was cited as an example of a supply chain database. Matchmaking events in States like Massachusetts have also proven effective in linking offshore wind developers with local suppliers.

The Moderator inquired as to when 50% of the U.S. offshore wind supply chain will be located on the East Coast. Answers varied, with some stakeholders seeing this occurring within a decade or by 2030, while other stakeholder suggested that this number is probably optimistic. It was also raised that this question could alternatively be framed as how many megawatts of OSW capacity will be installed when 50% of the supply chain is situated on the East Coast. One participant commented that while a precise MW number is hard to say, the market size is there. The bigger question is, how fast will we get to 50% of the OSW supply chain located on the East Coast? New Jersey's offshore wind solicitation schedule for provides the certainty needed for suppliers to make these type of investment decisions. Incentives were noted as another factor that influence localization of the supply chain.

Professional Services and Research & Development

Participants were asked what New Jersey can do to attract OSW-related professional services. These professional needs can vary between developers. Some developers outsource their design/research & development needs, while others handle all such services internally.

One stakeholder observed that partnering and collaboration with local universities, high schools, and trade schools can help establish a localized future offshore wind workforce. For high school students, an introductory offshore wind course, possibly presented by a developer, as well as field trips to meet offshore wind developers. For the trade schools, a "learn and earn" program regarding offshore wind might be a better fit. It was noted that the seasonal nature of tourism-related employment in many Jersey Shore communities results in regular seasonal unemployment patterns. The Moderator observed that OSW operations and maintenance activities are perfectly suited to benefit coastal communities. Timely, well-planned workforce development will be necessary but who should lead such an effort?. One stakeholder remarked that it can be difficult to connect research with industry, and that government may want to address this gap. Ørsted has significant engagement with New Jersey but different developers have different approaches. Some keep nearly all work in-house, while others contract this work out. Equinor expressed interest in developing the entire supply chain in New Jersey and recommended the Joint Industry Project (JIP) approach. Equinor wants to leverage New Jersey institutions in this effort and noted continuing workforce training (like cold water and other safety training) as critical.

Offshore Wind Workforce Development

SAFETY is our number one job noted a number of participants. Safety, access to effective and ongoing training, and cooperative programs with education institutions at all levels emerged as key factors in this discussion. A dialogue between state agencies, industry, and New Jersey's community colleges, vocational and high schools, and colleges and universities should begin as soon as possible. Making students aware of OSW-related opportunities was identified as a priority. Some methods of student engagement include introductory OSW courses, internships, field trips to meet developers, and developers giving presentations at schools.

Identified workforce development needs included certifications, cold water training, and OSHA requirements. Rather than "training workers from zero," OSW developers are likely to find workers from industries with overlapping and transferrable skill sets. Onshore wind, onshore power plants, and onshore substations involve electrical work similar to that which will be conducted in support of OSW. One stakeholder pointed out that organized labor organizations already have an onshore workforce, so "let's take it offshore." Synergies with the fishing industry were also suggested.

Representatives of organized labor noted their strong, year-after-year commitment to training and safety, and highlighted their willingness to work with OSW developers. One key issue is what training OSW developers will require of employees who will be working offshore. The Global Wind Organization training curriculum is commonly used overseas, but a U.S. equivalent to the GWO training does not exist at this time. A legal question was also raised: will unionized employees who complete the GWO training be reclassified as maritime workers under the Jones Act? This could render these workers unable to receive state workers compensation benefits.

Ultimately, safety training for offshore workers was identified as a top priority. The development of a subcommittee to discuss offshore safety training was recommended.

Recommendations

The Moderator asked stakeholders for recommendations, and participants offered a wide range of responses:

- Leverage the workforce pipeline scenario developed in connection with the proposed Amazon headquarters in Newark.
- Simplify New Jersey's offshore wind offtake process.
- Improve supply chain efficiency through logistics certifications.
- Develop a broader ports strategy.
- Create mechanism(s) and foster engagement between organized labor and OSW developers to address workforce development and training standards.
- Ensure appropriate training of specialized project managers, not just employees.
- Identify underutilized U.S. companies than can be leveraged to support OSW manufacturing.
- Collaborate and coordinate with neighboring states.
- Specific identification of infrastructure, macroeconomic, and microeconomic factors is required.
- County colleges are good sources for additional training.
- Manufacturing is key, but so is staging.
- Greater certainty in future offshore wind procurement schedules creates the certainty necessary to trigger investment by large suppliers.

The Moderator asked the best way to facilitate future engagement with this group of stakeholders. One recommendation was two to three follow-up working group meetings between organized labor and OSW developers regarding training issues. Alternatively, OSW developers could form a subcommittee, identify their training needs and any gaps, and then advise organized labor of their needs. The Business Network for Offshore Wind may be one avenue to facilitating these conversations.

Discussion Summary

Stantec summarized the following key discussion points and next steps for the group:

- Identify all pieces of the supply chain to understand what is existing and what is needed.
- Identify potential bottlenecks to avoid potentially critical scheduling issues.
- Identify a pipeline for manufacturing confidence.
- Need more information and training programs and understanding of supply chain to know where to fill gaps, preferably locally and working with other states on the Eastern

Seaboard.
- Safety is our first goal.

Next Steps:

- A draft OSWP will be forwarded to BPU by July 2019, and will be thereafter released for public comment.
- Written comments can be submitted to offshore.wind@bpu.nj.gov.

-end-

Note:

The information contained in these notes is assumed to be a complete and correct account of the items discussed, directions given, and conclusions drawn during the meeting. Any clarifications or corrections to this summary should be submitted to InGroup within five calendar days of the receipt of this summary. No response implies that information contained herein is agreed to be correct as written.

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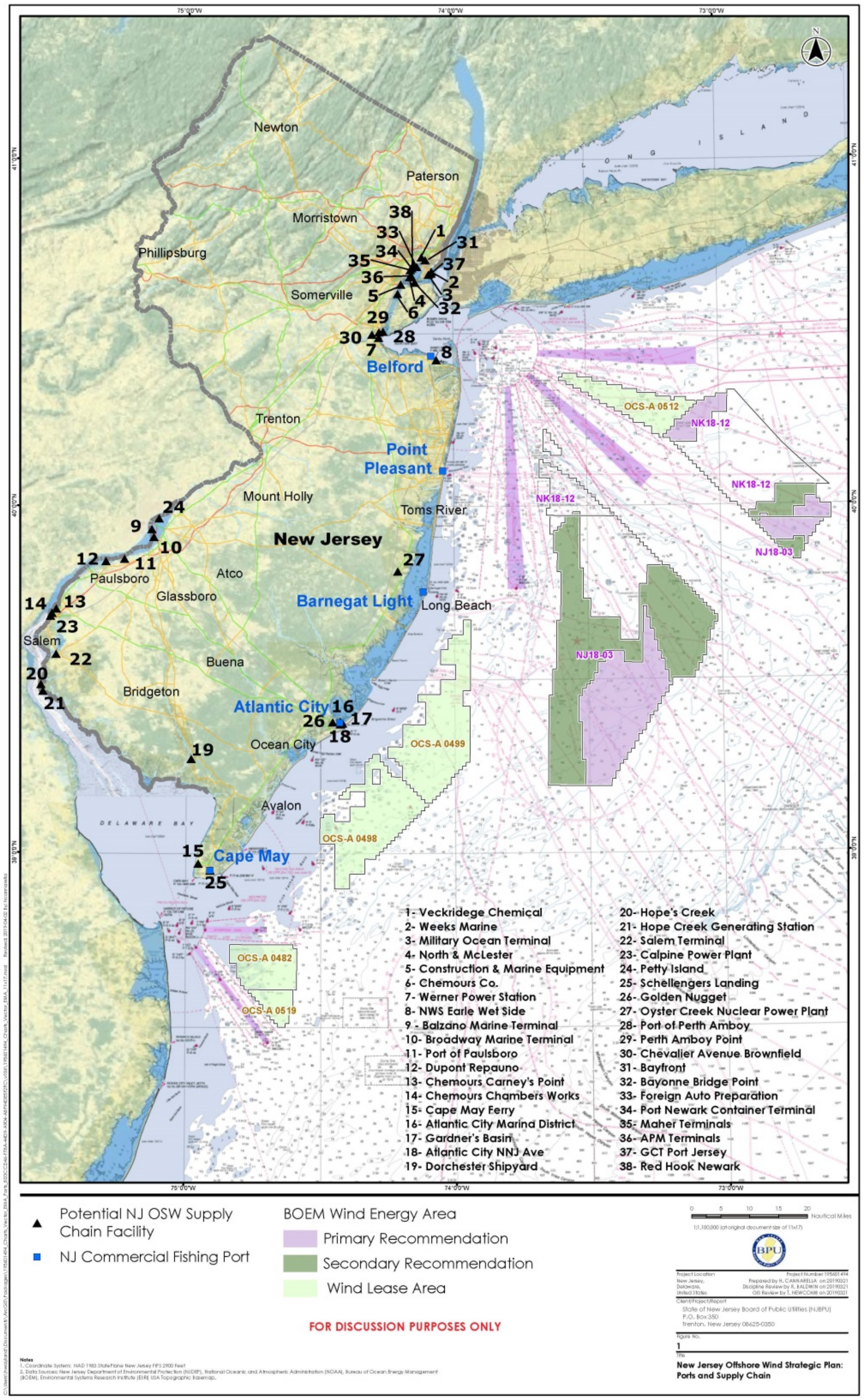
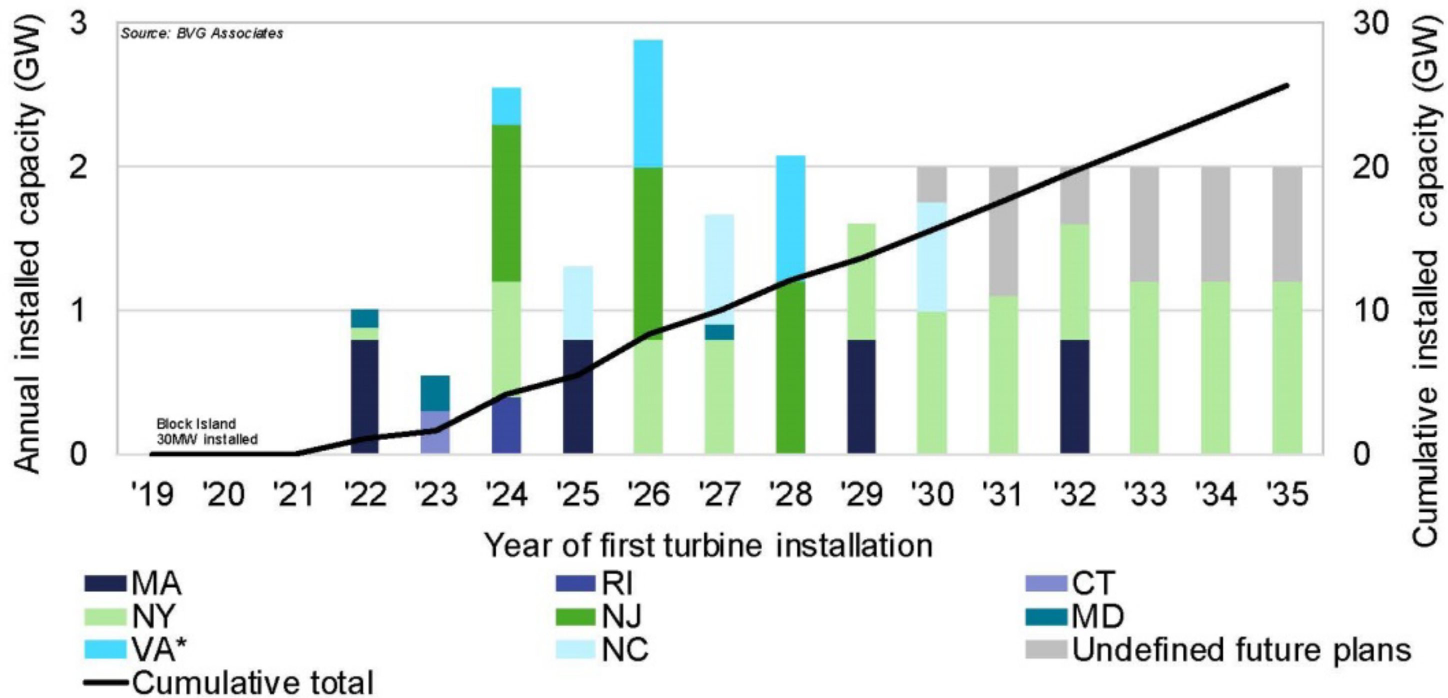
Summary prepared by: ***The New Jersey Board of Public Utilities***

Figure 1: New Jersey Ports and Harbors



US EAST COAST PIPELINE: CAPACITY BY ANNUAL INSTALLATION (MW)



- State driven offshore wind commitments have reached 19 GW for 2035
- Additional commitments anticipated, currently estimated at 6 GW
- By the end of 2019, offtake agreements expected to approach 5 GW

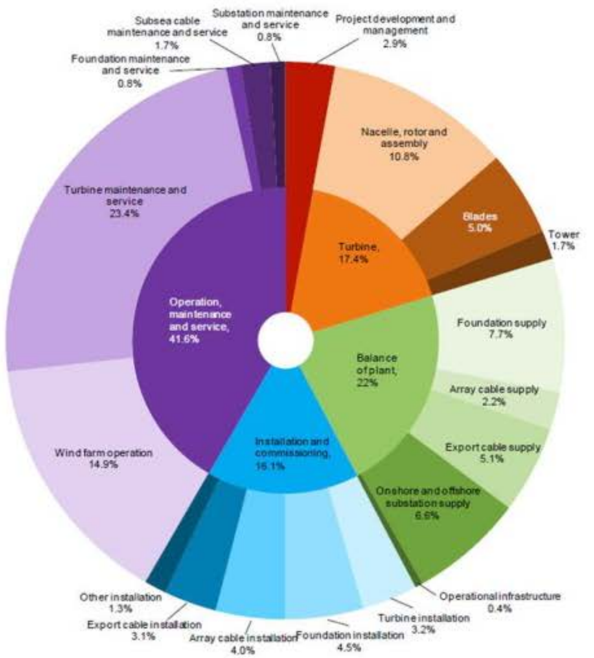
**North Carolina anticipated but not communicated

BVGassociates

Figure 2: U.S. East Coast Offshore Wind Pipeline through 2035

DIRECT FTP JOB REQUIREMENTS
(100 TURBINE PA INSTALLATION SCENARIO)

Element	Trade Workers	Assemblers	Managers	Engineers	Support Staff	Total
Project management & development	10	0	60	50	80	**200**
Blade manufacturing	100	430	30	10	30	**600**
Nacelle assembly	35	300	20	25	20	**400**
Tower manufacturing	120	50	10	5	15	**200**
Jacket manufacturing	580	20	25	10	15	**650**
Subsea cable manufacturing	25	320	15	15	25	**400**
Construction staging*	90	90	5	5	10	**200**
Substation manufacturing	200	240	20	15	25	**500**
Operations & maintenance**	400		35	20	45	**500**
Total	1,560	1,450	220	155	265	3,650



CAPEX and OPEX breakdown of an offshore wind farm

BVGassociates

Figure 3: Job Creation associated with Offshore Wind (left) / Offshore Wind CAPEX and OPEX Breakdown (right)

5. TRANSMISSION

Project: **New Jersey Board of Public Utilities, Offshore Wind Strategic Plan**

Date: April 22, 2019 (2:00 p.m. – 4:30 p.m.)

Location: Princeton University – Friend Center, Princeton, NJ

Subject: **Transmission Roundtable Discussion Summary**

Purpose: The purpose of this Roundtable Discussion was to secure stakeholder input for the development of the Offshore Wind Strategic Plan (OWSP) which is being undertaken by the New Jersey Board of Public Utilities (NJBPU) and New Jersey Department of Environmental Protection, as directed by Executive Order No. 8 (EO 8). The objective was to provide a forum in which stakeholders could discuss their concerns and provide recommendations relevant to transmission issues as New Jersey moves from 1,100 megawatts to 3,500 megawatts of offshore wind capacity.

The following is a summary, not a verbatim transcript, of the proceedings. Questions, comments, and dialogue have been paraphrased to convey main point(s).

Moderator:
Cynthia Holland, NJBPU

Facilitator:
Dan Grenier, Stantec

Roundtable Participants:

Sandeep Baidwan	Continuum Associates
Rich Baldwin	Ramboll
Jason Barker	Exelon (Atlantic City Electric)
Anthony Belacqua	Montclair State University
Murray Bevan	Retail Energy Supply Association
Clarke Bruno	Anbaric Development Partners
Doug Copeland	EDF Renewable Energy
Ali Daraeepour	Princeton University

Jessica Dealy	EDF Renewable Energy
Jeffrey Fitts	Princeton University
Joshua Gange	Bureau of Ocean Energy Management
Mario Giovannini	Exelon (Atlantic City Electric)
Sue Glatz	PJM Interconnection
Lawrence Hozempa	First Energy (JCP&L)
Cory Kelkenberg	Ørsted
Esam Khadr	PSEG
Kyle Kingman	Offshore Power, LLC
Tom Kreutz	Princeton University
Dana Lazarus	Con Edison (Rockland Electric Company)
Nicolas Lefevre-Marton	McKinsey & Company
Lauren Lepkoski	First Energy (JCP&L)
Susan LoFrumento	Con Edison (Rockland Electric Company)
Emmanuel Martin-Lauzer	Nexans
Andrew McNally	Exelon (Atlantic City Electric)
Markian Melnyk	Atlantic Wind Connection
Jodi Moskowitz	PSEG
Adrian Newall	PSEG
Brian O'Boyle	Con Edison (Rockland Electric Company)
Henry Ogden	State of New Jersey Division of the Rate Counsel
Mandar Pandit	GE Grid Solutions Group
Frank Peverly	Con Edison (Rockland Electric Company)
Warren Powell	Princeton University
JoAnne Seibel	Con Edison (Rockland Electric Company)
Richard Sellschop	McKinsey & Company
Pulin Shah	Exelon (Atlantic City Electric)
Cary Sklar	Prysmian
Marissa Slaten	Exelon (Atlantic City Electric)
Ada Statler	Natural Resources Defense Council
Lauren Thomas	PSEG
Sally Thomas	First Energy (JCP&L)
Madeline Urbish	Equinor
David Weaver	Exelon (Atlantic City Electric)
Ginny Wiik	Norwegian Consul General
Christen Wittman	EnBW North America
Richard Zeigler	First Energy (JCP&L)

Welcome and Introductions

NJBPU welcomed participants and explained that this session was the sixth in a series of issue-based stakeholder meetings regarding New Jersey's OWSP. Invited attendees were encouraged to share their thoughts and knowledge concerning transmission issues that will impact offshore wind (OSW) development in New Jersey, so that the state can develop a well-informed OWSP.

NJBPU provided an overview of the origin and process of the OWSP, including Governor

Murphy's EO8, and his directive to achieve 3,500 megawatts of OSW capacity by 2030. NJBPU noted that New Jersey's initial solicitation of 1,100 megawatts was released in 2018, and bids are currently under review by NJBPU.[1] The OWSP is intended to serve as a Roadmap, and will help guide New Jersey in moving from 1,100 megawatts to 3,500 megawatts of OSW capacity. The OWSP will be structured around six key areas of modeling and analysis: transmission, wholesale energy markets, supply chain and workforce development, ports and harbors, environmental protection, and commercial and recreational fisheries.

A key component of the OSWP process is engaging stakeholders and soliciting their input. NJBPU convened the roundtables to listen to stakeholders' concerns and knowledge, and to further the understanding of the development team and other stakeholders. Invited attendees were also encouraged to submit written comments to offshore.wind@bpu.nj.gov following the roundtable discussion.

The Facilitator provided housekeeping notes and roundtable meeting terms of engagement. Attendees were asked to be succinct and try to plan ahead, in order to provide input on issue(s) most important to them.

Discussion Summary

New Jersey's Offshore Wind Energy Area – A Brief Overview by Moderator

An overview of the OWSP was provided. The New York – New Jersey – Maryland cluster area has a 14-gigawatt OSW pipeline, [2]with 500 megawatts of active offtake agreements in place. By the end of 2019, nearly 2 gigawatts of offtake should be in place. Projections by the OWSP team envision regional OSW capacity reaching 25 gigawatts by 2035.

Integration of Offshore Wind into PJM[3]

Participants were asked for feedback on a number of issues impacting integration of OSW into PJM. It was noted that New Jersey does have high voltage substations located along the coast. To date, no public study has been conducted to identify interconnection points optimal for OSW use. Potential options for interconnection include Cardiff, Cedar, BL England, Lewes, Dennis, and Oyster Creek. Stakeholders asserted 230 kV (or higher) transmission is best, but 138 kV can handle lower capacities of OSW generation. One stakeholder stated that the interconnection point for an OSW facility must be: attractive in an electrical engineering sense, agreeable to the community, and environmentally acceptable. It was stated that it is also useful to maximize the injection of power at any single interconnection point at a single time, so that the same streets need not be dug up over and over.

Stakeholders then detailed PJM's well-established queue process. This process involves three

[1] On June 21, 2019 the Board unanimously approved Orsted's 1,100 MW Ocean Wind Project as a qualified offshore wind facility eligible to receive ORECs.
[2] This estimate does not include Virginia's goal of 2,500 MW of offshore wind capacity.
[3] PJM is the wholesale market operator for the Mid-Atlantic region, including all or part of 13 states (including New Jersey) and D.C.

planning studies: a Feasibility Study, a System Impact Study, and a Facilities Study. The studies are intended to provide developers with increasingly more refined information regarding the scope of required system upgrades, completion deadlines, and implementation costs. It was noted that PJM currently has four active offshore merchant transmission interconnection requests, with 0 megawatts of associated generation, in the queue.

PJM's queue process can accommodate OSW development in certain transmission paradigms. As it stands now, all offshore wind construction is seen by PJM as a generator interconnection process akin to onshore generation. PJM's Tariff also contemplates an alternative framework, the "State Agreement Approach" to transmission planning, which should be considered, but has not yet been fully developed. This state-driven mechanism, aimed at developing public policy projects, has never been utilized. The State Agreement Approach arises out of FERC Order 1000, and there was stakeholder encouragement that NJBPU consider this approach for developing transmission assets to serve New Jersey OSW facilities.

Several stakeholders stressed the need for a holistic approach to transmission planning. Ideally, this framework would account for OSW solicitations in New York and other neighboring states. Additionally, the holistic approach can reduce environmental impacts, lessen community disruption, enable systematic planning, and increase competition. It was recommended that a consortium of New Jersey electricity distribution companies (EDC) should be formed to discuss this issue.

One stakeholder stated that, in the OSW context, transmission is the most critical question that must be addressed by NJBPU. Proactive transmission planning will enable the integration of 3,500 megawatts of OSW generation capacity into the onshore grid. Transmission owners have deep and detailed knowledge of asset conditions, service areas, operational issues, resiliency, and development needs.

PJM opined that a new study is needed to address how the current transmission planning model can handle OSW generation at the projected levels. This study could also evaluate storage and other issues addressed in the last PJM Renewables Integration Study.

Inter-Regional Offshore Wind Capacity and Regional Transmission Solutions

Participants were asked for input regarding interregional cooperation on OSW and associated impacts. It was noted that PJM already studies and has rules in place for the interregional aspects of power generators. Some stakeholders encouraged New Jersey and New York to work together through the State Agreement Approach.

One participant noted that a major benefit of an interregional solution would be cost sharing with other states. Such a cost sharing arrangement might allow for the construction of a transmission backbone. Fair cost allocation between New Jersey and New York ratepayers will be critical. While the transmission backbone solution would enable greater control and management of power flows, it will likely be very expensive. Other stakeholders noted that establishing an acceptable cost allocation framework could be challenging, due in part to New Jersey's OSW funding mechanism. Since no rules have yet been developed, stakeholders claimed that there does appear to be flexibility in the "State Agreement Approach."

Another stakeholder observed that carefully planned renewable energy collaborations among Denmark, Norway, and Germany, supported by robust High-voltage Direct Current (HVDC) interconnectors, allowed European markets to attract investment and grow predictably. A lack of this type of interconnection could stymie the American OSW industry from the outset. Additionally, stakeholders identified access to New York City's large demand center as a benefit, because it might help to negate the need to construct extensive energy storage assets, and lessens the likelihood of curtailment of OSW facility output.

Some stakeholders stated that a joint operating agreement between PJM and NYISO (New York's wholesale market operator) may facilitate the cooperation necessary to ensure success for the first phase of OSW projects.

Concerns were also expressed about exposing ratepayers to risk associated with OSW generation and its related transmission infrastructure. Concerns were expressed about the equity associated with interregional transmission, in particular collaboration with New York. It was acknowledged that ratepayer risk must be minimized.

Transmission Upgrades

There was inquiry about New Jersey's maximum potential OSW build-out, and discussion about PJM performing an analysis regarding potential interconnection points and associated transmission system impacts. There was also discussion of collaboration with stakeholders.

A stakeholder highlighted Germany's experience. There, in one instance, construction of OSW generation assets was finished before the requisite transmission infrastructure was completed. This disconnect meant that power could not be delivered to the onshore grid. This created a lag in the project, resulting in damages. According to this stakeholder, even with these challenges, "people are harder to predict than engineering." New Jersey can avoid this situation by creating a planned offshore transmission system.

A discussion regarding cost allocation of an offshore transmission system followed. Discussion referenced the fact that cost allocation framework will be a function of how OSW development occurs. Stakeholders noted that an interconnected offshore grid that links more than one ISO would be more complicated in terms of cost allocation. One stakeholder noted that PJM should look beyond the interconnection queue process to develop an integrated transmission plan Another stakeholder noted that PJM could help by providing a framework within which developers can compete to interconnect. Discussion included reference to PJM's process for the interconnection queue and what type of guidance New Jersey could provide regarding its plans for OSW projects.

There was discussion about how the Bureau of Ocean and Energy Management (BOEM) regulates the ocean floor in federal waters. Discussion referenced the fact that BOEM would be the entity that would issue any offshore right-of-way for a transmission cable in federal waters. Stakeholders noted that current regulations permit an Outer Contintental Shelf (OCS) leaseholder one or more rights-of-way to enjoy the use of their lease. Stakeholders explained PJM would then be key in this process. Stakeholders discussed that BOEM cannot mandate a transmission backbone system, or otherwise cause transmission construction.

One stakeholder stated that it appears that this effort is has been viewed in terms of individual projects, rather than a holistic transmission planning effort. A need for proactive planning, beyond looking at the interconnection queue, was recommended.

Discussion noted that many of the projects that undergo PJM planning studies via the interconnection queue process are never placed into service. Additionally, it was referenced that the last study of a potential OSW transmission backbone was about 10 years ago, so a new study would be needed to examine interconnection options, timing, and other issues.

Transmission Options

At this time, all points of interconnection are onshore. However, discussion indicated a willingness among some stakeholders to work with OSW developers who are seeking a different transmission framework. One idea that was raised was to create a framework akin to the State Agreement Approach, but for an offshore grid with multiple connections. Other suggestions included developing an offshore transmission solution first, then creating the lead lines to the OSW generators. It was noted that FERC Order 807 requires open access, but this is separate from PJM's transmission planning process.

Another stakeholder noted that there are essentially two approaches to future OSW transmission development in the PJM footprint. One is the piecemeal approach, which is developer-led and proceeds on a project by project basis. Although this framework can prevent holistic thinking about infrastructure, it cannot be ignored that this approach has worked for decades. The alternative, according to that stakeholder, is the State Agreement Approach. Given the substantial OSW goals advanced by New Jersey and New York, there is a need to start planning transmission infrastructure in a manner that facilitates the integration of large quantities of OSW-generated electricity into the onshore grid in an efficient, cost-effective, and financially responsible manner. Some stakeholders commented that, without a coordinated approach to transmission planning, OSW development in the region will fade. HVDC transmission assets are long-term projects requiring substantial preparation and long lead times.

One stakeholder opined that OSW development in American waters will proceed in three phases. For the first round of OSW, the focus is just getting "steel in the water," and building social acceptance for OSW. The second phase will be focused on increasing efficiencies. The third phase must be planned in advance, or there will not be sufficient points into which future OSW facilities may interconnect.

Another stakeholder stated that it will be difficult to construct this transmission infrastructure as a merchant project. Although this approach can divert risk away from New Jersey ratepayers, there is a real possibility that the merchant transmission line could be over- or undersubscribed, leading to inefficiencies.

Storage and Offshore Wind

Discussion recognized the impact that energy storage could have on load forecasts. Another stakeholder stated that the PJM Renewables Integration Study cited a need for energy storage technologies to provide ancillary services to the grid. Along with near-term energy storage deployments, New Jersey Energy Master Plan calls for 2000 MW of storage by 2030.

Recommendations

Stakeholders offered a range of recommendations. Stakeholders across the spectrum emphasized the importance of a unified, well-coordinated approach to planning transmission for OSW facilities. It was recommended that this framework should include coordination with New York. Upfront transmission planning is necessary to OSW success. Multiple participants also requested that NJBPU coordinate a smaller-group discussion regarding transmission, for the purpose of developing a coordinated approach.

Stakeholders also advised that New Jersey should heed European experience in building transmission. Goals should be set as to what should be accomplished regarding offshore transmission for the next 1-2, 3-5, and 10-15 years. It was also noted that, while longer-term planning is critical, early OSW projects must not get "hung up" by the comprehensive transmission plan upon which future OSW projects will rely.

Stakeholders advised that siting policy should be aligned with legislative and policy goals. The value of energy depends upon the timing and location of its delivery. Careful planning facilitates value maximization.

Stakeholders referenced the support of New Jersey electric utilities for New Jersey's OSW goals. Discussion indicated that the electric utilities were willing to assist New Jersey by providing expertise regarding their respective systems, and by performing analyses aimed at developing cost-effective transmission to serve OSW facilities. Discussion also indicated that New Jersey's OSW goals are important to PJM. Discussion included sharing New Jersey's OWSP with BOEM, as it has any potential for impacting future OSW leasing in federal waters.

Stakeholder Recommendations

- A unified, well-coordinated approach to transmission planning is necessary.
- It would be helpful for NJBPU to have a smaller group discussion about the issue of transmission between PJM and Electric Utilities, then bring in offshore wind developers.
- If New Jersey's OWSP has any potential for impacting future leasing in federal waters, BPU should keep BOEM posted.
- A Planned approach for transmission development is recommended by multiple stakeholders. However, early offshore wind projects should not get hung up in the full comprehensive

transmission plan that future offshore wind projects should rely upon.

- An aggressive timeline mandates timely next steps.
- Align siting policy with legislative goals.
- Transmission backbone is not required currently.
- New Jersey should be open to dialogue with New York.
- The value of energy depends on the timing and location of its delivery. Careful planning of transmission facilitates ensure this.

Discussion Summary

Ramboll summarized the following key discussion points:

- PJM's State Agreement Approach requires further evaluation and consideration.
- Several stakeholders offered to participate in a combined study regarding OSW transmission.
- A number of participants recommended the development of smaller, focused working groups to examine offshore transmission.

Next Steps

- A draft OWSP will be forwarded to NJBPU, and will thereafter be released for public comment.
- Written comments can be submitted to offshore.wind@bpu.nj.gov.

-end-

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Summary prepared by: ***The New Jersey Board of Public Utilities***

6. WHOLESALE ENERGY MARKETS

Project: **New Jersey Board of Public Utilities, Offshore Wind Strategic Plan**

Date: April 22, 2019 (10:00 a.m. – 12:30 p.m.)

Location: Princeton University – Friend Center, Princeton, NJ

Subject: **Wholesale Energy Markets Roundtable Discussion Summary**

Purpose: The purpose of this Roundtable Discussion was to secure stakeholder input for the development of the Offshore Wind Strategic Plan (OWSP) which is being undertaken by the New Jersey Board of Public Utilities (NJBPU) and New Jersey Department of Environmental Protection, as directed by Executive Order No. 8 (EO8). The objective was to provide a forum in which stakeholders could discuss their concerns and provide recommendations relevant to wholesale energy market issues as New Jersey moves from 1,100 megawatts to 3,500 megawatts of offshore wind capacity.

The following is a summary, not a verbatim transcript, of the proceedings. Questions, comments, and dialogue have been paraphrased to convey main point(s).

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Cynthia Holland, NJBPU, Office of Federal and Regional Policy

Facilitator:
Dan Grenier, Stantec

Roundtable Participants:

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Stephen Bennett	PJM
Murray Bevan	Retail Energy Supply Association
Joseph Bowring	Monitoring Analytics
Stefanie Brand	State of New Jersey Division of the Rate Counsel
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Lathrop Craig	PSE&G
Evan Dean	First Energy (JCP&L)
Ray Depillo	PSE&G
Jeffrey Fitts	Princeton University
Steve Gabel	Gabel Associates
Joshua Gange	Bureau of Ocean Energy Management
Jamil Khan	Ørsted
Adam Keech	PJM
Tom Kreutz	Princeton University
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Somayeh Moazeni	Stevens Institute of Technology
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Felicia Thomas-Friel	State of New Jersey Division of the Rate Counsel
Madeline Urbish	River Crossing Strategy Group
Brian Vayda	New Jersey Public Power Authority
Christen Wittman	EnBW North America

Welcome and Introductions

Princeton University's Andlinger Center for Energy and the Environment provided welcoming remarks, and noted Princeton's ongoing continued support of New Jersey's offshore wind (OSW) objectives. NJBPU then explained that this session was the fifth in a series of issue-based stakeholder meetings regarding New Jersey's OWSP. Invited attendees were encouraged to share their thoughts and knowledge concerning wholesale energy market issues that will impact OSW development in New Jersey, so that the state can develop a well-informed OWSP.

NJBPU provided an overview of the origin and process of the OWSP, including Governor Murphy's EO8, and his directive to achieve 3,500 megawatts of OSW capacity by 2030. NJBPU noted that New Jersey's initial solicitation of 1,100 megawatts was released in 2018, and bids are currently under review by NJBPU.[1] The OWSP is intended to serve as a Roadmap, and will help guide New Jersey in moving from 1,100 megawatts to 3,500 megawatts of OSW capacity. The OWSP will be structured around six key areas of modeling and analysis: wholesale energy markets, transmission, supply chain and workforce development, ports and harbors,

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environmental protection, and commercial and recreational fisheries.

A key component of the OSWP process is engaging stakeholders and soliciting their input. NJBPU convened the roundtables to listen to stakeholders' concerns and knowledge, and to further the understanding of the development team and other stakeholders. Invited attendees were also encouraged to submit written comments to offshore.wind@bpu.nj.gov following the roundtable discussion.

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Energy and Capacity Pricing

Stakeholders were asked for input regarding potential impact(s) that build out of New Jersey OSW facilities will have upon wholesale electricity market pricing. Several attendees opined that OSW's near-zero marginal cost of generation will depress wholesale market prices for energy. Although this downward price pressure might vary vis-à-vis the geographic location of OSW projects, it is too early to make a conclusive judgment on this issue. Reducing wholesale electricity prices was described by some stakeholders as a significant benefit.

One stakeholder noted that, when accounting for the cost of offshore transmission infrastructure, OSW generation is "far more expensive" than other methods of electricity generation. This stakeholder expressed skepticism about "why" New Jersey is pursuing offshore wind. Another stakeholder responded to this comment, stating that the "too expensive" criticism does not account for all the benefits provided by OSW. Furthermore, OSW's levelized cost of energy has – and will continue to – decline as a function of improving technology, economies of scale, and other efficiencies.

It was observed that the high variability associated with wind-generated electricity may require the construction of compensating backup generation capacity. The electrical grid is able to absorb some variability, but this variability has attendant costs which must be carefully analyzed. At higher levels of wind penetration on the grid, additional flexibility will be required. Changing wholesale market structures will be required to accommodate large quantities of non-dispatchable generation resources like OSW.

With respect to OSW's potential impacts on transmission congestion, generally speaking, there is a lack of generation capacity near coastal areas. As a result, the electricity grid currently transmits power generated in western regions to more populated areas located farther east and closer to the coast. Stakeholders asserted that build-out of OSW generation would require transmission upgrades to accommodate new east to west electricity flows. Capacity resources, like OSW, have to pay for transmission upgrades. Another stakeholder commented that the cost and challenges of building new transmission and interconnection assets in New Jersey – the most densely populated American state – cannot be overlooked.

One stakeholder commented on the design of New Jersey's Offshore Wind Renewable Energy Credit (OREC) framework, and explained that significant distortions occurred in New Jersey's SREC pricing. This stakeholder asserted that these historical distortions have resulted in a lack of parity with Basic Generation Service.

The discussion then turned to the interrelated issues of OSW's impacts on flows of electricity across the New Jersey/New York seam, and how New York's goal of 9,000 megawatts of OSW will impact these flows. Several stakeholders commented that it was too early to make such a determination. Stakeholders noted the existence of a "chicken and egg" situation, where the outcome will likely turn on (1) which state brings OSW facilities online first, (2) the size of the OSW projects coming online, and (3) whether those OSW projects decrease electricity prices in either or both states. Ultimately, the two states will have large intermittent generation resources on either side of this seam, resulting in a more dynamic interface.

One participant remarked that greater regional transmission planning between New Jersey and New York, and between PJM and NYISO (the respective wholesale market operators), is required if either state wants to reach their OSW goal. Market and policy rules will impact the flow of energy across the New Jersey/New York seam. This flow may also ultimately impact the transmission planning process. Another consideration is whether the OSW power should interconnect at the closest point to the ocean, which would require building more onshore transmission, or whether it should interconnect closest to load.

However, another stakeholder cautioned that, in efforts involving both New Jersey and New York, New Jersey "always gets the short end of the stick," to the detriment of New Jersey ratepayers. New Jersey must be an equal partner if such collaborations are to be successful. It was also observed that New York "cannot land 9 gigawatts [of OSW-generated power] in New York." In this sense, New York needs New Jersey's cooperation.

Another comment focused on meteorological conditions and their impact on the power grid. Coastal storms tend to travel south to north, and their gusting winds impact New Jersey first, then New York. With high penetrations of wind generation, this can cause a surge and subsequent drop in power across the grid. The commenter opined that modeling these winds, and therefore analyzing the associated power surges, can be very difficult.

Stakeholders explained that the current transmission topology between New Jersey and New York is largely comprised of merchant transmission facilities. High penetrations of zero (or near-zero) marginal cost OSW generation assets will drive down prices, ostensibly reducing margins, and potentially changing the business cases for those merchant facilities.

Stakeholders also commented on the impact of carbon pricing in PJM on energy prices and OSW development. Although carbon pricing and participation in carbon trading schemes may place upward pressure on energy prices, they simultaneously increase the value of OSW generation. It was pointed out, however, that the RGGI carbon price has almost no effect on market prices. By contrast, NYISO's price does have an impact on pricing. Stakeholders noted that the fact that NYISO is a single-state wholesale market dictates their ability to more intricately manage carbon policy or pricing through market measures. By contrast, stakeholders observed that PJM – a multi-state market – cannot dictate a carbon price. PJM is studying potential mechanisms to address any leakage of greenhouse gas emissions, which will provide states further options for any potential leakage mitigation scheme a state may choose to adopt.

Capacity Market

Stakeholders were asked how OSW facilities compare to other capacity resources, as well as the appropriate capacity factor that should be used by PJM in calculating capacity value for OSW. It was noted that each OSW project and turbine have different capacity factors. OSW capacity factors tend to fall between the high 30's and upper 40's. However, this is a multifaceted determination that is influenced by a host of considerations, including, among other factors, wind speed, turbine model, project maintenance schemes, distance to shore, and transmission infrastructure configuration.

The issue of coordination of construction of OSW generation and associated transmission assets was also noted. How long can someone sit on transmission rights?

A stakeholder stated that PJM uses a capacity factor of 26% for OSW, and 14.7% for onshore wind installations. This stakeholder noted that, although it may have other benefits, OSW is prohibitive "by quite a bit" from a pure cost perspective.

In response, another stakeholder argued that critical aspects of OSW generation are being overlooked. Dispatchable generation assets have their own form of variability (*i.e.* fuel costs, grid seasonality). No single generation technology can itself provide the full range of benefits required to keep the grid operational and reliable. OSW must be valued in the context of a greater generation portfolio, and its value must be premised upon the full range of services it can provide to the grid. At one time, onshore wind was viewed as too expensive, but it evolved considerably over time, and costs fell. In this stakeholder's opinion, the real question to be asking is – how does offshore wind gradually fit into, and improve, the power grid? This individual further commented that we "should be less fearful of building 80 gigawatts than of building the first 8 gigawatts wrong."

Stakeholders also asserted that OSW is generally coincident with peak electricity demand hours. This coincidence is better-aligned during the winter than during summer months. Another stakeholder added that OSW peak times are aligned with storm activity.

A participant anticipated that OSW will be considered a capacity resource in future PJM capacity auctions. The challenge lies in determining the manner in which OSW's capacity value is calculated. It was argued that the focus should be on avoided cost, not net economic cost, in making this calculation. Another stakeholder noted that, regardless of the manner in which the payments are ultimately made, ratepayers must not pay twice for capacity resources. It was echoed that New Jersey's OSW program will have a rate impact, and might necessitate changes to New Jersey's Basic Generation Service (BGS) auction.

Stakeholders noted future OSW solicitations could mandate OSW projects participation in PJM's capacity market. If the Federal Energy Regulatory Commission (FERC) approves a "clean Minimum Offer Price Rule (MOPR)," over time, the likelihood is high that New Jersey's capacity prices will increase. FERC's approval of a "clean MOPR" would re-price the initial capacity bid of the OSW resource to the substantially higher (and administratively-determined by PJM) Cost of New Entry for OSW. By contrast, a "Fixed Resource Requirement alternative" mechanism may result in lower capacity prices.

In terms of determining capacity factors for "immature resources" – power generation units with less than three years of operational data – PJM uses a class-based default or a resource-specific analysis. To determine resource-specific data, PJM evaluates a range of factors, including power curves from OEMs, meteorological data, performance of nearby turbines, and the capacity factor requested by the immature resources. PJM then validates the appropriate capacity factor. Ten years of operational data are preferred.

Energy Storage

Stakeholders were asked for input regarding how incorporation of energy storage will impact OSW development in New Jersey. One stakeholder observed that the location of storage depends upon grid configuration and upon the location of bottlenecks (causing congestion) on the grid. Although it was agreed that storage does add value, these assets are generally bi-directional, and these flows of power will significantly impact the electricity distribution system. Electric Utilities will need to work with NJBPU to develop appropriate mechanisms for ensuring safety and reliability. Another participant asserted that, because of poor market design, "batteries are only economical for providing frequency regulation."

PJM Integration Studies

Stakeholders were next asked for input regarding PJM's Renewable Integration Study (PRIS). This study, completed in 2014, concluded that the transmission network within PJM's footprint could support up to 30% penetration of renewable electricity generation. One stakeholder clarified that the 30% figure included a caveat to reflect adequate expansion of transmission and ramping assets. Another participant stated that he conducted his own renewables integration modeling, and found that significant spinning reserves were required at 20% renewable penetration due to variability. It was also pointed out that Europe has succeeded with high renewable penetration, but appropriate planning has been key.

Stakeholders also discussed additional studies by PJM that could be leveraged to inform the OWSP. One study, entitled "PJM's Evolving Resource Mix and System Reliability," is available now. PJM is now commencing a carbon pricing study, with results expected towards the end of 2019.

Recommendations

The Moderator asked stakeholders for recommendations.

- To the extent possible, lean on competitive markets, not in terms of revenue generation, but to make New Jersey's OSW supply chain as competitive as possible. Let OSW developers, rather than New Jersey ratepayers, shoulder these risks.
- On a related note, if New Jersey's goal is to ensure that OSW development occurs at the lowest cost to ratepayers, NJBPU may want to adjust its procurement scheme. Requiring local content can increase costs. Let the OSW supply chain figure out the lowest-cost solution.
- There are numerous energy initiatives taking place in New Jersey right now, and NJBPU was cautioned not to "silo" itself. Because these energy goals are interconnected, it will be important not to focus myopically upon OSW to the detriment of other plans. A coordinated integrated approach is necessary.
- New Jersey should help ease local permitting requirements and land rights access for cable landings.
- Although OSW can help reduce carbon emissions, it will not solve climate change on its own. OSW "gets harder as you get close to 20%." Consider all options.
- The OWSP must capture and monetize all associated costs and benefits, including carbon costs, carbon-reduction benefits, other environmental/air quality impacts.

General Questions & Answers

Stakeholders offered a range of final questions and comments. One participant noted future challenges in terms of accurate modeling, and asked for more detail from NJBPU regarding New Jersey's OSW planning process. NJBPU explained that its primary charge is to consider the roadmap for New Jersey to move from 1,100 megawatts to 3,500 megawatts of OSW generation by 2030.

ORECs awarded by New Jersey will continue for 20 years, and the market revenues generated by an OSW project will be returned to ratepayers over that timeframe. However, OSW projects are expected to be operational for 25 years, and may be re-powered. Therefore, NJBPU needs to have a long-term vision. Markets are dynamic and changeable. NJBPU is not seeking to define what those future changes may be, but to set up an effective decision-making framework for integrating OSW into PJM, developing the supply chain, and determining environmental impacts. NJBPU will also consider other technologies and innovations but that is not NJBPU's task with respect to the OWSP. The OWSP will identify needs for additional technical studies.

Discussion Summary

Ramboll summarized the following key discussion points:

- The cost of transmission needs to be considered when determining OREC pricing.
- Variability of wind resources, and valuation of capacity revenues, are pricing considerations for OSW projects.
- Regional transmission planning, and interregional transmission coordination is critical.
- Coordination is needed to evolve market policy to fully compensate OSW generation.
- The effects of any carbon price imposed is a key consideration in OSW.
- Additional benefits of OSW must be quantified and considered.
- Leakage management is a key issue.
- Resource-specific capacity factors are available from PJM, but resource-specific data would be required to complete the necessary studies.
- OSW should be considered, and valued, as part of an energy portfolio.
- New Jersey ratepayers must not pay twice for capacity.
- Up to a certain, as-yet-undetermined threshold, the grid has the capacity to deal with variability of wind-generated electricity, independent of energy storage technologies.
- NJBPU's decision-making should not be "siloed," but should consider and collaborate with other energy initiatives.
- Permitting process should be streamlined.
- Requiring local content may put increase OSW project price, relative to allowing the OSW supply chain to make its own decisions as to lowest-cost options.

Next Steps:

- A draft OWSP will be forwarded to NJBPU, and will be thereafter released for public comment.
- Written comments can be submitted to offshore.wind@bpu.nj.gov.

-end-

Note:

The information contained in these notes is assumed to be a complete and correct account of the items discussed, directions given, and conclusions drawn during the meeting. Any clarifications or corrections to this summary should be submitted to InGroup within five calendar days of the receipt of this summary. No response implies that information contained herein is agreed to be correct as written.

Summary prepared by: ***The New Jersey Board of Public Utilities Staff***

APPENDIX B

Environmental and Natural Resource Technical Appendix

DRAFT

Prepared for:
New Jersey Board of Public Utilities

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Date:
July 2020

Project Number:
1690009544

ENVIRONMENTAL AND NATURAL RESOURCES TECHNICAL APPENDIX

RAMBOLL

ENVIRONMENT
& HEALTH

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ACRONYMS

AIS - Automatic Identification System
BOEM - Bureau of Ocean Energy Management
CRSSA - Center for Remote Sensing and Spatial Analysis
DOC - Department of Commerce
ESA - Endangered Species Act
EFH - Essential Fish Habitat
GIS - Geographic Information Systems
Hz – Hertz (= 1 vibration sound wave per second)
HMS - Highly Migratory Species
LFC - Low Frequency Cetaceans
kHz – Kilohertz (= 1,000 Hz)
kWh – Kilowatt (= 1,000 watts used for one hour)
MFA - Marine Fisheries Administration (NJDEP DFW)
MRA - Marine Resource Assessment (US Department of the Navy)
MDAT - Marine-Life Data and Analysis Team
MDMF - Massachusetts Division of Marine Fisheries
MAR - Mean Annual Revenue
MW – Megawatts (1 megawatt = 1,000 kW)
MARCO - Mid-Atlantic Regional Council on the Ocean
MFC - Mid Frequency Cetaceans
NCCOS - National Centers for Coastal Ocean Science (NOAA)
NCEI - National Centers for Environmental Information (NOAA, formerly the National Geophysical Data Center)
NMFS - National Marine Fisheries Service
NOAA - National Oceanic and Atmospheric Administration
NOS - National Ocean Service (NOAA)
NEFMC - New England Fishery Management Council
NJBPU - New Jersey Board of Public Utilities
NJDEP - New Jersey Department of Environmental Protection
NJDEP DFW - New Jersey Division of Fish and Wildlife

NYSERDA - New York State Energy Research and Development Authority
NARW - North Atlantic Right Whale
NEAMAP - Northeast Areas Monitoring and Assessment Program
NEFOP - Northeast Fisheries Observer Program
NEFSC –Northeast Fisheries Science Center (NOAA)
NEFSC - Northeast Fisheries Science Center (NMFS)
NROC - Northeast Regional Ocean Council
NAMERA - Northwest Atlantic Marine Ecoregional Assessment
OCM - Office for Coastal Management (NOAA NOS)
OWSP - Offshore Wind Strategic Plan (New Jersey)
OCS - Outer Continental Shelf
SEMARNAT - Secretariat of Environment and Natural Resources (Mexico)
SMAST - School of Marine Science and Technology (Massachusetts)
SPUE - Sightings Per Unit Effort
SOG - Speed Over Ground
SASI - Swept Area Seabed Impact (NEFMC)
TNC - The Nature Conservancy
USACE - United States Army Corps of Engineers
USFWS - United States Fish and Wildlife Service
UTM - Universal Transverse Mercator
URE - Unweighted Resource Evaluation
VMS - Vessel Monitoring System
VTR - Vessel Transit Report
W - Watt (= 1 joule per second; rate of energy transfer)
WSA - Weighted Susceptibility Analysis
WEA - Wind Energy Areas

1. INTRODUCTION

This environmental and natural resources technical appendix was prepared to support the Environmental Protection and the Commercial and Recreational Fisheries sections of the New Jersey Offshore Wind Strategic Plan (OWSP). The OWSP was developed pursuant to Executive Order No. 8 and Executive Order No. 92, which were signed by Governor Phil Murphy on January 31, 2018 and November 19, 2019, respectively (Murphy 2018, Murphy 2019). Executive Order No. 8 establishes a state-wide goal for wind energy generation off the coast of New Jersey of 3,500 megawatts (MW) by the year 2030. Executive Order No. 92 raises New Jersey's offshore wind goal to 7,500 MW by 2035.

The purpose of this document is to provide technical information, methods, and important caveats used in the analyses such that the evaluation is transparent and understandable, the results are repeatable, and the study's limitations are appropriately disclosed. In general, this body of work reflects a planning-level analysis and does not represent a comprehensive or detailed environmental impact analysis. Rather, it provides information regarding the relative susceptibility of environmental and natural resources to offshore wind development in and near existing planning areas off the coast of New Jersey.

A primary objective of the Environmental Protection and the Commercial and Recreational Fisheries chapters of the OWSP is to support assessment of environmental, natural and fisheries resources of waters off the coast of New Jersey for responsible development of offshore wind. This was done while simultaneously recognizing the value and uniqueness of New Jersey's coastal ocean. New Jersey's coastal ocean is defined in the context of the potential for offshore wind development and is labeled herein as the "study area" (Figure 1). Specifically, the boundaries of the study area are as follows:

<u>North and South Boundaries:</u> The northern boundary of the study area is the federal outer continental shelf (OCS) administrative boundary just north of the Fairways North New York Bight wind energy areas (WEAs). The southern boundary was developed to include lease area OCS-A 0490, with a 2 nautical mile wide buffer applied to the southern edge.

<u>Inshore Boundary:</u> The New Jersey Offshore Wind Energy: Feasibility Study (Atlantic Renewable Energy Corporation 2004) and the Ocean/Wind Power Ecological Baseline Studies (New Jersey Department of Environmental Protection [NJDEP] 2010) both indicate that in general, nearshore areas are less viable for offshore wind development than areas farther offshore. For example, environmental indices developed in NJDEP 2010 identifies the majority of the areas with highest sensitivity were located along the coast. AREC 2004 suggests that the conditionally viable areas for offshore wind development lies mostly beyond the three nautical mile jurisdictional limit. Based on the potential ecological effects, limited area, and development constraints (e.g., lower wind speed, air traffic restrictions), it is extremely unlikely that utility-scale wind energy projects will be developed in state waters (within 3 nautical miles from shore). Further, the nearshore environment is sufficiently different from the offshore environment such that it would not be appropriate (or efficient in the sense of data management, computing, or discussion) to include them in a single model, particularly when utility-scale wind development in these areas is unlikely and nearshore effects associated with cable landings and facilities will be evaluated under project specific New Jersey permitting and environmental review. The inshore boundary of the study area is therefore the 3 nautical mile state jurisdictional boundary.

Offshore Boundary: The offshore boundary is located at approximately the 60-meter (197 feet) depth contour and maintains at least a 2 nautical mile buffer from the WEA. The 60-meter (197 feet) depth contour is the practical outer edge of where nonfloating wind farm technologies may be expected.

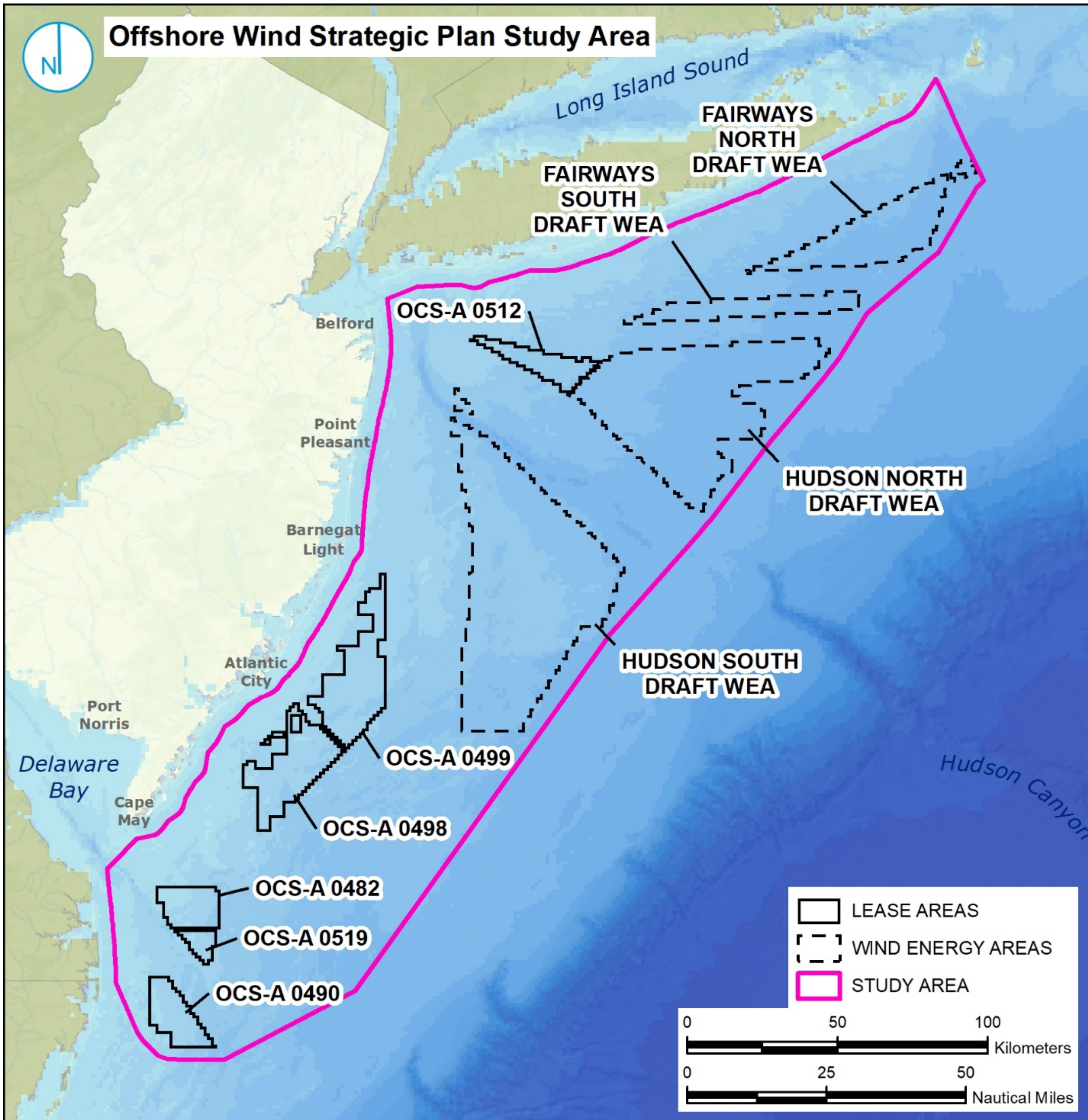


Figure 1: Offshore Wind Strategic Plan Study Area

The evaluations described herein collectively consider four major phases of offshore wind development such that the variation of susceptibilities of certain ocean resources at any phase will be captured. The four distinct phases of offshore wind development are preconstruction, construction, operations, and decommissioning. These phases and the major elements associated with each are described below.

Preconstruction: The preconstruction phase of offshore wind development includes planning, design, and surveying. These activities may include acoustic surveying and exploratory drilling. Noise-generating and bottom-disturbing surveys are of particular concern to environmental receptors. Primary environmental concerns during this phase include noise harassment of susceptible species, entanglements in survey gear and vessel strikes.

Construction: During the construction phase of offshore wind development, foundations for wind turbines and the offshore substation(s) are installed. Cables connecting the wind turbines, offshore substation(s), and onshore electrical grid are also installed in this phase. Depending on the foundation type, foundation installation may include pile driving. Primary environmental concerns during this phase include noise harassment of susceptible species (due to pile-driving noise and construction noise) including changes in behavior (e.g., feeding, communication, navigation, rearing of young), vessel strikes, entanglement in mooring lines/cables and possible habitat loss due to benthic changes, sediment disturbance, and water quality changes during foundation and cable installation. Additionally, a loss of access to commercial and recreational fishing may be an impact of the construction phase.

Operations: During the operations and maintenance phase, vessels will traffic between the operations and maintenance port and the lease area/WEA to conduct maintenance activities on the turbines and offshore substation. Cable and foundation maintenance will also occur. Maintenance will include repair or replacement of components based on routine inspection. Operations and maintenance strategies may include workboat-based support, heli-support, or offshore-based platform support. This phase makes up the longest time period of a wind farm's lifecycle, lasting 20 years or more. Primary environmental concerns during this phase are vessel strikes, change in behavior due to electromagnetic fields generated by cables, collision with structures, changes/interruptions of migratory pathways, effects of offshore structures on local ocean circulation and winds, and loss of habitat due to bottom-scouring and the presence of structures. New structures may create habitat for invertebrates, which could attract fish and subsequently bird species, potentially leading to avian collision with structures (Palmquist and Gard 2017). Fisheries impacts during the operations phase include loss of access for commercial fishing vessels, particularly for mobile bottom gear in areas where cables lie. Marine transit may be impacted by altering navigation patterns and routes.

Decommissioning: During the decommissioning phase, structures are fully or partly removed and retired. The goal of decommissioning is to leave the site in a similar condition as it began in. Primary environmental concerns during this phase are similar to those in the construction phase: vessel strikes, noise harassment, and change in habitat due to the removal of structures. Sediment disturbance could affect benthic species. There are a wide range of decommissioning options ranging from full removal to no removal, so effects from this phase are difficult to predict.

The approach to assessing the potential for environmental conflicts with offshore wind development as described above was undertaken in a collaborative manner with multiple stakeholders on behalf of New Jersey Board of Public Utilities (NJBPU). The effort included multiple workshops and workgroups, public outreach, stakeholder engagement, and input gathering, as well as key reviews by state resource agencies and departments through the course of an 18-month period. These steps were necessary to ensure that important issues and concerns were identified and were either addressed in the analysis or flagged as a data gap or need. This process included the following engagement activities and stakeholder input related to environmental protection and commercial and recreational fisheries listed below.

- Stakeholder meeting #1 Environmental Protection – March 1, 2019. Meeting participants included the following organizations:
  - Federal/National: American Littoral Society, National Wildlife Federation, Bureau of Ocean Energy Management (BOEM), National Oceanic and Atmospheric Administration (NOAA)/National Marine Fisheries Service (NMFS), Clean Water Action, Energy Foundation, Anglers for Offshore Wind Power, Endeavor Fisheries
  - State: NJBPU, Environment NJ, Conserve Wildlife Foundation of NJ, New Jersey Conservation Foundation, ReThink Energy NJ, New Jersey Audubon, The Dawson Corporation, Clean Ocean Action, New Jersey Work Environment
  - Regional/Local: Monmouth University Urban Coast Institute, Montclair University Marine Biology and Coastal Sciences, NMFS Greater Atlantic Regional Fisheries Office, Point Pleasant Fishermen's Dock Co-Op and Farm Bureau, Stockton University Marine Field Station
- Stakeholder meeting #2 Commercial and Recreational Fisheries – March 1, 2019. Meeting participants included the following organizations:
  - Federal/National: BOEM, Lund's Fisheries, Sea Watch International, North Atlantic Clam Association, Sea Risk Solutions, NOAA Northeast Fisheries Science Center, Responsible Offshore Development Alliance, The Dawson Corporation, Fisheries Survival Fund
  - Statewide: NJBPU, Garden State Seafood Association, Surfside Foods, NJDEP Marine Shellfisheries Council, New Jersey Sea Grant Consortium
  - Regional/Local: Point Pleasant Fisherman's Dock Co-op, LaMonica Fine Foods, Viking Village, Inc., Rutgers University Marine Cooperative Extension
- Insight, input, and technical review by Rutgers, The State University of New Jersey
- Multiple reviews and commentary by NJDEP, including NJDEP's Marine Fisheries Administration on early versions, interim deliverables, and analysis
- Reviews and guidance by NJBPU
- Analysis and synthesis of available information by Ramboll team experts
- Collection of public comments

This environmental and natural resources technical appendix presents information regarding New Jersey's unique coastal ocean, which contextualizes the environmental and fisheries-focused analyses conducted herein. The document presents the approach and methodology associated with a weighted susceptibility analysis (WSA) (Section 2) and an unweighted resource evaluation (URE) (Section 3). Results of the analyses conducted are presented at the end of their respective Sections. Section 4 presents conclusions and recommendations based on the work conducted herein. Section 5 presents the references used in support of this work.

1.1 Key Context: New Jersey's Coastal Ocean

The ocean off the New Jersey coast is a highly dynamic system driven by a unique combination of winds, tides, freshwater outflow from local rivers and estuaries, and local bathymetry. Collectively these drivers lead to a distinctive ocean environment with an abundant and diverse suite of natural, social, and economic resources such as marine fauna, local beaches, and some of the most ideal physical settings for offshore wind development in the world (e.g., reliable wind, wide continental shelf, relatively shallow waters, proximity to population centers). New Jersey's coastal ocean is a special resource that requires continued stewardship for shared use and conservation of valued characteristics.

1.1.1 New Jersey's Ocean in Relation to Offshore Wind

The ocean off the New Jersey coast is well suited to support the development of an offshore wind industry. The reliable wind resource and broad shallow shelf are among the environmental factors that are unique aspects that facilitate the deployment of offshore wind farms. At the same time, these characteristics, when combined with other factors such as outflow from the many rivers and estuaries, drive an ocean environment that is significantly dynamic, particularly from season to season. For example, the same broad shallow shelf that facilitates the deployment of structures well offshore leads to an inter-seasonal surface water temperature swing that is among the largest in the global ocean and is unique compared with any prior large-scale deployment of offshore wind farms. The tight coupling between the ocean and atmosphere translates this variability to the local marine weather, including summertime sea breezes, tropical storms and frequent nor'easters, and coastal lows in the fall and winter. New Jersey's coastal ocean also has extensive biological resources that utilize and respond to the unique conditions and changes that occur in the study area. Additional detail regarding New Jersey's unique coastal ocean in relation to the development of offshore wind is provided below.

1.1.1.1 Circulation and Currents

On average, the circulation of the ocean waters off the New Jersey coast is characterized by a steady drift from Sandy Hook toward Cape May (Beardsley and Boicourt 1981). Using arrays of long-term moorings, Lentz (2008) showed that the depth averaged flow is aligned along the isobaths, with the exception of the Hudson Shelf Valley, where the mean flow is shoreward up the shelf valley. Beardsley et al. (1976) suggest that the current variability of the Mid-Atlantic Bight is mostly wind driven. Moores et al. (1976) show that the wind driving this variability is predominately from the west/northwest, except in the summer months, when the wind is typically from the southwest. Ou et al. (1981) continue to show observationally that the variability is composed of a wind forced component and a larger-scale free wave component that is not correlated with the wind and propagates down shelf.

High frequency radar surface current mapping technology has supported circulation research in the region, including nearshore studies off the coast of New Jersey (Kohut et al. 2004) and the seasonal variability of the shelf circulation (Castelao et al. 2008, Dzwonkowski et al. 2009, Dzwonkowski et al. 2010, Gong et al. 2010). A recent 10-year analysis of the regional high frequency radar data indicates that annual mean surface flows are generally toward the southwest, relatively stable year to year, and much weaker than the observed variability (Roarty et al., Submitted). Examining seasonal means from the same 10-year dataset exhibit similar current patterns, with winter and summer having a more cross-shore orientation while spring and fall transitions are more alongshore. Fall and winter mean current speeds are larger and correspond to a time when the mean winds are stronger and cross-shore. Summer mean currents are weakest and correspond to a time when the mean wind usually opposes the alongshore flow toward Cape May. Again, intra-annual variability is much greater than interannual, with the fall season exhibiting the most interannual variability in the surface current patterns.

1.1.1.2 Wind

On average, wind speeds range from about 9 to 10 meters per second (m/s) with winds strengthening further from shore, and further to the northeast. Figure 2 presents the mean wind speeds at 120 m. While on average there is a strong wind resource in New Jersey's coastal ocean, it is important to note that the wind resources in this area are highly variable on shorter timescales, and there exists strong day-to-day variability from one area to another. Some factors that contribute to this variability include the formation of sea and land breezes, the passage of storm systems, and local effects due to ocean variability (Glenn et al. 2016, Seroka et al. 2016, 2018). In particular, sea breezes frequently occur throughout the peak summer energy load period and can be a significant driver in the available wind resource throughout the lease areas off the coast of New Jersey and WEAs during the afternoon and evening hours, in addition to driving changes in the energy demand depending on the breadth and intensity of the sea breeze–driven temperature drop. Additionally, climate change may alter both the intensity and distribution of the wind resource during the multidecade life span of offshore wind farms.

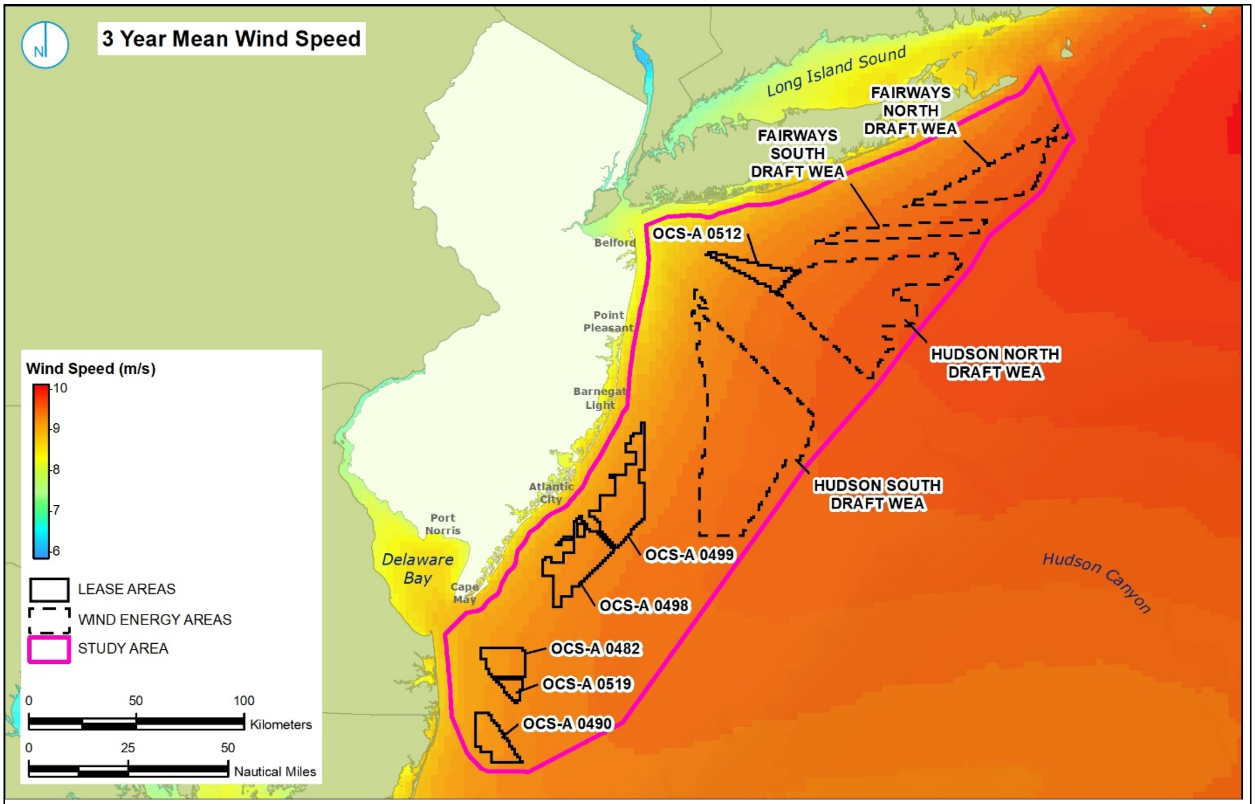
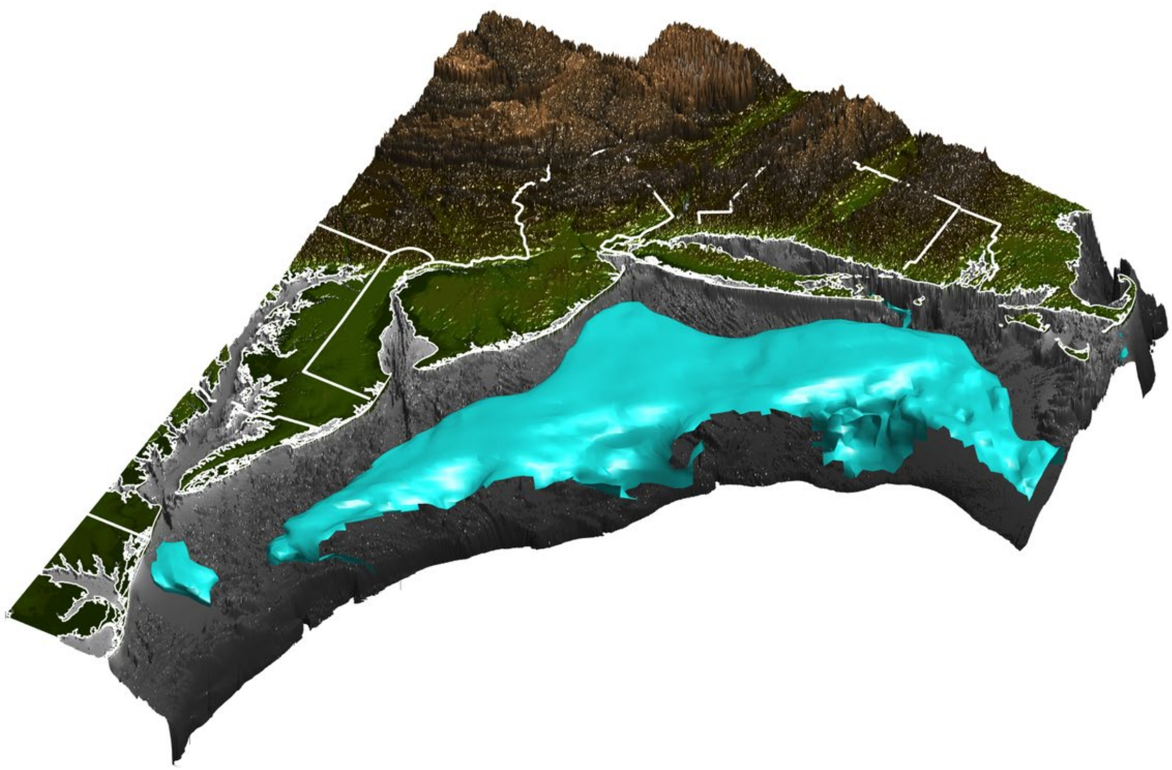


Figure 2: 3 Year Mean Wind Speed

1.1.1.3 Cold Pool

Seasonally, the study area experiences one of the largest temperature changes from summer to winter of any part of the ocean around the world. From winter to summer, swings in the surface temperature drive strong transitions in stratification, with cold, well-mixed conditions in the winter months and strongly stratified (layered) conditions during the summer (Houghton et al. 1982). In late spring and early summer, more sunlit hours and calmer winds heat the surface of the ocean. Ocean warming is limited to the surface, setting up a strong temperature gradient between the warmer surface and still-cold bottom waters, which isolates a continuous mid-shelf "cold pool" of water that extends from Nantucket to Cape Hatteras (Houghton et al. 1982). Local river discharge can augment this thermal stratification across most of the shelf (Chant et al. 2008) and provides pulses of nutrients and other material to the continental shelf of the Mid-Atlantic Bight. These riverine inputs are only a fraction of the supply from upstream sources delivered by a generally southwestward flow along the shelf (Fennel et al. 2006). In addition, upwelling along the coast occurs annually each summer. Upwelling is driven by southwest winds associated with the Bermuda High (Glenn et al. 2004, Glenn and Schofield 2003). Local upwelling can deliver cold pool water inshore and to the surface near the coast (Glenn et al. 2004). This upwelled water can drive the development of very large phytoplankton blooms that are advected offshore (Sha et al. 2015). The result is a unique ocean feature called the cold pool, a band of cold bottom water that extends the length of the Mid-Atlantic Bight from spring through early fall. During the summer, it moves along and across the shelf, providing cold water refuge for migrant species in the Mid-Atlantic Bight before more frequent storms break it apart in the fall. Since Offshore wind facilities have not yet been deployed in an ocean environment with a feature like the cold pool, it will be important that potential impacts to the annual formation, maintenance, and breakdown are investigated and considered in the planning and implementation of offshore wind. Figure 3 presents a visual representation of the cold pool.



Cold pool simulated by Dr. John Wilkin and visualized by Dr. Hugh Roarty and Mr. John Kerfoot (Rutgers University).

Figure 3: Modeled Cold Pool, 12°C on Aug. 10, 2013 01:00 UTC

1.1.1.4 Biological Resources

The intense ocean temperature variability off the New Jersey coast drives an equally variable ecosystem from the primary producers (Malone et al. 1988) to the highly migratory fisheries throughout the offshore wind lease areas. The tight coupling between the ocean conditions and the habitat preference of marine biota (including commercially and recreationally targeted species) leads to a species abundance and distribution that can greatly vary from season to season and year to year. Research has shown that many mobile marine species in the Mid-Atlantic Bight respond to changes in temperature in many ways—including changes in fecundity, mortality, migration patterns and timing, and stock distributions. For example, coupling an Atlantic butterfish (*Peprilus triacanthus*) thermal niche model to a 50 year ocean bottom temperature hindcast helped to narrow a previously wide confidence band in the stock assessment abundance indices for butterfish and establish a biological reference point by providing a better-defined estimate of catchability and therefore the understanding of stock history (NEFSC 2014).

In addition to gradual large-scale shifts in distribution with climate change, certain species have been known to disappear from the region for several years before returning. This scenario happened recently with the Atlantic mackerel (*Scomber scombrus*), which had been abundant in the region before becoming very sparse for a few years and then returning in high numbers. One contingent of this stock spawns in the Gulf of St. Lawrence before migrating south and mixing with a Mid-Atlantic Bight contingent (Studholme 1999). Thermal niche models coupled to ocean temperature hindcasts indicate that certain years, although they include favorable thermal habitat available in the Mid-Atlantic Bight, do not have a complete pathway of favorable thermal habitat connecting these northern spawning grounds to the Mid-Atlantic. This disconnect between habitat patches could help to explain in part why certain species may temporarily disappear from a region for several years, and it highlights the difficulty in predicting whether there will be optimal fishing in any specific area over the next few decades, especially for data-poor species such as mackerel.

Demersal fish, many of which are among recreational and commercial importance to New Jersey, utilize the continental shelf soft and hard bottom habitats for feeding and, during the winter, amass there to spawn during cross-shelf migrations. Some estuarine species such as summer flounder return to the ocean in late summer, with fine-scale timing variable as it is cued by local weather events (Sacket et al. 2007, 2008). Weakfish, bluefish, striped bass, drum, and smoothhound sharks also move between the estuary and shelf, as well as along the shelf (Grothues and Able 2007, Mann and Grothues 2009, Able et al. 2014, Turnure et al. 2015a, b). Winter flounder practice a migration inverse to that of summer flounder, spawning principally in estuaries in winter, but it appears that a contingent also remains on the shelf to spawn and that this contingent is becoming more important to reproduction as winter temperatures warm (Grothues et al. 2009, Grothues and Bochenek 2011, Able et al. 2014, Coleman 2015). Yellowtail flounder, winter flounder, summer flounder, fourspot flounder, and windowpane all co-occur with Atlantic sea scallops on the sandy bottom of Atlantic sea scallop beds, depending on season, along with several skate species (Grothues et al. 2017). The Atlantic sea scallop beds, especially those in the region of the cold pool, are important as nursery grounds for settling yellowtail flounder juveniles; thus, the recruitment of juveniles (as well as the distribution of adults) can vary greatly in response to the presence and strength of the cold pool (Sullivan et al. 2000, 2003, 2005, 2006).

Additionally, recreational fisheries for shark species, especially shortfin mako (*Isurus oxyrinchus*) and common thresher (*Alopis vulpinis*) on the continental shelf of the New York Bight represent significantly high value recreationally targeted species, especially considering costs of specialized fishing gear, vessels, and high-purse fishing tournaments. This is also the northern extent of pupping grounds for sand tiger (*Carcharius taurus*) and sand bar sharks (*Carcharhinus plumbeus*). All species of sharks and rays are electrosensitive, and elasmobranchs could sense EMFs when near the bottom, although observed responses are generally minor (NJDEP 2020).

The shellfish resources that occupy the bottom along the continental shelf are among the most important commercial fisheries in the United States, accounting for nearly 80% of the fisheries revenue. The Atlantic sea scallop (*Placopecten magellanicus)* is the second most valuable single species fishery in the United States, worth over $480 million in 2016, and the Mid-Atlantic commercial clam fisheries for Atlantic surfclam (*Spisula solidissima*) and ocean quahog (*Arctica islandica*) are stable year-round fisheries that land the second largest catch (by mass) in the region. The bivalve shellfish stocks are highly dependent on the unique oceanography of the Mid-Atlantic shelf, where strong stratification maintains relatively cold bottom water conditions over much of the year at latitudes further south than these boreal species typically occupy. Because these bivalve populations are mostly immobile as adults, the only way that they can shift spatially in response to changing ocean conditions is by larval dispersal (Zhang et al. 2015, 2016, Munroe et al. 2018), and on time frames that scale with their longevity that ranges from decades to centuries. Analysis by the NMFS Climate Vulnerability Assessment ranked Atlantic sea scallops, surfclams, and ocean quahogs particularly high in terms of overall climate vulnerability in the face of anticipated future changes in temperature, overall abundance, and benthic habitat (Hare et al. 2016). Atlantic sea scallops may be vulnerable on multiple fronts: their inshore distribution is limited by summer maximum bottom temperatures and the offshore extent of the distribution is probably limited by high recruit predation by sea stars (*Astropecten americanus*) which exists in deep water and its onshore distribution is limited by winter minimum bottom temperatures. Under this scenario, increased water temperatures would result in a contraction of Atlantic sea scallop distributions in the Mid-Atlantic Bight, with summer maxima isotherms moving offshore and winter minima isotherms moving inshore. This situation could have reverberating consequences for this highly valuable commercial resource. Changing bottom water conditions and consequent thermal stress has already been linked to observed changes in the fishable range of surfclams that have been occurring over the past two to three decades (Munroe et al. 2013, 2016, Narváez et al. 2015) and that have had tangible consequences for the commercial fishery (Powell et al. 2017).

The temperature dependence of so many fish species, coupled with the high variability of temperature in the region on a seasonal, interannual, and climate scale, suggests that Mid-Atlantic species of interest to commercial and recreational fishermen are likely to show significant variability in their distributions on both short and long timescales. This is confirmed by Nye et al. (2009), using NMFS survey data to show that several species in the Mid-Atlantic Bight have shifted northward and/or into deeper water with climate change over the past few decades. Certain species have also expanded or contracted their total occupied range in the region. As these population shifts continue to progress, fish currently exploited in the region may move into parts of the ocean they had not previously occupied, including those areas targeted for offshore wind development (particularly in deeper, cooler water). Furthermore, new warmer-water species may move into the region and support new commercial and recreational fishing interests.

1.1.1.5 Fishery Independent Sampling Programs

A number of fishery surveys occur off the coast of New Jersey. Fishery independent sampling (i.e., surveying) is essential for fisheries management. These long-running surveys inform stock assessments, ocean planning, climate science, and other vital programs. Fishery survey design is typically based on unrestricted access to the survey area for randomized site selection. These surveys will need to be adapted because of potential access limitations within the footprint of wind farms. Vessels may not be able to sample certain locations because of cables or turbines, or the survey vessel may not be able to operate its gear within wind farms at all depending on infrastructure spacing (e.g., the NOAA vessel R/V Bigelow, a 64 m vessel). The effort and expense of adapting surveys is not yet understood. At the federal level, NOAA Fisheries has established an internal working group to identify what will be required to adapt their surveys (listed below) in order to continue data collection in areas where offshore wind energy development occurs; however, a similar effort has not yet been initiated in New Jersey for state-sponsored surveys.

Federal Surveys

- NMFS Multispecies Bottom Trawl Survey
- NEFSC Atlantic Surfclam and Ocean Quahog Survey
- NEFSC Sea Scallop Survey
- VIMS Northeast Area Monitoring and Assessment Program (NEAMAP)
- Virginia Tech Horseshoe Crab Trawl Survey

State Surveys

- NJ Ocean Trawl Survey
- Inventory of NJ's Surf Clam Resources
- NJ Ventless Trap Survey

1.2 Analysis Conducted in Support of the OWSP

Two primary evaluations were conducted in support of the Environmental Protection and Commercial and Recreational Fisheries chapters of the New Jersey OWSP. The methods and assumptions used in conducting these planning-level analyses constitute the focus of this environmental and natural resources technical appendix.

The first evaluation is a weighted susceptibility analysis that examines key biological resources and specific taxonomic groups (e.g., birds, cetaceans, turtles) (Section 2). The second activity is an unweighted resource evaluation that depicts spatial fisheries data and other ocean uses within the study area relative to candidate wind development areas (i.e., lease areas, WEAs) (Section 3). The results of this body of work are anticipated to support decision-making and strategic planning as New Jersey achieves its offshore wind objectives by 2035. The objectives of the analyses conducted include the following:

- Expand the area of analysis from the NJDEP 2010 ecological baseline assessment (NJDEP 2010) to capture areas relevant to the existing leases, BOEM draft wind planning areas, and interstitial ocean between these areas from which New Jersey may procure offshore wind

- Identify biological resource and ocean use areas of higher and lower relative susceptibility to offshore wind development within the study area in the context of the state's goal of 7,500 MW of offshore wind and identify any significant data gaps
- Use the results to develop best management practices and identify the need for additional study, as well as development priorities and recommendations

This effort was conducted to identify the potential suitability of certain areas of New Jersey's coastal ocean for offshore wind development based on the relative susceptibility of certain resources to potential adverse effects, given existing and available data. The term "relative susceptibility" refers to the expected vulnerability of a resource group (e.g., birds, cetaceans) or habitat (e.g., essential fish habitat [EFH]), and ultimately these resources collectively, to offshore wind development at a specific location as compared with the vulnerability of the same resource throughout the entire New Jersey OWSP study area. Additional details regarding expected vulnerabilities are presented in Section 2.8.2.

The evaluation of environmental and natural resources and effects associated with offshore wind will be an iterative and adaptive process, and the OWSP recommends future studies and coordination through the existing Offshore Wind Environmental Resources Working Group to continue ongoing evaluations. Important aspects of the approach and assumptions used in these analyses are presented in greater detail below.

2. WEIGHTED SUSCEPTIBILITY ANALYSIS

This section presents the elements associated with the WSA conducted to support the Environmental Protection chapter of the OWSP. The WSA was applied to evaluate key biological resources and specific taxonomic groups (e.g., birds, cetaceans, turtles) for which suitable geospatial data are available. Suitable geospatial data are identified as data that are relevant, georeferenced and that do not require separate analysis/conversion prior to use.

Although the WSA and associated figures are intended to provide technical insights into the anticipated susceptibility of biota and fisheries activities to offshore wind development, it should be noted that these efforts reflect a broad overview, and not a comprehensive study of all available scientific information. This analysis provides information regarding the potential relative susceptibility of certain taxonomic groups, important fisheries, and other ocean resources to offshore wind development in the defined study area. Project-specific impacts associated with offshore wind farms are not evaluated here and will be evaluated thoroughly in respective environmental impact assessments for each project.

2.1 WSA Approach

This section describes the methodology, assumptions, and clarifications used to develop the WSAs. As introduced in the preceding section, a WSA was conducted to evaluate the relative susceptibility of biological resources and specific taxa to offshore wind development. "Weighting" means the application of a numerical adjustment factor that reflects the relative susceptibility of the resource group represented in a particular data layer; application of weighting values is discussed in Section 2.8. The term "relative susceptibility" refers to the vulnerability of a resource group (e.g., birds, cetaceans) or habitat (e.g., EFH), and ultimately these resources in whole, to offshore wind development at a specific location as compared with the vulnerability of the same resource or activity throughout the entire New Jersey OWSP study area. Assigned weights are intended to capture the overall "risk" to the resource, which is a function of both vulnerability and likelihood of occurrence.

Factors affecting vulnerability to offshore wind development include immobility, scarcity, sensitivity to certain activity (e.g., noise), economic importance, resiliency, and seasonality. The likelihood of occurrence qualitatively considers the chance that adverse effects happen, inclusive of existing federal stipulations, restrictions, and requirements that will be in place for a given resource. These requirements include federal lease stipulations such as vessel speed restrictions, marine mammal observers, noise restrictions, seasonal pile-driving restrictions, protected species reporting, lighting requirements, and exclusion zones for sighted species. A full list of the stipulations required by each BOEM lease can be found within the lease documents available on the BOEM website (BOEM 2020). The qualitative consideration of the chance for adverse effects does not include implementation of proposed recommendations for avoidance and minimization measures identified in the New Jersey Offshore Wind Strategic Plan, which are likely to be implemented but not guaranteed.

The susceptibility analysis used a weighted sum spatial overlay analysis of various taxonomic groups, each with individually weighted component layers ("ArcGIS Help" 2020). Weighted sum modeling facilitates rescaling among data layers by adjusting layer values relative to others according to a defined project-specific rubric and is one of the most common approaches for suitability modeling. This methodology has been used in similar marine spatial planning applications, such as the New York State Offshore Wind Master Plan (NYSERDA 2017), which evaluated and compared several modeling methods. Spatial overlay analysis allows examination of the relationship between assigned susceptibilities of resource layers relative to the other layers used in the same analysis. Esri's ArcMap and specific geographic information system (GIS) tools therein (e.g., projecting, clipping, and raster calculator) that were used to perform this analysis are described in the following sections.

WSA was conducted for the following biological resources:

- Specific taxonomic groups (e.g., birds, cetaceans)
- Sensitive habitats (e.g., EFH, artificial reefs)
- Endangered Species Act (ESA)–listed species (e.g., North Atlantic right whale [NARW] - *Eubalaena glacialis*)
- Species that have significant economic importance to New Jersey and for which abundance and distribution data are readily available (i.e., Atlantic surfclam [*Spisula solidissma*], ocean quahog [*Arctica islandica*], Atlantic sea scallop [*Placopecten magellanicus*])

The key outputs from the WSA are spatial overlay mapping products that reflect relative susceptibility of biological resources within the study area.

2.2 Modeling Area

As presented in Section 1, the study area for the purposes of the OWSP includes New Jersey's coastal ocean outside of the 3-mile state jurisdictional boundary (Figure 1). This area is inclusive of the currently identified offshore wind lease areas and candidate WEAs in proximity to the State of New Jersey. Figure 1 presents the boundaries and locations of leases and WEAs.

Offshore wind leases off the coast of New Jersey (south to north):

- OSC-A 0490 (US Wind Inc.)
- OCS-A 0519 (Skipjack Wind Farm)
- OCS-A 0482 (GSOE I, LLC)
- OCS-A 0498 (Ocean Wind)
- OCS-A 0499 (Atlantic Shores Offshore Wind, LLC)
- OCS-A 0512 (Boardwalk/Empire Wind)

Draft WEAs (south to north):

- Hudson South draft WEA
- Hudson North draft WEA
- Fairways South draft WEA
- Fairways North draft WEA

2.3 Layer Selection

The WSA analysis builds upon the above-described already existing baseline data and modeling products available to the public and resource agencies. In general, spatial data layer selection was guided by a literature/online data repository review, as well as coordination with NJBPU and NJDEP.

Layer selection also included the identification of certain species listed as threatened or endangered under the Endangered Species Act (ESA). Additional priority species were identified based on the recognition of their importance to New Jersey's commercial fisheries. In general, only existing spatial data layers that cover the study area were utilized. Layers that were available in digital format and with substantially continuous/complete spatial coverage were considered for use in the WSA. Substantially continuous/complete coverage means data within the study area where extensive data interpolations would not be needed. Extensive interpolations were deemed to increase uncertainty of the analyses to an unacceptable extent (i.e., value of the analyses would be considerably diminished). Data was obtained from various sources that had differing scales and systems of measurement. In Section 2.4, data sources are described in their original units which were all subsequently converted to meters for standardization in the analysis.

Raw data (such as species sighting records) or nonspatial data were not used because the data were not suitable for the analysis. Data layers that cover species groups (and therefore increase the pool of species evaluated) were prioritized over individual species where that information was available. Where data layers were available for ESA-listed species, individual species-specific layers were included, since effects to individuals can have more pronounced adverse effects. During stakeholder outreach, information on important spatial areas (i.e., for incorporation as discrete polygons within the study area) was identified as a need. Feedback from stakeholders suggested that the data sources and repositories that had been reviewed (e.g., the Mid-Atlantic Regional Council on the Ocean [MARCO]'s Mid-Atlantic Ocean Data Portal) already contained this user-specific data. Table 1 shows the layers included in the analysis. Individual layers included in the analysis are presented in greater detail in the following section.

Table 1: Weighted Susceptibility Analysis Data Layer Sources

Environmental Group	Specific Layer	Listed Species and Designated Habitats	Source(s)	Units	Notes
Birds	Roseate tern	ESA listed	Curtice et al. 2019	Abundance - total relative number of individuals per strip transect segment	No critical habitat has been designated for this species
	Higher displacement sensitivity	-			Species in this list were identified by MDAT Curtice et al. 2019 as having higher sensitivity to displacement by offshore wind
	Higher collision sensitivity	-			Species in this list were

Table 1: Weighted Susceptibility Analysis Data Layer Sources

Environmental Group	Specific Layer	Listed Species and Designated Habitats	Source(s)	Units	Notes
					identified by MDAT Curtice et al. 2019 as having higher sensitivity to collision by offshore wind
	All species	-			
Fish	Atlantic sturgeon	ESA listed	Curtice et al. 2019	Sum of average annual interpolated biomass (inverse distance weighted fish biomass [kg] per 4 km^2)	Critical habitat is outside the study area
	Demersal species	-			
	Species with designated EFH	-			
	Highly migratory species	-			
	All species				
Cetaceans	Blue whale	ESA listed	Curtice et al. 2019	Abundance - predicted animals per 100 km^2 (10 km x 10 km grid)	
	Fin whale				
	Sei whale				
	Sperm whale				
	North Atlantic right whale				Critically endangered
	All species	-			
Sea Turtles	Loggerhead turtle	ESA listed	NAMERA 2010	Sightings per unit effort (SPUE)	Critical habitat is outside the study area
	Leatherback turtle				Critical habitat is outside the study area
	Green sea turtle				Critical habitat is

Table 1: Weighted Susceptibility Analysis Data Layer Sources

Environmental Group	Specific Layer	Listed Species and Designated Habitats	Source(s)	Units	Notes
					outside the study area
Habitat	Essential fish habitat	Designated EFH	TNC and NOAA 2015	Number of species/life stages with EFH in cell	
	Essential fish habitat highly migratory species	Designated EFH	NROC 2015		
	Artificial reefs	-	NJDEP DFW MFA	Area boundaries	
Benthic Invertebrates	American lobster	-	Curtice et al. 2019	Sum of average annual interpolated biomass (inverse distance weighted fish biomass [kg] per 4 km^2)	
	Horseshoe crab	-			
	Jonah crab	-			
	Atlantic sea scallops	-			
	Sea star	-	SMAST 2016	Abundance - average number of animals/10 km^2	
	Crab	-			
	Hermit crab	-			
	Moon snail	-			
	Atlantic surfclam	-	NMFS NEFSC	Expanded catch weight (lbs)	Provided by NJDEP
	Ocean quahog	-			Provided by NJDEP

Notes:

See Table 2 for species included in composite species layers

EFH = essential fish habitat

Following identification and selection of individual layers reflecting important priorities listed above, these layers were categorized to reflect collections of biological resources of broad resource/taxonomic groups. The categorization consolidated 30 individual layers of data into six biological resource subgroups as follows: 1) birds, 2) cetaceans, 3) sea turtles, 4) fish, 5) habitat, and 6) benthic invertebrates. Additional detail on the data used to assess these subgroups is summarized below. The data sources are discussed in depth in Section 2.4.

- The birds subgroup includes data layers reflecting avian relative abundance information, displacement sensitivity, and data on the ESA-listed roseate tern (*Sterna dougllii*), sourced from the Marine-Life Data and Analysis Team (MDAT) technical report (Curtice et al. 2019).

- Fish as a subgroup are evaluated using data layers reflective of biomass for 82 species, with additional focus on those species with designated EFH and an individual data layer dedicated to the evaluation of Atlantic sturgeon (*Acipenser oxyrhynchus*). All data used in the evaluation of this subgroup are sourced from the MDAT technical report (Curtice et al. 2019).
- The cetaceans subgroup is represented by abundance for 34 species and layers reflecting ESA-listed species. Data for this subgroup are from the MDAT technical report (Curtice et al. 2019).
- The subgroup sea turtles is comprised of data layers for individual ESA-listed species loggerhead (*Caretta caretta*), leatherback (*Dermochelys coriacea*), and green sea (*Chelonia mydas*) turtles based on sightings per unit effort as presented in the Northwest Atlantic Marine Ecoregional Assessment (Greene 2010).
- The habitat subgroup is comprised of data layers reflecting number of species and life stages for designated EFHs and EFH highly migratory species, area boundaries for marine conservation focal areas, NARW habitats, and artificial reefs. These layers are sourced from The Nature Conservancy (TNC) and NOAA (2015), the Northeast Regional Ocean Council (NROC) (Shmookler 2015), NJDEP Division of Fish and Wildlife (NJDEP DFW) (2017), and the Department of Commerce (DOC) and NMFS (2018b).
- The subgroup benthic invertebrates is evaluated as multiple data layers conveying the density of Atlantic sea scallops and other select benthic invertebrates per 10 km^2 obtained from the University of Massachusetts at Dartmouth School of Marine Science and Technology (School of Marine Science and Technology [SMAST] 2016). Atlantic surfclam and ocean quahog data from the NMFS Northeast Fishery Science Center (NEFSC), provided by the NJDEP DFW were also incorporated into the benthic invertebrates subgroup. This data reflected a raster density of 100 x 100 ft, which was converted to metric units consistent with other data within the WSA. The MDAT technical report (Curtice et al. 2019) fisheries data are also used for specific benthic invertebrates.

Table 2 shows the specific species that are included in any layers that contain multiple species (composite species layers).

Table 2: Composite Species Layers

Environmental Group	Specific Layer	Source(s)	Individual Species in Layer
Birds	Higher displacement sensitivity	Curtice et al. 2019	Arctic tern, Atlantic puffin, Black guillemot, Black scoter, Bridled tern, Common eider, Common loon, Common murre, Common tern, Great black-backed gull, Long-tailed duck, Manx shearwater, Northern gannet, Razorbill, Red-throated loon, Roseate tern, Sooty tern, Surf scoter, Thick-billed murre, and White-winged scoter
	Higher collision sensitivity		Arctic tern, Atlantic puffin, Audubon's shearwater, Black guillemot, Black scoter, Black-legged kittiwake, Bridled tern, Common eider, Common loon, Common murre, Common tern, Cory's shearwater, Double-crested cormorant, Great black-backed gull, Great shearwater, Great skua, Herring gull, Horned grebe, Laughing gull, Leach's storm petrel, Long-tailed duck, Manx shearwater, Northern fulmar, Northern gannet, Parasitic jaeger, Pomarine jaeger, Razorbill, Red phalarope, Red-breasted merganser, Red-necked phalarope, Red-throated loon, Roseate tern, Sooty shearwater,

Table 2: Composite Species Layers

Environmental Group	Specific Layer	Source(s)	Individual Species in Layer
			Sooty tern, South polar skua, Surf scoter, Thick-billed murre, White-winged scoter, and Wilson's storm petrel
	All species		Arctic tern, Atlantic puffin, Audubon's shearwater, Band-rumped storm petrel, Black guillemot, Black scoter, Black-capped petrel, Black-legged kittiwake, Bonaparte's gull, Bridled Tern, Brown pelican, Common eider, Common loon, Common murre, Common tern, Cory's shearwater, Double-crested cormorant, Dovekie, Great black-backed gull, Great shearwater, Great Skua, Herring gull, Horned grebe, Laughing gull, Leach's storm petrel, Least tern, Long-tailed duck, Manx shearwater, Northern fulmar, Northern gannet, Parasitic Jaeger, Pomarine jaeger, Razorbill, Red phalarope, Red-breasted Merganser, Red-necked phalarope, Red-throated loon, Ring-billed gull, Roseate tern, Royal tern, Sooty shearwater, Sooty Tern, South Polar Skua, Surf scoter, Thick-billed Murre, White-winged scoter, and Wilson's storm petrel
Fish	Demersal species	Curtice et al. 2019	Acadian redfish, American plaice, Atlantic cod, Atlantic halibut, Atlantic Wolffish, Barndoor skate, Black sea bass, Clearnose skate, Cunner, Fourspot flounder, Goosefish, Haddock, Little skate, Longhorn sculpin, Ocean pout, Offshore hake, Pollock, Red hake, Rosette skate, Scup, Sea raven, Silver hake, Smooth skate, Spotted hake, Summer flounder, Tautog, Thorny skate, White hake, Windowpane, Winter flounder, Witch flounder, and Yellowtail flounder
	Species with designated EFH		Acadian redfish, American plaice, Atlantic cod, Atlantic halibut, Atlantic herring, Atlantic mackerel, Atlantic Wolffish, Barndoor skate, Black sea bass, Bluefish, Butterfish, Clearnose skate, Goosefish, Haddock, Little skate, Longfin squid, Northern shortfin squid, Ocean pout, Offshore hake, Pollock, Red hake, Rosette skate, Scup, Sea scallop, Silver hake, Smooth skate, Spiny dogfish, Summer flounder, Thorny skate, Tilefish, White hake, Windowpane, Winter flounder, Winter skate, Witch flounder, and Yellowtail flounder
	Highly migratory species		Atlantic Sharpnose Shark, Sand tiger
	All species		Acadian redfish, Alewife, American eel, American lobster, American plaice, American shad, Atlantic cod, Atlantic croaker, Atlantic halibut, Atlantic herring, Atlantic mackerel, Atlantic menhaden, Atlantic sharpnose shark, Atlantic sturgeon, Atlantic torpedo, Atlantic wolffish, Banded drum, Barndoor skate, Bay anchovy, Black sea bass, Blackbelly rosefish, Blueback herring, Bluefish, Bluntnose stingray, Bullnose ray, Butterfish, Clearnose skate, Cunner, Cusk, Fourspot flounder, Goosefish, Gulf stream flounder, Haddock, Hickory shad, Horseshoe crab, Jonah crab, Little skate, Longfin squid, Longhorn sculpin, Northern shrimp, Northern kingfish, Northern pipefish, Northern puffer, Northern searobin, Northern shortfin squid, Ocean pout, Offshore Hake, Pigfish,

Table 2: Composite Species Layers

Environmental Group	Specific Layer	Source(s)	Individual Species in Layer
			Pinfish, Pollock, Red hake, Rosette skate, Roughtail stingray, Round herring, Sand Lace, Sand tiger, Scup, Sea raven, Sea scallop, Silver hake, Smooth dogfish, Smooth skate, Southern stingray, Spiny butterfly ray, Spiny dogfish, Spotted hake, Spot, Striped anchovy, Striped bass, Striped searobin, Summer flounder, Tautog, Thorny skate, Tilefish, Weakfish, White hake, Windowpane, Winter flounder, Winter skate, Witch flounder, and Yellowtail flounder
Cetaceans	All species	Curtice et al. 2019	Atlantic spotted dolphin, Atlantic white-sided dolphin, Blainville's beaked whale, Blue whale, Bottlenose dolphin, Bryde's whale, Clymene dolphin, Cuvier's beaked whale, Dwarf sperm whale, False killer whale, Fin whale, Fraser's dolphin, Gervais' beaked whale, Harbor porpoise, Humpback whale, Killer whale, Long-finned pilot whale, Melon-headed whale, Minke whale, North Atlantic right whale, Northern bottlenose whale, Pantropical spotted dolphin, Pygmy sperm whale, Risso's dolphin, Rough-toothed dolphin, Sei whale, Short-beaked common dolphin, Short-finned pilot whale, Sowerby's beaked whale, Sperm whale, Spinner dolphin, Striped dolphin, True's beaked whale, and White-beaked dolphin
Habitat	Essential fish habitat	TNC and NOAA 2015	American plaice, Atlantic cod, Atlantic halibut, Atlantic herring, Atlantic sea scallop, Atlantic wolffish, Barndoor skate, Black sea bass, Bluefish, Butterfish, Clearnose skate, Haddock, Little skate, Longfin inshore squid, Mackerel, Monkfish, Northern shortfin squid, Ocean pout, Offshore hake, Pollock, Quahog, Redfish, Red crab, Red hake, Rosette skate, Scup, Silver hake, Smooth skate, Spiny dogfish, Surfclam, Summer flounder, Tilefish, Thorny skate, White hake, Windowpane flounder, Winter flounder, Winter skate, Witch flounder, and Yellowtail flounder
	Essential fish habitat highly migratory species	NROC 2015	Albacore tuna, Angel shark, Atlantic sharpnose shark, Basking shark, Bigeye thresher shark, Bigeye tuna, Bignose shark, Blacknose shark, Blacktip shark, Bluefin Tuna, Blue Marlin, Blue shark, Bonnethead shark, Bull shark, Caribbean reef shark, Common thresher shark, Dusky shark, Finetooth shark, Great hammerhead shark, Lemon shark, Longbill spearfish, Longfin mako shark, Night shark, Nurse shark, Oceanic whitetip shark, Porbeagle roundscale spearfish, Shark, Sailfish, Sandbar shark, Sand tiger shark, Scalloped hammerhead shark, Shortfin mako shark, Silky shark, Skipjack tuna, Smooth dogfish, Spinner shark, Swordfish, Tiger shark, Whale shark, White marlin, White shark, and Yellowfin tuna

The spatial data comprising subgroups discussed above are presented individually in Figures 8-33 in Section 2.6. Other sources used in the evaluation of biological resources subgroups and layer selection that were consulted but not specifically mentioned above include the following:

- New Jersey Department of Environmental Protection (NJDEP). 2010. Ocean/Wind Power Ecological Baseline Studies. Volumes 1 through 4. Prepared by: Geo-Marine, Inc. https://www.nj.gov/dep/dsr/ocean- wind/index.htm
- NOAA. 2018. New Jersey Special Management Zone Areas. Office for Coastal Zone Management. https://www.greateratlantic.fisheries.noaa.gov/sustainable/species/bsbass/12_special_management_zones.html
- Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS). 2018. Speed Restrictions and Recommended Lanes to Protect North Atlantic Right Whales. https://portal.midatlanticocean.org/static/data_manager/metadata/html/SMA_all_po.html#2
- NOAA. 2013. Deep Coral Predictive Habitat Modeling in the U.S. Atlantic and Gulf of Mexico: Focusing on Uncharted Deep-Sea Corals. https://coastalscience.noaa.gov/project/deep-coral-habitat-modeling-atlantic-gulf-mexico/
- New Jersey Ocean Trawl Data. The NJDEP Marine Fisheries Administration (MFA) routinely conducts ocean trawl surveys off the New Jersey coast. The ocean trawl data contain valuable information that should help inform the sustainable implementation of offshore wind off the New Jersey coast. However, the data provided did not have sufficient spatial coverage over the OWSP study area (Figure 4) and are limited to the 30-meter depth contour. Input from MFA regarding the trawl survey will be critical in identifying important considerations for future iterations of that ongoing research such that its integrity is maintained, and results can be used to further assess the relationship of certain resources and development of offshore wind.

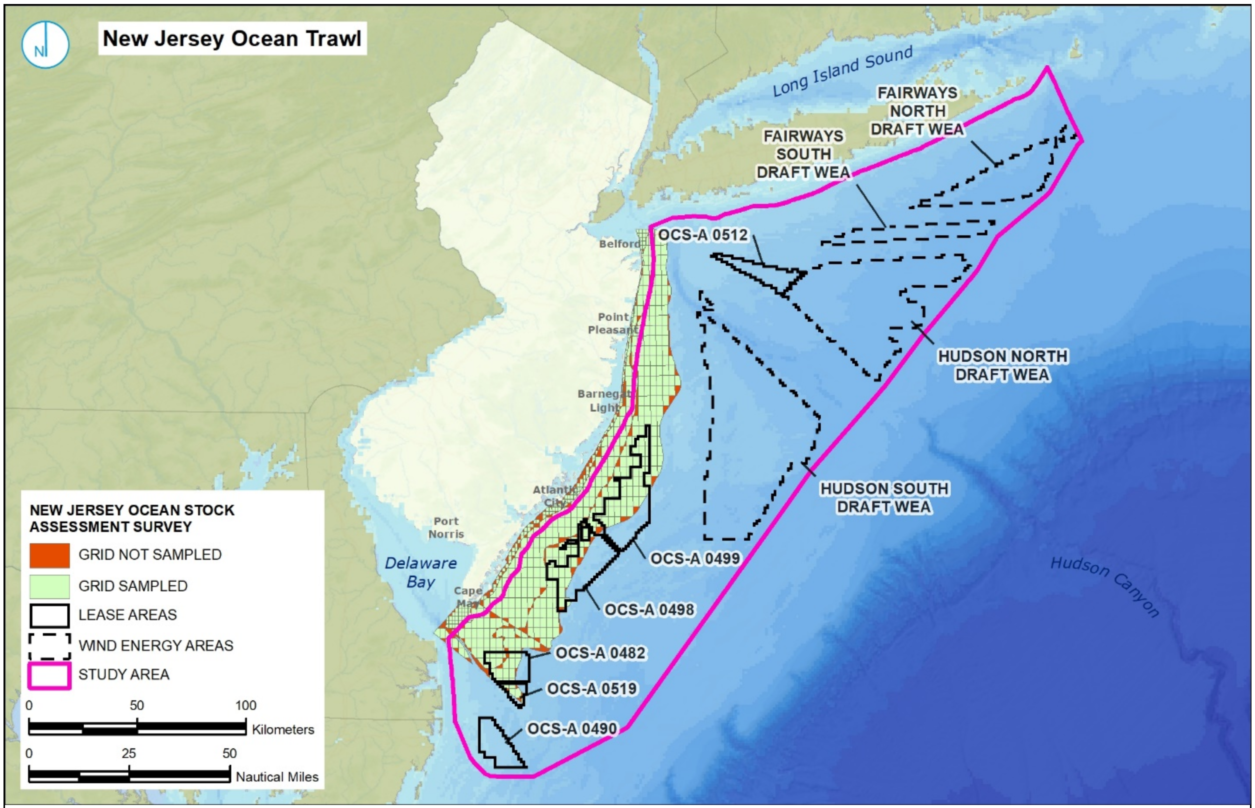


Figure 4: New Jersey Ocean Trawl

2.4 WSA Data Sources

The WSA is a compilation of data sources from several surveys and studies that were used to develop resource layers for incorporation into the analysis. This section discusses the data sources with the intent of facilitating an understanding of the data collection, compilation, interpolation, and/or summary methods used by the source reports. Only data sources used for the WSA are included in this section. For more detailed information, please refer to the technical source reports cited.

2.4.1 Curtice et al. 2019

The technical report on the methods and development of marine-life data to support regional ocean planning and management was developed by Curtice et al. (2019) on behalf of the MDAT. The MDAT is comprised of the Marine Geospatial Ecology Lab of Duke University, NROC, the NOAA National Centers for Coastal Ocean Science (NCCOS), the NOAA NEFSC, and Loyola University Chicago.

The MDAT developed “base layer” distribution products (individual species map layers) for cetacean, avian, and fish species. Cetacean and avian data were habitat-based density estimates that incorporated physical and biological habitat parameters. Fish data were based on original bottom trawl data and were influenced by recommendations from working groups and other experts. Cetacean abundance products show predicted abundances of animals on an annual and monthly or seasonal basis. Avian relative density products show how abundant of a given species is predicted to be in one area on an annual and seasonal basis. Fish products show biomass in kilograms per tow for fall and spring and are not meant to be used to determine absolute fish biomass hotspots

The MDAT report clarifies that individual base layers are not well served to develop a general understanding of the overall richness or diversity in a particular area but may be thought of as a "reference library" to be viewed when detailed research is required for agency decision-making. MDAT's "summary" products are comprised of layers from multiple species and distill hundreds of layer and time combinations into more simplified layers. All-species layers were created by combining individual species layers. Important caveats to note are that group-level products were created from annual prediction models, and groups may be dominated by one or a few species of very high abundance or biomass, which are often not species of particular concern. The GIS data from this report was downloaded from http://seamap.env.duke.edu/models/mdat/ (March 2020). The following describes the information that was utilized from the MDAT report, how the MDAT compiled summary project layers, and how the layers were incorporated into the WSA analysis.

Avian Species

Data Overview: A comprehensive synthesis of models and data on marine and coastal birds was used to develop long-term average predictive maps of marine bird relative density. Relative density results are the long-term average relative abundance of individuals per unit area. These data should not be used to infer absolute density because of the collection and compilation methodology of the survey data. Rather, these data can be used to evaluate how many more of a certain species are likely to be in a certain area relative to other areas. For avian summary layers, the long-term relative density results were first normalized by their mean values; therefore, summary products essentially weighted each species' contribution equally.

Avian species data cover the US exclusive economic zone for the East Coast in a 2 kilometer (km) x 2 km grid. The MDAT report uncertainty maps show that although model predictions span the entire exclusive economic zone, more survey data are nearer to the coast than further offshore, suggesting offshore predictions are supported by fewer data. Temporal coverage ranges from 1978-2016 and is defined by seasons as the following:

- Winter: December 1 to February 28/29
- Spring: March 1 to May 31
- Summer: June 1 to August 31
- Fall: September 1 to November 30

When creating the species summary layers (e.g., all-species layer, highly displacement/collision sensitive layers), MDAT first normalized individual species layers by their mean values, essentially "weighting" each species' contribution equally. Total relative abundance maps were calculated by stacking individual species' predicted annual long-term average relative density layers and summing the values, resulting in total predicted long-term average relative abundance of all individuals in that cell. Therefore, these products reflect relative abundance, not predicted absolute abundance. For example, the higher displacement sensitivity species group areas with highest relative abundance values are areas where species that are most vulnerable to displacement due to offshore wind energy development tend to be most abundant. The avian total relative abundance data are reported as total relative number of individuals per strip transect segment. Avian total relative density is based on normalized individual species annual relative density distributions. This normalization reduces the effect of large predicted populations in these layers.

Layer Usage: The WSA uses all-species, higher displacement sensitivity, higher collision sensitivity, and roseate tern layers from this dataset. Several species appear in two or more of these layers, resulting in these species having a higher representation in the analysis. Of the avian species layers used in the WSA, 41% of the species appear in all three of the summary layers, and 83% appear in two or more layers. The roseate tern appears in all four layers incorporated in the WSA, which was considered appropriate due to its status as a federally listed endangered species. The repeated representation of some species across layers indicates their importance as protected species or as susceptible to offshore wind effects. The redundancy in representation of some species was considered conservative.

Fish Species

Data Overview: The MDAT fish species products are based on NEFSC fisheries-independent bottom trawl survey data from four sources. The fish species products are representations of the original trawl data, as opposed to the avian and cetacean data from MDAT, which show abundance and distribution. The fisheries trawl data come from four sources (NEFSC, North East Areas Monitoring and Assessment Program [NEAMAP], Massachusetts Division of Marine Fisheries [MDMF], and Maine and New Hampshire state trawls) but mostly rely on the NEFSC trawling data. It should be noted that biomass is dependent on vessel and gear type, which has been standardized across federal survey vessels but not between state and federal surveys. Thus, all biomass abundance estimates are relative, with unknown selectivity across species and locations. The trawl data were converted from kilograms per tow to an inverse distance weighted interpolation surface. (Note: Data were transformed using a cubic root prior to interpolation.) The interpolation considered bathymetry by using depth as a third dimension of distance.

NEFSC trawl surveys were conducted in spring 2010-2017 and fall 2010-2016 and spatially range from Cape Hatteras, North Carolina to the Gulf of Maine. The records for fall 2017 were removed because of incomplete coverage. The fish species data cover 99.9% of the WEAs and 95.1% of the study area. See the Data Gaps section (Section 2.5) for a visualization of data coverage. The biomass values were established by interpolation using inverse distance weighting and modified depending on bathymetry. Layers for individual years were averaged to produce a spring and fall plot for each species.

The MDAT created total biomass maps (for all species and for species groups) by stacking each individual species' inverse distance weighted interpolation layers and summing the values of the pixels, resulting in the total interpolated biomass of all individuals of the included species. The fish total biomass data are shown as the sum of the average annual interpolated biomass for all species and for all tows in each grid cell (2 km x 2 km).

Layer Usage: The WSA uses all-species, species with designated EFH, demersal species, highly migratory species, and Atlantic sturgeon layers. Several species appear in two or more of these layers, resulting in these species having a higher representation in the analysis. Of the fish species layers used in the WSA, 32% of the species appear in all four of the multispecies layers, and 56% appear in two or more layers. The repeated representation of some species across layers indicates their importance as protected species or as susceptible to offshore wind effects. The redundancy in representation of some species was considered conservative.

The data presented in the report by Curtice et al. (2019) utilized the NOAA NEFSC groundfish survey, may not fully capture the habitat usage of New Jersey coastal waters species frequently found elsewhere in the water column such as Atlantic mackerel (*Scomber scombrus*) and menhaden

(*Brevoortia tyrannus*). These species may not be adequately represented in the WSA. The WSA also uses data from the MDAT fish layers for the benthic species analysis. The individual species layers for American lobster (*Homarus americanus*), horseshoe crab (Limulidae), and Jonah crab (*Cancer borealis*) were used to contribute more species to the benthic subgroup analysis.

Cetaceans

Data Overview: Comprehensive cetacean habitat-based density surface models were created for all species sighted at least once during NOAA abundance surveys of the East Coast. Species with too few sightings to model a density surface were fitted with a "stratified density model," which estimated abundances with traditional distance sampling methodology. The densities for these species were assumed to be uniform throughout each stratum (geographic area). In addition, some species had too few sightings to fit individual detection function, in which case sightings were pooled with sightings from other species that exhibit similar detectability ("proxy species"). For more information on the cetacean layer modeling, please refer to the MDAT report.

Cetacean model data sources ranged from 1992-2016; they are on a monthly basis when possible and on an annual basis when the data do not support a monthly resolution. The cetacean data fully cover the WEAs and study area.

The MDAT created total abundance maps (for all species and for species groups) by stacking individual species' predicted annual abundance layers and summing the values of the cells, resulting in total predicted abundance for all individual species in that cell. The cetacean total abundance data are shown as predicted animals per 100 km^2.

Layer Usage: The WSA analysis uses the all-species, blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), and NARW layers from this dataset. The individual species layers are also included in the all-species layer, resulting in their double inclusion in the WSA. The blue whale species layer was modeled by MDAT using a stratified density model (as explained above) and therefore has a uniform density.

2.4.2 SMAST 2016

The dataset was prepared by the University of Massachusetts Dartmouth School of Marine Science and Technology (SMAST) and NROC in April 2016. The data are comprised of average presence (for the sand dollar [*Echinarachnius parma*], bryozoans or hydrozoans, and sponges) or abundance (for Atlantic sea scallops, sea stars [Asteroidea], crabs [Brachyura], hermit crabs [Paguroidea], moon snails [Naticoidea], flatfish [Pleuronectiformes], red hake [*Urophycis chuss*], and skate [Rajidae]). Average presence and abundance are reported for each cell from the New England Fishery Management Council Swept Area Seabed Impact (SASI) model from 2003-2012. The GIS data from this report were downloaded from https://www.northeastoceandata.org/data-download/ (March 2020).

Data Overview: The data were collected via the University of Massachusetts Dartmouth SMAST video survey, which covered the continental shelf from the southern Mid-Atlantic to the US-Canadian border. The video cameras were lowered to the seafloor on 1.6 km to 5.6 km grids and provided 2.84 m^2 and 0.60 m^2 quadrat images of the seafloor. Four quadrats were collected at each station (allowing the vessel to drift 50 m in between). Within each quadrat, macroinvertebrates and fish were counted and the substrate was identified. The SMAST data were assigned to SASI model grid cells, and the values from each station were combined to create an average and standard deviation value for each SASI cell. Abundance was calculated for species that had more than one species present in the majority of cells, while presence was calculated for rare or isolated species. Both abundance and presence were averaged across time.

Temporally the data show average presence and abundance from 2003-2012. Spatially, the data mostly cover the OWSP study area, with some gaps at the edges of some of the lease areas. The following lease areas lack complete spatial coverage at the edges: OCS-A 0499, OCS-A 0498, OCS-A 0482, OCS-A 0519, OCS-A 0490, and Fairways North draft WEA. In order to preserve data quality obtained from SMAST, the data were not extrapolated to reach the edges of the WEAs or study area. The SMAST data cover 86.2% of the study area and 94.9% of the WEAs. See the Data Gaps section (Section 2.5) for a visual representation of the SMAST data coverage.

Layer Usage: The data were downloaded as one layer with attributes for the various species. The layer was separated by attribute to create individual layers for each species to be weighted in the WSA. The WSA uses the SMAST dataset for the benthic organisms subgroup. Refer to the data standardization section (Section 2.5) for details on the manipulation of the SMAST data.

2.4.3 NAMERA 2010

Data Overview: Geospatial data for loggerhead, leatherback, and green sea turtles were collected by the US Navy's Marine Resource Assessment (MRA) (originally collected by the NMFS-NEFSC) via aerial and shipboard surveys during daylight hours. The study used effort-corrected sightings data to overcome potential survey bias. It calculated sightings per unit effort (SPUE), allowing spatial and temporal comparison of the data. The GIS data from this report were downloaded from https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/marine/namera/namera/Pages/Spatial-Data.aspx (March 2020).

SPUE are calculated as:

$$SPUE = \frac{1000 * (number\ of\ animals\ sighted)}{Effort}$$

The data fully cover the OWSP study area. The Navy Northeast MRA fully covers the entire study area from 1979-2003. The seasons were defined as follows:

- Winter: January-March
- Spring: April-June
- Summer: July-September
- Fall: October-December

Layer Usage: The WSA uses loggerhead, leatherback, and green sea turtle data layers from this data source. The data are provided in SPUE, which serve as a proxy for relative abundance while allowing for spatial comparisons within the study area.

2.4.4 New Jersey Department of Environmental Protection Atlantic Surfclam/Ocean Quahog (NJDEP)

Data Overview: The NJDEP-provided Atlantic surfclam and ocean quahog data that were comprised of point data reflecting trawl survey collections. Density heat maps for Atlantic surfclam and ocean quahog were created by the NJDEP Marine Fisheries Administration using data from the NOAA

Fisheries-NEFSC Atlantic surfclam and ocean quahog survey. Raw survey data for the years 2012, 2015, and 2018 were obtained from NEFSC and subset of the data was selected using NEFSC staff-recommended criteria for representative tows. Expanded catch data were used which are fishery-independent data, and factors such as dredge size, length of tow, and vessel speed can vary from commercial vessels. Density values for the heat map are evenly distributed between the lowest and highest recorded catch. Note that commercial viability cannot be inferred from these density values, and "low" density should not be interpreted as poor fishing. The density heat map was created by NJDEP using a kernel density interpolation tool. The GIS data from this report were provided by NJDEP to Ramboll in the fall of 2019 and incorporated as received into the analysis.

The surveys were conducted in 2012, 2015, and 2018. Spatially, the interpolated surface covers the study area; however, a quarter or more of the study area have zero values. The ocean quahog layer has nonzero raster data values for 74.8% of the study area, while the Atlantic surfclam has nonzero raster data values for 68.1% of the study area. Area of zero density, particularly in the southern portion of the study area, may represent absence of sampling rather than lack of species presence.

Layer Usage: The data provided by NJDEP are used in the benthic organisms subgroup of the WSA. Refer to Section 2.7 for details regarding the standardization of the benthic subgroup input layers.

2.4.5 The Nature Conservancy and National Oceanic and Atmospheric Administration 2015

Data Overview: EFH is defined as those waters and substrate necessary for fish for spawning, breeding, feeding, or growth to maturity. Geospatial data for EFHs were obtained from NOAA survey data (analyzed by TNC) that were originally developed for the MARCO web mapping portal. The data include the 39 species managed by NMFS in the Northeast and Mid-Atlantic. The following species are included: American plaice (*Hippoglossoides platessoides),* Atlantic cod (*Gadus morhua*), Atlantic halibut (*Hippoglossus hippoglossus*), Atlantic herring (*Clupea harengus*), Atlantic sea scallop (*Placopecten magellanicus*), Atlantic wolffish (*Anarhichas lupus*), barndoor skate (*Dipturus laevis*), black sea bass (*Centropristis striata*), bluefish (*Pomatomus saltatrix*), tilefish (spp.), butterfish (*Peprilus triacanthus*), clearnose skate (*Raja eglanteria*), haddock (*Melanogrammus aeglefinus*), little skate (*Leucoraja erinacea*), longfin inshore squid (*Doryteuthis pealeii*), Atlantic mackerel (*Scomber scombrus*), monkfish (*Lophius americanus*), northern shortfin squid (*Doryteuthis pealeii*), ocean pout (*Zoarces americanus*), offshore hake (*Merluccius albidus*), Atlantic pollock (*Pollachius pollachius*), quahog (*Mercenaria mercenaria*), acadian redfish (*Sebastes fasciatus*), red crab (*Paralithodes camtschaticus),* red hake (*Urophycis chuss*), rosette skate (*Leucoraja garmani*), scup (*Stenotomus chrysops*), silver hake (*Merluccius bilinearis*), smooth skate (Anacanthobatidae), spiny dogfish (*Squalus acanthias*), Altantic surfclam (*Spisula solidissima*), summer flounder (*Paralichthys dentatus*), thorny skate (*Amblyraja radiata*), white hake (*Urophycis tenuis*), windowpane flounder (*Scophthalmus aquosus*), winter flounder (*Pseudopleuronectes americanus*), winter skate (*Leucoraja ocellate*), witch flounder (*Glyptocephalus cynoglossus*), and yellowtail flounder (*Limanda ferruginea*) (March 2020).

The feature class was provided in 10-minute x 10-minute rectangles and converted to metric units (approximately 14.3 km x 18.5 km) that completely cover the study area. Since biological/ocean current data are dynamic, the positional accuracy of these resources should be considered approximate. The data were published in February 2015.

Layer Usage: The EFH data were used for the habitat subgroup of the WSA. Refer to Section 2.7 for information regarding how this layer was merged with other habitat layers.

2.4.6 NROC 2015

Data Overview: The dataset for EFH for highly migratory species was prepared for the Northeast Regional Ocean Council (NROC) for broad-scale visualization to support coastal and ocean planning. Highly migratory species are fish such as tuna, sharks, and swordfish that live and migrate throughout the Atlantic Ocean and Gulf of Mexico. The source datasets included records denoting EFH for different life stages, which were merged together to create a single feature that represented a species in any of its life stages. The dataset shows the number of species that have overlapping EFH in a given area. These data include 42 highly migratory species EFH datasets from NMFS as of the publication date. The data are presented as total number of species that have EFH in an area. Species represented in this product are albacore tuna (*Thunnus alalonga*), angelshark (*Squalus squatina*), Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), basking shark (*Cetorhinus maximus*), bigeye thresher shark (*Alopias superciliosus*), bigeye tuna (*Thunnus obesus*), bignose shark (*Carcharhinus altimus*), blacknose shark (*Carcharhinus acronotus*), blacktip shark (*Carcharhinus limbatus*), bluefin tuna (*Thunnus thynnus*), blue marlin (*Makaira nigricans*), blue shark (*Prionace glauca*), bonnethead shark (*Sphyrna tiburo*), bull shark (*Carcharhinus leucas*), Caribbean reef shark (*Carcharhinus perezii*), common thresher shark (*Alopias vulpinus*), dusky shark (*Carcharhinus obscurus*), finetooth shark (*Carcharhinus isodon*), great hammerhead shark (*Sphyrna mokarran*), lemon shark (*Negaprion brevirostris*), longbill spearfish (*Tetrapturus pfluegeri*), longfin mako shark (*Isurus paucus*), night shark (*Carcharhinus signatus*), nurse shark (*Ginglymostoma cirratum*), oceanic whitetip shark (*Carcharhinus longimanus*), porbeagle roundscale spearfish (*Tetrapturus georgii*), shark (spp.), Atlantic sailfish (*Istiophorus albicans*), sandbar shark (*Carcharhinus plumbeus*), sand tiger shark (*Carcharias taurus*), scalloped hammerhead shark (*Sphyrna lewini*), shortfin mako shark (*Isurus oxyrinchus*), silky shark (*Carcharhinus falciformis*), skipjack tuna (*Katsuwonus pelamis*), smooth dogfish (*Mustelus canis*), spinner shark (*Carcharhinus brevipinna*), swordfish (*Xiphias gladius*), tiger shark (*Galeocerdo cuvier*), whale shark (*Rhincodon typus*), white marlin (*Kajikia albida*), white shark (*Carcharodon carcharias*), and yellowfin tuna (*Thunnus albacares*). The GIS data from this report were downloaded from https://portal.midatlanticocean.org/data-catalog/conservation/ (March 2020). These data completely cover the OWSP study area. The EFH boundaries are current as of August 2014.

Layer Usage: The EFH highly migratory species data were used for the habitat subgroup of the WSA. Refer to Section 2.7 for information regarding how this layer was merged with other habitat layers.

2.4.7 NJDEP Open Data

Data Overview: The dataset for artificial reefs was published by the NJDEP in October 2019. The layer is also used in conjunction with the other New Jersey recreational fishing layers in the URE (Section 3). The Division of Fish and Wildlife Marine Fisheries Administration (MFA) created the updated digital Prime Fishing Grounds Map through direct interviews with recreational fishing boat captains during the summer of 2003 (28 party boat captains, 47 charter boat captains, and 22 private boat captains from each fishing port along the coast of New Jersey). The interview method consisted of the captains' editing previously created fishing ground charts (home port charts and charter boat charts), usually expanding the areas. In 2018, the Prime Fishing Grounds Map was updated to include 17 artificial reef sites and updated home port charts. The data fully cover the study area.

Layer Usage: The artificial reefs data were used for the habitat subgroup of the WSA. Refer to Section 2.7 for information regarding how this layer was merged with other habitat layers.

2.5 Data Gaps

Stakeholders defined priority resources as ESA-listed species and commercially important species during the Environmental Roundtable Discussion held on March 1, 2019 at Rutgers University (Environmental Roundtable Discussion 2019). For this evaluation, data gaps are identified where no appropriate spatial information is publicly available for a priority resource (Table 3).

Table 3: Data Gaps for Weighted Susceptibility Analysis

Subgrouping	Resource	Data Gap Rationale
Birds	Piping plover [1]	No usable distribution data,[2] ESA-listed species
	Red knot [1]	No usable distribution data, ESA-listed species
Fish	Shortnose sturgeon	No usable distribution data, ESA-listed species
Other mammals	Pinnipeds	No useable distribution data
	Bats [3]	No useable distribution data
Sea turtles	Hawksbill turtle	No usable distribution data, ESA-listed species
	Kemp’s Ridley turtle	No usable distribution data, ESA-listed species

[1] Piping plover (*Charadrius melodus*) and red knot (*Calidris canutus [rufa]*) typically forage along coastal margins in the manner characteristic of many shorebird species. It is acknowledged that this preferred habitat is outside of the study area; however, these species are identified as potential data gaps due to their conservation listing and potential in-flight occurrence within the lease/WEAs.

[2] “No usable distribution data” is not intended to suggest a total absence of information in the scientific literature. Rather, it indicates only that readily available information in the public domain that was suitable for use in the WSA was not identified.

[3] Bat activity is shown to decrease as distance from shore increases and is greatest between July 15th and October 15th (Peterson et al. 2016).

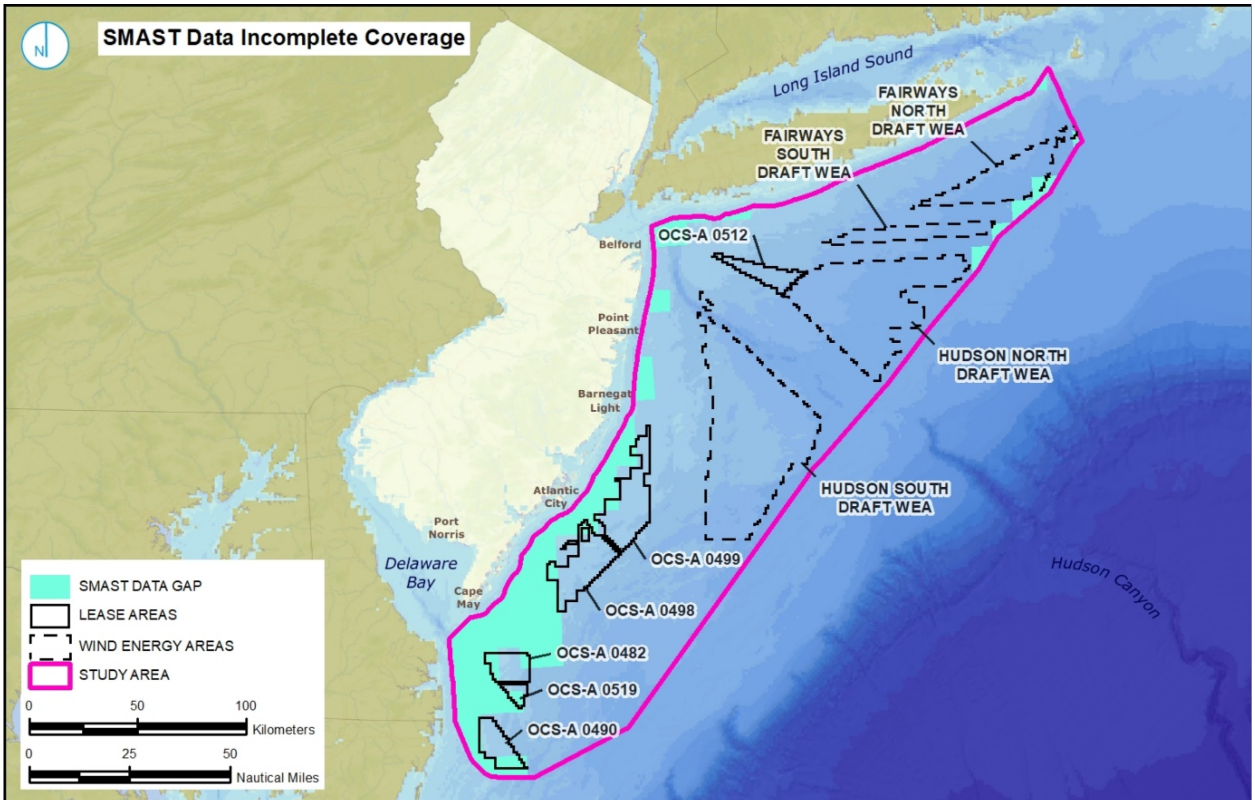


Figure 5: SMAST Data Incomplete Coverage

In several cases, some GIS data are available and useable, but with incomplete coverage within the study area. The SMAST dataset, used for the benthic species subgroup, has incomplete data coverage particularly within the southwestern portion of the OWSP study area. Figure 5 shows the area of the OWSP that the SMAST data do not fully cover. These data gaps (shown in teal in Figure 5) overlap with portions of OCS-A 0499, 0498, 0492, 0519, and 0490, as well as the Fairways North draft WEA. The SMAST data cover 86.2% of the study area and 94.9% of the WEAs. This incomplete coverage is incorporated into the interpretation of the benthic invertebrate subgroup weighted analysis figure (Figure 39 in Section 2.10.6) and the overall environmental susceptibility summary figure (Figure 40 in Section 2.10.7).

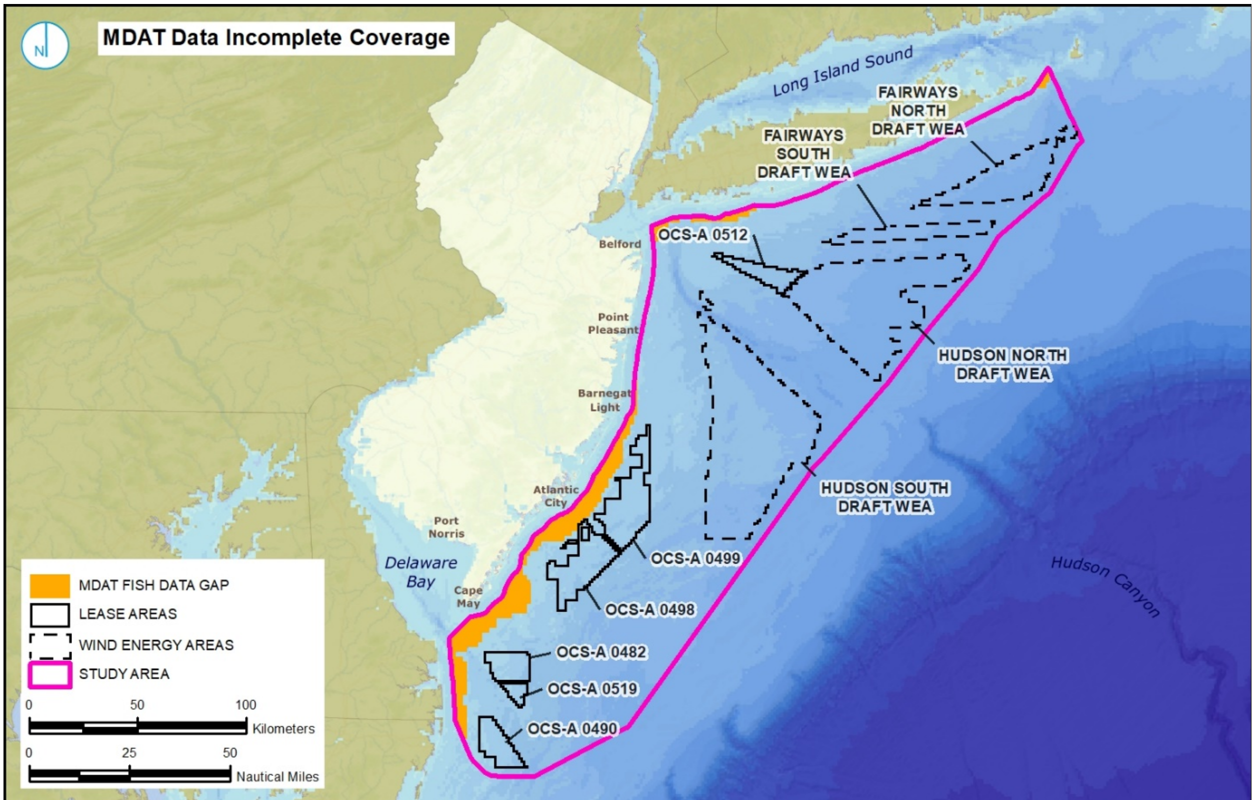


Figure 6: MDAT Data Incomplete Coverage

The MDAT fish species data also have incomplete coverage in the area along the coast of southern New Jersey. Figure 6 shows the area that this dataset does not cover (in orange). The fish species data cover 99.9% of the WEAs and 95.1% of the study area. This incomplete coverage is incorporated into the interpretation of the fish and benthic invertebrate subgroups weighted analysis figure (Figures 35 and 39 in Section 2.10.2 and 2.10.6) and the environmental summary figure (Figure 40 in Section 2.10.7).

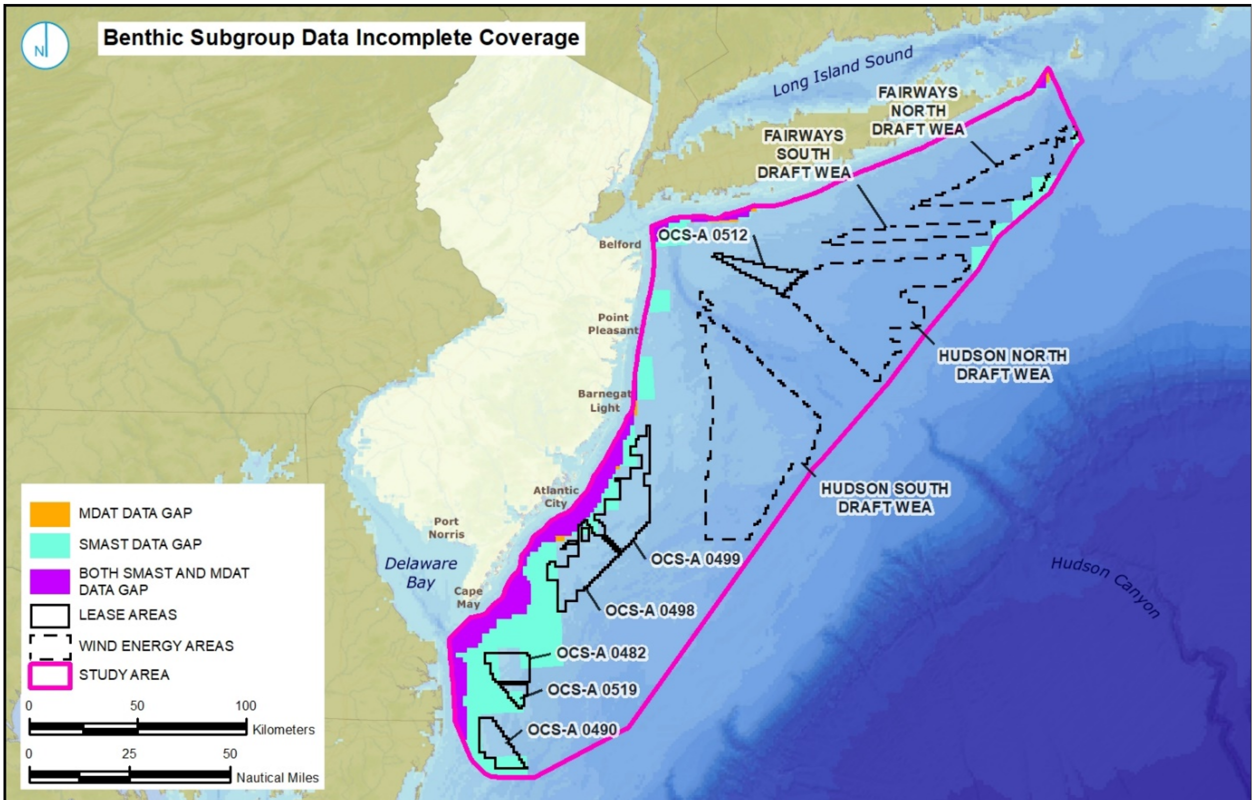


Figure 7: Benthic Subgroup Data Incomplete Coverage

Both of the datasets with incomplete coverage discussed above are used in the benthic subgroup analysis. Figure 7 shows their combined lack of coverage and represents total data gaps for the benthic species subgroup. This incomplete coverage is incorporated into the interpretation of the benthic invertebrate subgroups weighted analysis (Figure 39 in Section 2.10.6) and the environmental summary figure (Figure 40 in Section 2.10.7).

2.6 Individual Layers

This section presents additional details and depictions of the component data layers utilized for each subgroup described in Section 2.3.

2.6.1 Birds Subgroup Inputs

Bird subgroup input layers display avian abundance data from the MDAT avian abundance technical report. Relative density model results are the long-term average relative abundance of individuals per unit area. The data was provided by the MDAT in a grid consisting of 2 km x 2 km cells.

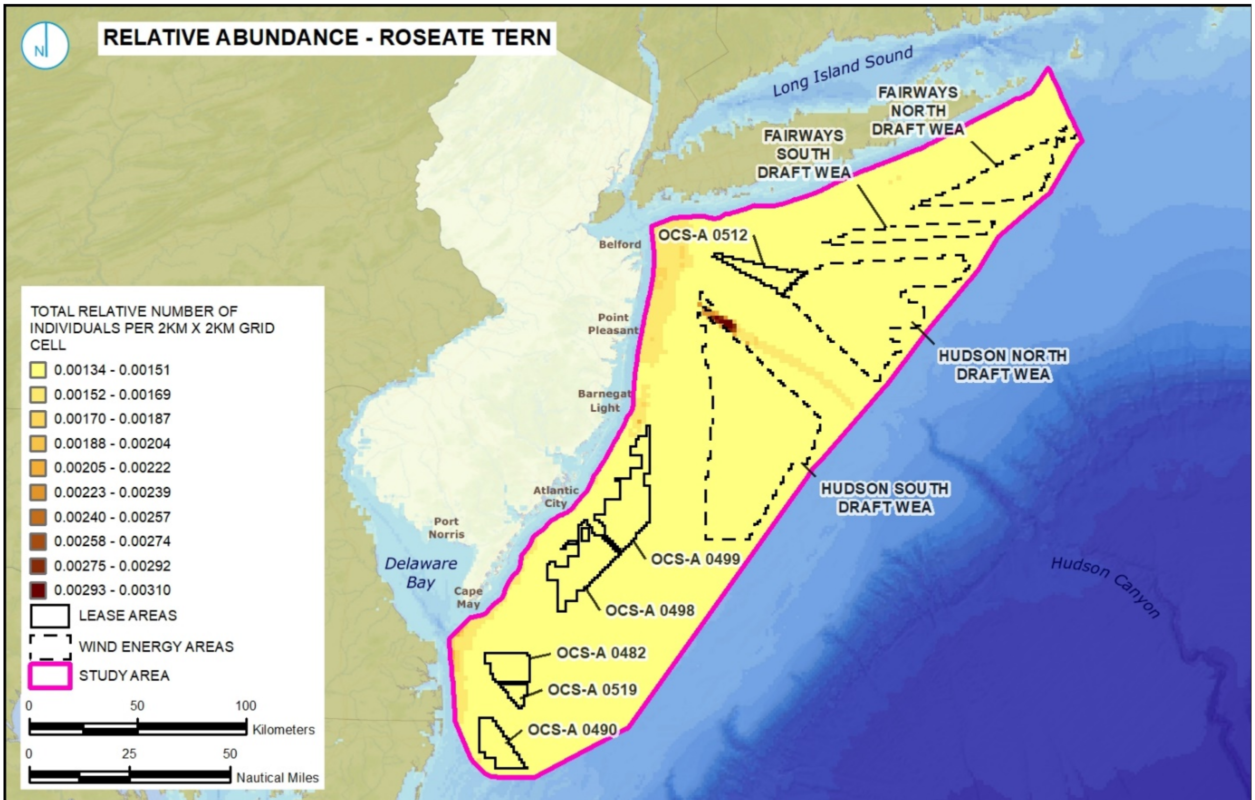


Figure 8: Relative Abundance - Roseate Tern

<u>Key Points:</u> Roseate tern data indicate extremely low annual relative densities in offshore areas, including existing wind lease areas and WEAs within the study area. There is a small area within the Hudson Canyon (generally between the Hudson South Draft WEA and OCS-A 0512) that has a higher relative abundance within the lease area. However, the total relative number of individuals per grid cell (2 km x 2 km) is still very small (~0.003 individuals per grid cell).

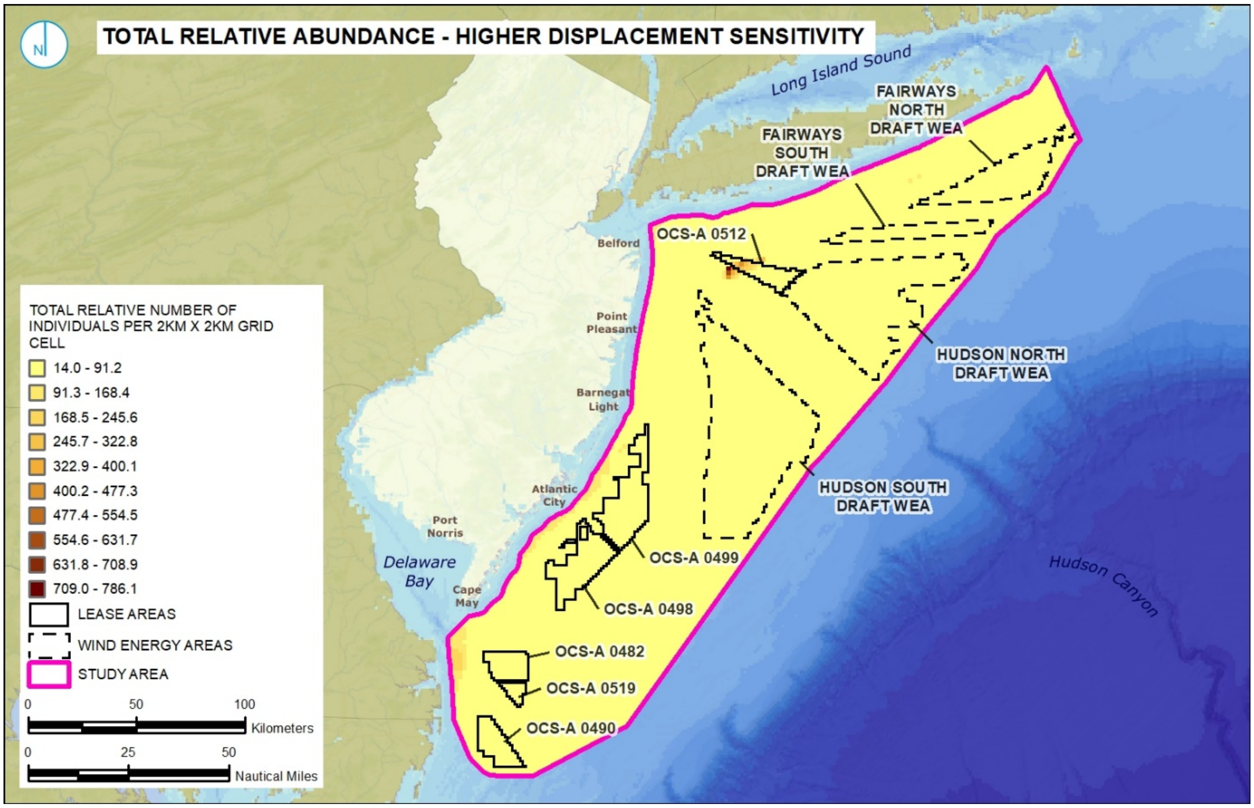


Figure 9: Total Relative Abundance – Higher Displacement Sensitivity

Key Points: Total relative abundance data for higher displacement sensitive species data indicate extremely low annual relative densities in offshore areas, including existing wind lease areas and WEAs within the study area. Table 2 shows the list of displacement-sensitive birds included in this susceptibility analysis. There is a small area of higher relative abundance within OCS-A 0512, with cell values in the 300-400 range (relative number of individuals per 2 km x 2 km grid cell).

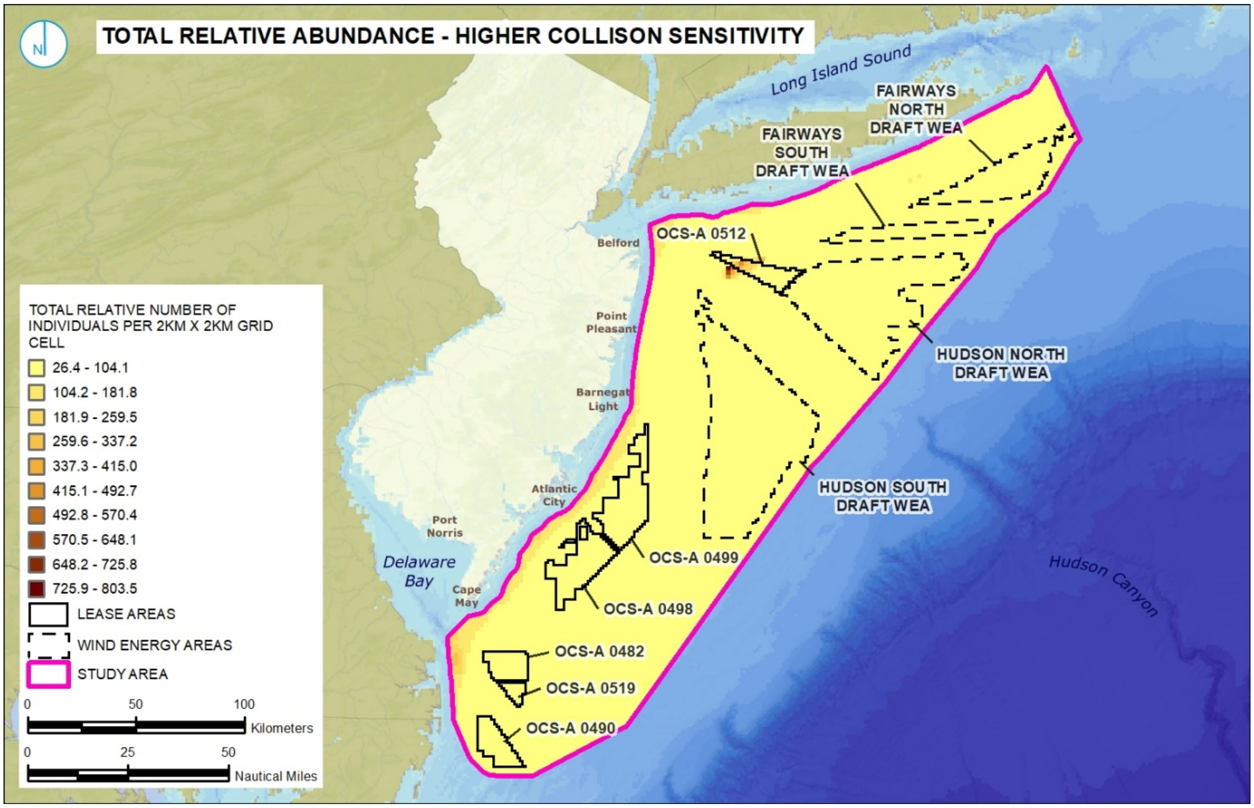


Figure 10: Total Relative Abundance – Higher Collision Sensitivity

<u>Key Points:</u> Total relative abundance data for higher collision sensitive species data indicate extremely low annual relative densities in offshore areas, including existing wind lease areas and WEAs within the study area. There is a small area of higher relative abundance within OCS-A 0512, with cell values in the 300-400 range (relative number of individuals per 2 km x 2 km grid cell). This trend is nearly identical to the higher displacement sensitivity trend discussed in Figure 9. The similarity between higher displacement and higher collision layers is expected because of similar included species. There are more species included in the higher collision sensitivity layer than the higher displacement sensitivity layer. See Table 2 for a list of included species for each layer.

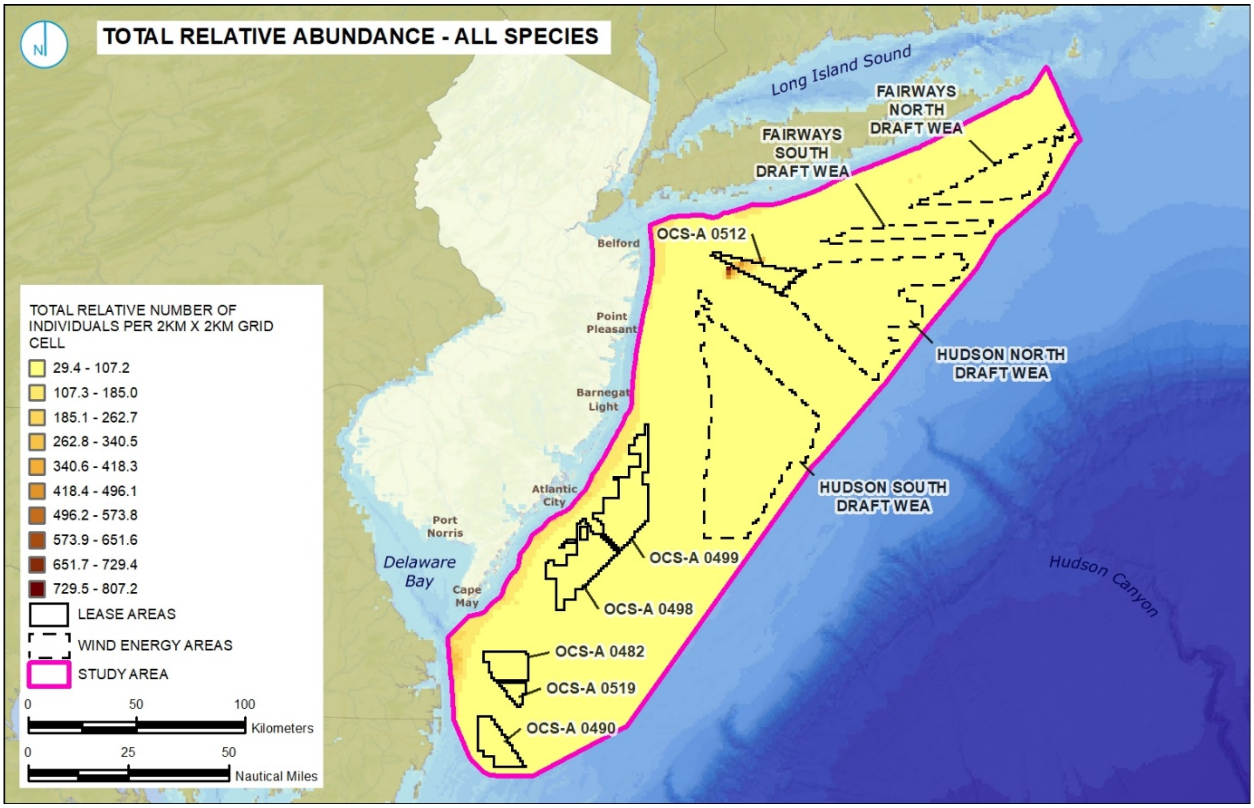


Figure 11: Total Relative Abundance – All Species

Key Points: Total relative abundance data for higher collision susceptible species data indicate extremely low annual relative densities in offshore areas, including existing wind lease areas and WEAs within the study area. There is a small area of higher relative abundance within OCS-A 0512, with cell values in the 200-300 range (relative number of individuals per 2 km x 2 km grid cell). This layer is very similar to the higher collision and higher displacement susceptible species layers discussed above. Again, this is due to similar species inclusion between layers. See Table 2 for a list of included species for each layer.

2.6.2 Fish Subgroup Inputs

Fish subgroup input layers show average annual interpolated total species biomass from the MDAT fish abundance technical report. The biomass values can be interpreted as abundance. Data are displayed as provided in the Northwest Atlantic Marine Ecoregional Assessment report. Figure 16 shows average annual interpolated total species biomass for all tows in a 2 km x 2 km resolution, as provided by the MDAT.

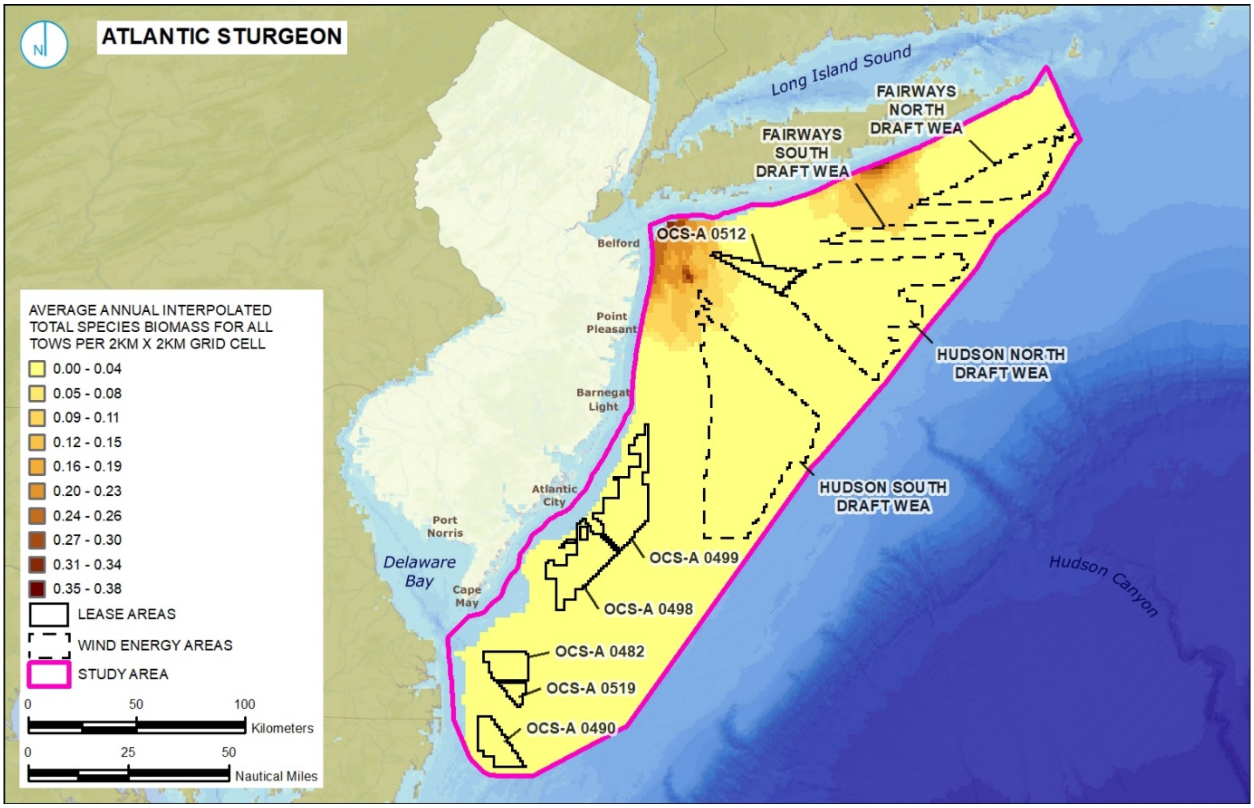


Figure 12: Atlantic Sturgeon

Key Points: Interpolated biomass throughout the majority of the study area, including existing lease areas and WEAs, is low. The highest areas of abundance occur in relative proximity to shore within the northwestern corner of the study area associated with the Hudson Shelf Valley. An area of higher abundance exists off the coast of Long Island near the Fairways South and North draft WEAs. No lease areas or draft WEAs have noteworthy Atlantic sturgeon abundance.

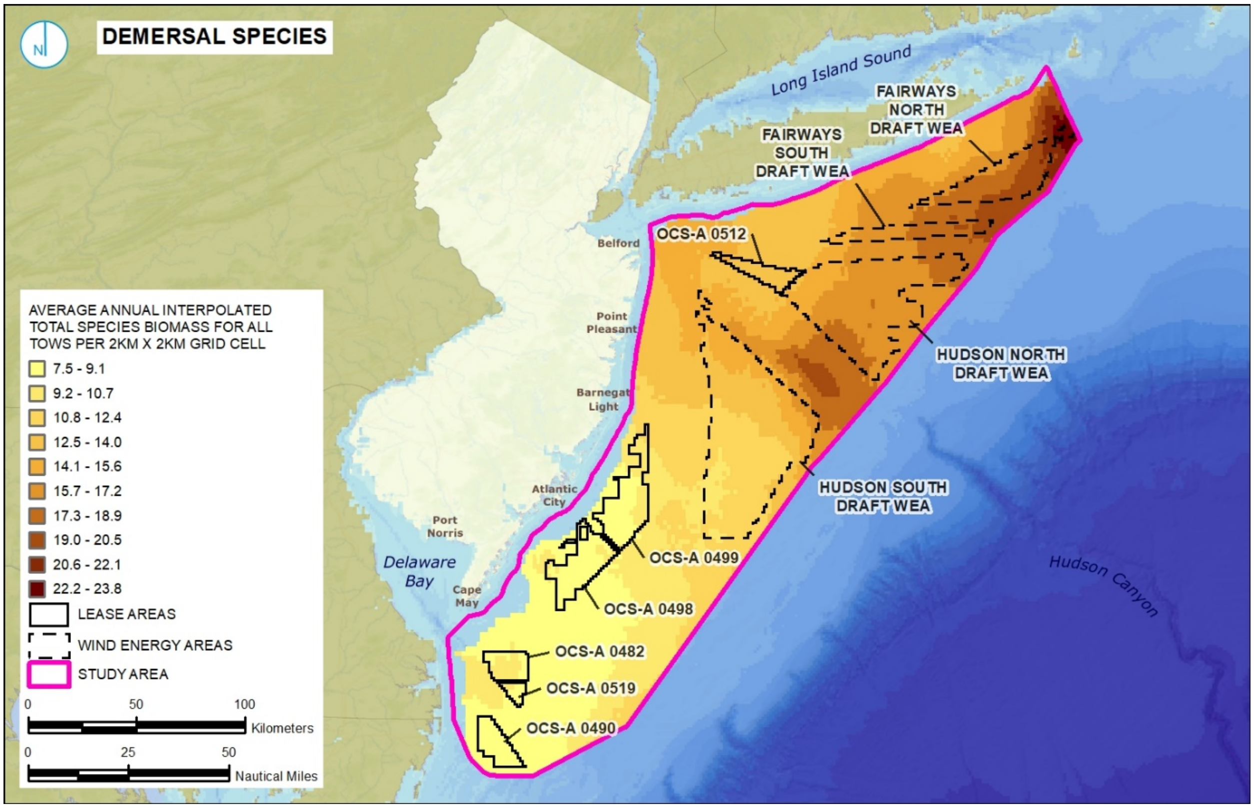


Figure 13: Demersal Species

<u>Key Points:</u> Interpolated biomass increases from south to north within the OWSP study area. The five southern lease areas are least affected by demersal species prevalence. There are areas of higher abundance within the Hudson Canyon and on the eastern portions of the Hudson North draft WEA and the Fairways North and South draft WEAs, with the Fairways North draft WEA having the highest abundances.

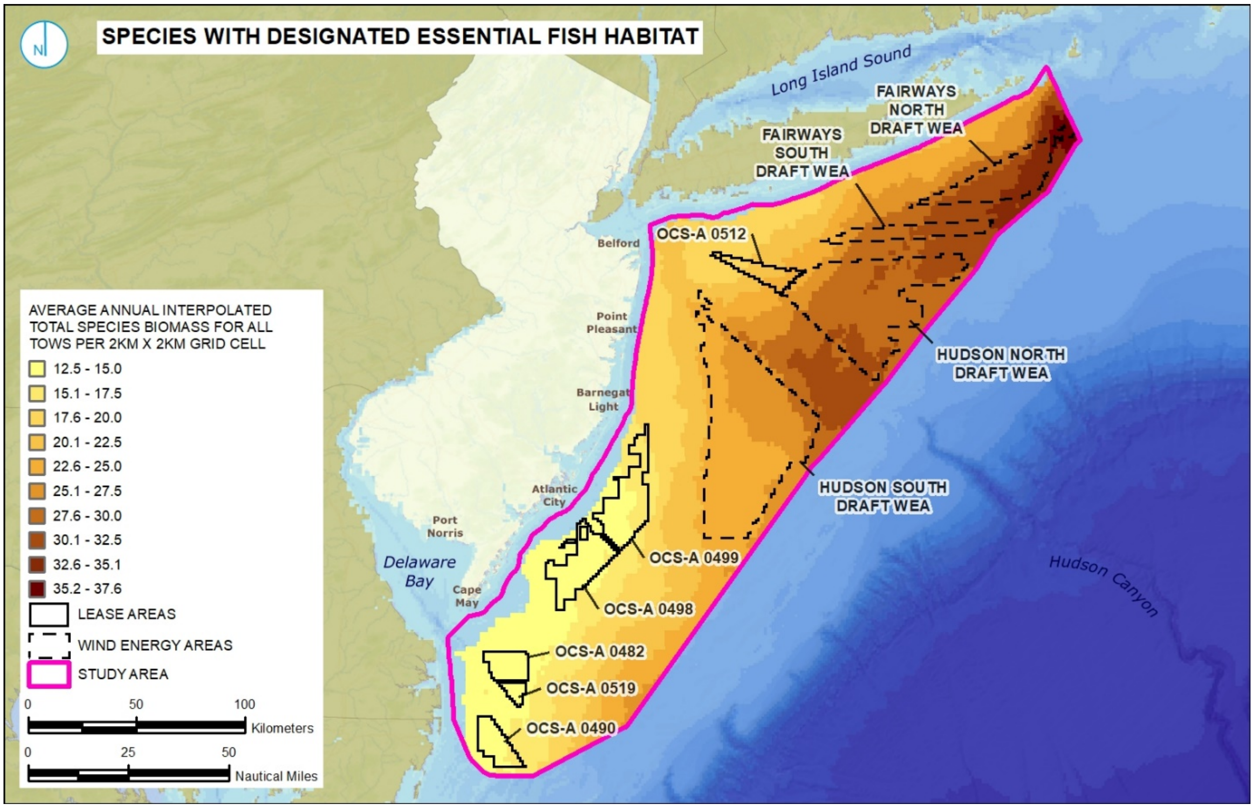


Figure 14: Species with Designated Essential Fish Habitat

Key Points: The species with designated EFH follow a trend similar to that of the demersal species, with increasing abundances from south to north. The northern portion of the Hudson South draft WEA has moderate abundances. There are areas of higher abundance within the Hudson Canyon and on the eastern portions of the Hudson North draft WEA and the Fairways North and South draft WEAs, with the Fairways North draft WEA having the highest abundances. The biomass values (kilograms per tow) are higher for this layer than for demersal species.

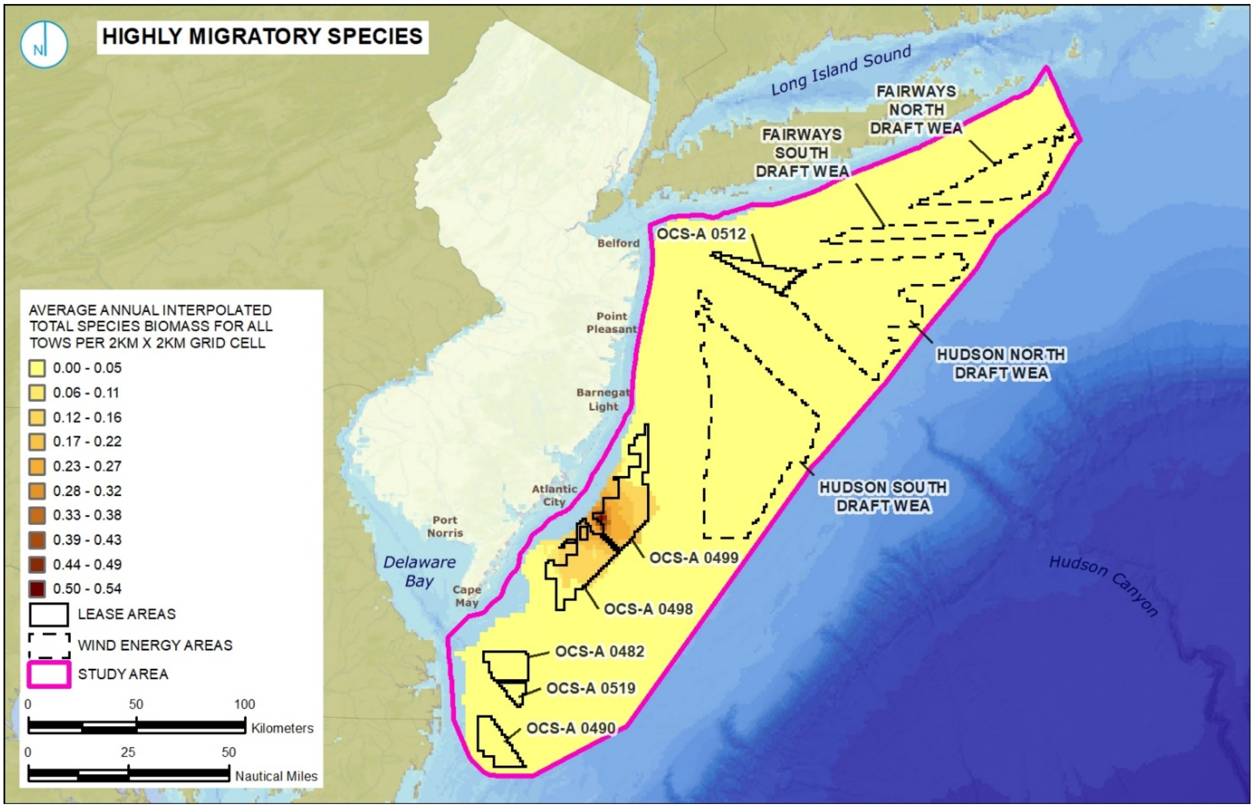


Figure 15: Highly Migratory Species

Key Points: The highly migratory species figure shows higher species abundance within the OCS-A 0498 and OCS-A 0499 lease areas. This species layer is comprised of solely Atlantic sharpnose shark and sand tiger. Abundance of these species within the majority of the OWSP study area is close to zero.

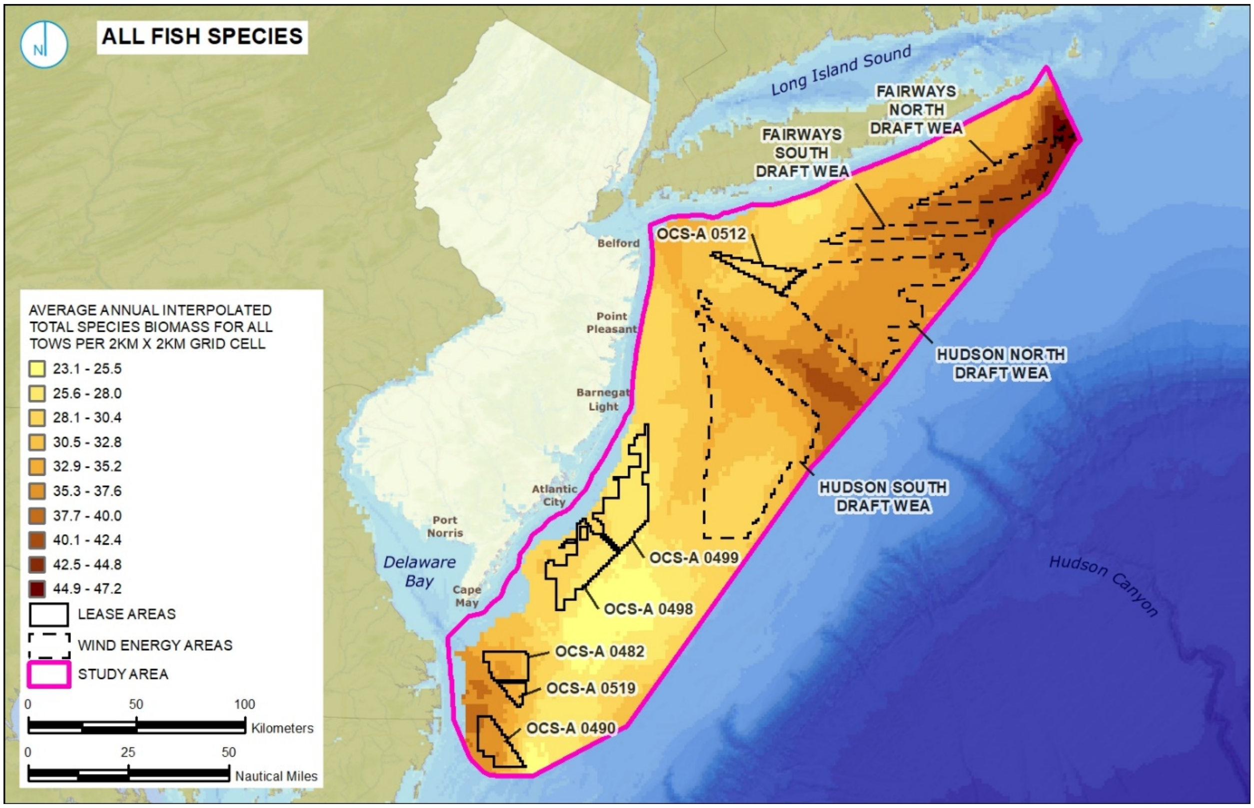


Figure 16: All Fish Species

Key Points: The all fish species abundance layer shows a trend similar to that of the demersal species and species with designated EFH layers. Specifically, there is an area of higher abundance within the Hudson Canyon, and abundance generally increases from south to north as well as with distance from shore in the northern portion of the study area. The Fairways North draft WEA shows the highest all fish species abundance, with cell values in the 35-40 kg/tow per grid cell range.

2.6.3 Cetaceans Subgroup Inputs

Cetacean subgroup figures display cetacean abundance data from the MDAT mammal abundance technical report. The individual species maps represent the results of distance sampling modeling methodology applied to over 20 years of aerial and shipboard cetacean surveys, linked with remote sensing and ocean model environmental covariates. Cetacean models were created for the entire US East Coast and southeast Canada. The data was provided by the MDAT as a grid consisting of 10 km x 10 km cells.

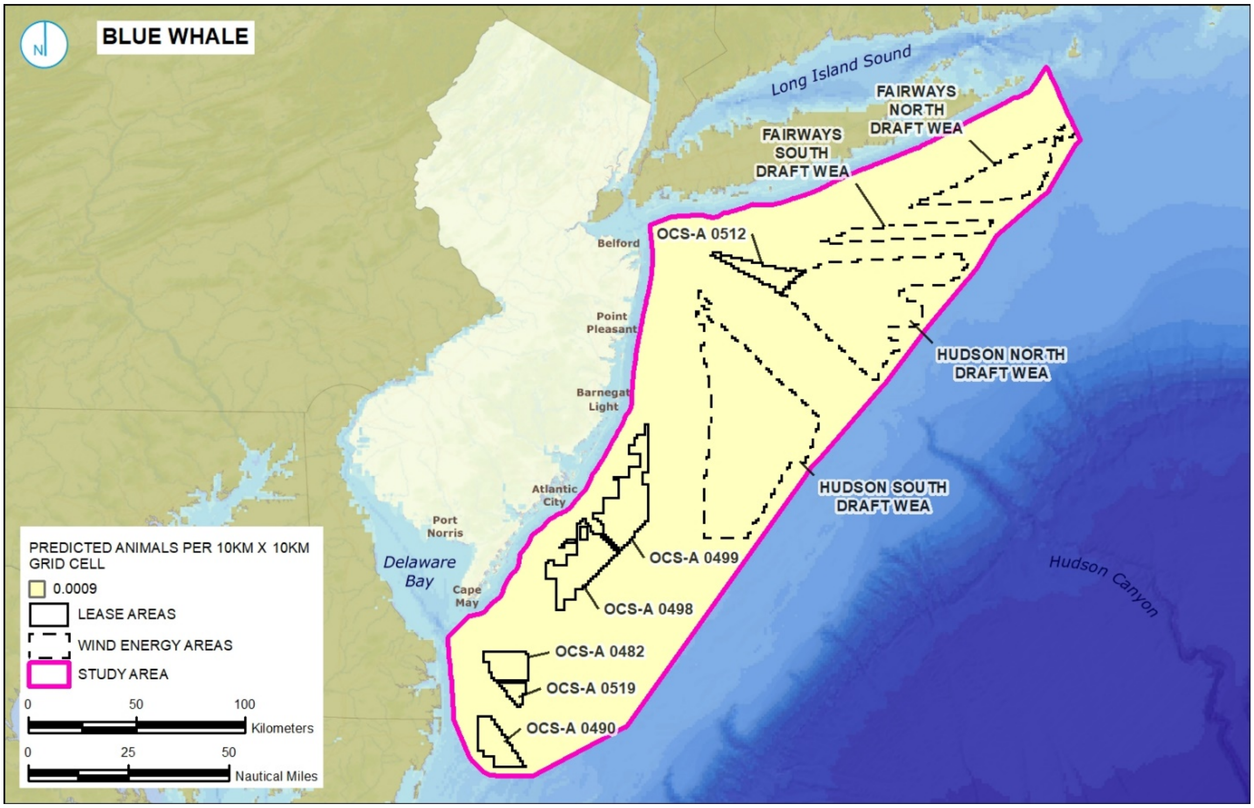


Figure 17: Blue Whale

Key Points: Based upon more than 20 years of survey data, the annual abundance of blue whales is extremely low throughout the study area, with less than 0.001 animals per 100 km^2 expected. The blue whale layer was compiled using a stratified density model, because there were too few sightings to model abundance accurately. The raster for blue whale, therefore, has a uniform value throughout the study area.

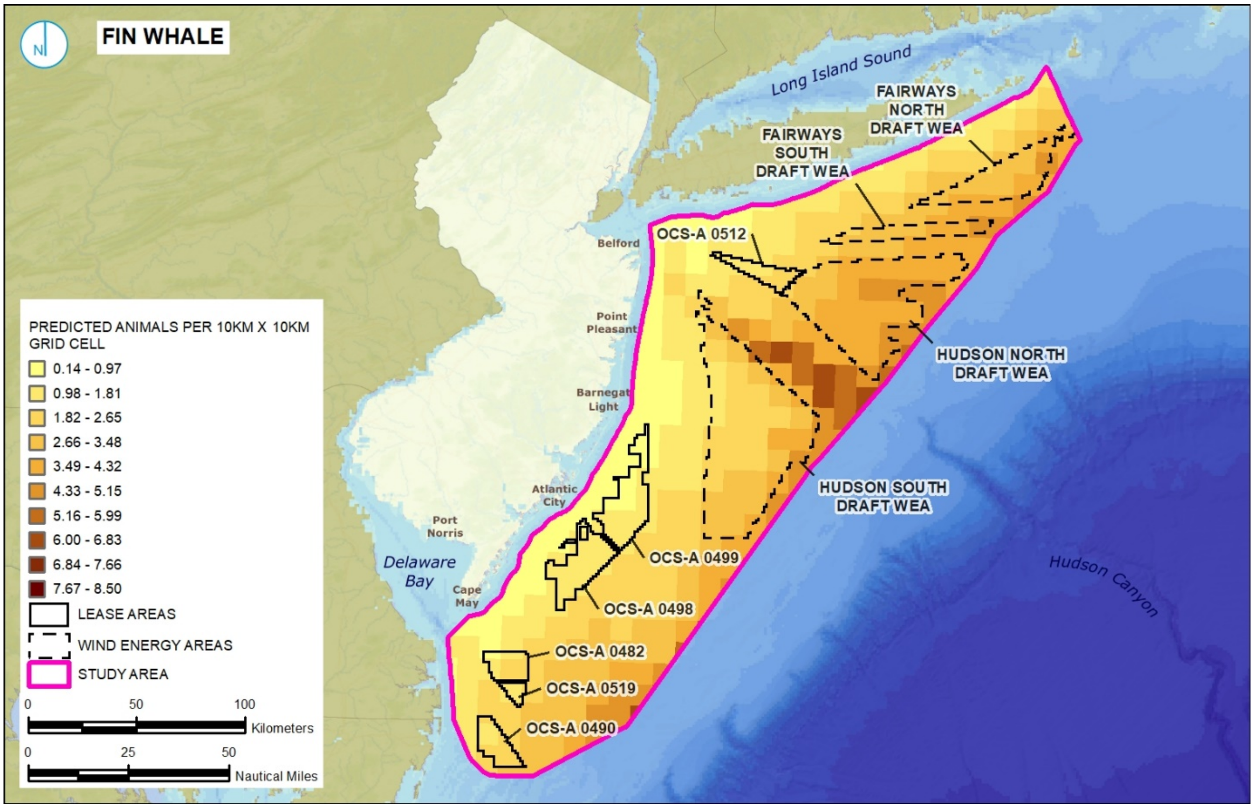


Figure 18: Fin Whale

Key Points: The density of fin whales is less than five individuals per 100 km^2 throughout most of the study area and in any wind lease area or WEA. Fin whale densities increase within the Hudson Canyon to around four to six individuals expected per 100 km^2.

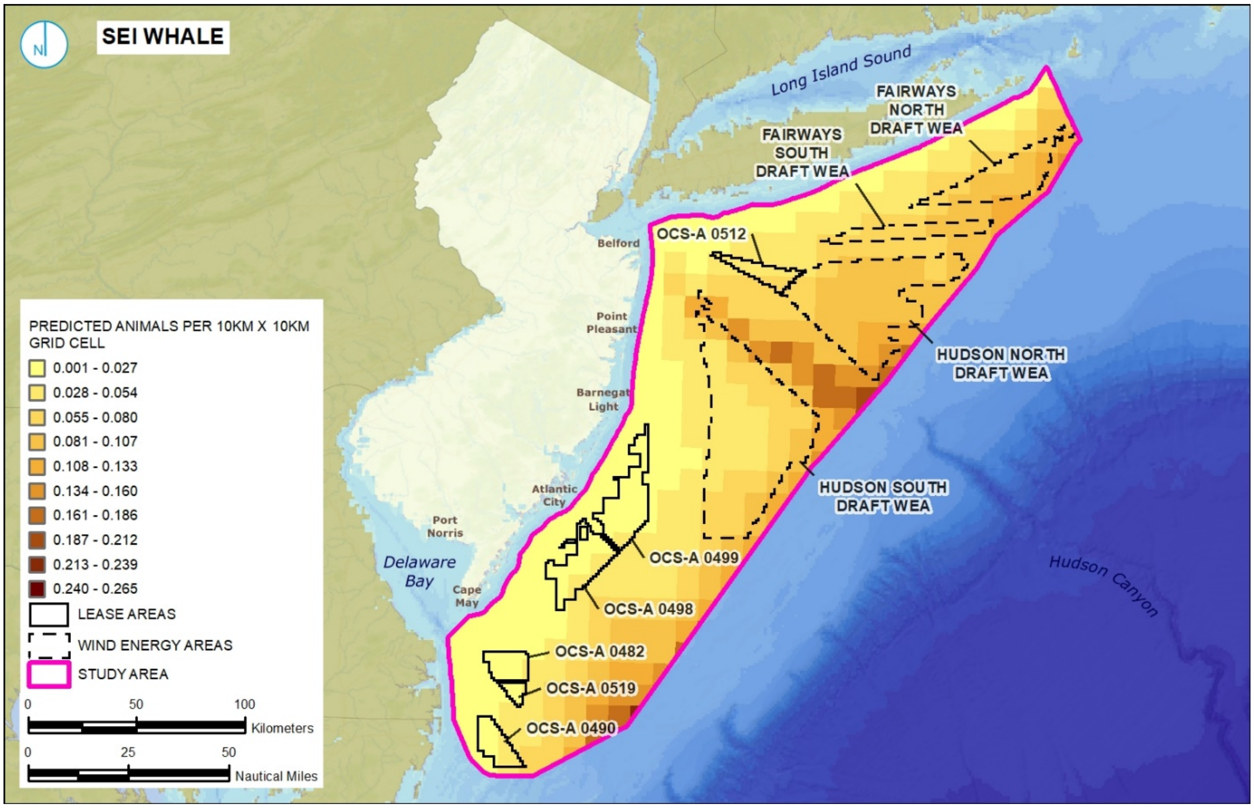


Figure 19: Sei Whale

Key Points: The density of sei whales is less than 0.25 individuals per 100 km^2 throughout the study area and in any wind lease area or WEA. Sei whale densities are slightly higher within the Hudson Canyon (~0.15-0.125 individuals per 100 km^2 in some areas) and are very low within the lease areas and draft WEAs (<0.1 individuals per 100 km^2).

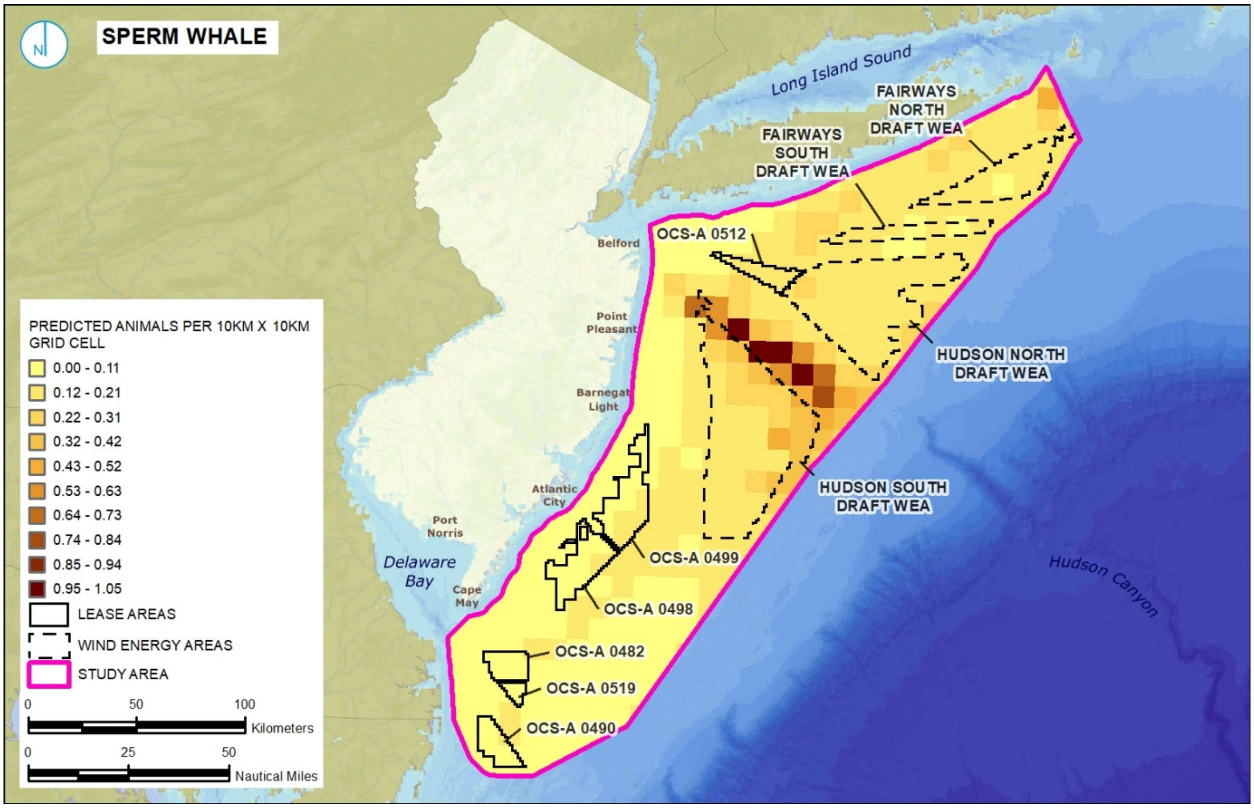


Figure 20: Sperm Whale

Key Points: The annual abundance of sperm whales is less than 1.05 individuals per 100 km^2 throughout the study area and in any wind lease area or WEA. The highest density of sperm whales occurs in the Hudson Canyon. The lease areas and draft WEAs are expected to contain low abundances of sperm whales (<0.3 individuals per 100 km^2), aside from the northern edge of the Hudson South draft WEA, which borders the higher abundance area within the Hudson Canyon.

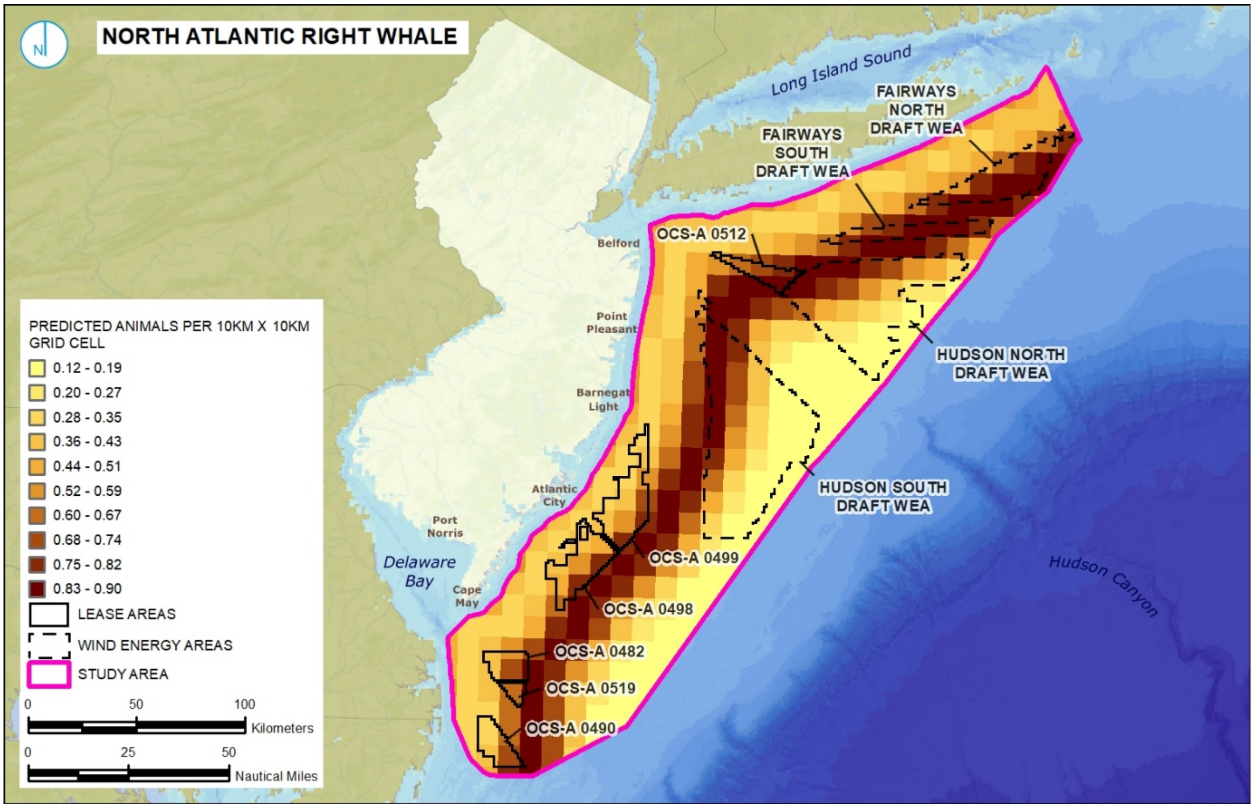


Figure 21: North Atlantic Right Whale

<u>Key Points:</u> The annual abundance of the NARW is highest in the study area at depth contours between 30 and 40 meters, at up to 0.9 animals per 100 km^2. Areas that are shallower (as well as much deeper) than this range show less relative density, including significant portions of existing wind lease areas and WEAs. The NARW high abundance areas are present in all lease areas and draft WEAs but do not exceed 0.9 individuals per 100 km^2.

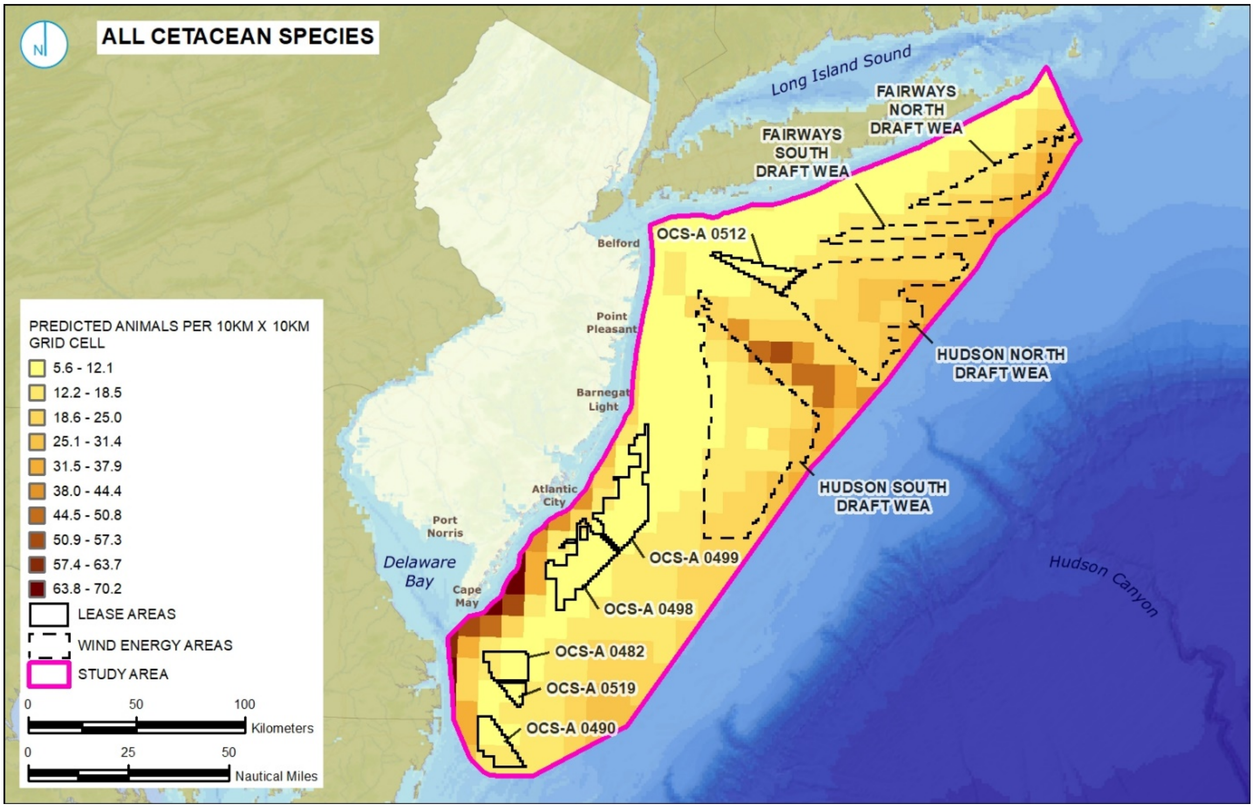


Figure 22: All Cetacean Species

Key Points: The figure for all cetacean species shows that cetaceans are most abundant in shallower waters off the coast of Cape May and within the Hudson Canyon. Cetaceans are less abundant within the lease areas and draft WEAs, remaining below 30 expected individuals per 100 km^2. Aside from the area of higher abundance off Cape May (due to dolphin abundance in this area), overall cetacean abundance increases with depth and distance from shore.

2.6.4 Sea Turtles Subgroup Inputs

Sea turtles subgroup figures show sightings per unit effort (SPUE) provided by the Northwest Atlantic Marine Ecoregional Assessment report for loggerhead, leatherback, and green sea turtles. Observations were provided by the source as 10-minute squares (approximately 14.3 km x 18.5 km) and provided seasonally. The Ramboll assessment used the average amount of sightings per season and summed them for an annual representation.

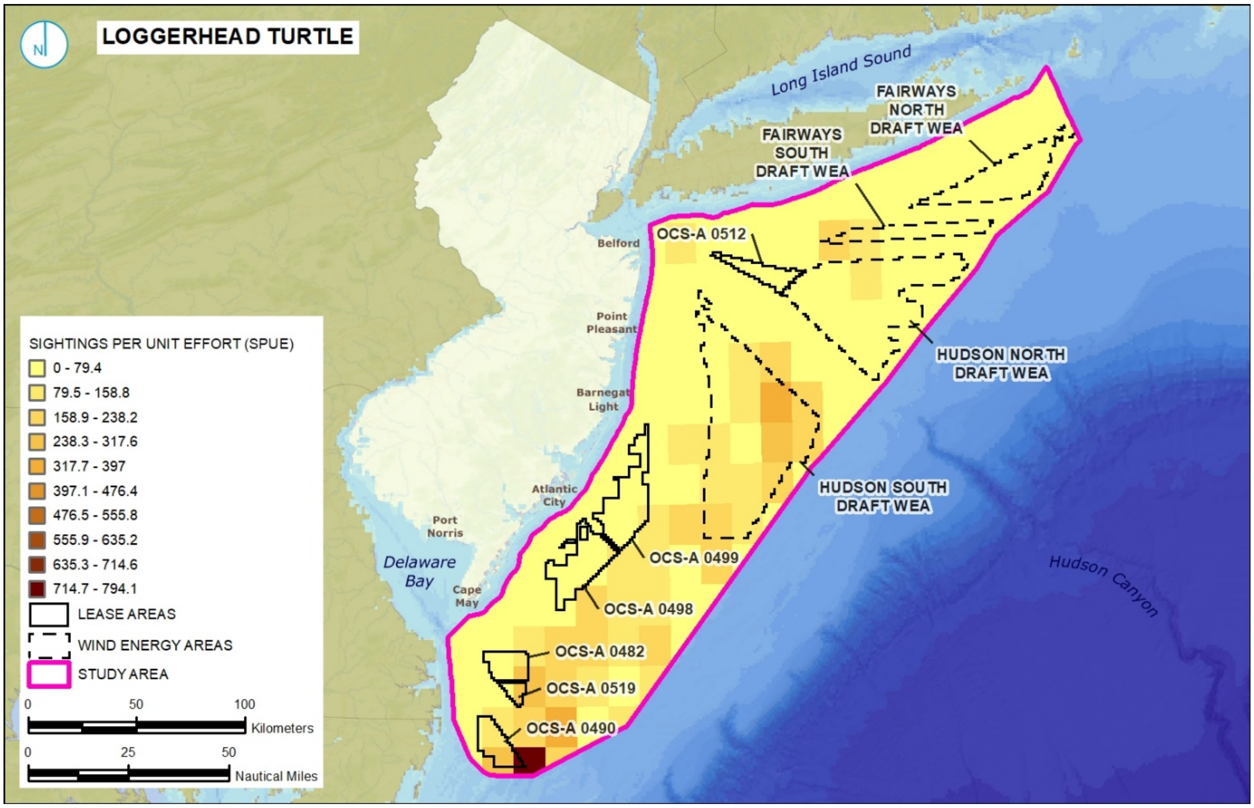


Figure 23: Loggerhead Turtle

Key Points: SPUE yielded variable results in the study area, with higher densities generally in the center of the study area near the 40-meter depth contour. The southern tip of OCS-A 0490 has an area of high loggerhead turtle abundance within the 714-794 SPUE range. The majority of the study area has lower relative abundance of loggerhead turtles. Some areas within the Hudson South draft WEA have higher loggerhead abundance in the 200-300 SPUE range.

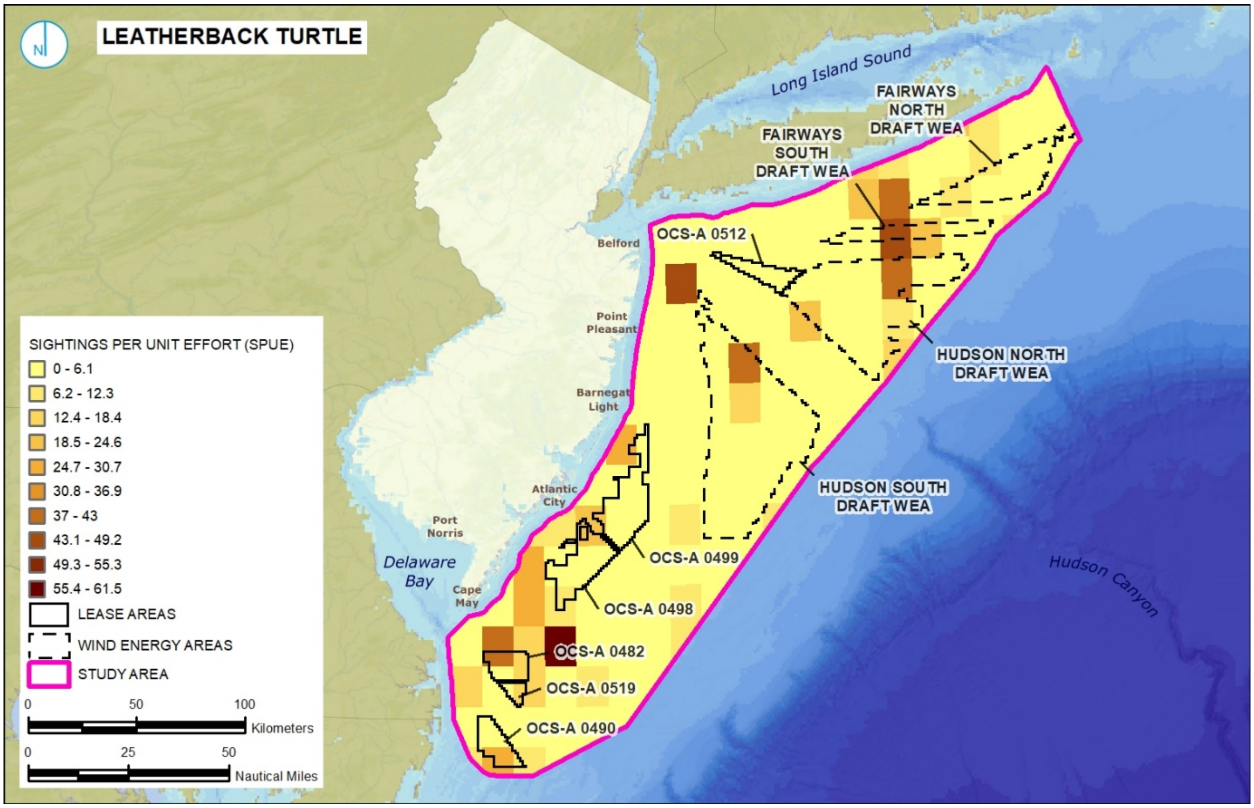


Figure 24: Leatherback Turtle

<u>Key Points:</u> SPUE are sporadic within the study area; however, available data show greater occurrences within and between the northern aspects of lease area OCS-A 0482 and within the Hudson South draft WEA, the Hudson North draft WEA, and the Fairways South draft WEA.

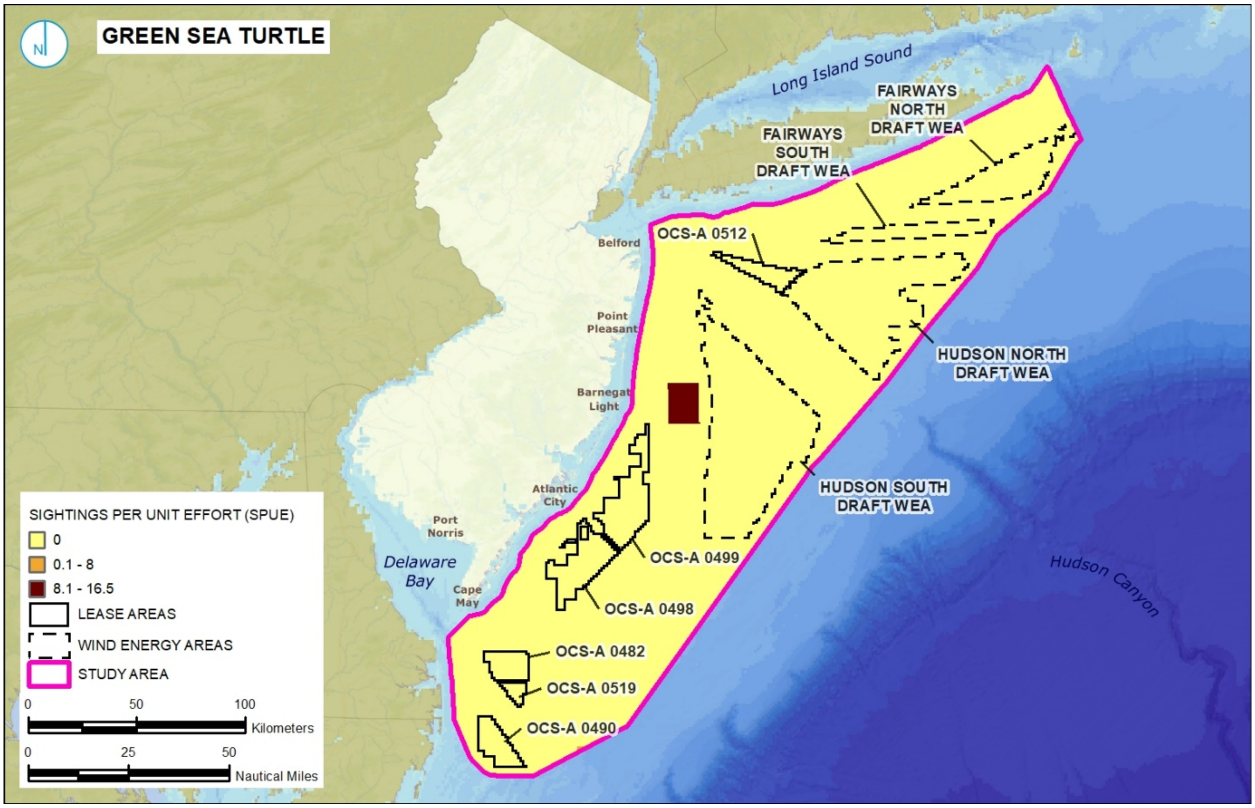


Figure 25: Green Sea Turtle

Key Points: Green sea turtles show low abundance throughout the study area. Only one cell within the study area showed sightings, west of Hudson South draft WEA.

2.6.5 Habitat Subgroup Inputs

The EFH figure (Figure 26) displays a number of overlapping EFHs provided by NOAA, with analysis by TNC. This layer was provided as an overlay of EFH polygons for all 39 species under federal management in the Mid-Atlantic and Northeast, provided in 10-minute x 10-minute cells (approximately 14.3 km x 18.5 km). It was developed for general visualization and informational purposes only and does not necessarily represent the most important habitats. TNC obtained individual EFH layers from NOAA. This layer does not represent EFHs for individual species but rather the number of overlapping EFHs in any given location.

The EFH for highly migratory species figure (Figure 27) shows the number of overlapping EFHs for highly migratory species, provided by NOAA. This dataset is an aggregation of numerous EFH spatial data products for highly migratory species. The source data for this product included 42 available highly migratory species EFH datasets from NMFS as of the publication date.

The artificial reefs figure (Figure 28) shows artificial reef sites of New Jersey. Companion data on prime fishing grounds of New Jersey are provided in the unweighted resource evaluation (URE, Section 3.3).

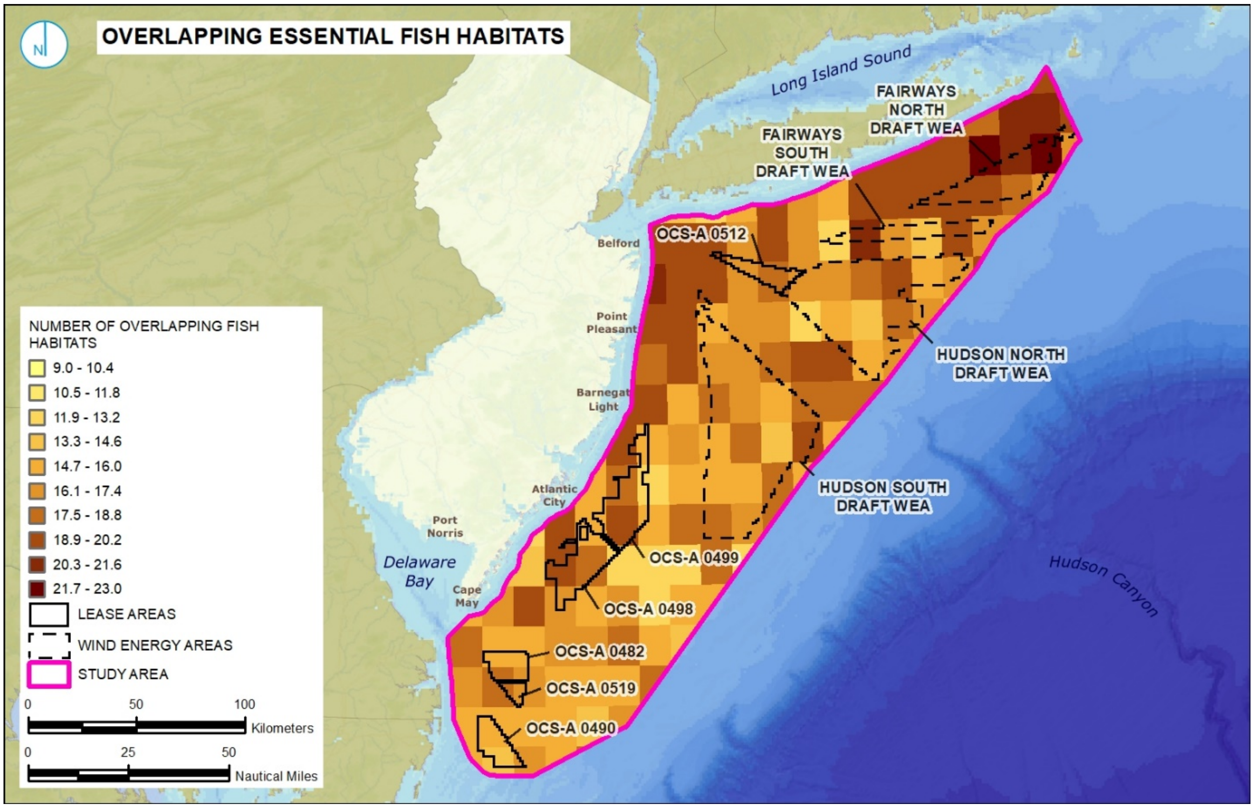


Figure 26: Overlapping Essential Fish Habitats

Key Points: The number of overlapping designated EFHs is generally high within the study area, usually ranging from 9-23 different species. Most of the WEAs and existing leases are associated with the areas at the higher end of this range. The highest numbers of overlapping EFHs exist in the Fairways North draft WEA, while OCS-A 0490 has relatively fewer overlapping EFHs.

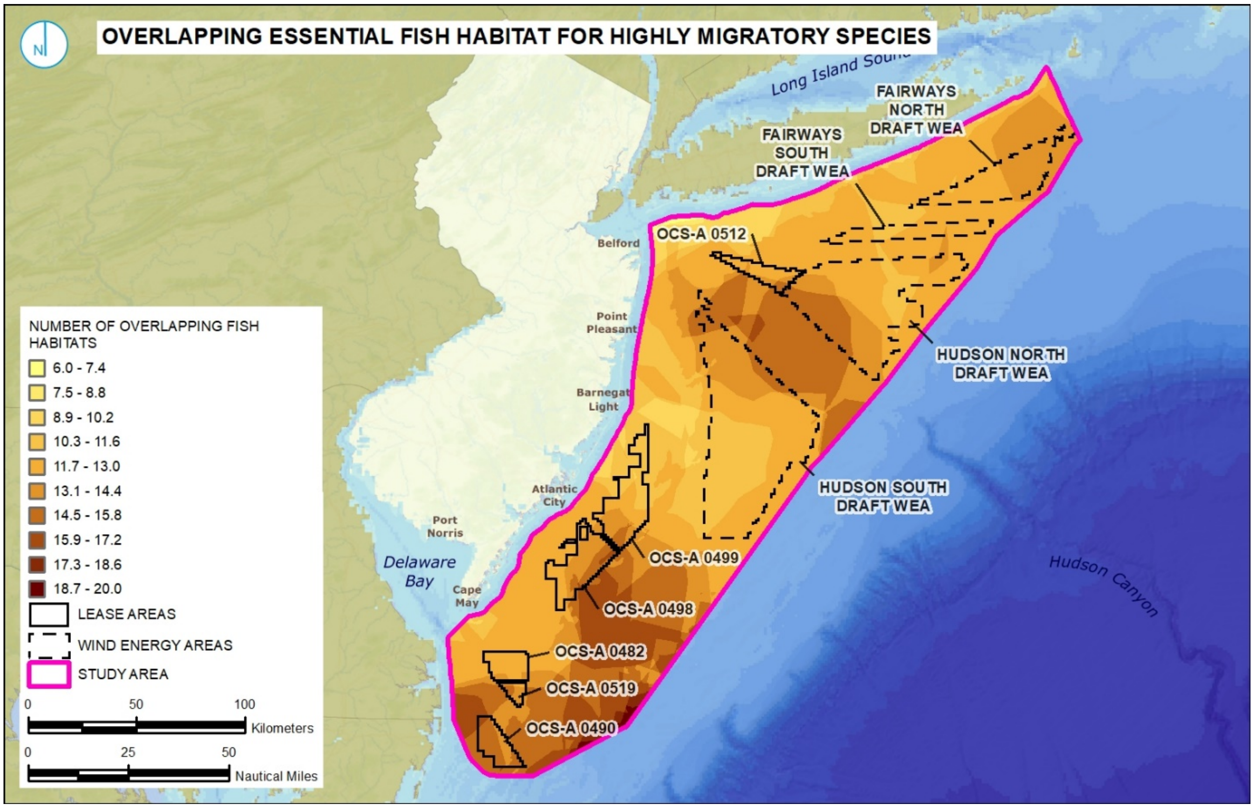


Figure 27: Overlapping Essential Fish Habitats for Highly Migratory Species

Key Points: Most of the study area and nearly all of the existing lease areas and WEAs are associated with approximately 11-15 overlapping designated EFHs for highly migratory species. A higher amount of designated EFH for highly migratory species is seen in waters deeper than about 50 meters, with the peak overlap occurring in offshore canyons and continental shelf breaks. The number of overlapping EFHs for highly migratory species increases from north to south, aside from a higher amount within the Hudson Canyon. In contrast to Figure 26 above, OCS-A 0490 has more EFH for highly migratory species than the other lease areas/draft WEAs.

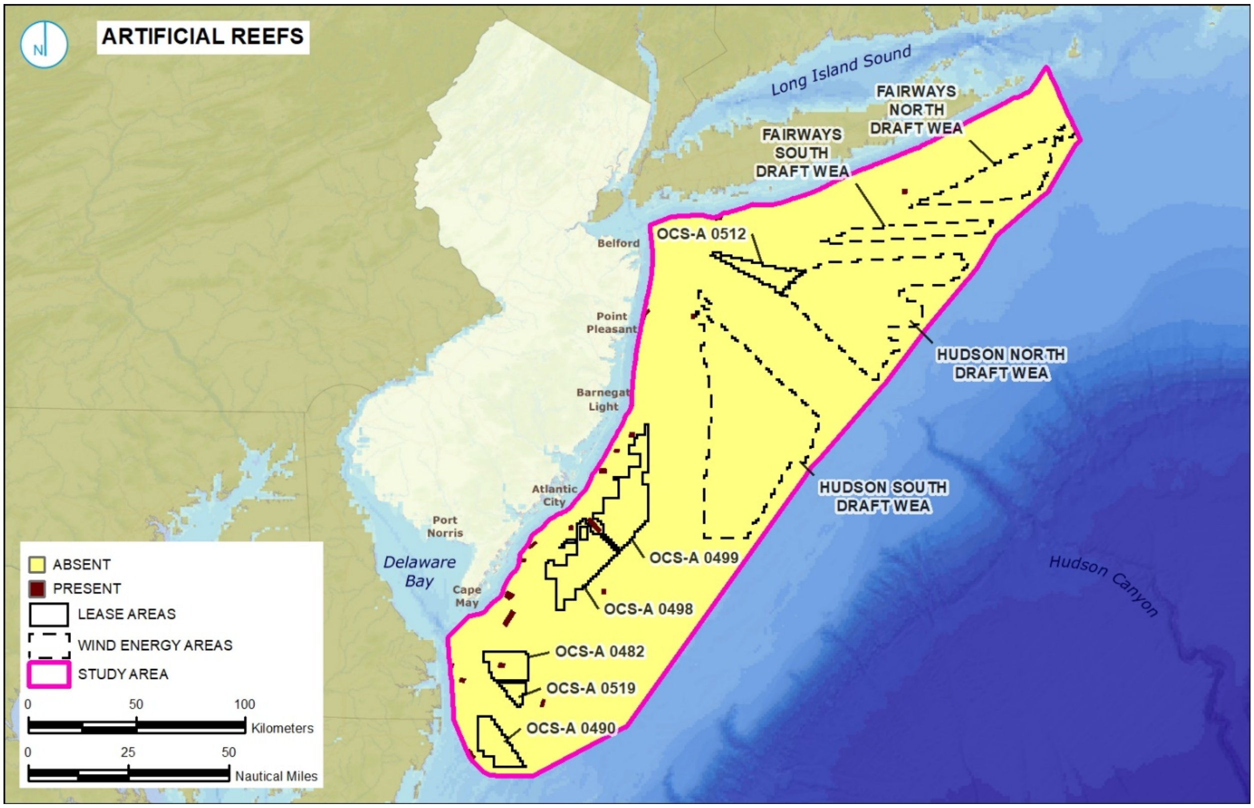


Figure 28: Artificial Reefs

Key Points: Artificial reefs are not abundant within the study area; they primarily appear sporadically off the coast of southern New Jersey. Lease areas OCS-A 0499 and OCS-A 0498 boundaries avoid artificial reefs. One artificial reef exists within lease area OCS-A 0482.

2.6.6 Benthic Invertebrates Subgroup Inputs

The ocean quahog and Atlantic surfclam figures show density heat maps for these species that were created by the NJDEP Marine Fisheries Administration using data from the NOAA Fisheries NEFSC Atlantic surfclam and ocean quahog survey. Data on the Atlantic sea scallops and on select benthic invertebrates (American lobster, horseshoe crab, and Jonah crab) came from the MDAT technical report fish data in units of biomass. The data for select benthic invertebrates from the SMAST grouping (SMAST 2016 abundance data for sea star, crab, hermit crab, moon snail) was in units of abundance (average number of individuals per 10 km^2).

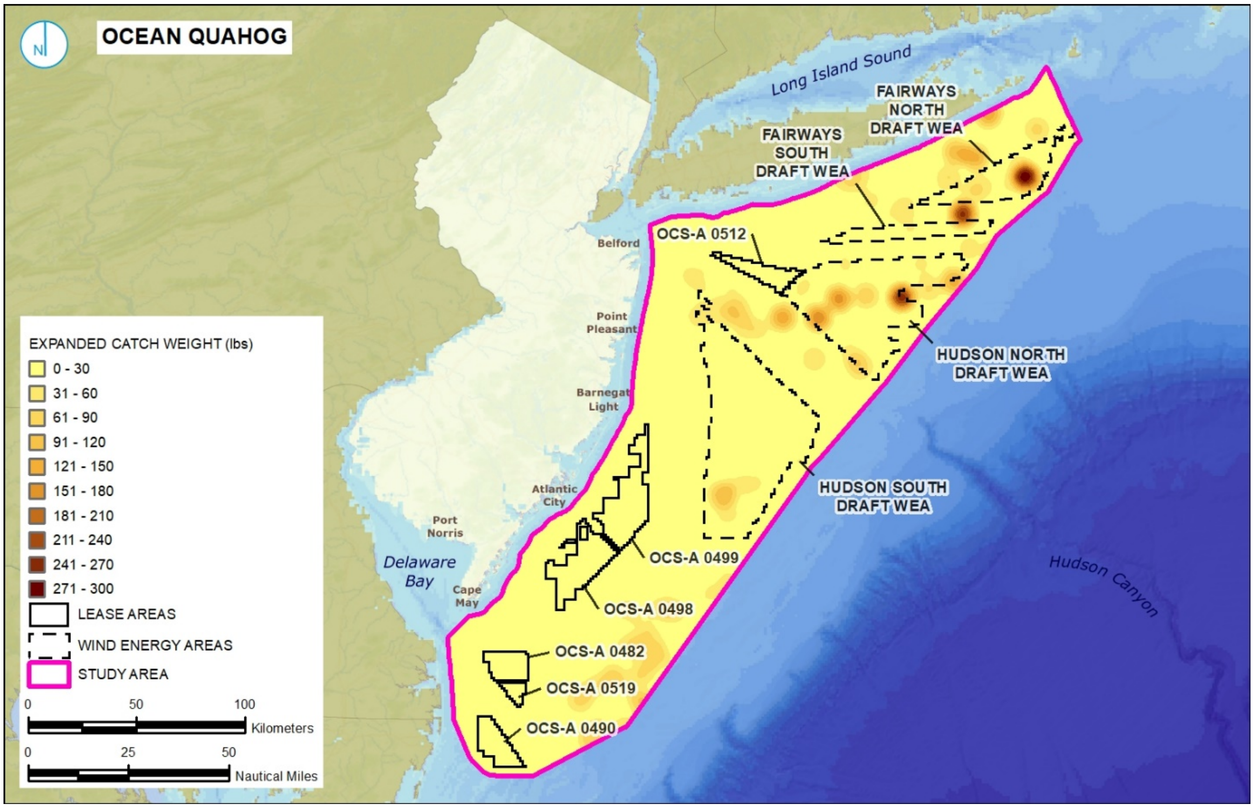


Figure 29: Ocean Quahog

<u>Key Points:</u> This layer shows sporadic hot spots of ocean quahog expanded catch weights within the Hudson North draft WEA and Fairways North draft WEA. The other lease areas and draft WEAs contain a low abundance of ocean quahog.

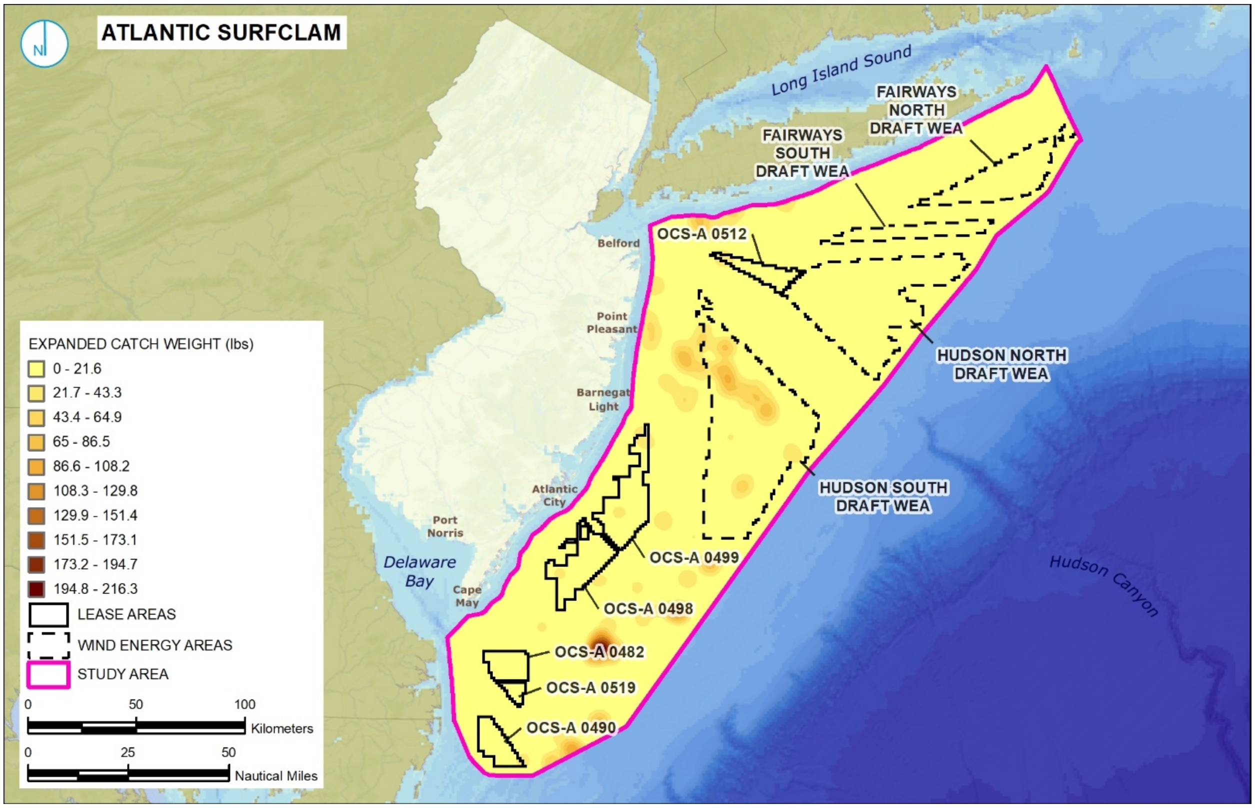


Figure 30: Atlantic Surfclam

<u>Key Points:</u> There is an area of high abundance of Atlantic surfclam east of OCS-A 0498. Moderate abundances also exist within the Hudson South draft WEA. The rest of the lease areas/draft WEAs show low abundances of Atlantic surfclam.

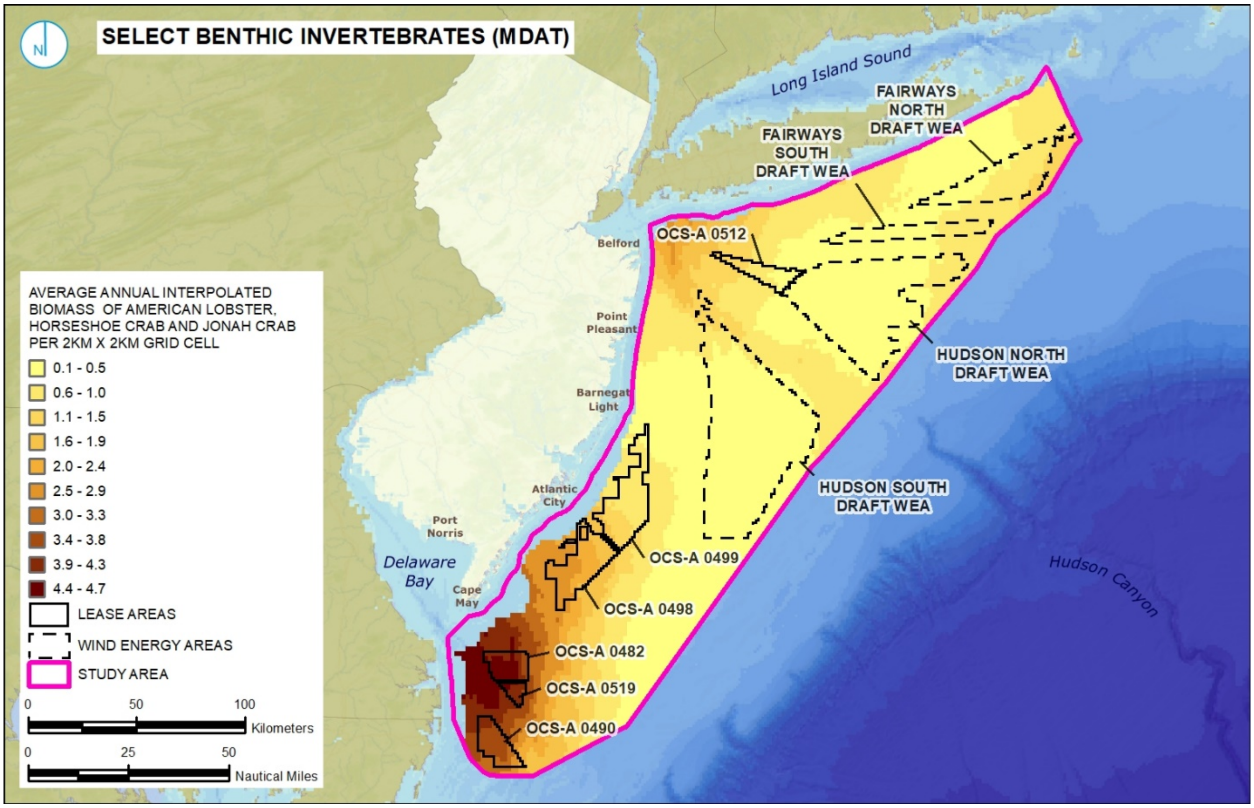


Figure 31: Select Benthic Invertebrates (MDAT)

<u>Key Points:</u> The MDAT select benthic invertebrates figure shows high abundances (in interpolated biomass kg/tow per 2 km x 2 km grid cell) of American lobster, horseshoe crab, and Jonah crab in the southern portion of the OWSP study area. OCS-A 0482, 0519, and 0490 show particularly high levels of these animals. OCS-A 0498 shows moderate abundance, and the remaining lease areas/draft WEAs show low abundance of these animals.

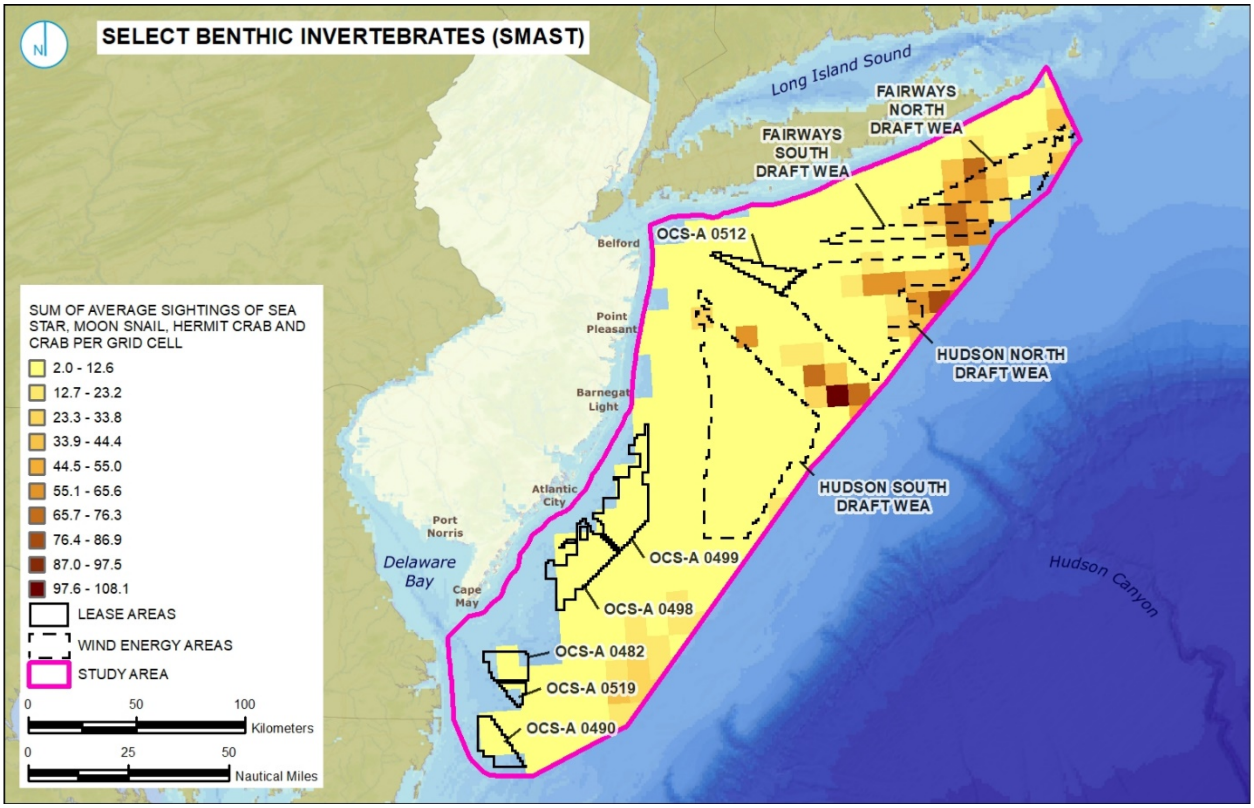


Figure 32: Select Benthic Invertebrates (SMAST)

Key Points: This dataset has limited coverage in the southwestern portion of the OWSP study area. The figure shows higher abundances of sea star, moon snail, hermit crab, and crab in the Hudson Canyon and within the north draft WEAs. Low abundances of these invertebrates are shown in all areas south of the Hudson Canyon.

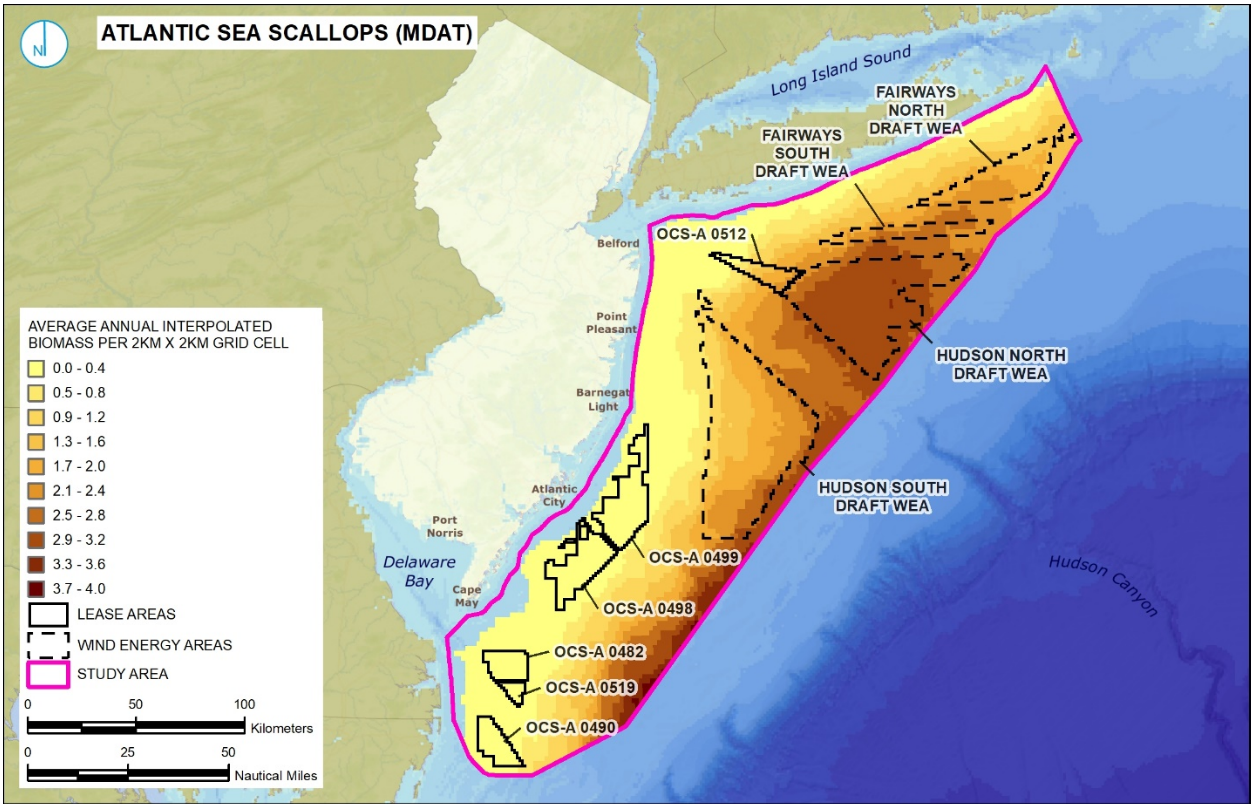


Figure 33: Atlantic Sea Scallops (MDAT)

Key Points: This figure shows higher Atlantic sea scallop abundance further north and offshore. The southern lease areas have relatively low Atlantic sea scallop abundances, the Hudson South draft WEA and Fairways North draft WEA have moderate abundances, and the Hudson North draft WEA has the highest abundance of the lease areas and draft WEAs.

2.7 Data Standardization

Following the gathering of layers from data sources, a data preparation process was undertaken. The data preparation process was necessary to convert the data from various sources into a format in which the data could be compared and/or merged. The data preparation consisted of two primary activities: standardization and rescaling. Data standardization activities were applied to all datasets. Data rescaling activities were applied to the habitat and benthic subgroup layers. The standardization and rescaling processes are described below. Standardization and rescaling (when applicable) were performed prior to weighting and summing the data. The weighting and summing processes are described in greater detail below.

The GIS team reviewed the available data sources to determine the required standardization of each layer. "Standardization" refers to formatting the data such that data from different sources are comparable, which includes implementing a standard grid size, coordinate system, map projection, and clipping the data to the study area. All the data sources used in the analysis were provided either as a raster[4] or as a grid-like vector polygon.[5] The vector grid-like polygons were converted to raster at the same resolution as the source had provided. The majority of available data had grid sizes that clustered into three sizes: 10 kilometers (km) x 10 km, 2 km x 2 km, and 100 meters (m) x 100 m. All spatial layers were clipped to the study area and converted to raster format with the same cell size of 100 m x 100 m. Data were resampled[6] to the new 100 m resolution without smoothing or interpolation. The 100 m x 100 m process grid represents a balance between being small enough to capture the required detail of the data and large enough that processing can be performed efficiently. This 100 m x 100 m process grid size also allows for more granular features such as artificial reefs to be incorporated into GIS layers. It should be noted that 100 m cell size is used for standardization and does not reflect the resolution of the data analysis. Most source dataset resolutions are 2 to 10 km and do not support analysis at a finer scale. All layers were projected to the same map projection, Universal Transverse Mercator (UTM) Zone 18N,[7] and expressed in metric units. UTM Zone 18N was selected because the study area was located more than 3 nautical miles offshore, and it is therefore more appropriate than the New Jersey state plane coordinate system.

"Rescaling" refers to stretching or shrinking the scale of values that a particular dataset ranges such that it can be compared with data from other sources that may have been provided in different mathematical units. This method was used in certain circumstances (described below) in order to transform data to a unitless low-to-high scale. Selected layers were ultimately normalized to a unitless score that ranged from 0 to 1,000, such that 0 represents the least susceptible area for an offshore wind development and 1,000 represents the most susceptible area. For continuous data, individual cell values were rescaled by determining the minimum and maximum values of the data in the study area and transforming the data to the 0-1,000 range, within 3 decimal points of precision. For binary data (e.g., presence or absence, as with the location of artificial reefs), individual cells were recorded as 0 (resource absent/least susceptible to offshore wind development) or 1,000 (resource present/most susceptible to offshore wind development).

Methods for data rescaling depend on the nature of the raw data. For example, binary data (e.g., presence or absence, as with the location of artificial reefs) are recorded as 0 or 1,000, reflecting the relatively least and most sensitive conditions for offshore wind development for that parameter. Continuous data are rescaled to a 0-1,000 unitless score. The equation below was used when the lowest values of the data were less susceptible, and the higher values were more susceptible.

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[4] In GIS, a raster layer is a matrix of cells or pixels organized into a grid where each cell contains a value representing information for that cell, such as species abundance.

[5] In GIS, a polygon feature is a two-dimensional shape used to represent the shape and location of homogeneous spatial data. For example, an EFH area or an artificial reef can be represented using a polygon. In certain circumstances, data were provided as a "grid" of polygons (loggerhead turtle, leatherback turtle, green sea turtle, and EFH data were in this format). These data, although similar to a raster, were converted to a raster for analysis.

[6] "Resample" is a GIS tool that allows a user to change the spatial resolution of a raster dataset. In this case, the data were resampled so that all layers would have the same spatial resolution (grid). In some cases, rasters that have the correct resolution must be resampled so that their grid cells "line-up" with the other rasters they are to be combined with.

[7] The projection is NAD (North American Datum) 1983 UTM (Universal Transverse Mercator) Zone 18 North.

$$w = \left(\frac{(min - i)}{(min - max)}\right) \times 1{,}000$$

Where:

w = the rescaled value (between 0 and 1,000)
i = the original cell value in the raster
min = the lowest value in the study area raster
max = the highest value in the study area raster

Specific notes regarding rescaling are provided below for each subgroup.

Layers comprising the birds, cetaceans, fish, and sea turtles subgroups were combined without first rescaling the individual layers on a 0-1,000 scale because these layers were all provided in the same mathematical units within subgroups. This course of action avoids imparting bias into the dataset by artificially inflating abundance data within a given layer. For example, the roseate tern has extremely low species abundance within the study area. Rescaling the roseate tern layer to reflect the same order of magnitude as the other bird subgroup layers would magnify roseate tern abundance artificially, while reducing the representation of the all bird species layer. The weighting process (described in Section 2.8) is intended to address the importance of endangered or rare species, such as the roseate tern. The decision not to resale individual layers also acknowledges the higher level of uncertainty present in individual species layers. Thus, the analyses for birds, cetaceans, fish, and sea turtles reflect overall abundance of resources within the study area without artificially magnifying species with low abundances. Additional specifics related to data preparation procedures for each subgroup are described below.

2.7.1 Birds Subgroup Data Standardization

The birds subgroup data layers were sourced from the MDAT technical report as a raster in units of relative abundance in a 2 km x 2 km grid, provided on an annual basis. The bird subgroup raster layers were standardized to the 100 m x 100 m resolution and projected to UTM before weighting and summing.

2.7.2 Fish Subgroup Data Standardization

The fish subgroup data layers were sourced from the MDAT technical report as a raster in units of biomass (sum of average annual interpolated biomass [inverse distance weighted fish biomass measured as kilograms per 4 km^2]). The data layers provided were separated by season, presented in spring and fall. The layers were summed to obtain an annual layer. The data for the fish analysis were standardized to the 100 m x 100 m resolution and projected to UTM before weighting and summing.

2.7.3 Cetaceans Subgroup Data Standardization

The cetaceans subgroup data layers were sourced from the MDAT technical report as a raster in units of predicted abundance (predicted animals per 100 km^2). Most of the data were provided on an annual basis; however, data for a few of the species were provided on a monthly basis. The monthly layers were summed to obtain an annual layer. The data for the cetacean analysis were standardized to the 100 m x 100 m resolution and projected to UTM before weighting and summing.

2.7.4 Sea Turtles Subgroup Data Standardization

The sea turtle subgroup data layers were sourced from the NAMERA report and were provided as a polygon shapefile in SPUE. The data were provided on a seasonal basis, with the layer giving an average value per season (total sightings/total effort). The seasonal sightings were then summed to obtain an annual layer. These data were converted from polygon format to raster format, resampled to the 100 m x 100 m resolution, and projected to UTM before weighting and summing.

2.7.5 Habitat Subgroup Data Standardization

Data layers for the habitat subgroup came from three different sources. The EFH for highly migratory species (NROC 2015) and EFH (TNC and NOAA 2015) data were provided as polygons reported in the same units (number of overlapping species with EFH). However, the artificial reef data (NJDEP Open Data) were provided as polygons reported on a present/absent basis. A 0.25 nautical mile buffer was incorporated around the artificial reef locations as a measure of conservatism and to ensure the locations were represented at the scale of the analysis. The buffered artificial reef polygon layer was converted to a 100 m x 100 m raster. The EFH and EFH highly migratory species polygons were also converted to a 100 m x 100 m raster. To standardize the data, all three layers were resampled to the 100 m x 100 m resolution (to ensure the raster cells "lined up") and projected to UTM.

Because of the varying mathematical units between the EFH layers and the artificial reef layers, the EFH and EFH highly migratory species layers were rescaled to a 0-1,000 scale (as described in Section 2.7), and the artificial reefs were converted to a 0-1,000 scale (cells were designated 0 for absent and 1,000 for present artificial reefs) prior to weighting in order to create a scale of relative abundance for each of the layers included.

2.7.6 Benthic Invertebrates Subgroup Data Standardization

Data layers for the benthic invertebrates subgroup came from three different sources. The Atlantic sea scallops and select[8] benthic invertebrates data from the MDAT grouping (American lobster, horseshoe crab, and Jonah crab) came from the MDAT technical report fish data as a raster in units of biomass (sum of average annual interpolated biomass [inverse distance weighted fish biomass measured as kilograms per 4 km^2]). Data for each species were provided as a spring and a fall layer and then summed to get an annual representation for each species. The American lobster, horseshoe crab, and Jonah crab individual layers were summed together to develop the select benthic invertebrates layer.

The data for select benthic invertebrates from the SMAST grouping (SMAST 2016 abundance data for sea star, crab [spp.], hermit crab, moon snail) were in units of abundance (average number of individuals per 10 km^2). The SMAST data were provided as a polygon shapefile, with each polygon containing abundance values for multiple species. The individual selected species abundance values were summed, and the data were converted to a 100 m x 100 m raster.

The Atlantic surfclam and ocean quahog data were provided by NJDEP as separate rasters in units of expanded catch weight (lbs).

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[8] The term "select" is used in reference to both the MDAT and the SMAST datasets to reflect the fact that not all benthic invertebrates available from those sources were utilized in the analysis. Rather, only those species with abundance data were selected for use based on model requirements. The term does not imply that these species were chosen over others for their particular relevance, importance, resource priority, or prevalence.

To standardize these layers, all were resampled to the 100 m x 100 m resolution, projected to UTM, and rescaled (0-1,000 as described in Section 2.7) prior to weighting and summing.

2.8 Intra-subgroup Cross-Layer Weighting System

As its name suggests, the WSA incorporates weighting of individual data layers comprising the biological resource subgroups to develop a multilayer, weighted sum, spatial overlay analysis. In this process, the weighted layers are combined to develop composite GIS layers that describe the susceptibilities of resource subgroups to offshore wind development. A total of seven figures (Figures 34-40) are developed through this process, one figure for each subgroup (n=6, reflecting the component layers and associated weighting) and one overall environmental composite figure that captures all biological resource subgroups simultaneously.

An intra-subgroup cross-layer weighting system (i.e., susceptibility weightings) is required to produce the subgroup and composite figures. In this process, a specific weighting is applied to all cells in a GIS layer to reflect the relative susceptibility of that resource or activity to offshore wind development. Intra-subgroup cross-layer weightings were assigned based on a number of factors, including species life history traits, regulatory/protected status, and input from the NJDEP and Ramboll team experts. The intra-subgroup cross-layer weightings are intended to reflect the potential susceptibility of the resource reflected in the layer to offshore wind development.

The assignment of intra-subgroup cross-layer weightings holistically considers the preconstruction, construction, operations, and decommissioning activities associated with offshore wind and assumes that standard construction industry operating procedures and federal lease stipulations and requirements will be in place. These measures were considered based on understanding of their expected effectiveness and likelihood of implementation. Susceptibilities identified in the WSA are also subject to additional recommendations for best management practices that are identified and discussed further in the OWSP.

All layers included in the analysis represent recognized resources of interest; for this reason, no layer was assigned a weight of 0. Therefore, the potential unitless susceptibility weights may range from 0.25 to 1.0. A matrix was developed to standardize the assignment of the susceptibility weights. The two primary factors used to develop this matrix are 1) species conservation status and 2) species vulnerability to offshore wind development (Table 4). For the "species conservation status" factor, species that are ESA listed and/or have designated EFH may receive a susceptibility weighting that ranges from moderate (0.5) to high (1.0).

For the "species vulnerability" factor, species that have increased vulnerability to offshore wind development because of life history traits, large area of effect (e.g., bird susceptibility), permanent effects (e.g., mortality), high magnitude effects (e.g., take of endangered species), or effects that are long term or likely (e.g., habitat loss) may receive a moderate (0.5) to high (1.0) weighting, depending on their conservation status. The following potential effects were considered during the development of the "species vulnerability" factor.

Preconstruction

- Mortality/injury due to collision (between fauna and vessels, or fauna and structures), acoustic surveying, or exploratory drilling
- Change in behavior, particularly displacement due to noise (from acoustic surveying and exploratory drilling)

Construction

- Mortality/injury due to collision (between fauna and vessels, or fauna and structures), crushing, and burial, or from impulsive noises
- Change in behavior from displacement due to noise (particularly from pile driving)
- Change in habitat due to benthic habitat loss, sedimentation/deposition, bottom disturbance, water quality degradation, habitat loss due to occupying structures

Operations

- Mortality/injury due to collision (between fauna and vessels, or fauna and structures)
- Change in behavior from displacement due to electromagnetic fields, structure attraction/repulsion (including potential for increased fishing pressure)
- Change in habitat due to bottom-scouring, habitat loss due to occupying structures

Decommissioning

- Mortality/injury due to collision with vessels involved in the decommissioning process
- Change in behavior, particularly displacement due to noise from the decommissioning process
- Change in habitat - removing foundations would remove habitat/colonization created over the life span of the turbine (e.g., ~30 years)

Table 4: Layer Susceptibility Weighting Matrix

Resource		**Vulnerability to Potential Offshore Wind Development**	
Conservation Status of Population/Recognition of Essential Habitat	Not ESA listed or not designated EFH	Limited (0.25)	Moderate (0.5)
	ESA-listed species or designated EFH	Moderate (0.5)	Elevated (0.75) High (1.0)

Additional considerations are used to adjust the weightings either up or down. A low likelihood of occurrence and/or low predictability of site fidelity would decrease weighting. The presence of critically endangered species (e.g., NARW), such that injury or mortality of a small number of individuals may have population-level effects, would increase weighting. Mandatory federal lease stipulations expected to be undertaken by any offshore wind developer, eliminating or substantially reducing potential effects, would decrease weighting.

Following implementation of the above process, draft weightings of all layers were compared against each other to ensure consistency of approach across all species/resources.

2.8.1 Cross-Layer Weightings

Weightings for each layer are presented in Table 5 below. The rationale for the weighting of each layer is discussed in the section that follows.

Table 5: Cross-Layer Weightings

Subgroup	Specific Layer	Cross-Layer Susceptibility Weighting
Birds	All species	Limited (0.25)
	Displacement sensitive	Moderate (0.5)
	Collision sensitive	Moderate (0.5)
	Roseate tern*	Elevated (0.75)
Fish	All species biomass (fall/spring)	Limited (0.25)
	Demersal species biomass (fall/spring)	Moderate (0.5)
	Highly migratory species biomass (fall/spring)	Limited (0.25)
	Species with designated EFH biomass (fall/spring)**	Moderate (0.5)
	Atlantic sturgeon biomass *	Elevated (0.75)
Cetaceans	All species	Moderate (0.5)
	Blue whale*	Elevated (0.75)
	Fin whale*	Elevated (0.75)
	Sei whale*	Elevated (0.75)
	Sperm whale*	Elevated (0.75)
	North Atlantic right whale*	High (1.0)
Sea turtles	Loggerhead turtle*	Moderate (0.5)
	Leatherback turtle*	Moderate (0.5)
	Green sea turtle*	Moderate (0.5)
Habitat	Essential fish habitat**	Moderate (0.5)
	Essential fish habitat - highly migratory species**	Moderate (0.5)
	Artificial reefs	High (1.0)
Benthic invertebrates	Atlantic surfclam	Elevated (0.75)
	Ocean quahog	Elevated (0.75)
	Atlantic sea scallop (MDAT 2019 abundance data)	Elevated (0.75)
	Select benthic invertebrates – SMAST (SMAST 2016 abundance data for sea star, crab [spp.], hermit crab, moon snail)	Limited (0.25)

Table 5: Cross-Layer Weightings

Subgroup	Specific Layer	Cross-Layer Susceptibility Weighting
	Select benthic invertebrates – MDAT (MDAT 2019 American lobster, horseshoe crab, Jonah crab)	Limited (0.25)
Notes: * Endangered Species Act (ESA)-listed species **Essential fish habitat (EFH)		

2.8.2 Layer Weighting Rationale

2.8.2.1 Birds Subgroup Weighting Rationale

General – The GIS layers used in the avian WSA were taken from a multiyear research effort by the MDAT (Curtice et al. 2019). The MDAT was started in 2014 by the Marine Geospatial Ecology Lab of Duke University and includes NROC, the NOAA NCCOS, the NOAA NEFSC, and Loyola University Chicago. Avian abundance data in Curtice et al. (2019) leveraged work done by NCCOS under a BOEM contract to produce predictive maps of marine bird relative density from large databases of at-sea transect survey and environmental data in the US Atlantic (Winship et al. 2018).

All Species –Table 2 lists all the birds included in the susceptibility analysis, totaling 47 separate species. These species differ greatly in preferred habitat, likely occurrence, and thus relative susceptibility to offshore wind development. With few exceptions (e.g., roseate tern), this list does not include ESA-listed species. Given the absence of ESA-listed species and broad species grouping, a weighting of limited (0.25) has been assigned.

Collision Sensitive – Table 2 shows the list of collision-sensitive birds included in the susceptibility analysis. The list was taken from Robinson Willmott et al. (2013) and was developed using the following parameters: annual occurrence, nocturnal flight ranking, diurnal flight ranking, percent time in the rotor swept zone of turbines, macro avoidance of wind turbines, and breeding/feeding time in the Atlantic outer continental shelf. This list includes all species on the displacement-sensitive list as well as additional species that may be susceptible to collision but are less likely to also be displaced from preferred habitat. Effects of collision are arguably more severe than displacement but ranking this layer as moderate (0.5) will effectively assign greater weight to the subset of species on both the displacement-sensitive and collision-sensitive lists.

Displacement Sensitive –Table 2 shows the list of displacement-sensitive birds included in the susceptibility analysis. These species may be displaced from their feeding or breeding grounds during construction, operation, and decommissioning of a wind facility. Desholm and Kahlert (2005) found that the percentage of flocks entering an offshore facility area near the Danish coast decreased more than 4.5-fold from the preconstruction to the operation phase. While this effect is less direct (and harder to quantify) than effects from collisions, displacement from preferred habitat may have important population-level effects on species fecundity and fitness. The list of displacement-sensitive birds was derived in Robinson Willmott et al. (2013) and was developed using the following parameters: disturbance ranking, macro-avoidance, habitat flexibility, annual occurrence, and breeding/feeding time in the Atlantic outer continental shelf. The list is a subset of the collision-sensitive bird list and consists of a suite of seabirds that might be present offshore for large periods of the year. Because this suite of species is theoretically susceptible to effects from displacement and collision, and spatial concentrations may indicate presence of preferred feeding grounds, a moderate (0.5) ranking was assigned.

Roseate Tern - Potential effects to federally listed species, whether displacement or collision, have greater potential effects on populations. Robinson Willmott et al. (2013) ranked the sensitivity of 177 migratory bird species to offshore wind energy projects. The roseate tern ranked 4th highest in population sensitivity (related to range and population size), 7th highest in collision sensitivity, and 3rd highest for displacement sensitivity. Therefore, an elevated (0.75) susceptibility ranking is assigned for this species.

2.8.2.2 Fish Subgroup Weighting Rationale

General – Offshore wind development can have positive and negative effects on fish species. Positive effects are associated with the reef effect, the sheltering effect, and the fact that offshore wind power will reduce global carbon emissions and consequent negative impacts of climate change. The reef effect occurs when foundations (e.g., oil platforms, offshore wind platforms, docks, etc.) provide hard substrate for marine organism colonization and increase diversity and density of many fish taxa (Helvey 2002). However, the same traits that make these "artificial reefs" attractive to native species, also make them attractive to invasive species. Some fish species may benefit from the sheltering effect whereby fish are protected from commercial fishing due to the challenges of using mobile fishing gear in offshore wind farms.

Potential negative effects of offshore wind development and operation on fish species include seabed disturbance, sensory disturbance (e.g., noise, vibrations, and visual disturbance), habitat removal, and changes in prey availability. Fish that live and feed on or near the bottom of the ocean are most likely to be affected by seabed disturbance and habitat removal stresses associated with offshore wind development. Clearing, grading, excavation, and pile driving activities during the offshore wind construction phase have the potential to cause a temporary increase in suspended sediment which can negatively affect nearby demersal species, although it is possible that these activities can bring about a short-term increase in benthic prey availability. Underwater noise can cause behavioral and physiological effects to fish species. Behavioral effects include increases in avoidance behavior in response to underwater noise or vibration and potential changes disruption in interspecies communication patterns. Physiological changes include swim bladder and inner ear damage, and death, and are most likely to occur closest to the sound/vibration source. Behavioral changes can occur over much larger areas. Thomsen et al. (2006) found that cod and herring were able to perceive pile drive-generated noise up to 80 km away from the source, but Thomsen et al. (2006) also highlights the fact that there have only been a limited number of studies related to fish and underwater noise.

All Species – Given the broad range of species represented and general lack of ESA-listed species and the highly mobile nature of many fish species, a limited (0.25) ranking was assigned to this group.

Demersal Species – Nonfloating (i.e., stationary) offshore wind foundations reduce the availability of benthic habitat, albeit over only a small portion of the ocean floor. Species with strong affinity with benthic habitats will be affected during preconstruction and construction phases by underwater noise, direct contact, sediment suspension/deposition, and habitat loss. Relative to pelagic species, demersal taxa will have the highest likelihood for EMF exposure during the operation phase, as well as an elevated likelihood of mortality/injury. A moderate (0.50) ranking was assigned to this group.

Highly Migratory Species (HMS) with Designated EFH – This defined group of fish species has a high recreational/sport and/or commercial importance and includes tunas, swordfish, sharks, and billfish. HMS are typically pelagic, fast moving, and have life history characteristics that would indicate a low likelihood of being affected by direct contact, sediment suspension/deposition, and EMF. A limited (0.25) ranking was assigned to this group.

Species with Designated EFH – This group includes all fish and invertebrate species with commercial and/or recreational/sport importance that are federally managed. This group includes species with benthic and pelagic life stages and a wide range of life history characteristics that could be affected during preconstruction and construction phases by underwater noise, direct contact, and sediment suspension/deposition. A moderate (0.50) ranking was assigned to this group.

Atlantic Sturgeon – Atlantic sturgeon are an ESA-listed species with benthic life history characteristics. They are a large and generally slow-moving fish species therefore higher likelihood of vessel strike direct contact. Brown (2010) examined a total of 28 Atlantic sturgeon mortalities in the Delaware River/Bay between 2005 and 2008 and found that 50% of these were likely to have been caused by vessel strikes. Given this species rarity, benthic life history characteristics, and susceptibility to vessel strikes, an elevated (0.75) ranking was assigned to this group.

2.8.2.3 Cetaceans Subgroup Weighting Rationale

General - The GIS layers used in the cetacean WSA were also taken from the published MDAT data (Curtice et al. 2019). In general, Curtice et al. (2019) coupled visual line transect surveys with physiographic and oceanographic data to create a habitat-based density model that yields density estimates (animals/100 km^2). This model used over 17,800 hours (i.e., ~ 2 years) of visual survey data collected during 21 separate survey programs over a 24 year period (1992-2016).

Two primary offshore wind–related stressors were considered when developing the cross-layer susceptibility weights for cetaceans: 1) collision risk and 2) underwater noise. Increased vessel traffic associated with all phases of offshore wind development will increase the risk of vessel-cetacean collisions. Animal size and diving depth are the two most important parameters for predicting this risk. Generally, there is a positive relationship between cetacean size and vessel strikes (Jensen and Silber 2004, Van Der Hoop et al. 2012). For example, using observations from 1970-2009, Van Der Hoop et al. (2012) reported a combined total of 128 vessel strikes for the three largest whales in their database (fin, humpback, NARW) but only 32 vessel strikes for the smaller species (minke, sei, sperm whales). With respect to diving depth, it is self-evident that species that spend more time in deeper water (i.e., deep-diving cetaceans) will encounter fewer vessels. The sperm whale, the only deep-diving species included in the Ver Der Hoop et al. (2012) study, was observed to have the fewest vessel strikes.

Underwater noise can cause behavioral changes, displacement, and/or noise-related injury in cetaceans. NMFS (2018) divides cetaceans into three groups based on their hearing range. The most common/abundant group in the focal area (baleen whales) are low frequency cetaceans (LFCs) and hear in the range of 7 hertz (Hz) to 35 kilohertz (kHz). Mid frequency cetaceans (MFCs; 150 Hz to 160 kHz) include sperm whales, beaked whales, and dolphins. High frequency cetaceans (HFCs; harbor porpoise, dwarf and pygmy sperm whales) hear in the range of 275 Hz to 160 kHz.

The sources of offshore wind–related underwater noise vary depending on the phase of offshore wind development. Preconstruction noise is related to vessels and geophysical evaluations. The echo sounding devices used during these preconstruction surveys typically use a low energy, narrow directed beam of sound with frequencies between 12 kHz and 20 kHz. While some echo sounders produce sound pressure levels that can cause hearing injury to cetaceans that are in close proximity to the instrument (O'Brien et al. 2005), these mobile, short duration, narrowly focused beams are more likely to interfere with communication and cause behavioral changes. Quick et al. (2017) found that the use of an echo sounder elicited behavioral changes in short-finned pilot whales of off Cape Hatteras, North Carolina.

Relative to other phases of offshore wind development, noise from the construction phase (primarily pile driving) is likely to cause the highest risk to cetaceans. According to Energinet.dk (2015), the typical pile driving delivers 30 to 50 blows per minute, and it can take 4,000 to 6,000 blows to install a pile into the seafloor. Impulsive sound from this activity can travel long distances (>4,265 ft; Erbe 2009) and has the potential to cause behavioral changes and noise-related injury. Brant et al. (2011) evaluated underwater noise associated with pile driving at two wind farm construction sites in the Danish North Sea and measured sound pressure levels of 176 decibels (dB) re 1 micro Pascal (μPa) at 2,362 ft (720 m) at one site and between 167 and 170 dB re 1 μPa at 2,460 ft (750 m) at the other. These values are close to the NOAA-defined value for behavioral disruption (160 dB root mean square; rms) but well below the onset thresholds for permanent threshold shift (i.e., permanent hearing loss) from impulsive noise (202 to 232 dB for peak sound pressure levels). LFCs are thought to be more sensitive to pile-driving noises than MFCs or HFCs because low frequency noise from pile driving travels farther from the source. For example, near the source (steel piles advanced via hydraulic piston hammers during the construction of a highway bridge), Erbe (2009) measured a broad frequency range (40 Hz to >40 kHz). However, only noise with a frequency of less than 400 Hz remained at a distance of approximately 4,265 ft (1300 m) from the source.

All Species –Table 2 shows the list of all cetaceans included in the susceptibility analysis. This species list is a combination of MFCs and LFCs. This species list is also a combination of small species (less strike risk) and larger species (higher strike risk), and a combination of nonlisted (many delphinids) and ESA-listed species (also assessed separately). This layer is comprised of a broad grouping of 33 species, including those with varying susceptibilities to offshore wind development, and therefore it was given a moderate (0.5) ranking.

Blue Whale – The blue whale is a federally listed species, so there is a potential for population-level negative effects if individuals are injured or killed. In addition, this is a large species with a higher likelihood of vessel strike. The blue whale is an LFC; therefore, there is increased potential for noise effects. This species was given an elevated (0.75) susceptibility ranking.

Fin Whale – The fin whale is a federally listed species, so there is the potential for population-level negative effects if individuals are injured or killed. In addition, this is a large species with a higher likelihood of vessel strike. The fin whale is an LFC; therefore, there is increased potential for noise effects. This species was given an elevated (0.75) susceptibility ranking.

Sei Whale – The sei whale is a federally listed species, and therefore there is the potential for population-level negative effects if individuals are injured or killed. In addition, this is a large species with a higher likelihood of vessel strike. The sei whale is an LFC, and therefore there is increased potential for noise effects. This species was given an elevated (0.75) susceptibility ranking.

Sperm Whale – The sperm whale is a federally listed species, and therefore there is the potential for population-level negative effects if individuals are injured or killed. In addition, this is a large species with a higher likelihood of vessel strike. The sperm whale is an MFC and is therefore less likely to be affected by underwater noise than an LFC, so this is a somewhat lesser concern. Vulnerability to vessel strikes and ESA-listed status were the reasons this species was given an elevated (0.75) susceptibility ranking.

North Atlantic Right Whale – Because this species has only about 400 known individuals in the western North Atlantic Ocean and just 95 reproductively active females (NOAA 2020), there is significant risk of population-level effects due to injury or mortality. Indeed, Fujiwara and Caswell (2001) used a database of 10,000 photo-documented right whale observations and population matrix modeling to demonstrate that the prevention of even two female mortalities per year would increase the population growth rate to replacement level (i.e., no population loss).This species also has a high vessel strike risk due to its large size and shallow diving habit. Although NARWs have additional species-specific mitigation measures (e.g., timing windows, seasonal management areas), a high (1.0) susceptibility ranking is given for this species given its critically endangered status.

2.8.2.4 Sea Turtles Subgroup Weighting Rationale

General – The WSA for sea turtles is focused on three species—leatherback turtles, loggerhead turtles, and green sea turtles. Although additional listed sea turtles have been sighted off the coast of New Jersey (e.g., green sea turtle), Ramboll could find no appropriate species-specific spatial data for use in this analysis. The sea turtle data used in the WSA was taken from one source:

The Northwest Atlantic Marine Ecoregional Assessment (Greene 2010) uses data from the US Navy's Marine Resource Assessments. The NAMERA (2010) report includes observations from Maine to North Carolina—an area much larger than that covered by the WSA. The Navy used 24 years (1979-2003) of daylight aerial and shipboard observations made by the NMFS. This dataset included 187 observations of leatherbacks, 1,876 observations of loggerheads, and 5 observations of green sea turtles. The majority of these species' observations were made during the summer months off the coasts of New Jersey, Delaware, Maryland, Virginia, and North Carolina. However, a significant number of loggerhead observations were made in the spring and fall, mainly off the coasts of Delaware, Maryland, Virginia, and North Carolina.

Additional data are available from the New Jersey Ecological Baseline Study (NJDEP 2010) but were not used in the weighted sum analysis because of the nearshore collection and lack of data in the study area. This survey was a 24-month long survey to determine the spatial distribution of marine mammals and sea turtles in the nearshore waters of New Jersey between Stone Harbor and Seaside Park (shoreline to approximately 20 miles offshore). Survey data were collected using aerial line transect surveys, shipboard line transect surveys, and passive acoustic monitoring. Only loggerhead turtles and leatherback turtles were observed during this survey effort, and both species were observed in summer. There were 63 loggerhead sightings in the summer, three observations in the spring, and two in the winter. Loggerhead observations were fairly evenly distributed within the survey area. Leatherback observations were less abundant throughout the survey area (12 turtles in summer) and mostly restricted to the deeper waters (59 to 98 feet).

The sources of risk from offshore wind development activities for sea turtles are similar to those discussed above for cetaceans (i.e., vessel collision and underwater noise). While there is a dearth of information related to how sea turtles respond to underwater noise, several studies have demonstrated their ability to perceive low frequency sounds (<1,000 Hz; Lenhardt et al. 1996, O'Hara 1990, Bartol et al. 1999). Vessel movement (Samuel et al. 2005) and pile-driving activities produce underwater sound in the low frequency range (15 to 2,000 Hz; Dahl et al. 2015, Illingworth and Rodkin 2007). The fact that sea turtle hearing range overlaps with offshore wind low frequency anthropogenic underwater noise increases the likelihood that sea turtles might experience behavioral changes, displacement, and/or noise-related injury in response to this stressor, but only a few studies have evaluated this issue.

The US Army Corps of Engineers (USACE) (1997) summarizes several studies that evaluate sea turtle response to seismic noise (air guns) that could be used to disperse sea turtles away from navigational dredging activities. While seismic noise is not the same as the impulsive noise generated from pile driving, these noises are similar enough for the USACE to use these studies to gain insight into the relationship between turtle behavior and underwater noise (Edmonds et al. 2016). Moein et al. (1994) found that captive turtles responded to the first few seismic noise exposures by avoiding the source. However, upon subsequent exposures, avoidance behavior was minimal, indicating habituation to this noise source. McCauley et al. (2000) found that captive loggerhead and green turtles demonstrated statistically significant increases in "fast swimming" and "direction changing" behaviors in response to seismic noise.

Increased vessel traffic associated with all phases of offshore wind development and operations has the potential to cause risk to sea turtles. Vessel strike is listed as a threat to species recovery in several sea turtle recovery plans (NMFS and USFWS 2008, NMFS and USFWS 1991, NMFS et al. 2011) and several studies have corroborated this threat (Denkinger et al. 2013, Yaghmour 2020, Foley et al. 2019). Unpublished data in NMFS and US Fish and Wildlife Service (USFWS) (2008) reports indicated that 14.9% of the stranded loggerhead turtles observed in the US Atlantic and Gulf of Mexico between 1997 and 2005 showed propeller and collision injuries. Yaghmour (2020) evaluated 4 years of stranding events along the coast of Sharjah, United Arab Emirates. Eleven percent of the 102 strandings had evidence of vessel strike injury. However, neither of these studies (NMFS and USFWS 2008, Yaghmour 2020) included necropsies, so it is possible that vessel strike occurred postmortem. In contrast, during a long-term (1986-2014) study of stranded turtles in Florida, Foley et al. (2019) found that about 30% of the stranded loggerheads, leatherbacks, and green turtles exhibited vessel strike injury. Necropsies of 194 stranded turtles with vessel strike injuries demonstrated that the cause of death for more than 90% of these cases was vessel strike. Foley et al. (2019) also found a negative relationship between the probability of vessel strike and distance from a navigable waterway or marina (i.e., the closer a turtle is to a navigable waterway or marina, the higher the probability of vessel strike). Foley et al. (2019) went on to hypothesize that the nearshore area (<0.62 miles from shore) is the area where most loggerheads and green turtles are struck by motorized vessels. This generality is especially true during turtle mating and nesting season. This evidence, along with the fact that the majority of offshore wind–related vessel traffic will be more than 20 miles offshore, indicates that, as long as offshore wind vessels follow nearshore best management practices (e.g., timing restrictions, go-slow zones, no-entry areas), vessel strike injury to sea turtles can be minimized.

An additional risk for sea turtles may be related to entanglement with recreational anglers due to increased fishing pressure at offshore wind turbines brought about by a real or perceived "reef effect" (i.e., offshore wind foundations provide hard substrate for colonization and increase diversity and density of many taxa, including sport fish). A 2019 survey indicated that many recreational anglers have the perception that the Block Island Wind Farm has improved fishing off the coast of Rhode

Island (Prevost 2019). While mandated trawl surveys have not found significant differences in fish abundance between preconstruction and postconstruction surveys, this perception is likely to increase fishing pressure and consequent sea turtle entanglement risk in these areas. Ramboll could find no information on the effect of the Block Island Wind Farm on sea turtles, but sea turtles are sparsely distributed in the waters off Rhode Island (Greene 2010).

Loggerhead Turtle – This species may be exposed to some increased entanglement risk from potential increased recreational fishing in the area due to the "reef effect" of turbine foundations and bases; given their listed status, and the severity to individuals that might be affected, a moderate (0.5) susceptibility ranking is assigned.

Leatherback Turtle – Like the loggerhead turtle, this federally listed species may be exposed to increased entanglement risk from potential increased fishing in the area. A moderate (0.5) susceptibility ranking is assigned for this species.

Green Turtle – Similar to the loggerhead and leatherback turtles, green turtles are federally listed and may be exposed to increased entanglement risk from potentially increased fishing. A moderate (0.5) susceptibility ranking is assigned.

2.8.2.5 Habitat Subgroup Weighting Rationale

General – This WSA evaluates habitats separately from the species they support because these two entities respond differently to potential offshore wind stresses. For example, offshore benthic habitats are not subject to vessel strikes nor are they affected by underwater noise. Habitat may be affected by the placement of turbine foundations (habitat loss), or foundation construction activities (bottom disturbance), but construction effects to EFH are likely to be short-term and spatially constrained.

Essential Fish Habitat – EFH is a defined area established to preserve habitat for all life stages of federally managed fish and invertebrate species. Habitat includes the physical substrate, chemical, and biological properties that are used by the designated species to support a sustainable commercial and recreational fishery and a healthy ecosystem. This includes habitats for species with benthic and pelagic life stages and a wide range of life history characteristics. As essential fish habitat is important to protect, but offshore wind effects during construction are likely to be short-term and spatially constrained, this habitat type was assigned a moderate (0.5) ranking.

EFH for HMS – Defined habitat area that supports life stages of HMS including tunas, swordfish, sharks, and billfish. HMS are typically pelagic, fast moving, and migrate over large areas. A moderate ranking (0.5) was assigned to this habitat group for the above-described reasons.

Artificial Reefs – Artificial reefs are established locations intended to support and enhance biological productivity of a specific area. They are created by placing hard and heterogenous material on the sea floor to create habitat complexity. Following installation, artificial reefs are inhabited by numerous species and provide unique ecological functions including habitat, erosion protection, safe refuge from predators, and organic enrichment of nearby sediments. A high (1.0) ranking is given to these areas because of their productivity and rarity, and the fact that they are much more likely to be affected by sediment deposition relative to surrounding homogenous habitat types.

2.8.2.6 Benthic Invertebrates Subgroup Weighting Rationale

Atlantic Surfclam – The Atlantic surfclam is one of New Jersey's most commercially important shellfish. Atlantic surfclams have relatively fast growth rates, but they are vulnerable because of benthic habitat loss, bottom disturbance, and sedimentation associated with offshore wind development. The Atlantic surfclam is not a listed species under the ESA and is considered a sustainably managed fishery (i.e., not overfished) (NOAA 2016). Based on the immobility and commercial value of this species, an elevated (0.75) susceptibility ranking is assigned.

Ocean Quahog – Like the surfclam, the ocean quahog is an important shellfish species and among the most commercially valuable species in New Jersey. Like other shellfish, the ocean quahog can be affected by offshore wind development because of disturbance to the seafloor. Immobility and the commercial importance of the ocean quahog in New Jersey are the reasons a weighting of elevated (0.75) has been assigned.

Atlantic Sea Scallop – Atlantic sea scallops are very mobile in the larval life stage but much less mobile in the adult stage. Mobile larvae are not particularly sensitive to offshore wind development. Adult-stage Atlantic sea scallops may be affected by benthic habitat loss, bottom disturbance, and sedimentation/deposition brought about by offshore wind development. No ESA-listed Atlantic sea scallop species are known to occur in the study area. Given the commercial value of this species, an elevated (0.75) susceptibility ranking is given for this group.

Select Benthic Invertebrates – SMAST/MDAT – The SMAST data include abundance data for sea star, crab, hermit crab, and moon snail. The MDAT data include American lobster, horseshoe crab, and Jonah crab. Some of the species included in this group are mobile (especially in the larval stage), and some are more stationary and may not be able to avoid the localized effects of offshore wind development (benthic habitat loss and sedimentation). This layer is comprised of a grouping of species, and no ESA-listed benthic organisms are known to occur in the study area. A limited (0.25) susceptibility ranking is given for this species group.

2.9 Weighted Sum Process

The final step in the performance of the WSA analysis was the combining of individual input layers (found in Section 2.6) within each of the biological resource subgroups. This process incorporated weightings assigned in Section 2.8 and was completed using the following approach:

Step 1 – Weighting Layers

Inputs: Standardized individual layers

Outputs: Weighted individual layers

Following the data standardization process described in Section 2.7, each individual layer within a subgroup is weighted by multiplying the standardized data values (e.g., abundance values) by the corresponding layer-specific weightings defined in Section 2.8.

Step 2 – Summing Individual Layers

Inputs: Weighted individual layers

Outputs: Subgroup layers (Figures 34-39)

The weighted individual biological resource layers within a subgroup were summed and rescaled (by the same process detailed in Section 2.7) to obtain a final overall "susceptibility value" for each subgroup, where 0 is least susceptible and 1,000 is most susceptible to offshore wind development. The susceptibility values were then categorized into 10 classes based on equal interval ranges. Each class was given a "susceptibility score" ranging from 1-10, where susceptibility values 0-100 were assigned a 1, values 101-200 were assigned a 2, and so forth. The equal interval method enables differences in relative susceptibility between subgroups to be elucidated.

Step 3 – Summing Subgroups

Inputs: Subgroup layers (Figures 34-39)

Output: Overall environmental susceptibility layer (Figure 40)

The last step combines the six resource subgroup figures into an aggregate figure representative of the combined susceptibility of all resource subgroups over the OWSP study area (Figure 40). This figure is created by summing the biological resource subgroup layers and then normalizing to obtain susceptibility values ranging from 0-1,000. The equal interval method (described in Step 2) was applied to obtain a range of susceptibility scores from 1-10.

2.9.1 Weighted Sum Caveats

Certain considerations were made in order to 1) account for scenarios where there was incomplete data coverage among the individual input layers that were combined and 2) combine subgroup layers. This section describes the logical steps and rationale for the approach elected by the GIS team.

The benthic subgroup summary overlay was created by summing the rescaled weighted layers as described above, despite the varying coverage of the source data layers. The NJDEP ocean quahog and Atlantic surfclam layers fully covered the study area, while the SMAST and MDAT select benthic organisms and Atlantic sea scallops layers had incomplete coverage (see Section 2.5). When dealing with varying levels of coverage, one approach is to "average" the layers, taking into account areas of partial coverage. For example, if a certain cell had coverage by the NJDEP data layers and MDAT data, but not the SMAST data, the weighted layers would be summed and then divided by three to acknowledge that only three of the layers had coverage for that cell.

The averaging method was considered; however, the GIS team decided instead to sum the weighted layers (as described in Step 2) in order to follow a more conservative approach. Summing the layers yields an overall higher relative abundance value for each cell, whereas averaging them would mute the higher values. However, a drawback of this approach is that in areas of incomplete data coverage, fewer layers were summed than in areas with complete coverage. The areas that have incomplete data coverage therefore carry a level of uncertainty. See Section 2.5 for a visualization of data coverage.

The decision to average versus sum was also considered with regard to creating the overall environmental susceptibility layer (Figure 40). In this case, the averaging approach would sum the six subgroup layers and then divide by six, in order to obtain an average environmental susceptibility for each cell.

However, the GIS team elected to sum rather than average in this case, once again to follow a more conservative approach. Averaging the individual subgroups would have muted high susceptibility zones. For example, the birds subgroup showed low susceptibility throughout the study area. Therefore, averaging the other subgroups with the birds subgroup layer would have lowered susceptibility scores for the other subgroups that may have had high susceptibility zones. It should be noted that the overall environmental susceptibility layer is not intended to summarize overall environmental effects over the study area. Rather, it is a high-level visualization that may be used to determine which areas are overall more environmentally susceptible to offshore wind development.

2.10 Interpretation of Overlays

The WSA is intended to inform the development of offshore wind in New Jersey by providing a mapping of relatively high and low areas of potential conflict for offshore wind development. These areas of higher and lower potential for conflict reflect the relative susceptibility of biological resources evaluated herein. The areas of higher or lower susceptibility depicted on the subgroup figures are relative susceptibilities (1-least susceptible, 10-most susceptible) and should be interpreted only in the context of this analysis within the defined study area.

Highly ranked areas represent areas where there may be a need for greater environmental considerations than lower ranked areas. For example, high susceptibility areas could indicate a greater potential density of ESA-listed species. If an area has been identified as having a higher level of susceptibility or conflict, this does not mean that offshore wind development should not be considered in that area; instead, it indicates that additional measures may be required to mitigate conflicts for development.

Similarly, areas identified with lower susceptibility or conflict should not necessarily be assumed to be the best areas for offshore wind development, since this analysis does not consider every environmental element, biological resource, or processes. Furthermore, the overlays are heavily influenced by the data limitations of the original data sources (e.g., cell size, number of years of survey data, seasonal distribution of survey data, sampling density, and predictive modeling assumptions). The relative susceptibilities presented in the WSA figures should be considered alongside other recommended studies, analyses, and conservation priorities.

2.10.1 Birds Subgroup Interpretation

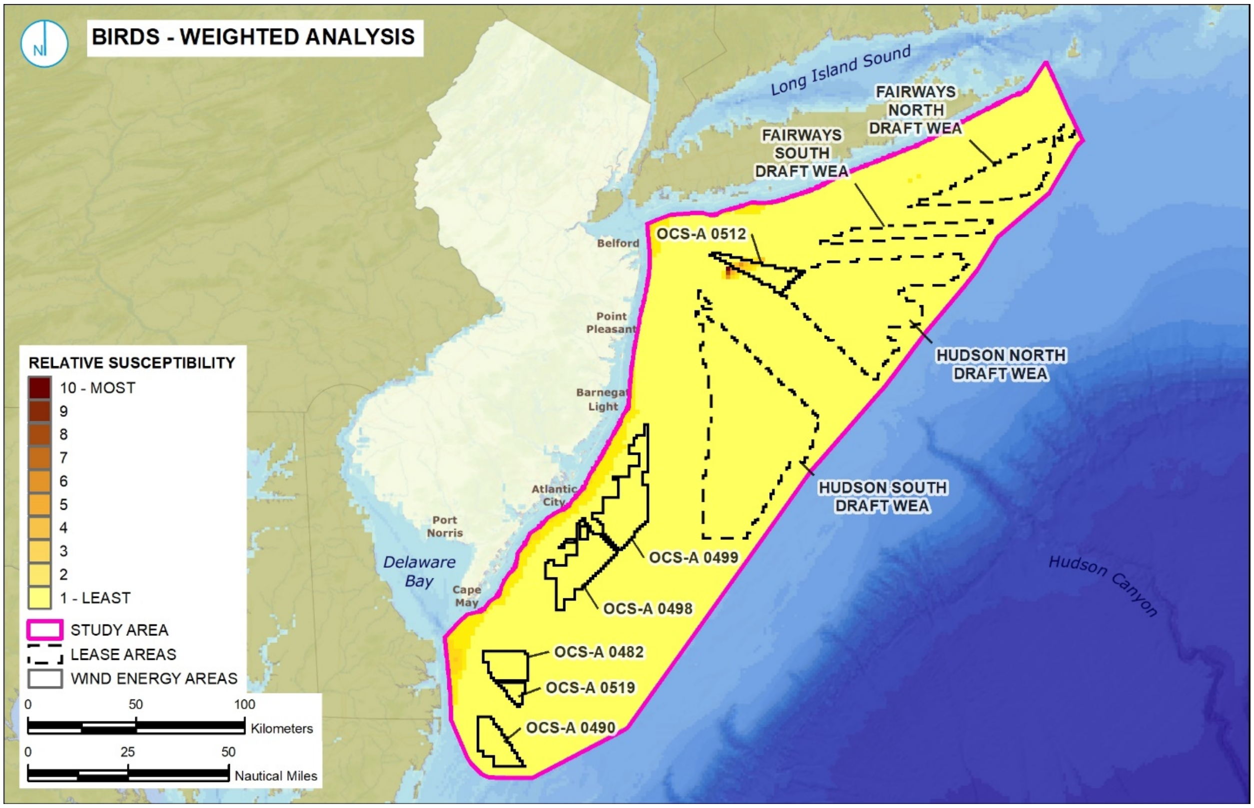

Figure 34: Birds Weighted Sum Analysis

Figure 34 shows the weighted sum susceptibility of the birds subgroup. Low levels of relative susceptibility for birds is prevalent throughout the vast majority of the study area (leases and WEAs). This generally reflects a low overall abundance of collision and displacement sensitive birds in offshore areas. There is a small area of moderate relative susceptibility identified within OCS-A 0512, associated with increased density of individuals per 2 km^2 from the collision- and displacement-sensitive component layers. Although roseate tern is weighted as "elevated" susceptibility, its extremely low densities suggest low potential for negative effects, even in the westernmost portion of the Hudson South WEA along the Hudson Canyon.

2.10.2 Fish Subgroup Interpretation

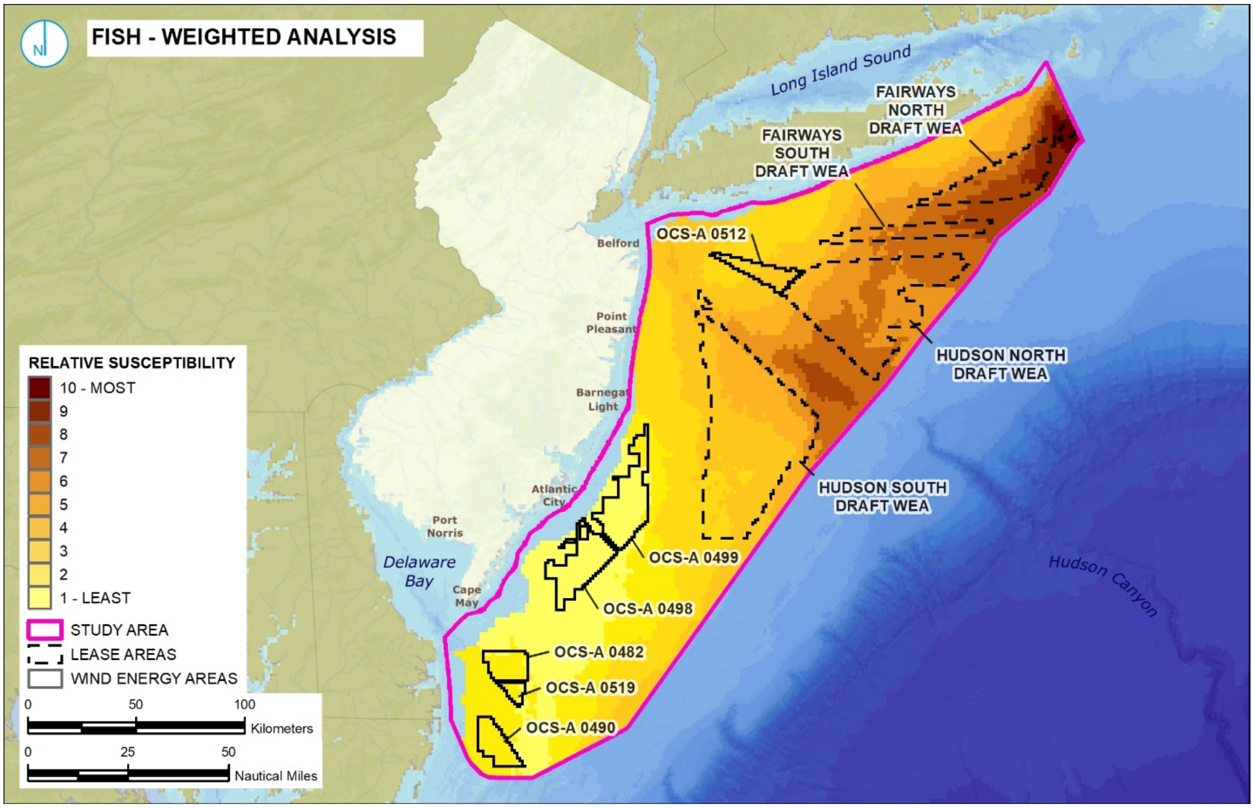

Figure 35: Fish Weighted Sum Analysis

Figure 35 shows the weighted sum of the fish subgroup individual layers. There is an area of higher relative susceptibility along the Hudson Shelf Valley (leading to the Hudson Canyon). The Fairways North draft WEA, Fairways South draft WEA, and Hudson North draft WEA show the highest areas of relative susceptibility for fish species, which is specifically associated with abundance of demersal species and species with designated essential fish habitat. Despite the elevated weighing of Atlantic sturgeon, distinct areas of potential conflict where these species are abundant are not apparent. The lease areas south of the Hudson Canyon show low relative susceptibility for fish species. It is apparent that relative susceptibility increases slightly as water depths increase.

2.10.3 Cetaceans Subgroup Interpretation

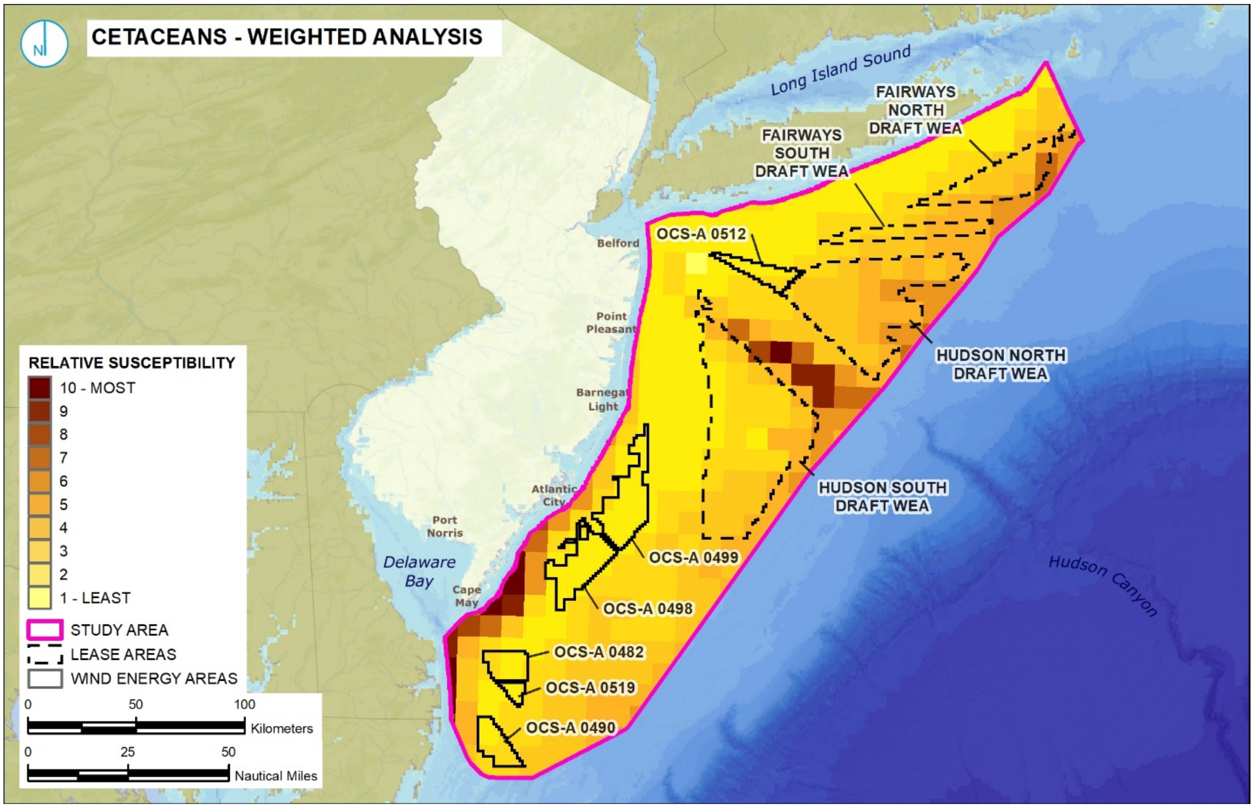

Figure 36: Cetaceans Weighted Sum Analysis

Figure 36 shows the weighted sum of the cetacean subgroup individual layers. The area off the coast of Cape May and the Hudson Canyon show the highest relative susceptibility for cetaceans. Near Cape May, this appears to be associated with nearshore presence of dolphins. Higher susceptibility in the Hudson Canyon is associated with individual species (i.e., fin whale, sei whale, sperm whale) as well as the "all-species" input. NARW susceptibilities are not apparent despite the high weighting of 1 in this analysis, due to their low abundance within the study area. The lease areas and WEAs show relatively low susceptibility for cetaceans despite the moderate to high weightings of the component layers. Vessels traveling to and from the lease areas or WEAs from marshaling or operations and maintenance ports may have to travel in areas of high relative susceptibility, putting cetaceans at risk for vessel strikes.

2.10.4 Sea Turtles Subgroup Interpretation

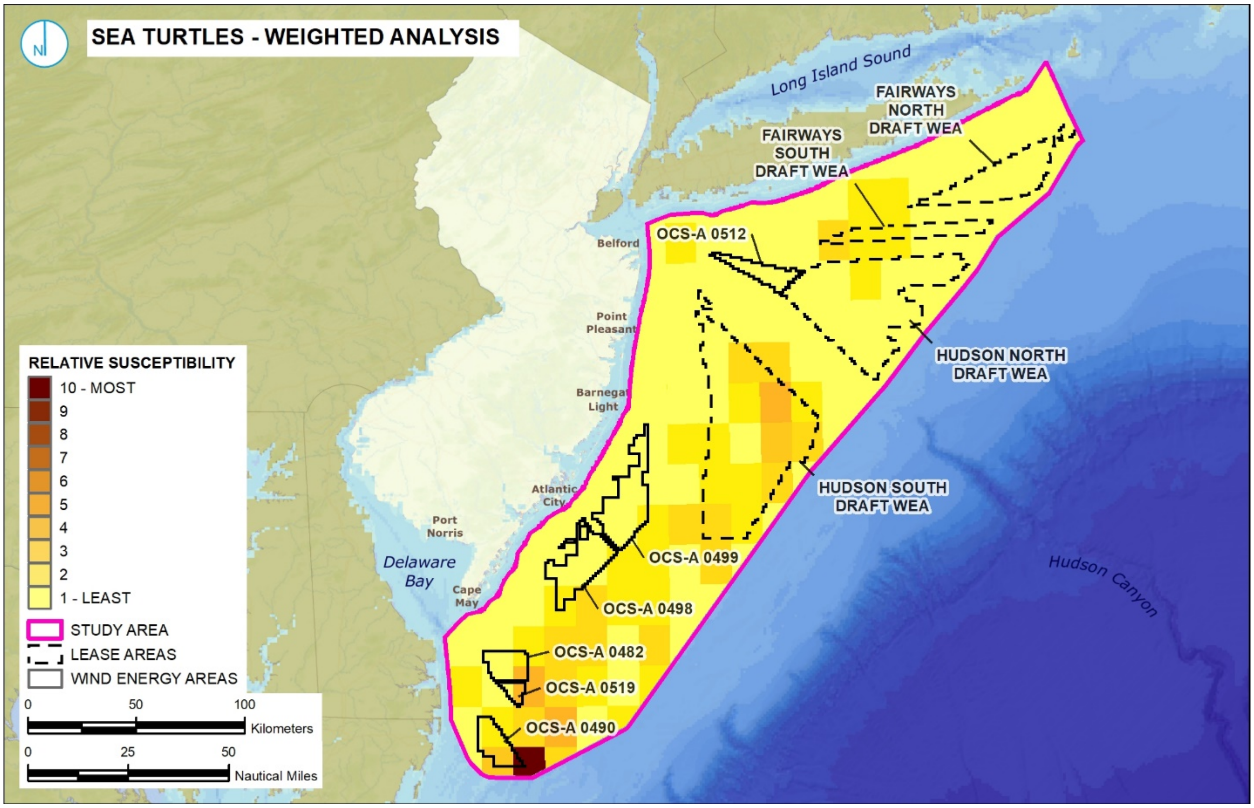

Figure 37: Sea Turtles Weighted Sum Analysis

Figure 37 shows the weighted sum of the sea turtle subgroup individual layers. The southeastern corner of OCS-A 0490 appears to have the highest abundance of sea turtles and is therefore the most susceptible to offshore wind development. There are areas of moderate turtle susceptibility within OCS-A 0490, 0519, 0482, and the Hudson South draft WEA. The susceptibilities identified are driven primarily due to abundance of loggerhead turtle. The remaining lease areas and WEAs depict relatively low sea turtle susceptibility.

2.10.5 Habitat Subgroup Interpretation

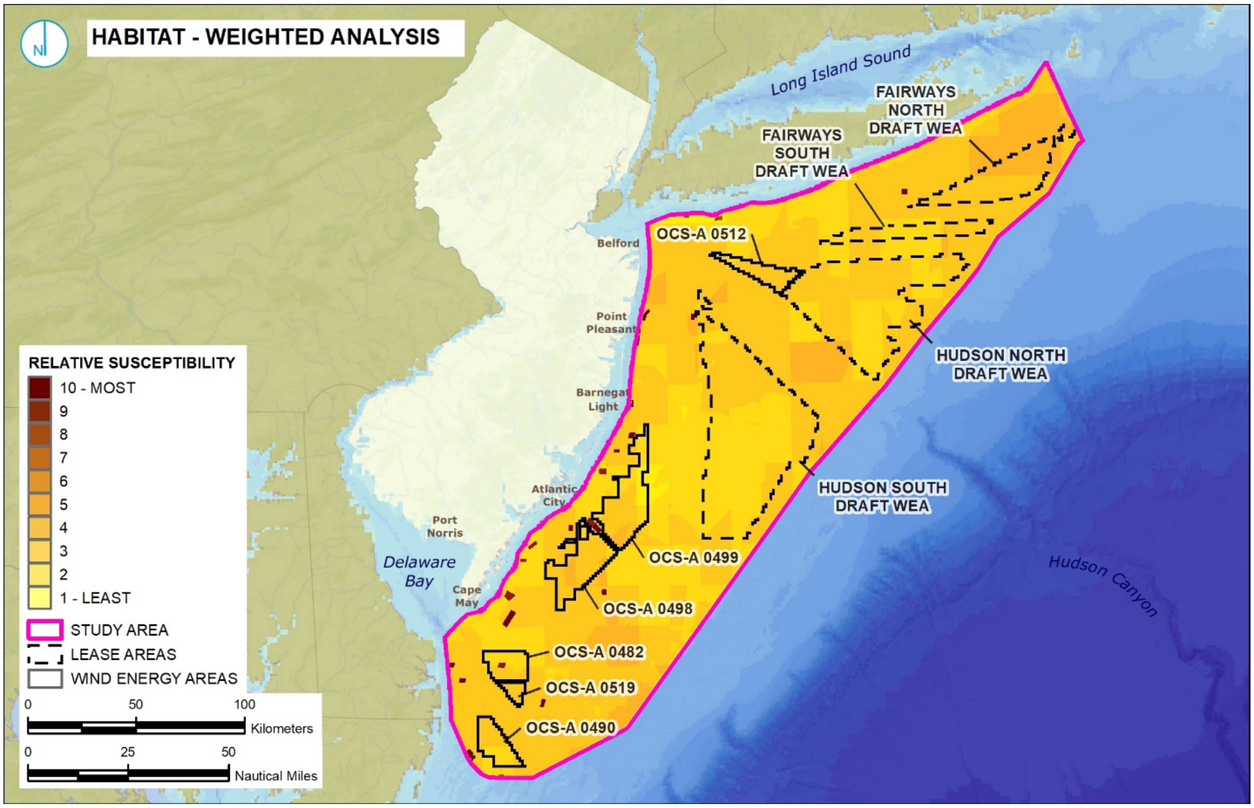

Figure 38: Habitat Weighted Sum Analysis

Figure 38 shows the weighted sum of the habitat subgroup individual layers. The relative susceptibility of habitats appears to be low to moderate within the OWSP study area with the exception of areas where artificial reefs exist, which exhibit very high susceptibility. Most areas within the study area have three to seven overlapping areas of designated EFHs which is the primary driver in the relative susceptibilities observed.

2.10.6 Benthic Invertebrates Subgroup Interpretation

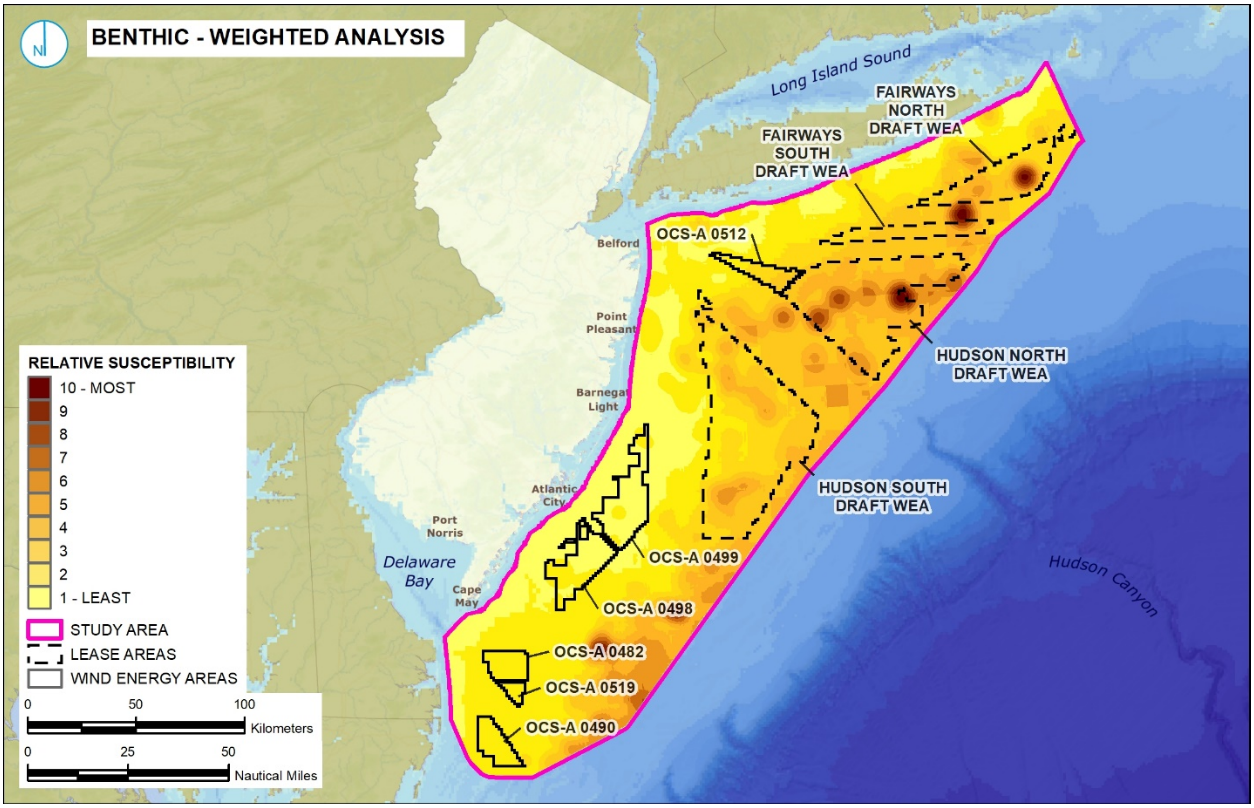

Figure 39: Benthic Weighted Sum Analysis

Figure 39 shows the weighted sum of the benthic invertebrates subgroup. The analysis of the benthic invertebrates subgroup within the study area generally shows that zones of higher relative susceptibility are found further north and offshore, while the areas further south and in shallower waters are less susceptible. Low potential for conflict exists with the New Jersey lease areas; however, some of the WEAs (particularly north of Hudson Canyon) may be more susceptible. Areas of greatest conflict are driven primarily by abundance of Atlantic sea scallop and ocean quahog.

2.10.7 Overall Environmental Susceptibility Interpretation

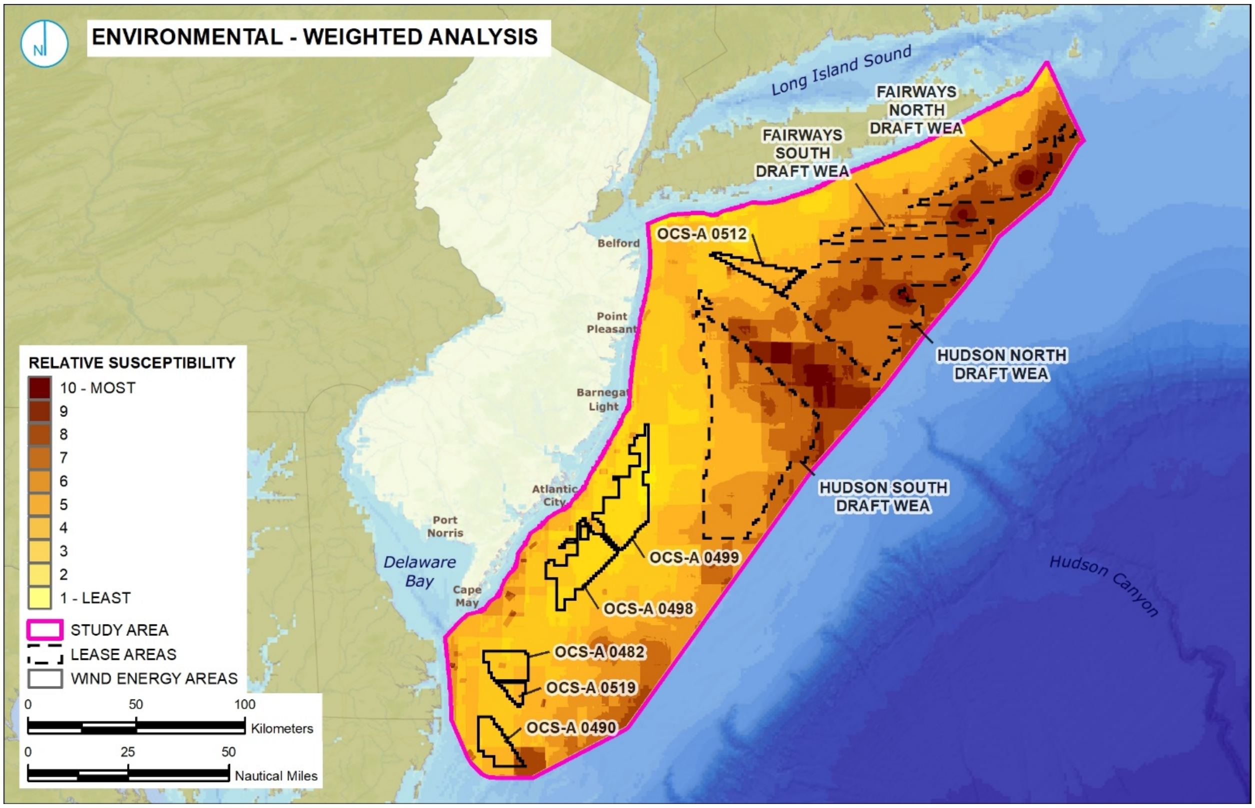

Figure 40: Overall Environmental Susceptibility

Figure 40 shows total environmental susceptibility after the six WSA subgroup layers are combined. Overall, the northernmost WEAs appear to be the most susceptible to offshore wind development. The Hudson Canyon area also shows moderate to high environmental susceptibility and the trend of increased susceptibility with depth and distance from shore holds true in this composite analysis. The southern lease areas appear to be less environmentally susceptible to offshore wind development, particularly in OCS-A 0498 and OCS-A 0499.

The overall environmental susceptibility depicted in this figure equally represents all component subgroups. Therefore, the primary drivers of conflict are commensurate with the susceptibilities identified in Figures 34 through 39, specifically collision- and dispersion-sensitive birds, demersal fish, cetaceans including dolphins and individual species (fin, sei, and sperm whales), and loggerhead sea turtles, as well as Atlantic sea scallops and ocean quahogs.

2.11 WSA Model Sensitivity Analysis

Model sensitivity testing is standard practice in quantitative modeling. In model sensitivity testing, the effect of input parameters is examined with respect to their influence on model results, so that the relationships between model inputs and outputs may be better understood. Model sensitivity testing also provides insight into uncertainty, the robustness of a model, and provides a means for finding errors. Model sensitivity testing was performed for the WSA and is discussed in greater detail below.

The sensitivity analysis was completed sequentially, one subgroup at a time, by changing all of the cross-layer susceptibility weights (Table 5) within a subgroup to the highest level (i.e., 1.0 unitless) and rerunning two separate models: 1) a sensitivity model that includes only that subgroup (referred to as "model sensitivity analysis"), and 2) a sensitivity model that incorporates the model sensitivity analysis into the overall environmental susceptibility model (referred to as "overall environmental result - model sensitivity analysis"). The resultant model sensitivity results were then compared to the original weighted sum figures for the subgroup (Figures 34-39) and the overall environmental susceptibility model (Figure 40) to evaluate the effect of applying the maximum weighting for the subgroup's individual layers.

Figures 41-46 allow for two side-by-side comparisons of model sensitivity results to the original weighted sum figures. Each figure is comprised of four panels: 1) the panel in the upper left represents the model sensitivity analysis for a particular subgroup; 2) the panel in the upper right represents the original subgroup weighted sum analyses for comparison (Figures 34-39); 3) the panel in the lower left represents the overall environmental result - model sensitivity analysis for a subgroup; and 4) the panel in the lower right represents the original overall environmental susceptibility model (Figure 40) for comparison. Graphical representations of these results are included in Figures 47 and 48.

The results of the model sensitivity analysis are discussed below in terms of differences in "susceptibility scores," which refer to the equal interval method described in Step 2 of Section 2.9. Particular attention was given to whether the results of the sensitivity analysis would change the broader takeaways identified for the particular subgroup, and ultimately the overall environmental susceptibility result (Figure 40).

2.11.1 Birds Subgroup Sensitivity Analysis

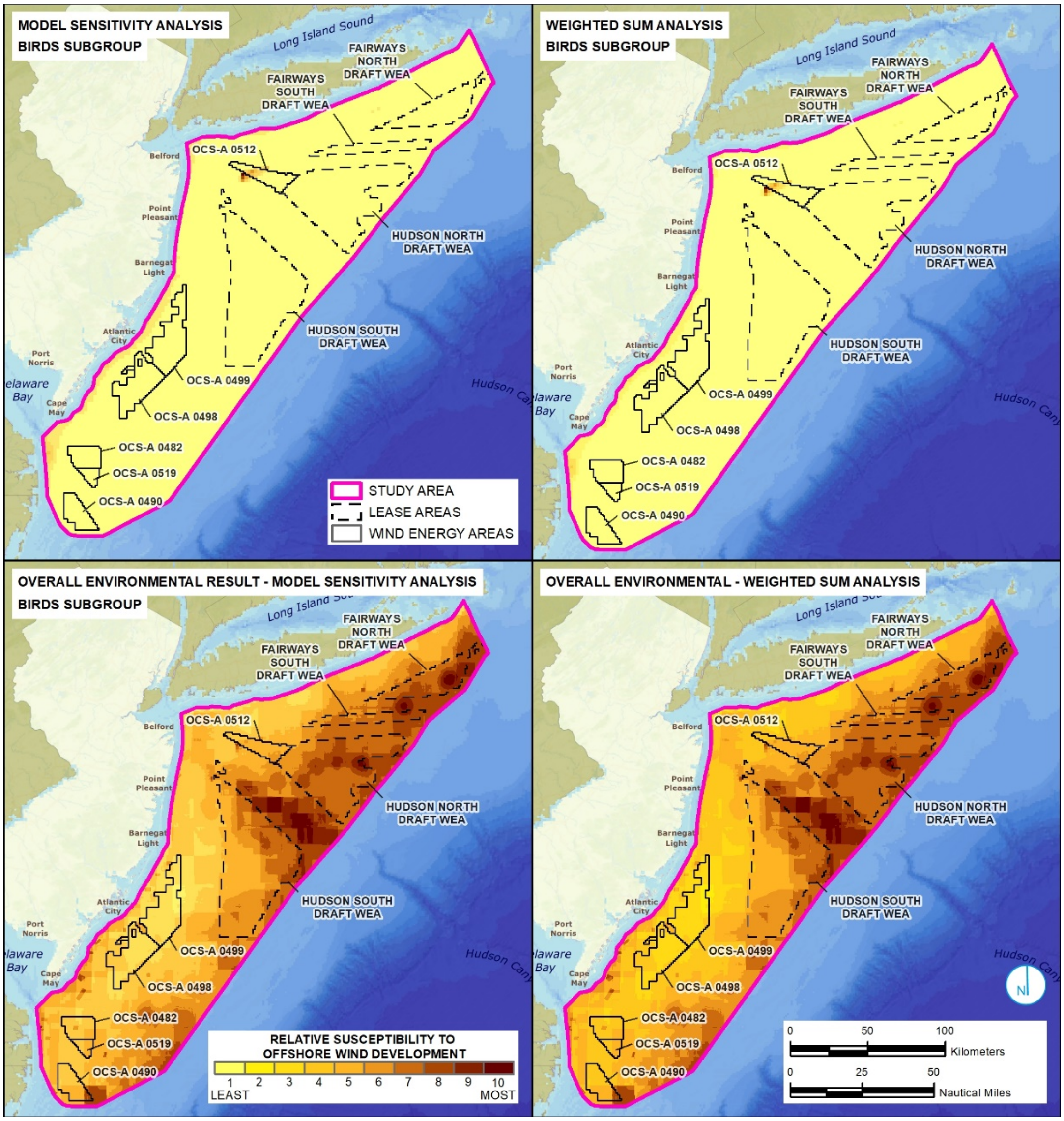

Figure 41: Birds WSA Sensitivity Analysis

Model sensitivity testing (i.e., weighting of 1) on the bird subgroup reveals only minimal variation compared with the original weighted sum result for this subgroup (Figure 41). The absence of variation is primarily due to the low abundance values for most component layers of this subgroup (Figure 47). Despite an increase in weighting, the low abundance values temper the result. Slight increases of the sensitivity model result are observable along the western margin of the study area, reflecting the increase in weighting from 0.25 in the original analysis to 1 in the sensitivity analysis, which reflects the greater nearshore abundance of the included avian species relative to offshore abundance. The impact of increasing the cross-layer weights for this subgroup on the overall environmental weighted sum analysis is also minimal (Figures 41 and 48). The results of this sensitivity analysis do not materially change the assessment of susceptibility for the bird subgroup.

2.11.2 Fish Subgroup Sensitivity Analysis

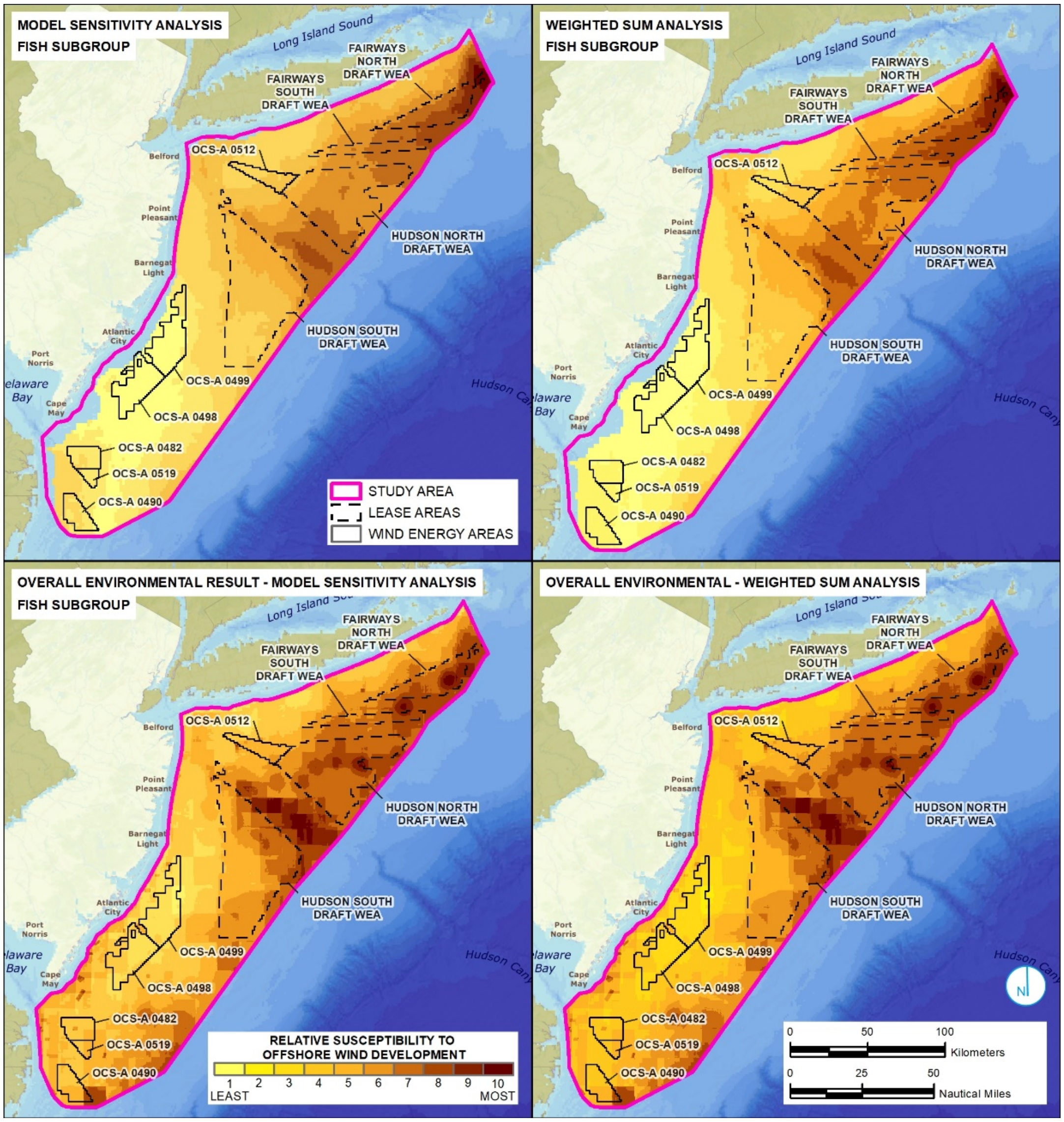

Figure 42: Fish WSA Sensitivity Analysis

The model sensitivity results for the fish subgroup do not result in a notably altered depiction of relative susceptibility (Figures 42 and 47). In general, areas of relatively susceptibility are similar, particularly in the northeastern portions of the study area. When all fish layers are assigned a weighting of 1, the model is driven primarily by the all-species, the demersal fish, and the species with designated EFH layers. The abundance is much greater for these layers than for Atlantic sturgeon, which was more heavily weighted than these layers in the original analysis. Slight increases in relative susceptibility are observable in lease areas OCS-A 0490, 0519, and 0482 with no noticeable change observed in lease areas OCS-A 0498 and 0499. The impact of increasing the cross-layer weights for this subgroup on the overall environmental weighted sum analysis is also minimal (Figures 42 and 48). The largest percentage change from the overall environmental model sensitivity analysis for fish compared to the overall environmental weighted sum analysis was a 0.66% increase in the number 5 susceptibility category (Figure 48). Therefore, despite the very slight increases in the southernmost lease areas, the results of the sensitivity analysis do not materially change the assessment of susceptibility for the fish subgroup.

2.11.3 Cetaceans Subgroup Sensitivity Analysis

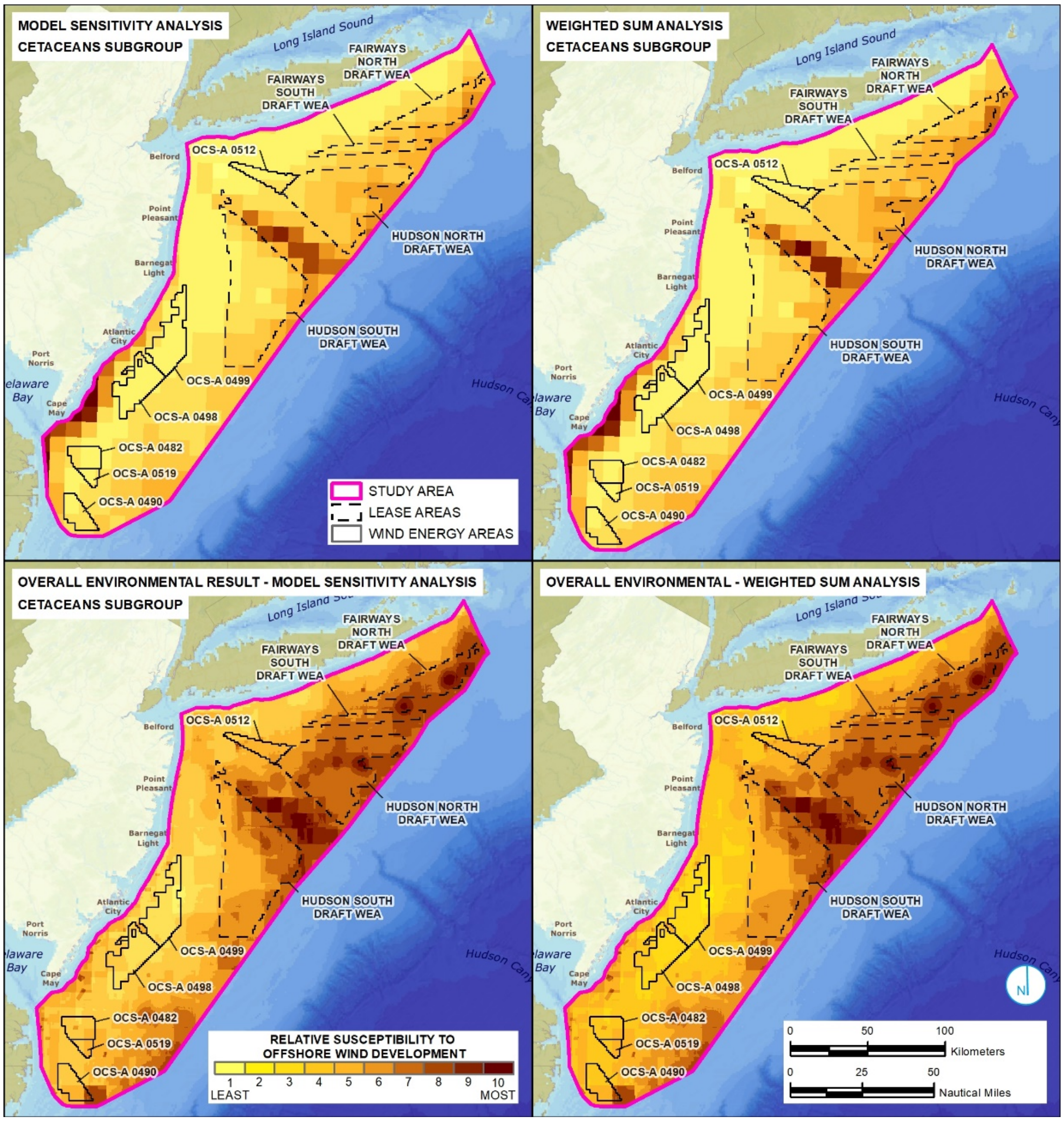

Figure 43: Cetacean WSA Model Sensitivity Analysis

Examination of model sensitivity via the cetaceans subgroup did not reveal significant effects of weighting changes compared to the original analysis (Figures 43 and 47). The cetaceans subgroup is comprised of layers that were weighted "elevated" or "high" in the original analysis and therefore were subject to only a small change through the performance of the sensitivity analysis. This small change in weighting results in a similarly small change in the assessment of relative susceptibility. No new areas of susceptibility are identified, and the areas of potential conflict are mirrored in both iterations (Figure 43). The impact of increasing the cross-layer weights for this subgroup compared to the overall environmental weighted sum analysis is also minimal (Figures 43 and 48). The largest percentage change from the overall environmental model sensitivity analysis for cetaceans compared to the overall environmental weighted sum analysis was a 0.12% increase in the number 4 susceptibility category (Figure 48). The results of the sensitivity analysis do not materially change the assessment of susceptibility for the cetaceans subgroup.

2.11.4 Sea Turtles Subgroup Sensitivity Analysis

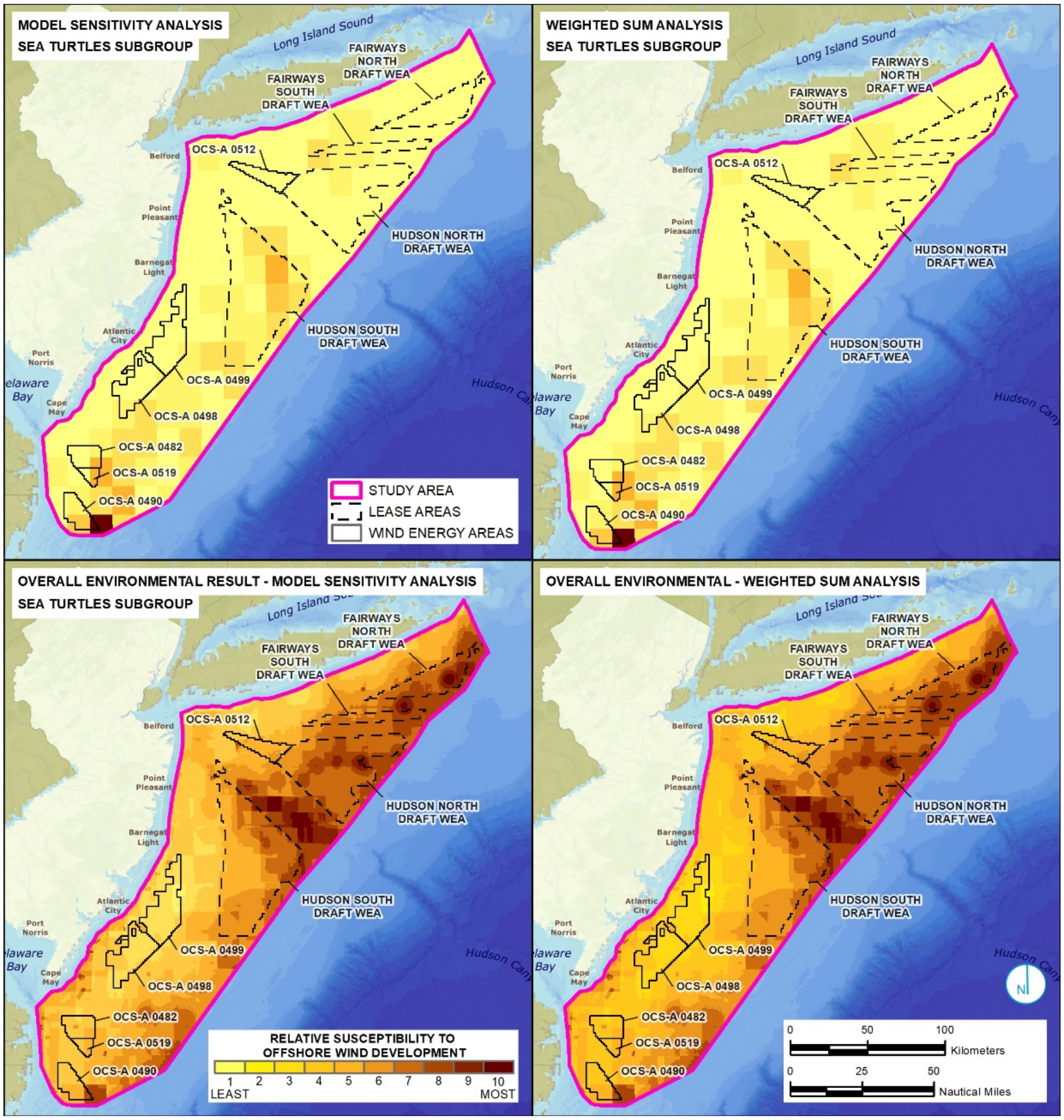

Figure 44: Sea Turtles WSA Model Sensitivity Analysis

The sea turtle sensitivity analysis does not depict major differences from the original weighted sum result (Figures 44 and 47). No difference in these two results is generally expected, because the individual species layers for the sea turtle subgroup have equal weightings (0.5) in the original analysis. When examined in the sensitivity testing, the weightings of individual layers change proportionally to 1, and therefore no difference that would be discernable occurs. The impact of increasing the cross-layer weights for this subgroup compared to the overall environmental weighted sum analysis is also minimal (Figures 44 and 48). The largest percentage change from the overall environmental model sensitivity analysis for sea turtles compared to the overall environmental weighted sum analysis was a 0.014% decrease in the number 4 susceptibility category (Figure 48). The results of the sensitivity analysis do not materially change the assessment of susceptibility for the sea turtles subgroup.

2.11.5 Habitat Subgroup Sensitivity Analysis

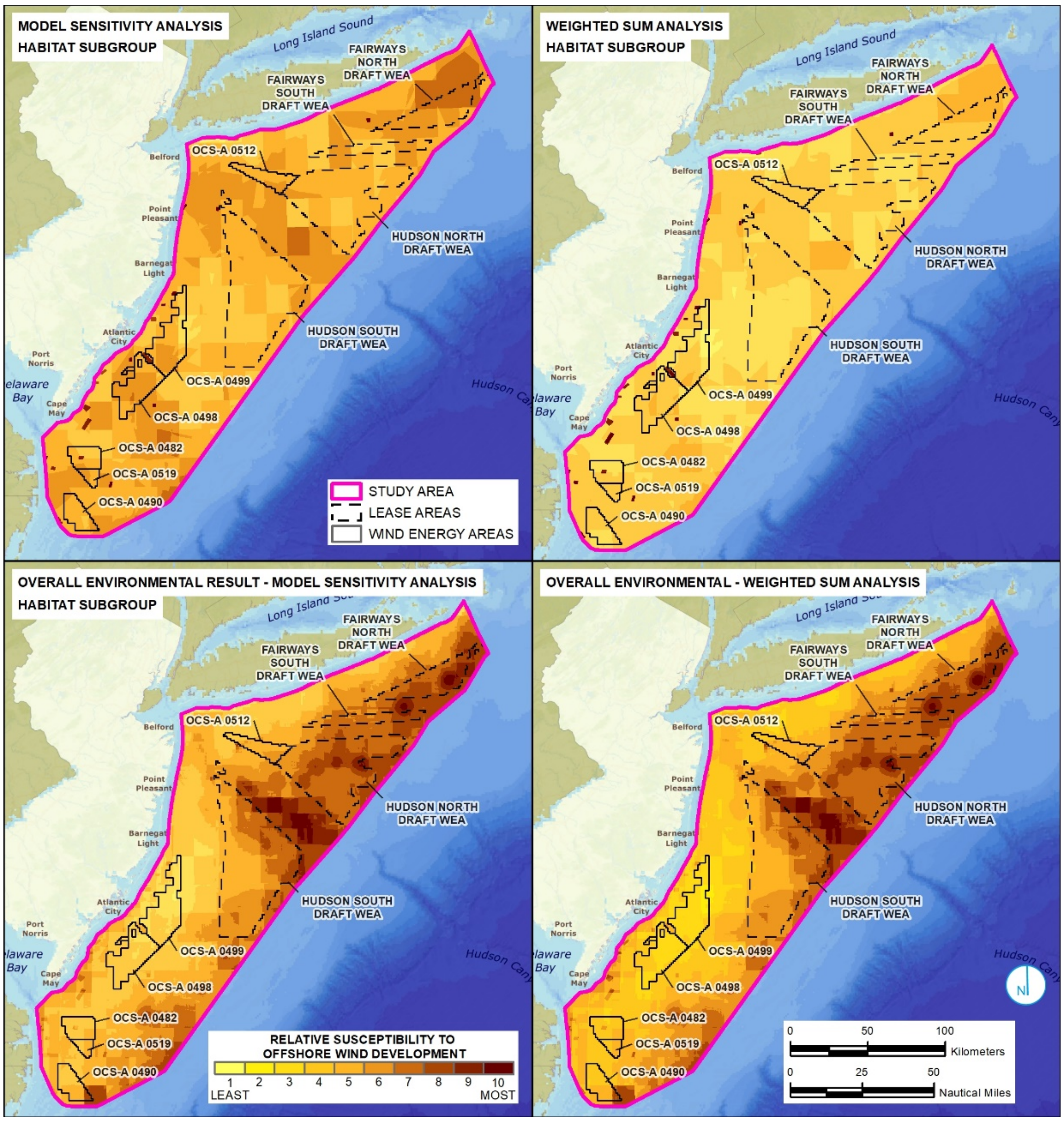

Figure 45: Habitat WSA Model Sensitivity Analysis

Examination of the habitat sensitivity analysis results reveals a difference in the distribution of the susceptibility scores compared with the results of the assigned weightings in the original analysis

(Figures 45 and 47). In the sensitivity results, the data are more broadly distributed in the middle ranges of the relative susceptibility scores. Upon examination it was determined that the individual layers for EFH and the EFH for highly migratory species are the primary drivers of these differences, reflecting two factors. The first is the doubling of the susceptibility weighting from 0.5 to 1, which elevates the magnitude of the susceptibility witnessed in the model sensitivity analysis. The second factor relates to the rescaling procedure completed for this subgroup, which converts the individual layers into the same units for comparison. The rescaling is more pronounced in the model sensitivity analysis (weighting of 1) compared to the original analysis which tempers the rescaling. The model sensitivity analysis does not change the interpretation of susceptibility for artificial reefs; however, areas of greater susceptibility are identified in lease and WEAs in the model sensitivity result, but only in the moderate susceptibility score ranges. This pattern (i.e., increase in moderate susceptibility score) holds true for the overall environmental result - model sensitivity analysis where there was a 3.6% increase in the number 5 susceptibility category and a 2.5 % decrease in the number 8 category (Figures 45 and 48).

2.11.6 Benthic Invertebrates Subgroup Sensitivity Analysis

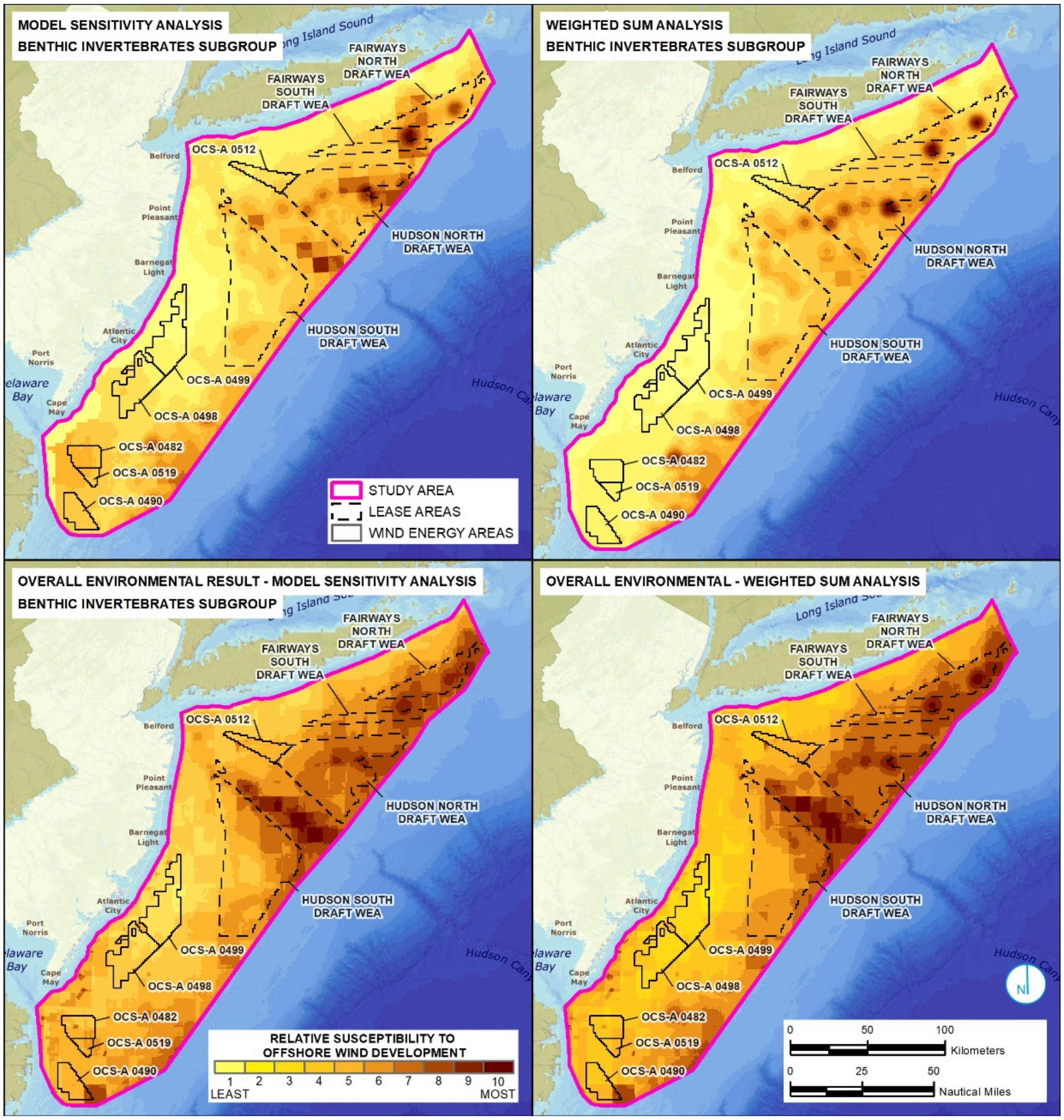

Figure 46: Benthic WSA Model Sensitivity Analysis

The model sensitivity analysis conducted for the benthic subgroup reveals discernable change relative to the original analysis, with nearly all the change occurring within the middle ranges of susceptibility scores and limited change in the lowest two and highest three susceptibility scores (Figures 46 and 47). Similar to the result in the model sensitivity analysis conducted for the habitat subgroup, the difference in the result between the original analysis and the model sensitivity analysis is largely related to the rescaling that occurs within this subgroup. The change for the lower weighted layers (i.e., select benthic invertebrates) is the most pronounced, commensurate with the change from 0.25 to 1. The difference between the overall environmental result - model sensitivity analysis and the overall environmental weighted sum are presented in Figures 46 and 48. Spatial patterns for both comparisons are generally similar, although greater susceptibility is suggested by both analyses in lease areas OCS-A 0490, 0519, and 0482. Figure 48 depicts increases in the following relative susceptibility categories in the overall environmental result - model sensitivity analysis: category 5 (2.2%), category 6 (1.0%), category 7 (0.7%), category 8 (0.9%), and category 9 (0.4%). These are relatively minor changes indicating that the results of these sensitivity analyses do not materially change the assessment of susceptibility for the benthic subgroup.

2.11.7 Model Sensitivity Discussion

After completion of the model sensitivity analysis on each subgroup, influences of weighting are better understood. The sensitivity analysis results show the weighted layers have an appropriate change to reflect the importance of the higher-ranking weights, while also accounting for the relative abundance of the weighted layers. The sensitivity analysis also identifies where the model is less influenced by changes to the weighting and the factors affecting model sensitivity.

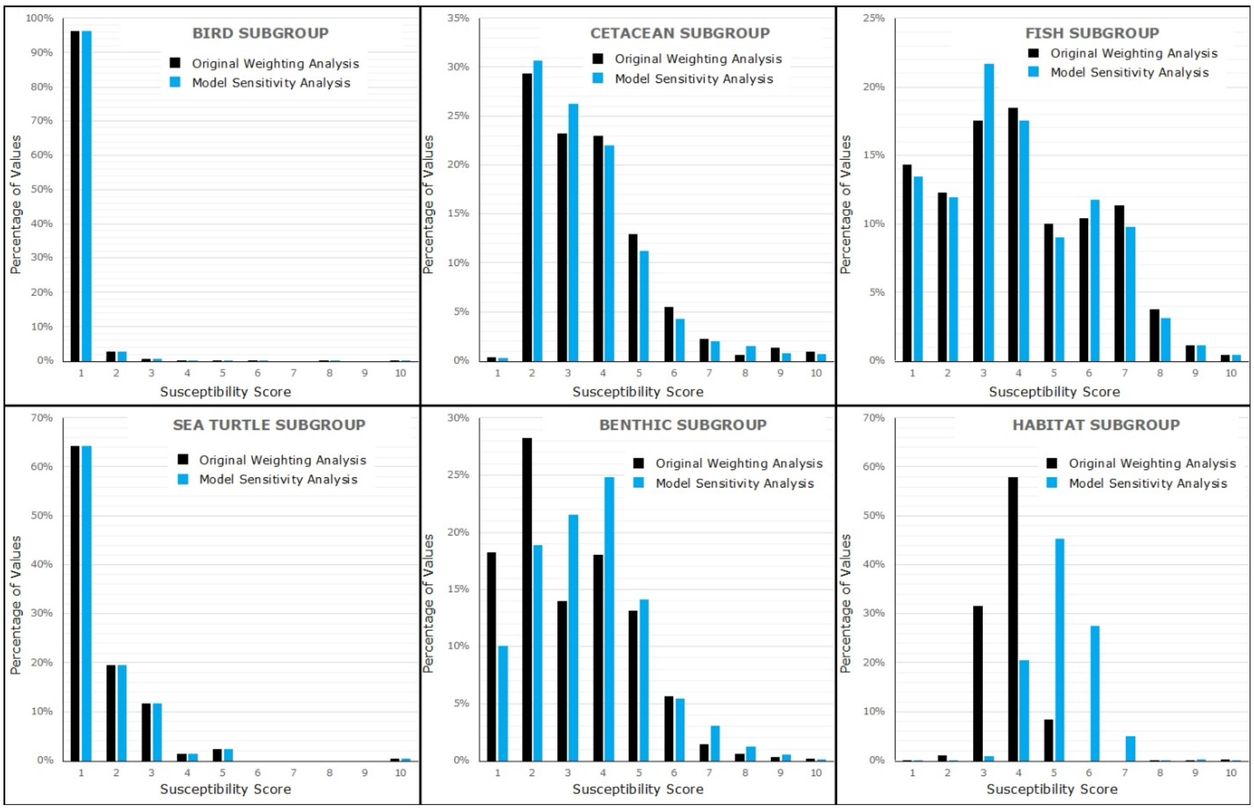

Figure 47: Results of Model Sensitivity Analysis Compared to Original Weighted Subgroup Analysis

The susceptibility scores developed for each biological resource subgroup during the original weighted overlay analysis were compared to the susceptibility scores computed for these subgroups during the model sensitivity analysis and these comparisons are shown on Figure 47. In general, the shape of the distribution of these scores are similar between both the original and the sensitivity analysis, reflecting the underlying abundance data within each subgroup. For subgroups with similarly weighted individual layers in both iterations of the analysis (i.e., birds and sea turtles), no changes were observed. Increases in susceptibility were observed in most cases (cetaceans, fish, habitat, and benthic invertebrate subgroups), with the least pronounced changes for cetaceans due to the “elevated” and “high” weightings associated with the original analysis. The cetaceans and fish subgroups saw decreases in susceptibility in the mean range of susceptibility scores during the sensitivity analysis, primarily associated with the relative increase on the lower and higher ends of the scale. This is due to the abundance data being more pronounced at the tails of the distribution rather than "muted" by the application of a weighting during the original analysis. The most dramatic differences between the original analysis and model sensitivity analysis were observed for the benthic invertebrate and habitat subgroups. The pronounced differences are associated with the data rescaling process, wherein the model sensitivity analysis retains the major differences in abundance data compared to the original analysis smooths the data considerably. Taken by itself, number of layers included within a subgroup does not appear to drive model sensitivity. Figure 48 compares the changes associated with increasing the subgroup cross-layer weights on the overall environmental weighted sum analysis. These results are similar to those shown in Figure 47, with most subgroups showing little change in the distribution of susceptibility between the analyses. The largest differences are again associated with the benthic invertebrate and habitat subgroups.

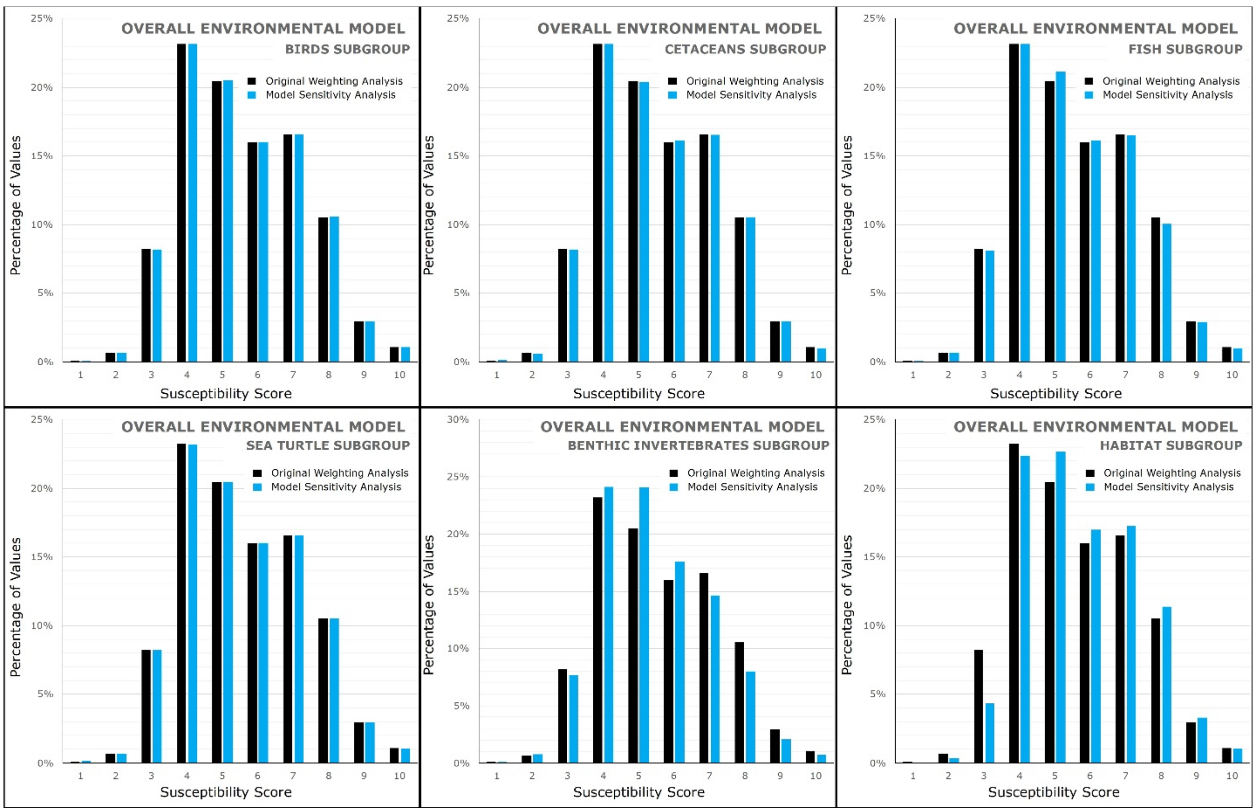

Figure 48: Results of Model Sensitivity Analysis Compared to Original Weighted Overall Environmental Susceptibility Analysis

Based on review of the model sensitivity analysis (Figures 41-48), several factors are identified as having an impact on model sensitivity:

- Abundance within individual input layers. When individual input layers that make up a subgroup show similar trends in (high) abundance but have notable differences in originally assigned weightings due to particular vulnerabilities, the model is sensitive to a change to the max weighting value. In other words, in this scenario altering the weightings of both layers to the maximum value will elevate the estimated susceptibility of the layer that was originally weighted lower relative to the layer that was originally weighted higher.
- Original weightings. The variability in the original weightings of individual layers will determine, by definition, how much sensitivity is inherent in the model. For example, the sea turtles subgroup included species layers that are all weighted equally (at 0.5). Therefore, changing those weights to 1.0 does not have an effect on the end result. That is, the model is not sensitive to increases in weighting between layers where original weightings were generally equivalent.
- Rescaling. The model is sensitive to weighting adjustments for data subject to rescaling (completed for the purposes of normalizing mathematical units). When individual layers were rescaled prior to weighting (benthic and habitat subgroups), they are made to be within the same scale and range (typically "stretching") the data range. Therefore, assigned weighting will have a "scaled" effect on the established ranges. The model sensitivity analysis assigns a weighting of 1 to each of the layers, effectively allowing the abundance data subject to the "stretching" to be more pronounced.

3. UNWEIGHTED RESOURCE EVALUATION

The unweighted resource evaluation (URE) was conducted in order to inform the Environmental Protection and the Commercial and Recreational Fisheries chapters of the New Jersey OWSP. The purpose of the URE is to depict occurrence data relative to candidate offshore wind development areas for evaluation. Specifically, the URE was conducted to assess ocean areas used for the following:

- Commercial fishing (based on distinct data sources)
  - Vessel monitoring system (VMS) information (Fontenault 2018)
  - Vessel transit report (VTR) information (R. U. Grant F. Walton Center for Remote Sensing and Spatial Analysis [CRSSA])
  - Mean annual revenue (MAR), based on analysis of VMS and VTR data (Kirkpatrick et al. 2017)
- Recreational fishing
- Social uses
- Shipping and utilities
- Restricted areas
- Vessel transit counts (based on automatic identification system [AIS] data)

The results of the URE are occurrence figures (e.g., "heat maps") that reflect data that have not been weighted or scored. Information regarding the sources, data inputs, and results is provided in turn below.

3.1 Commercial Fisheries

Commercial fisheries were assessed by examining heat map depictions of VMS, VTR, and MAR data as presented in this section.

3.1.1 Vessel Monitoring System

A VMS is a program of fisheries surveillance in which equipment that is installed on fishing vessels provides information about the vessels' position and general activity. VMS is required aboard federally permitted vessels participating in a number of limited access and moratorium fisheries along the western Atlantic coast (VMS and DAS requirements for vessel owners/operators, 50 CFR 648.10 (1996). The VMS unit must transmit a signal at least every hour, or at least twice per hour for vessels issued an Atlantic sea scallop permit. While VMS is a viable tool for tracking locations of a fishing vessel, VMS alone cannot indicate if a vessel is actually fishing. Managers predict fishing activity based on speed changes within the VMS in combination with catch reporting programs. This allows for an accurate representation of fishing activity within a given location. When fishing activities are analyzed within a potential area, VMS must be used in combination with trip reporting data to obtain an accurate representation of the area assessed.

3.1.1.1 Data

The following sources and authorities of VMS information were retrieved from Northeast Ocean Data portal as presented in Fontenault (2018):

- VMS – NOAA NMFS
- George Lapointe, NROC Fisheries Consultant
- Stakeholder fisherman, agencies, and organizations in the Northeast region
- VMS Activity Declaration Code Format for the Greater Atlantic Region, NMFS (March 2014)

These datasets use VMS data from NMFS for the years 2006-2016 to characterize the density of commercial fishing vessel activity for seven fisheries in the Northeast and Mid-Atlantic regions of the United States. The standardized density of locations for vessels that use VMS for each fishery for three aggregate time periods is shown in the figures below. Most fisheries used the time frames 2006-2010, 2011-2014, and 2015-2016, aside from Atlantic surfclam/ocean quahog fishery, which used 2006-2010, 2012-2014, and 2015-2016 since habitat closures implemented by the New England Fishery Management Council in 2012 noticeably affected the spatial use patterns in this fishery when compared with the period before 2012. Squid products are available for 2014 and 2015-2016, and pelagic products are available for the 2014 and 2015-2016 periods only, due to data availability from NMFS. According to the data source, data were log transformed and standardized and are best interpreted qualitatively (Fontenault 2018). There are two types of products:

- Density grids that characterize all VMS records for each time period
- Density grids that characterize VMS records below a speed threshold for the 2011-2014 and 2015-2016 periods only; speed thresholds were vetted through engagement with fishermen in each fishery

The limitations of these data should be understood prior to their use. The VMS data do not necessarily distinguish between fishing activity, vessel transit, and other vessel activities. For certain datasets, vessel activity below a speed threshold that was determined with industry input is shown to attempt to differentiate fishing areas from transit and other vessel activity. However, nonfishing activities that occur at low speeds, such as processing catch, sorting, drifting, or idling in port are still shown by the datasets that incorporate speed information. The data source suggests that these datasets indicate relative levels of vessel presence. It is possible that shifts in fishing effort are the result of changes in management. Therefore, discretion is required to interpret these results.

In addition to the above data considerations, the following caveats are specific to individual fisheries:

Multispecies

VMS data include fisheries with a limited access multispecies permit fishing under a Category A or B days-at-sea or catch-regulated species or ocean pout while on a sector trip, or those with a limited access northeast multispecies small vessel category or Handgear A permit that fish in multiple northeast multispecies broad stock areas (50 CFR 648.10).

Herring, Squid, and Pelagics

For these species, it is possible that vessels fish under one species code but fish in another fishery (e.g., herring VMS code but fishing for mackerel). VMS activity patterns can appear to be unusual in one of the three fisheries and additional exploration of fishing activity in all three fisheries is required to best understand what is occurring in a particular fishery.

Atlantic Sea Scallop

Atlantic sea scallop-associated VMS activity in Mid-Atlantic areas that are identified during periods when the fishery is closed likely reflects scallop permit holders actually targeting summer flounder, scup, and black seabass.

Atlantic Surfclam/Ocean Quahog[9]

VMS activity in areas between Georges Bank and the Mid-Atlantic region in the area south of Cape Cod. Areas identified in the dataset that are typically deeper than where surfclam/ocean quahog fishing typically occur likely reflect overlapping transit lines and not actual fishing activity.

[9] Atlantic City is the primary fishing port for these species, which provide much of the world's supply of clams. In 2017, over 18.3 million lbs of surfclam meats were landed in Atlantic City, which were valued at $15 million, and 16.5 million lbs of quahogs meats were landed, which were valued at $17.5 million.

3.1.1.2 VMS Analysis

The VMS data were analyzed to determine the locations where fishing activity is prominent for different species and types of fish. A summary of each layer and the key points that are relevant to offshore wind development can be found below. VMS datasets were used as input to create density polygons representing the density of commercial fishing vessel activity in the Northeast and Mid-Atlantic regions.

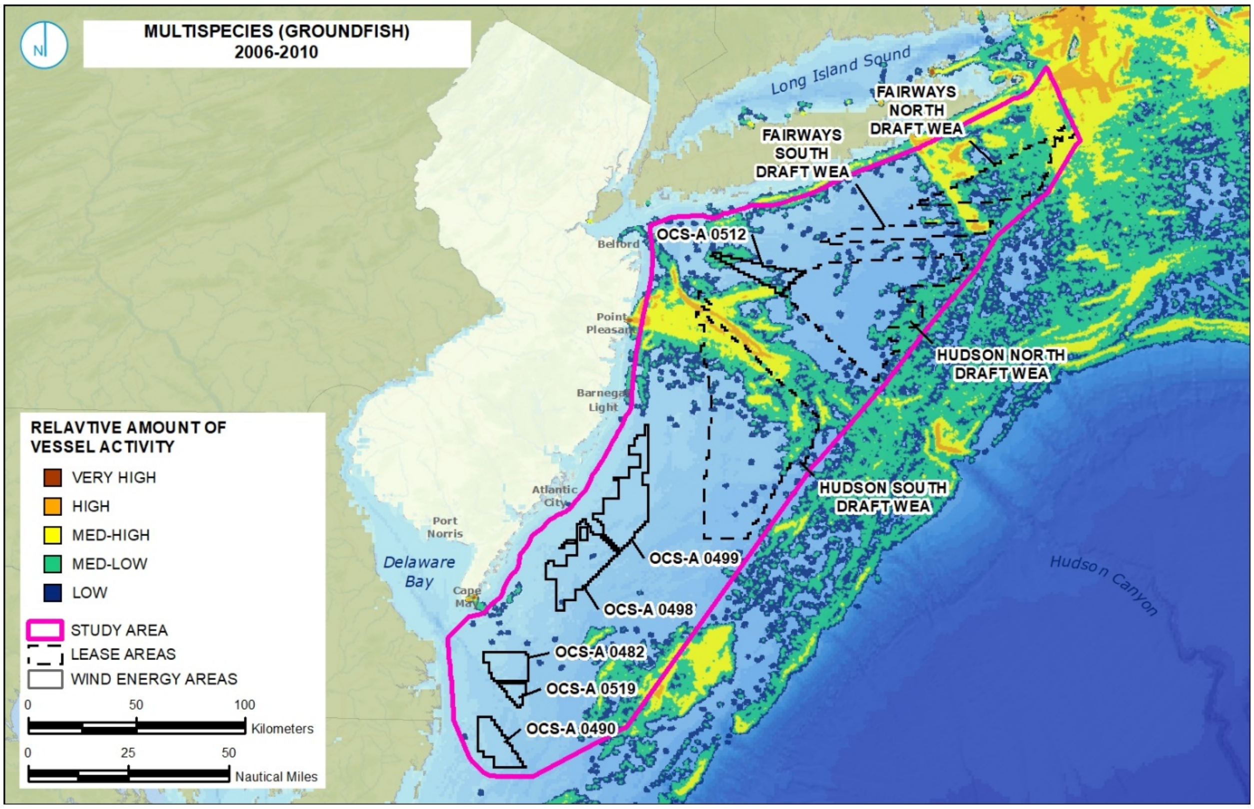

Figure 49: Multispecies (Groundfish) 2006-2010

<u>Layer Description:</u> These data represent all VMS signals between 2006 and 2010 reported under the multispecies fisheries (American plaice, Atlantic cod, Atlantic halibut, haddock, ocean pout, pollock, redfish, white hake, windowpane flounder, winter flounder, witch flounder, and yellowtail flounder).

<u>Key Points:</u> The VMS data suggest that between 2006 and 2010, there were high levels of groundfish fishing to the east of the New Jersey and Delaware lease areas. There were also significant amounts of activities in the Hudson Canyon, partially affecting the Hudson South draft WEA. The Fairways North draft WEA is largely covered by medium-low to medium-high fishing activity. Layers generated from data that do not include speed over ground (SOG) information do not distinguish between fishing activity, vessel transit, or other vessel activities.

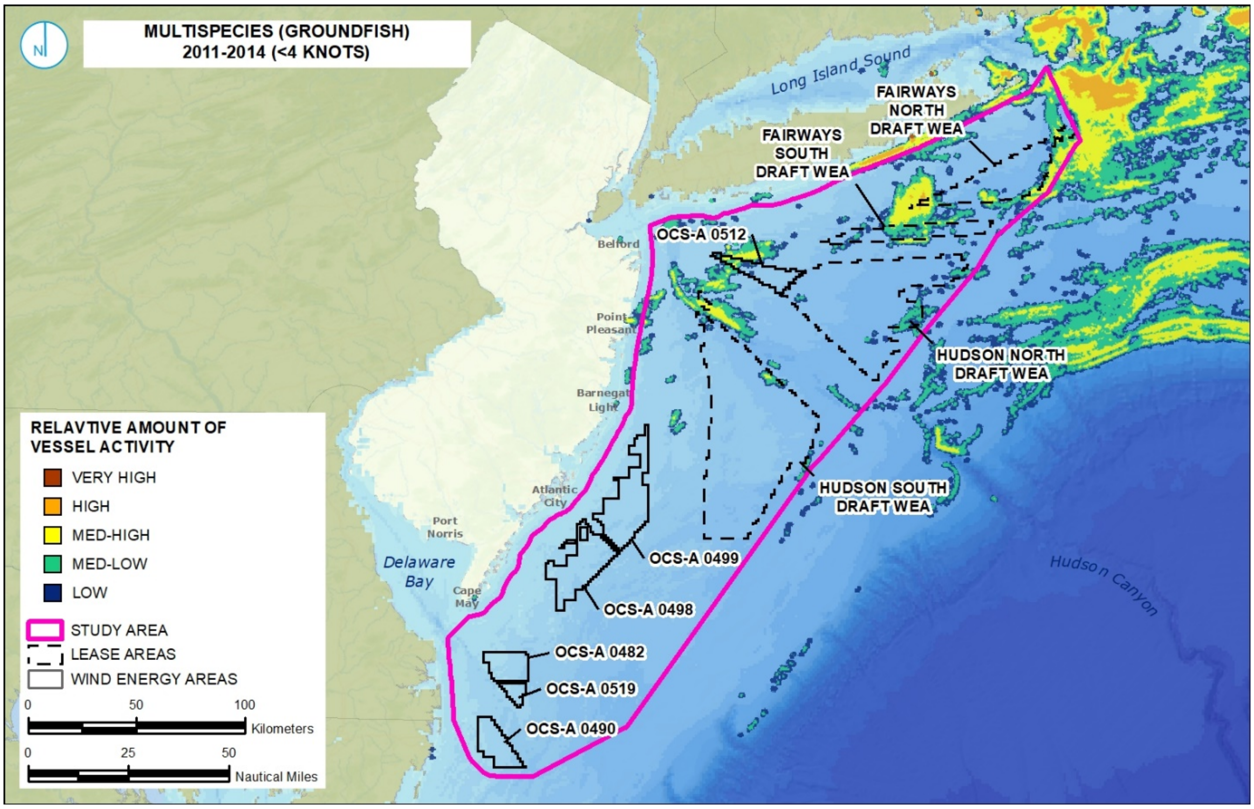

Figure 50: Multispecies (Groundfish) 2011-2014 (<4 knots)

<u>Layer Description:</u> These data represent all VMS pings between 2011 and 2014 reported under the multispecies fisheries (American plaice, Atlantic cod, Atlantic halibut, haddock, ocean pout, pollock, redfish, white hake, windowpane flounder, winter flounder, witch flounder, and yellowtail flounder). Data from 2011-2016 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

<u>Key Points:</u> The 2011-2014 VMS data, which incorporate SOG information (<4 knots), suggest a reduction of fishing activity relative to that shown in Figure 49. These reductions are particularly evident in the Hudson Canyon, off the south shore of Long Island, and in the southern half of the OWSP study area. A medium-high fishing area still exists between the Fairways North and South draft WEAs but does not cover the Fairways North draft WEA. Layers generated from data that include SOG information indicate relative levels of vessel presence at speeds associated with fishing activity.

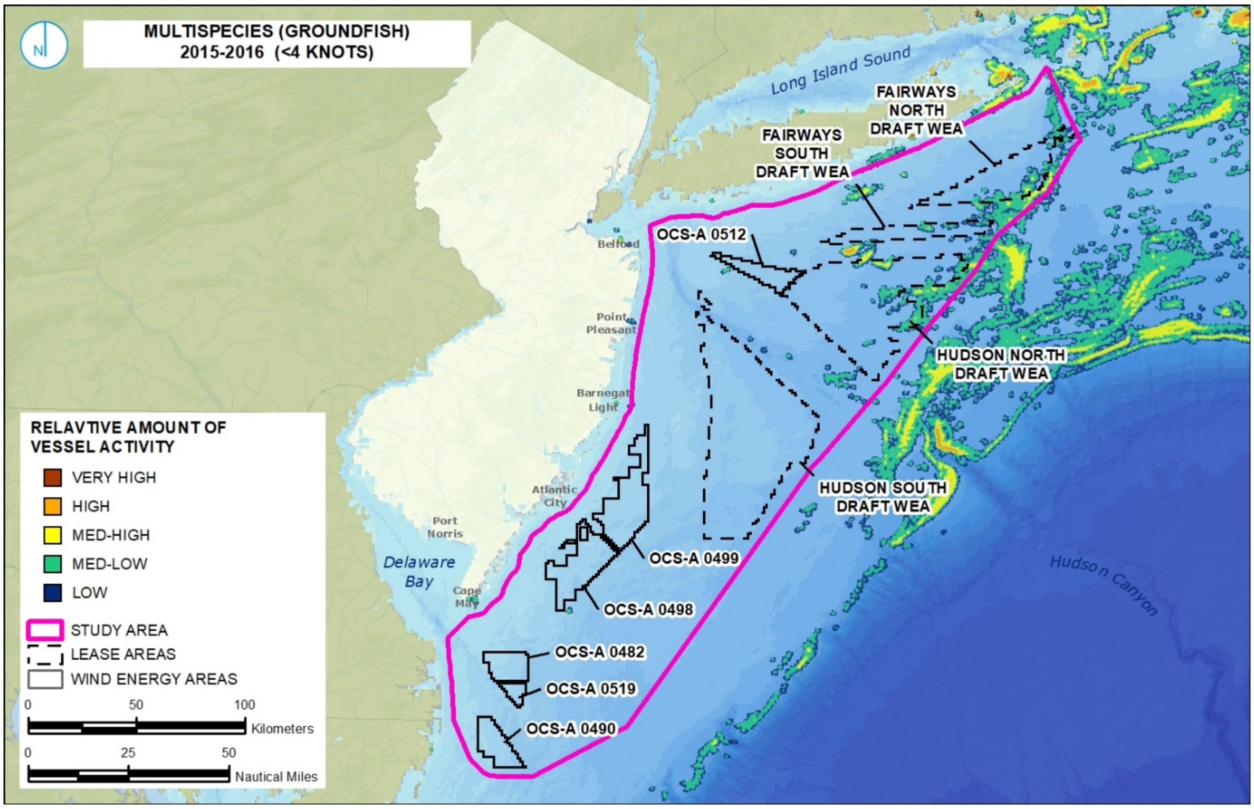

Figure 51: Multispecies (Groundfish) 2015-2016 (<4 knots)

Layer Description: These data represent all VMS pings between 2015 and 2016 reported under the multispecies fisheries (American plaice, Atlantic cod, Atlantic halibut, haddock, ocean pout, pollock, redfish, white hake, windowpane flounder, winter flounder, witch flounder, and yellowtail flounder). Data from 2011-2016 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2015-2016 VMS data, which incorporate SOG information (<4 knots), suggest a further reduction in fishing activity relative to that shown in Figure 50. This layer shows very little groundfish fishing activity within the study area, with some medium-low areas in the northern portion of the study areas, particularly surrounding the Hudson North draft WEA, Fairways South draft WEA, and Fairways North draft WEA.

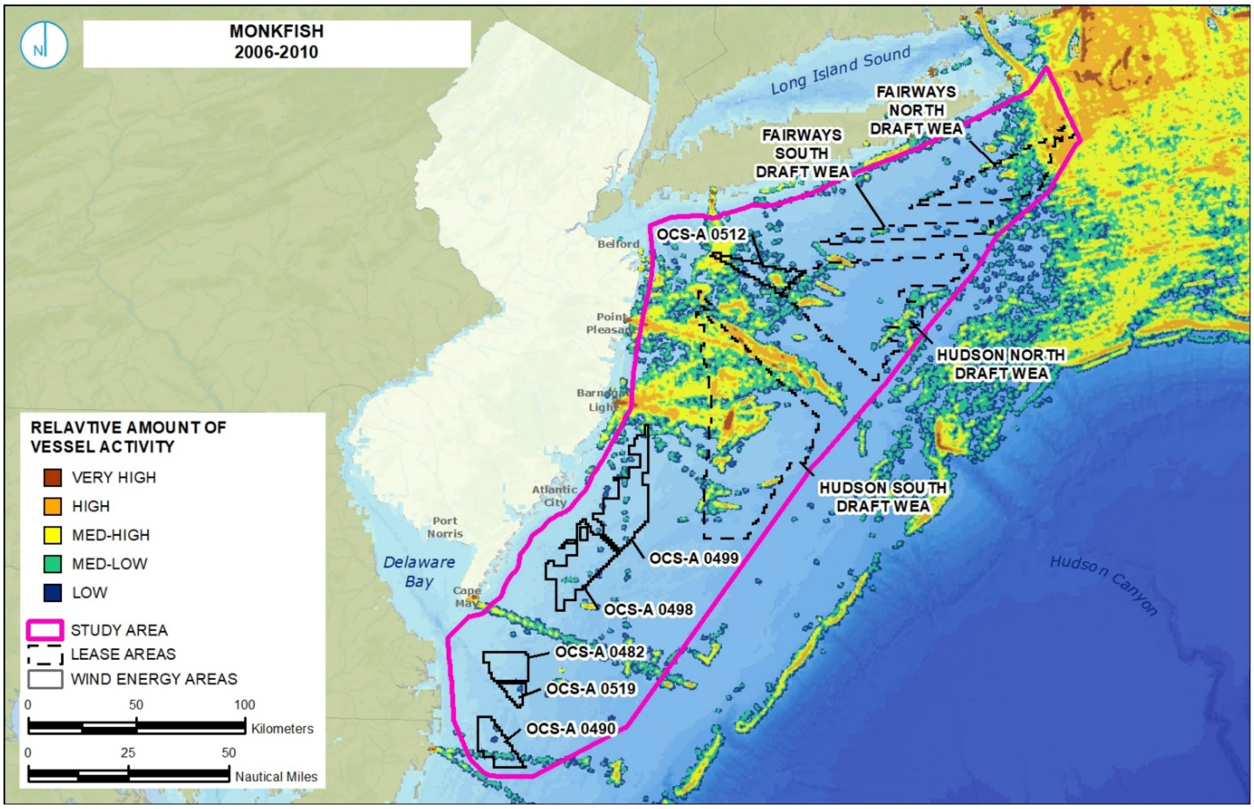

Figure 52: Monkfish 2006-2010

<u>Layer Description:</u> These data are for the period from 2006-2010. The monkfish fishery is managed using a days-at-sea and trip limit management system.

<u>Key Points:</u> The 2006-2010 VMS data (without SOG information) suggest that little monkfish fishing took place in the New Jersey and Delaware lease areas during this period. There were high activities off northern New Jersey and within the Hudson Canyon, particularly within the Hudson South draft WEA and in the northern tip of the Fairways North draft WEA.

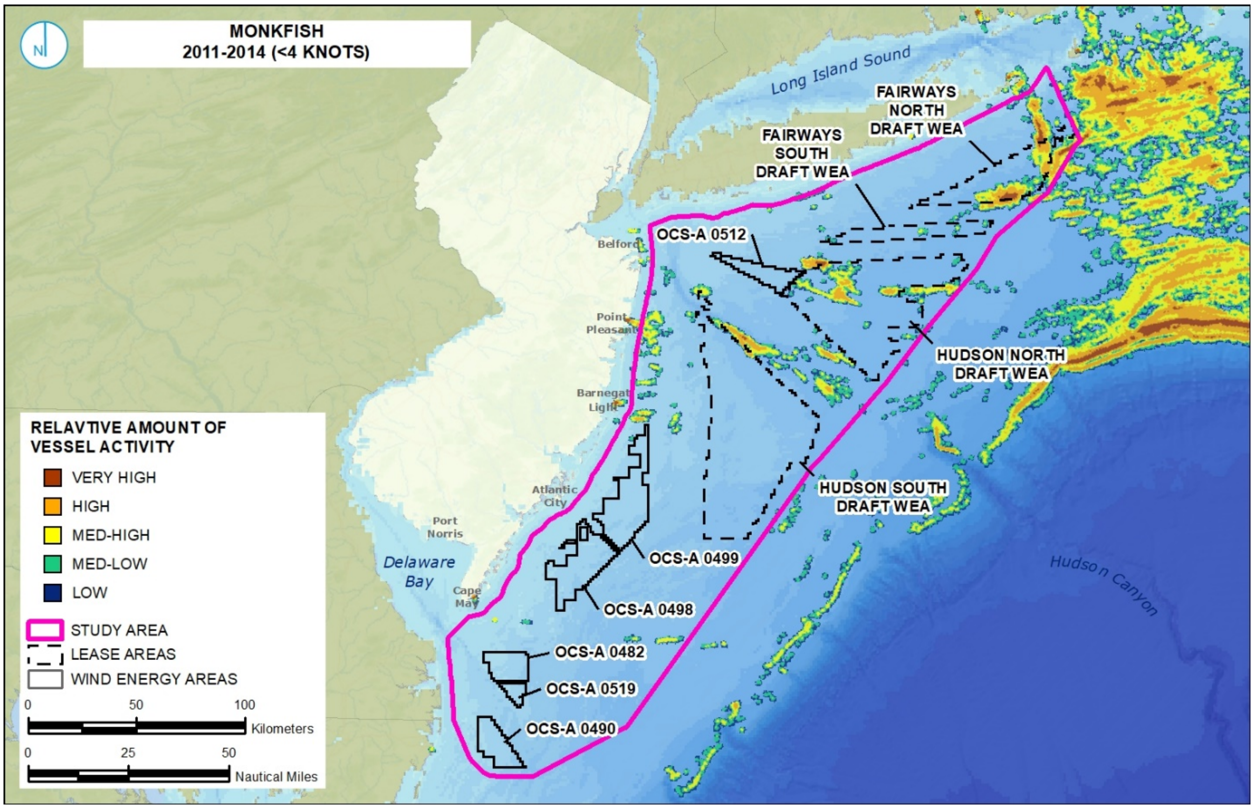

Figure 53: Monkfish 2011-2014 (<4 knots)

Layer Description: These data are for the period from 2011-2014. The monkfish fishery is managed using a days-at-sea and trip limit management system. Data from 2011-2014 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2011-2014 VMS data (with SOG information) suggest a general reduction in monkfish fishing activity relative to the 2006-2010 data, with only minor conflicts associated with the BOEM Hudson North WEA and a very high level of activity within the Fairways North draft WEA.

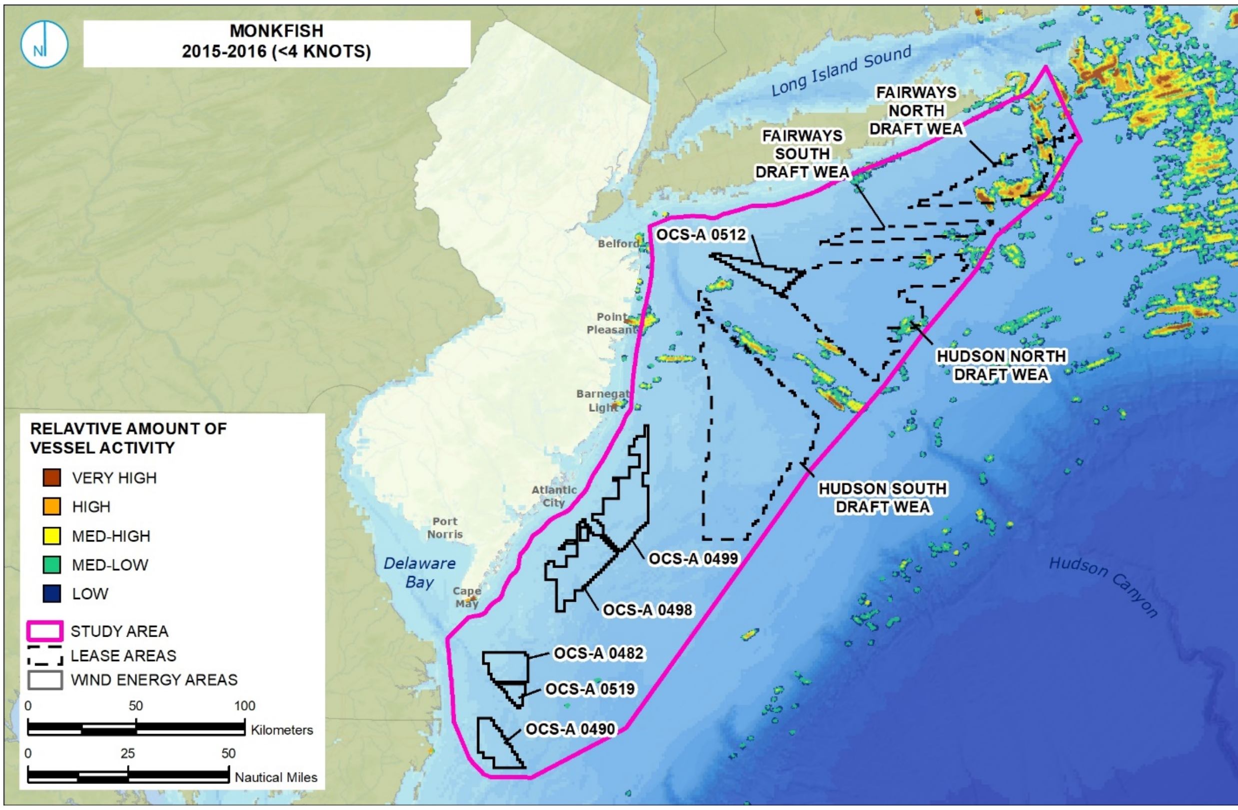

Figure 54: Monkfish 2015-2016 (<4 knots)

Layer Description: These data are for the period from 2015-2016. The monkfish fishery is managed using a days-at-sea and trip limit management system. Data from 2015-2016 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2015-2016 VMS data (with SOG information) continue to suggest a general reduction in monkfish fishing activity relative to the 2006-2010 and the 2011-2014 data. The only minor conflicts are associated with the BOEM Fairways North draft WEA where there is some high to very high vessel activity along the eastern boundary of this WEA.

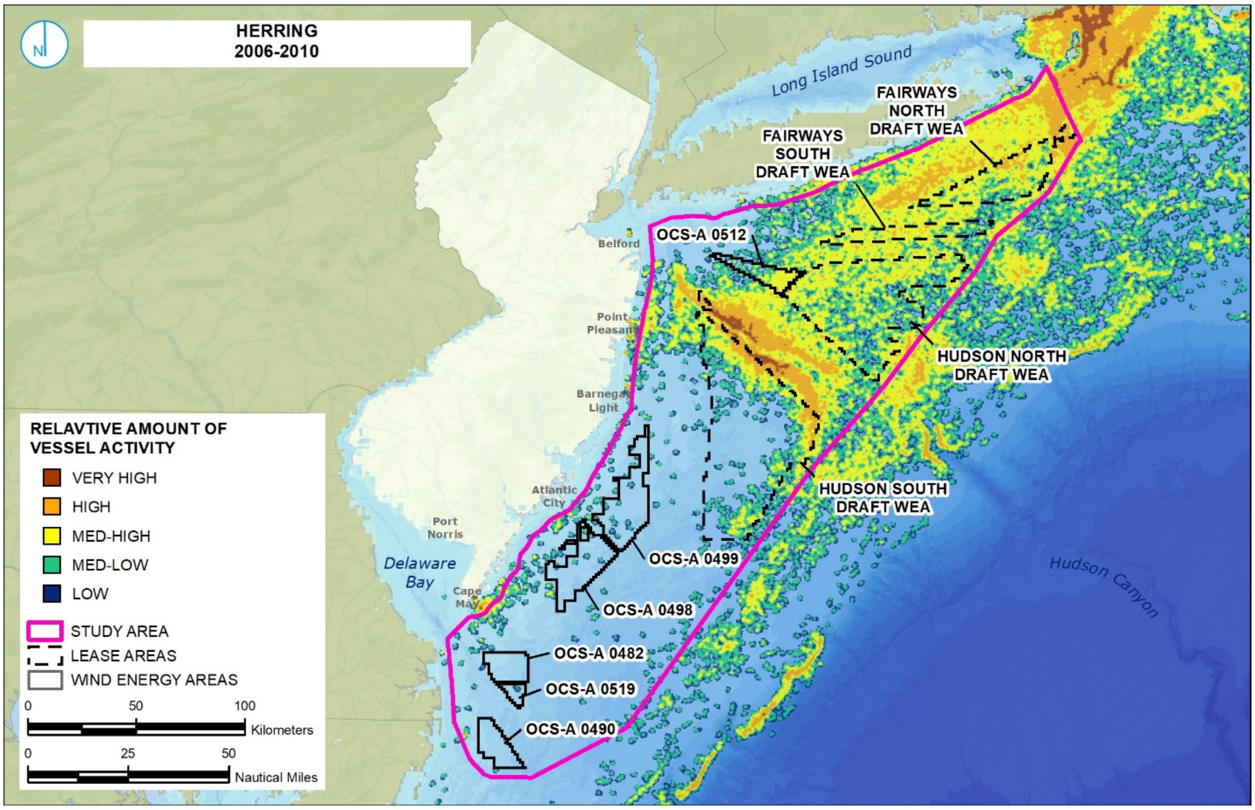

Figure 55: Herring 2006-2010

Layer Description: These data are for the period from 2006-2010. Some vessels reporting activity in the herring fishery through VMS may be fishing in other fisheries (e.g., squid, mackerel, butterfish) but also possess a federal herring permit requiring VMS use.

Key Points: The 2015-2016 VMS data suggest very little herring fishing activity in the study area south of the Hudson Canyon. However, herring fishing activity in, and north of the Hudson Canyon is predominantly medium-high within the draft WEAs. There is some high activity along the northern boundary of the Hudson South draft WEA and the Fairways North draft WEA.

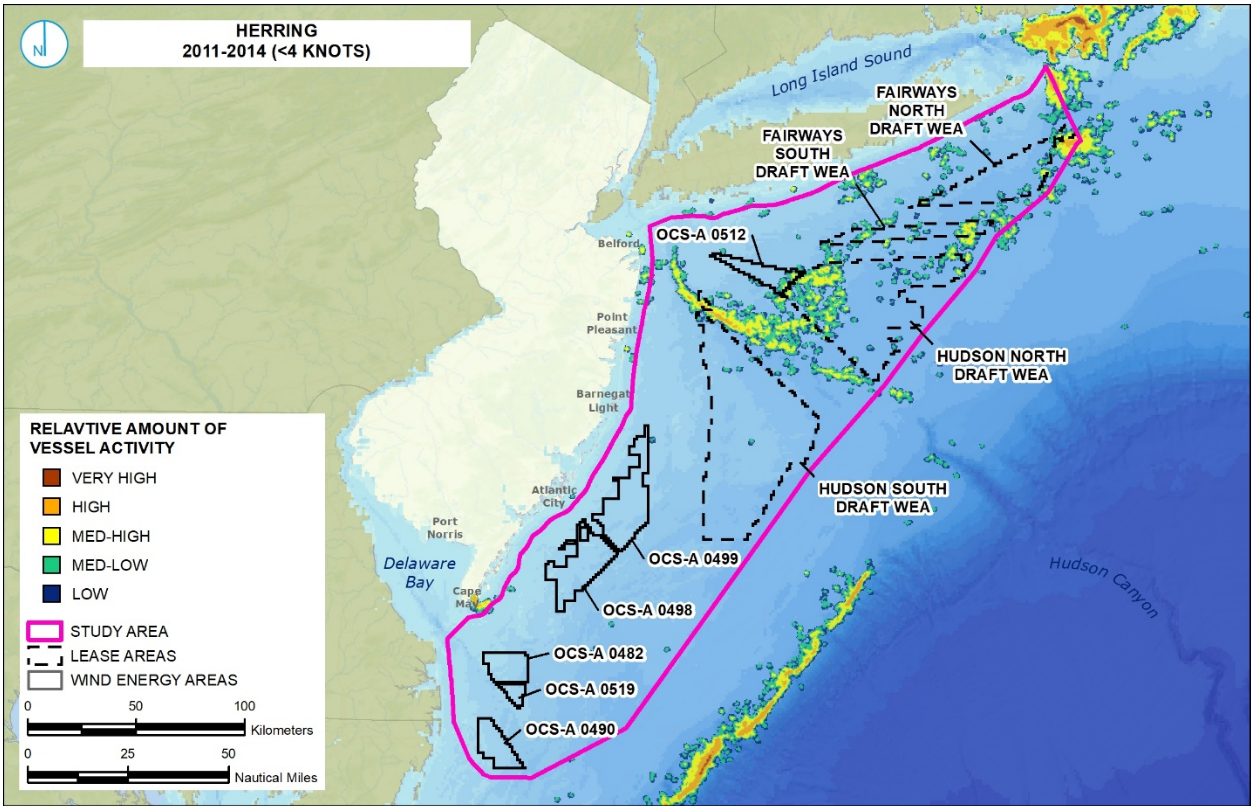

Figure 56: Herring 2011-2014 (<4 knots)

Layer Description: Data represent all VMS pings between 2011 and 2014 reported by vessels with a federal herring permit. Some vessels reporting activity in the herring fishery through VMS may be fishing in other fisheries (e.g., squid, mackerel, butterfish) but also possess a federal herring permit requiring VMS use. Data from 2011-2014 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2011-2014 VMS data (with SOG information) suggest a considerable reduction in herring fishing activity relative to the 2006-2010 data, with only minor conflicts associated with the Hudson North draft WEA and the Fairways South draft WEA.

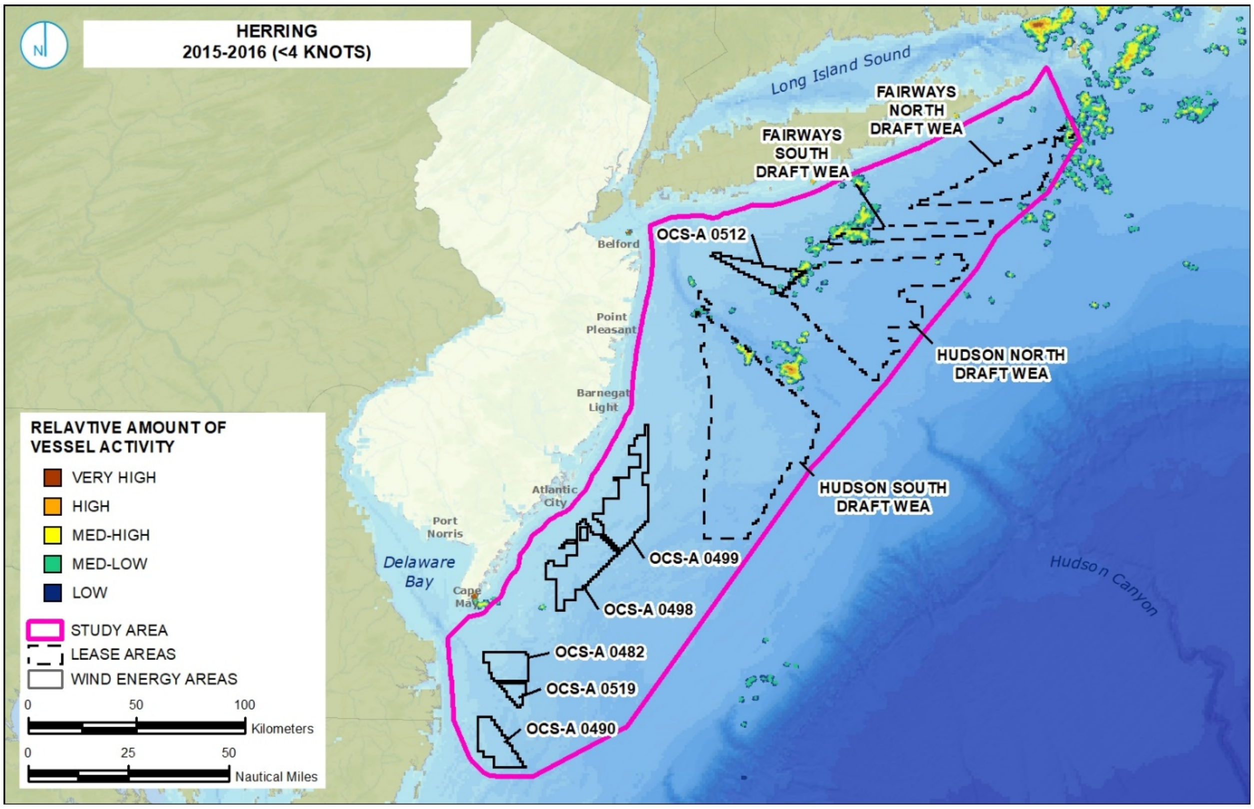

Figure 57: Herring 2015-2016 (<4 knots)

Layer Description: Data represent all VMS pings between 2015 and 2016 reported by vessels with a federal herring permit. Some vessels reporting activity in the herring fishery through VMS may be fishing in other fisheries (e.g., squid, mackerel, butterfish) but also possess a federal herring permit requiring VMS use. Data from 2015-2016 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2015-2016 VMS data (with SOG information) suggest very little herring fishing activity within the study area. These data indicate that fishing for this species occurs in the Hudson Canyon and off the coast of Long Island, with some medium-high activity within the Fairways South draft WEA.

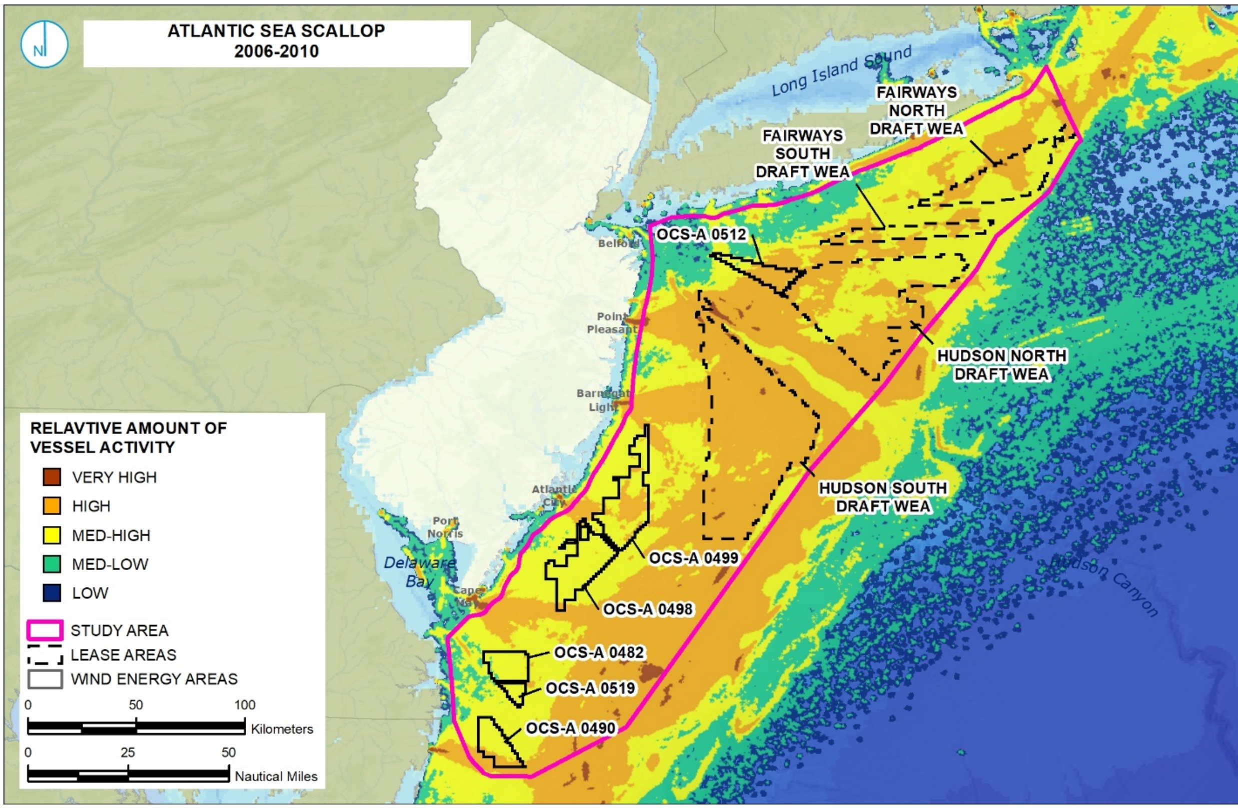

Figure 58: Atlantic Sea Scallop 2006-2010

<u>Layer Description:</u> Data represent all VMS pings between 2006 and 2010 reported by vessels with a federal Atlantic sea scallop permit. This includes limited access vessels and general access category vessels in the Atlantic sea scallop fishery.

<u>Key Points:</u> The 2006-2010 Atlantic sea scallop data (without SOG information) suggest a significant amount of fishing activity that extended as far as 60 miles off the shores of Maryland, Delaware, New Jersey, and Long Island. All lease areas and draft WEAs are show medium-high activity, but the Hudson South draft WEA and OCS-A 0512 areas show the highest Atlantic sea scallop fishing activity.

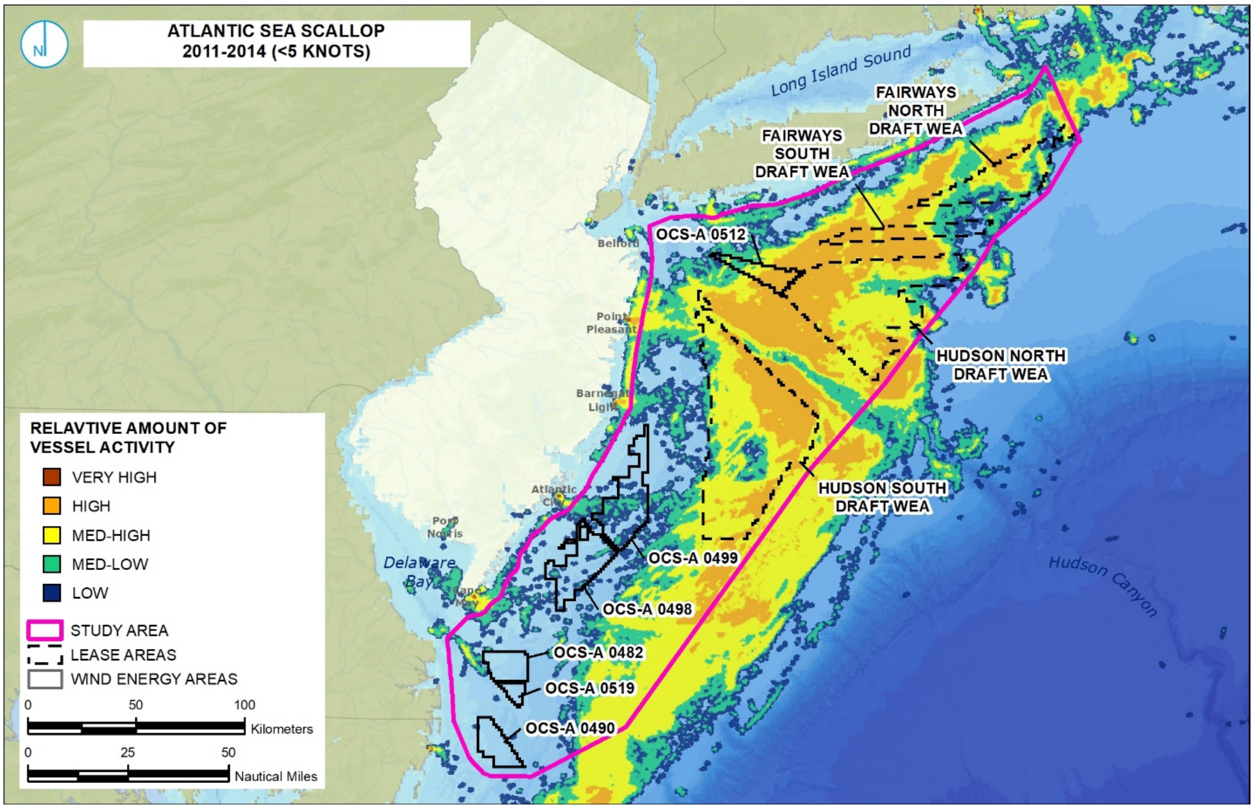

Figure 59: Atlantic Sea Scallop 2011-2014 (<5 knots)

<u>Layer Description:</u> Data represent all VMS pings between 2011 and 2014 reported by vessels with a federal Atlantic sea scallop permit. This includes limited access vessels and general access category vessels in the Atlantic sea scallop fishery. Data from 2011-2014 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

<u>Key Points:</u> The 2011-2014 Atlantic sea scallop data (with SOG information) also suggest a significant amount of fishing activity in the southern portion of the Hudson South WEA and within the entire Hudson North WEA. However, relative to the 2006-2010 data without SOG information, these data show less Atlantic sea scallop fishing activity within approximately 25 miles of land. These data indicate that Atlantic sea scallops may be migrating eastward, possibly toward deeper/cooler water or the shift may be due to fisheries management measures. The Hudson South draft WEA shows lower activity compared with the 2006-2010 data, but the Hudson North draft WEA, OCS-A 0512, and Fairways South draft WEA show significant portions with high Atlantic sea scallop fishing activity.

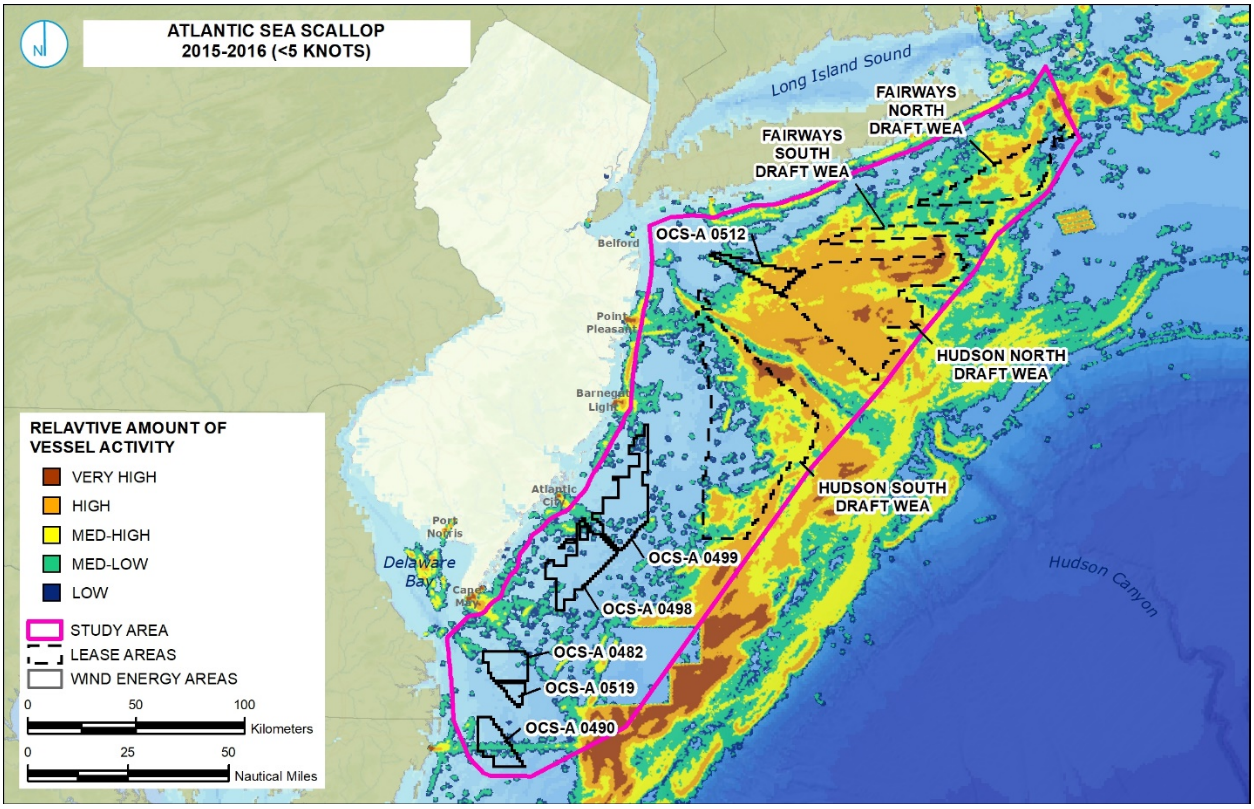

Figure 60: Atlantic Sea Scallop 2015-2016 (<5 knots)

<u>Layer Description:</u> Data represent all VMS pings between 2015 and 2016 reported by vessels with a federal Atlantic sea scallop permit. This includes limited access vessels and general access category vessels in the Atlantic sea scallop fishery. Data from 2015-2016 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

<u>Key Points:</u> The 2015-2016 Atlantic sea scallop data (with SOG information) continue to suggest a significant amount of fishing activity in the Hudson South WEA and within the entire Hudson North WEA. The Fairways South draft WEA and Fairways North draft WEA show lower levels of activity compared with the 2011-2014 data. Relative to the 2011-2014 data, these data show that the area of significant Atlantic sea scallop fishing activity continued to migrate eastward, possibly toward deeper/cooler water.

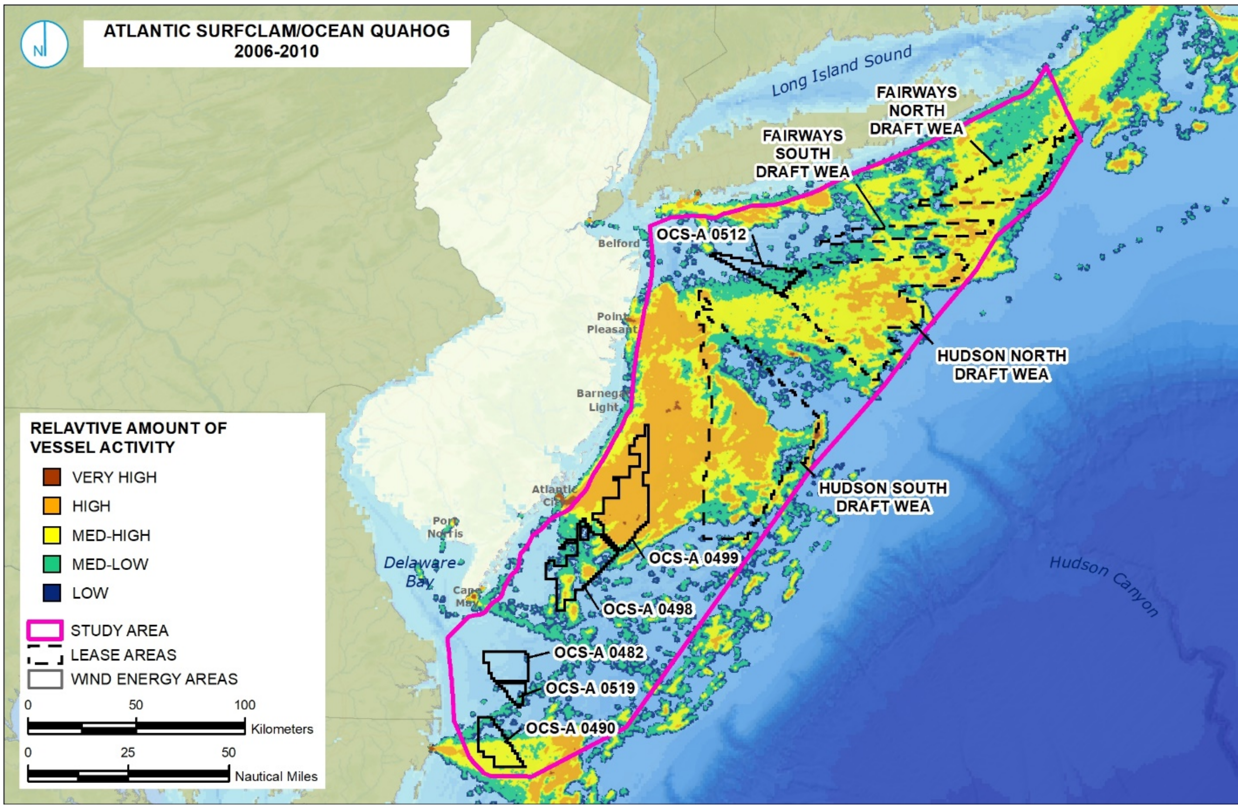

Figure 61: Atlantic Surfclam/Ocean Quahog 2006-2010

Layer Description: These data represent all VMS pings between 2006 and 2010 reported by vessels with a federal surfclam/ocean quahog permit.

Key Points: The 2006-2010 surfclam and quahog data (without SOG information) suggest high levels of fishing in the northern New Jersey lease area (OCS-A 0499) and a significant portion of the Hudson South draft WEA. The Hudson North draft WEA, Fairways South draft WEA, Fairways North draft WEA, and OCS-A 0490 show medium-high activity.

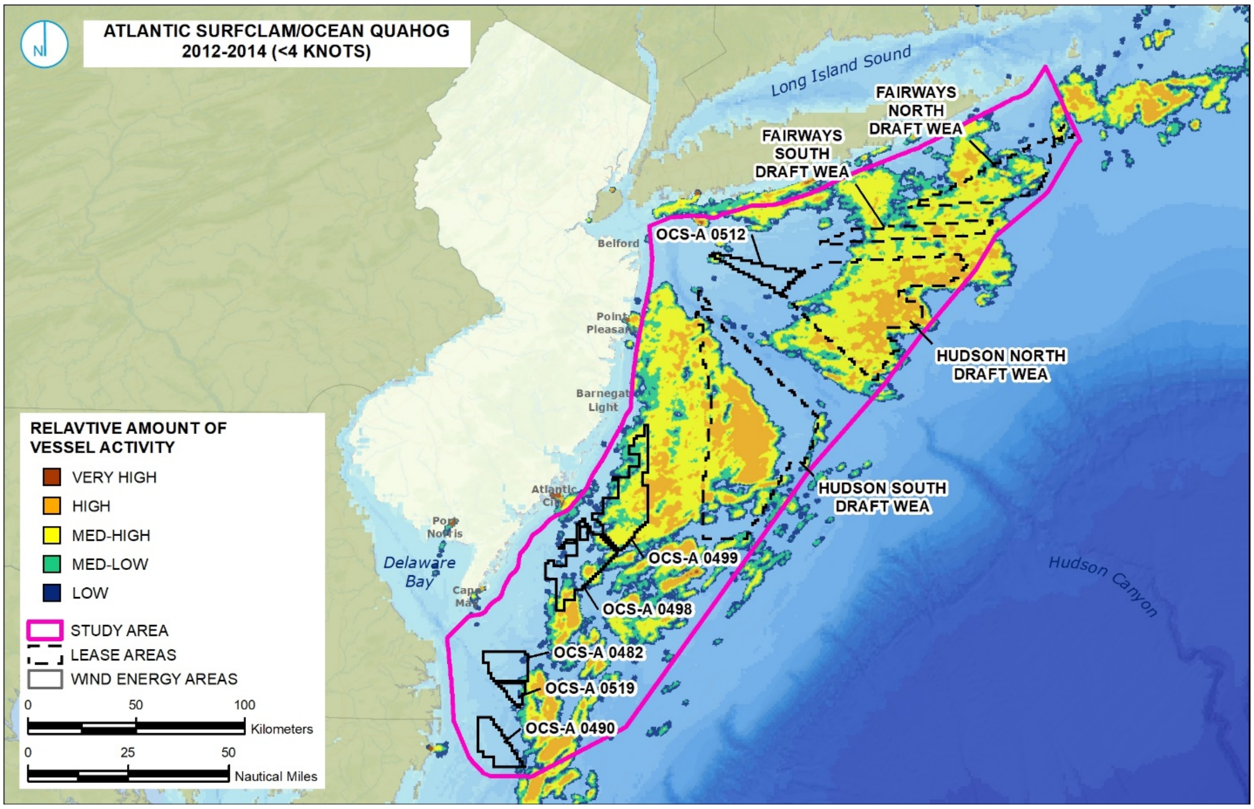

Figure 62: Atlantic Surfclam/Ocean Quahog 2012-2014 (<4 knots)

Layer Description: These data represent all VMS pings between 2012 and 2014 reported by vessels with a federal surfclam/ocean quahog permit. Data from 2012-2014 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2012-2014 surfclam and quahog data (with SOG information) continue to suggest high levels of fishing in the northern New Jersey lease area and portions of the Hudson South draft WEA. Medium to high levels of surfclam/quahog fishing occurred in the Hudson North draft WEA and the Fairways North and South draft WEAs. Relative to the 2006-2010 data, these data may indicate a general migration of this fishery to the north and east to colder and deeper waters, although this apparent shift may be the result of the addition of the SOG information.

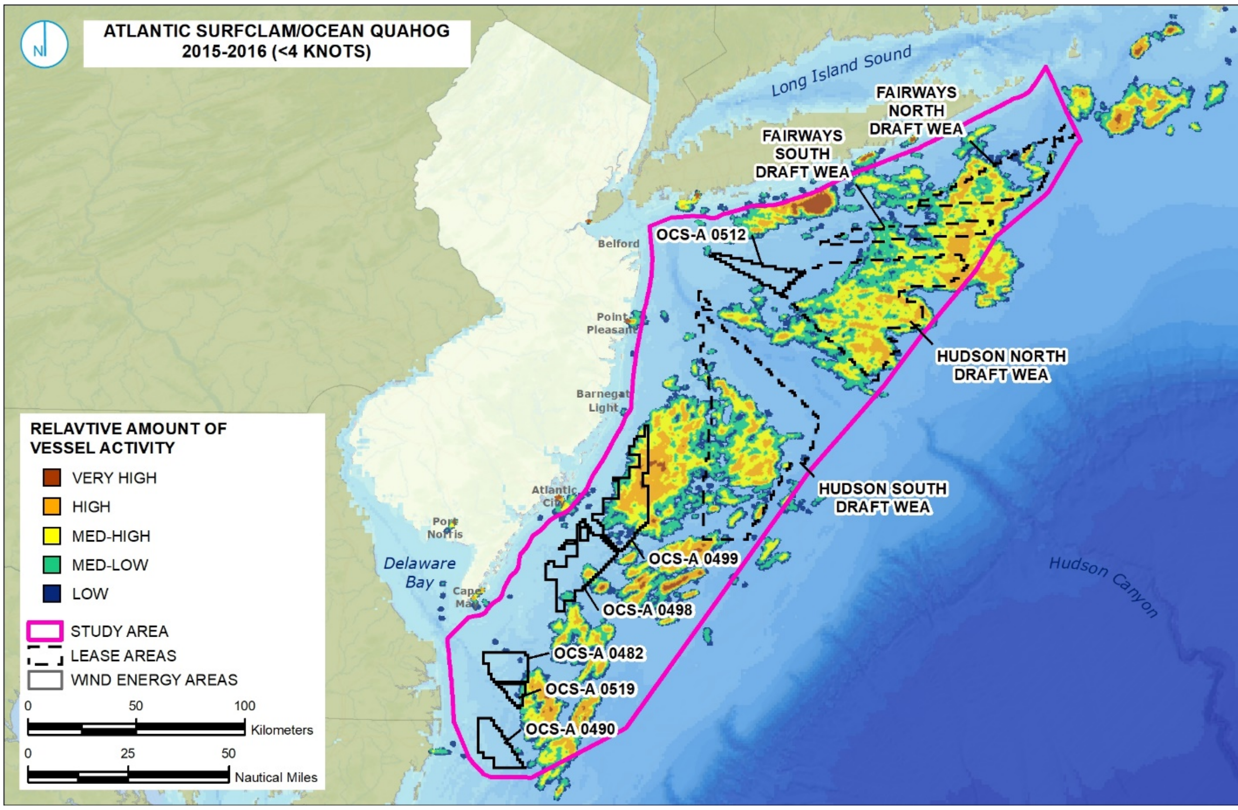

Figure 63: Atlantic Surfclam/Ocean Quahog 2015-2016 (<4 knots)

Layer Description: These data represent all VMS pings between 2015 and 2016 reported by vessels with a federal surfclam/ocean quahog permit. Data from 2015-2016 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2015-2016 surfclam and quahog data (with SOG information) continue to suggest high levels of fishing in lease area OCS-A 0499 and portions of the Hudson South draft WEA. Medium to high levels of surfclam/quahog fishing occurred in the Hudson North draft WEA and the Fairways North and South draft WEAs. Relative to the 2012-2014 data, these data may continue to indicate a general migration of this fishery to the east into colder and deeper waters.

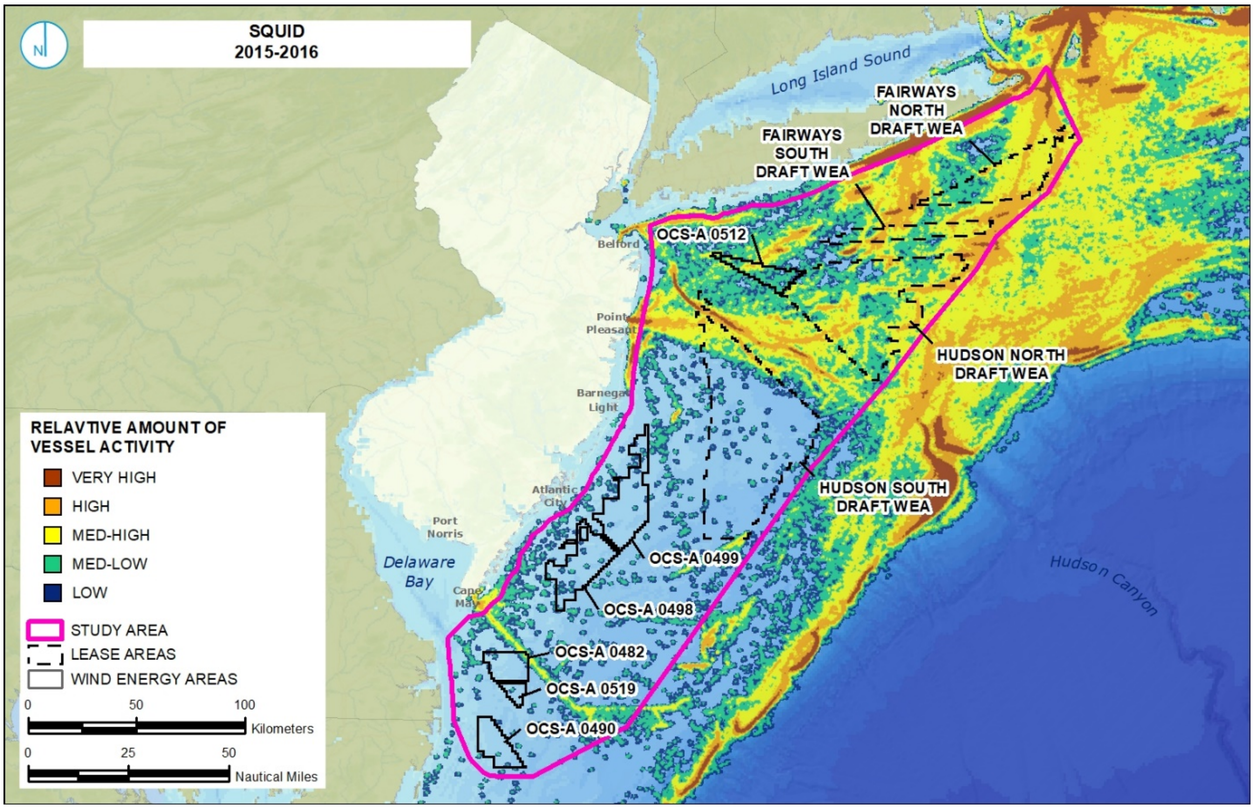

Figure 64: Squid 2015-2016

Layer Description: These data represent all VMS pings between 2015 and 2016 reported by vessels with a squid permit.

Key Points: The 2015-2016 squid fishing data (without SOG information) suggest high levels of activity along the Hudson Canyon and north off the shore of Long Island, as well as along the continental shelf break adjacent to Maryland, Delaware, New Jersey, and Long Island. The northern lease areas and draft WEAs have medium to high squid fishing area coverage, while all lease areas south of the Hudson North draft WEA have limited overlap with squid fisheries.

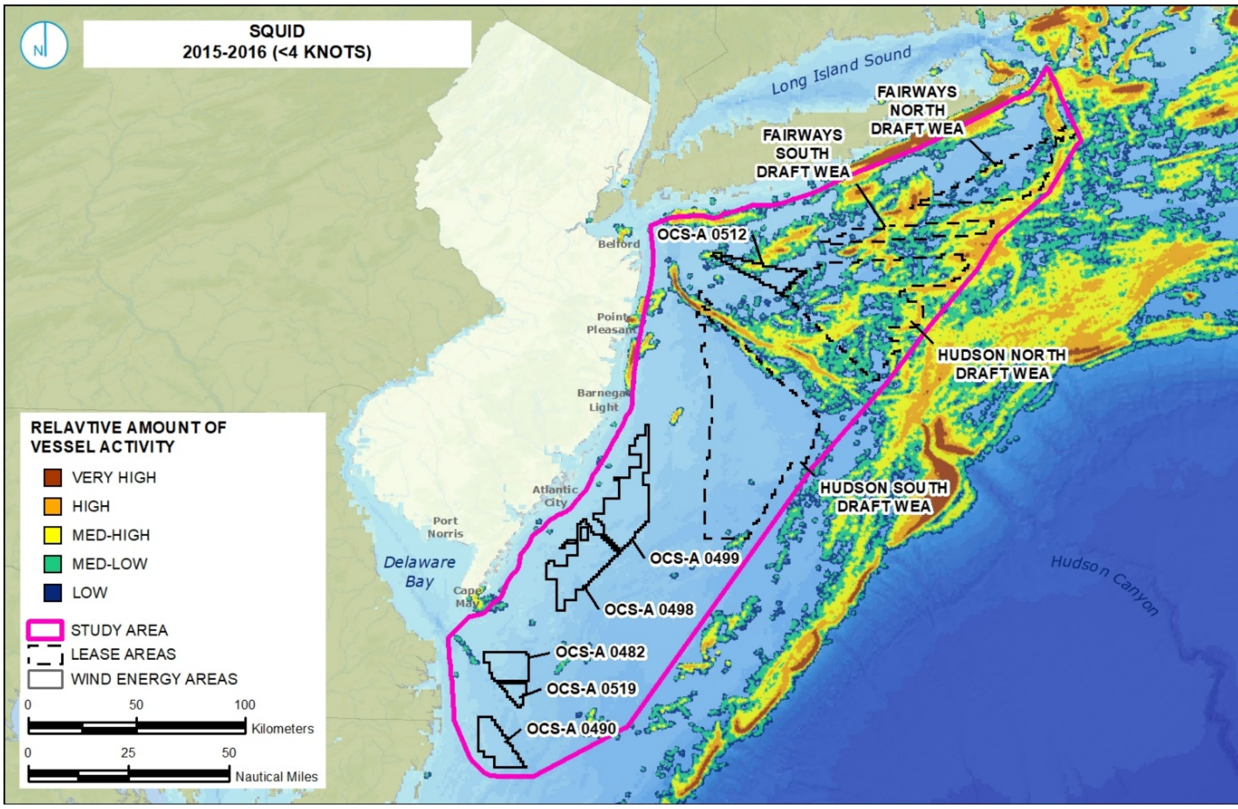

Figure 65: Squid 2015-2016 (<4 knots)

Layer Description: These data represent all VMS pings between 2015 and 2016 reported by vessels with a squid permit. These data also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2015-2016 squid fishing data (with SOG information) also suggest high levels of activity along the Hudson Canyon and to the north and along the continental shelf. Relative to the 2015-2016 data without SOG information, these data show markedly less fishing activity within the study area south of the Hudson Canyon. The northern lease areas and draft WEAs still show the existence of squid fisheries, but with less intensity because of consideration of the SOG information.

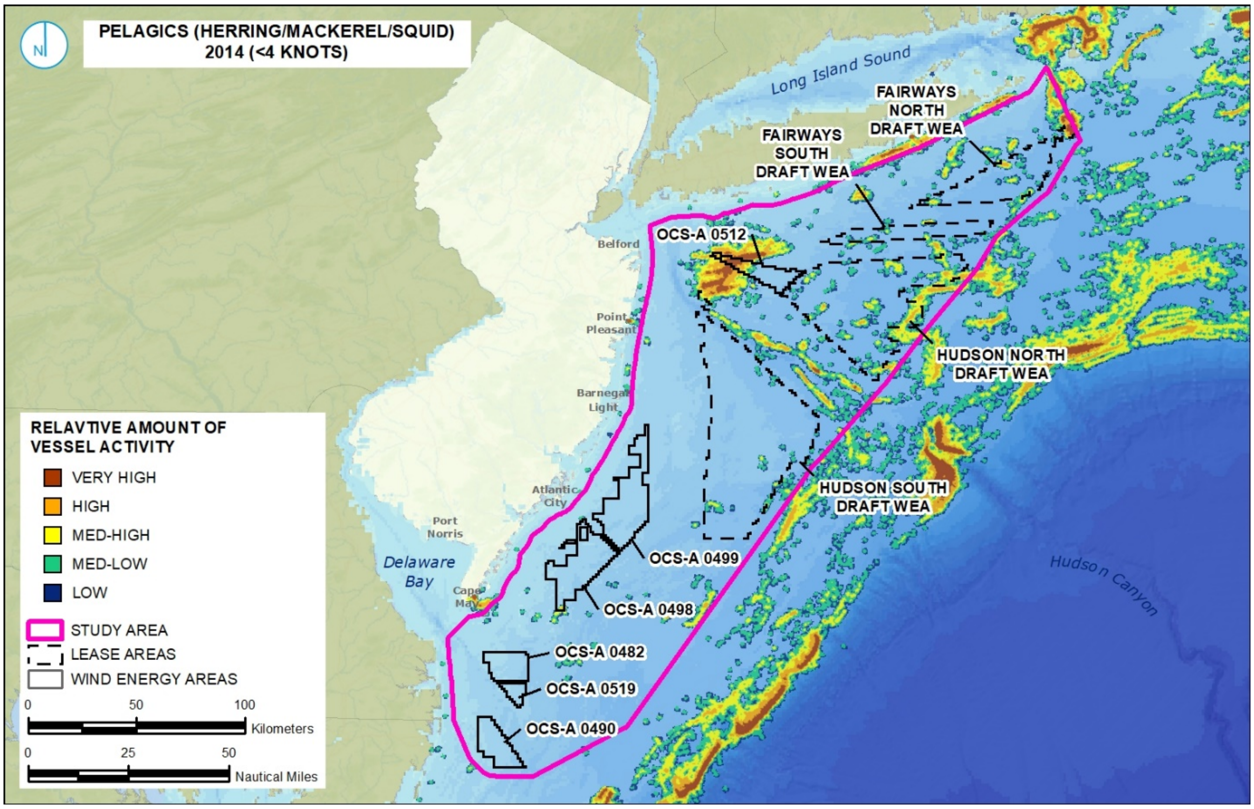

Figure 66: Pelagics (Herring, Squid, Mackerel) 2014 (<4 knots)

Layer Description: These data represent all VMS pings in 2014 reported by vessels in a pelagic fishery. These data also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2014 (<4 knots) fishing data for pelagic fish (herring, mackerel, and squid) suggest little fishing activity in the study area with only minor conflicts with the New Jersey and Delaware lease areas and the BOEM WEAs. The western tip of OCS-A 0512 is shown as a high value area for this fishery.

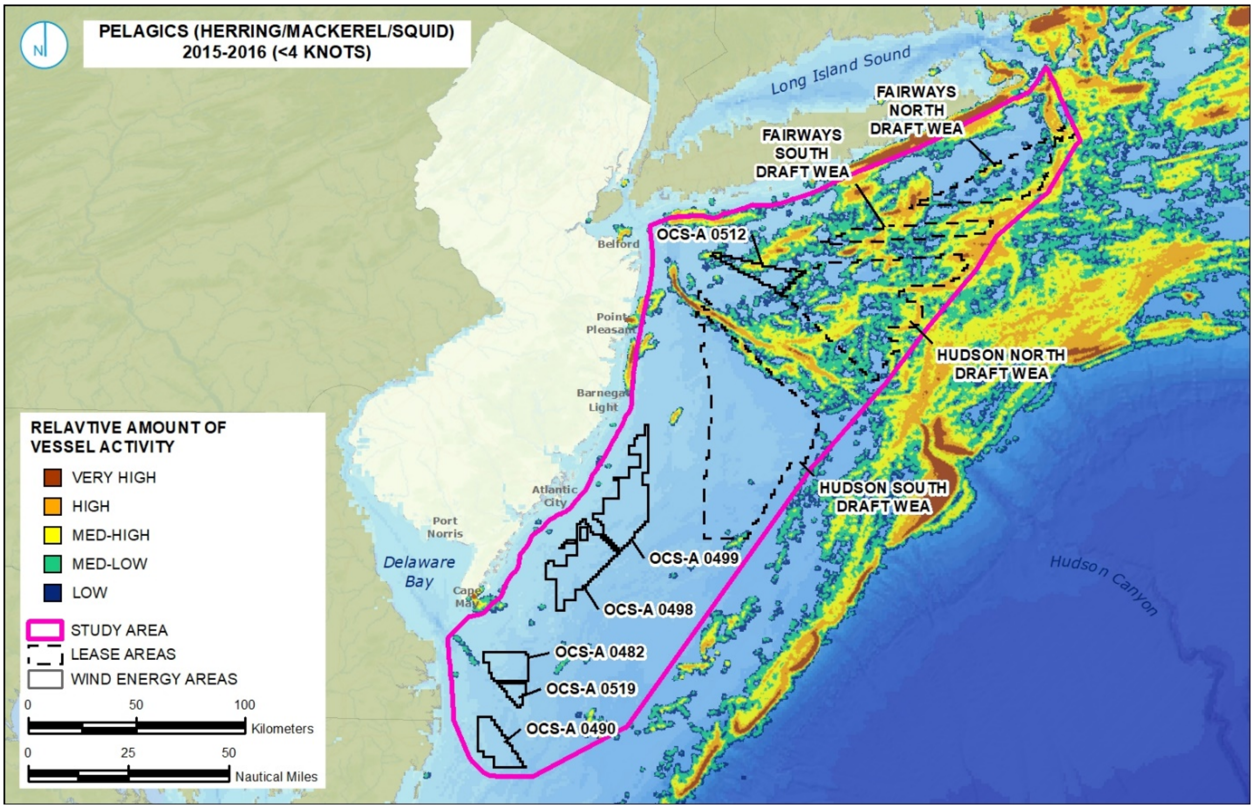

Figure 67: Pelagics (Herring, Squid, Mackerel) 2015-2016 (<4 knots)

Layer Description: These data represent all VMS pings between 2015 and 2016 reported by vessels in a pelagic fishery. Data from 2011-2016 also included SOG information in order to assess the possibility of identifying transit versus fishing activity based on speed thresholds identified by industry and agency interviews.

Key Points: The 2015-2016 (<4 knots) fishing data for pelagic fish (herring, mackerel, and squid) are consistent with the 2014 data for this species group, suggesting little fishing activity in the study area south of the Hudson Canyon. Relative to the 2014 data, these data show much more fishing activity in the lease area/draft WEAs north of the Hudson Canyon at medium-high levels.

3.1.2 Vessel Trip Reports

Use of a VTR is a reporting method by which commercial and party/charter fishing vessels report their harvest for a given trip. In general, VTRs are required to be submitted by all federally permitted fishing vessels, regardless of species targeted or whether fishing is occurring in state or federal waters (see specific state and federal rules for exceptions to this generality). Note that in some cases a vessel is not required to submit a VTR. These situations include, but are not limited to, vessels fishing only for American lobster, vessels not engaged in fishing activity with no onboard product, vessels operating under a scientific Letter of Acknowledgement (LOA), or vessels operating as a herring carrier. VTRs include general vessel information, gear type, gear size, area fished, and the estimated weight of the species landed. VTRs must be completed for each day of fishing trip (i.e., a multiday trip only requires one VTR unless the vessel changed gear or fished in another statistical area). These reports give resource managers a basic understanding of what is happening in a given fishery and help contribute to accurate quota management. While VTRs are a valuable resource, there are limitations to the data. These reports rely on fishermen actively filling out the reports in an accurate manner, and reports are submitted with estimated weights as the vessels are returning to port. VTRs alone cannot be used to monitor fisheries. Managers pair VTRs with dealer reports (to get an exact weight) and the VMS to get an accurate representation of landings being made. VTRs are a valuable resource for understanding fishing activity, especially when used with the other resources at hand.

3.1.2.1 Data

The VTR figures in this section show density polygons that were created using trip location point data (Commercial Fishing – VTR. R. U. Grant F. Walton CRSSA). The density polygon maps represent the frequency at which an area is visited in "fisherdays" (number of crew multiplied by trip length). The total labor represented in a VTR includes crew time and transit time, but it does not represent ex-vessel value or landing weight. The maps do not represent a fishing area, or "hot spot," or any individual crew or vessel. Rather, the data were aggregated to the community level and show community presence. The VTR data are presented with the following caveats:

- The maps only represent fishing activity during the years 2006-2014. Additional fishing areas may not be represented due to shifting market dynamics, regulatory changes, and rotational fishing strategies.
- The maps only show fishing activity conducted by vessels that held federal fishing permits. Some state-licensed activity may also be included in cases where vessels hold both state and federal permits. State-licensed fishing includes whelks, striped bass, black sea bass, and lobster.
- Fishermen are required to report only one geographic position per trip for a VTR unless they are switching gear or moving to a new statistical area. Therefore, fixed gear activity (see Table 6 for a list of fixed versus passive gear) is more accurately represented than mobile gear activity, and single day trips are more accurately represented than multiday trips.
- Fisheries data are complex and difficult to map. Different methods (VMS, VTR) have different strengths and weaknesses as far as representation and accuracy. The VTR maps are intended to guide discussions regarding potentially affected fishing communities for ocean planning, permitting, and management decision-making, and they are not detailed enough to be used for construction planning.

Susceptibility to offshore wind development by gear type is based on how (i.e., active versus passive fishing methods) and where in the water column (i.e., benthic versus pelagic) the fishery occurs, and the associated potential for conflicts with offshore wind. Pelagic gear is generally considered less susceptible to offshore wind development than benthic gear, and passive gear was generally considered less susceptible than active gear. This assumption is based on the higher potential for gear entanglement in the benthic versus pelagic setting, the differences in vessel sizes, and associated maneuverability differences (smaller in passive versus active gear types). These attributes are detailed further in Table 6.

Table 6: Fishing Mode for Each Gear Type

Gear Type	Benthic	Pelagic	Active	Passive
Midwater trawls (otter trawl, midwater pair trawl)		X	X	
Seine (purse seine, Danish seine)		X	X	
Pot trap	X			X
Atlantic sea scallop trawl	X		X	
Longline (freezer, wet-fish, bottom, midwater)		X		X
Gill net	X			X
Atlantic sea scallop dredge	X		X	
Dredge	X		X	
Bottom trawls (beam trawl, bottom otter trawl, bottom pair trawl)	X		X	

Table 6: Fishing Mode for Each Gear Type

Gear Type	Benthic	Pelagic	Active	Passive
Hand (primarily bandit reels)		X		X

Gear types that are benthic and active are considered the most susceptible to offshore wind development. These include Atlantic sea scallop trawl, Atlantic sea scallop dredge, dredge, and bottom trawl.

The VTR data were analyzed to determine fishing activity in certain areas off the coast of New Jersey. A summary of each layer and the key points that are relevant to offshore wind development can be found below. VTR location point data were used as input to create density polygons representing visitation frequency ("fisherdays"). The data shown on the figures was retrieved from Rutgers University Center for Remote Sensing and Spatial Analysis (CRSSA).

3.1.2.2 VTR Analysis

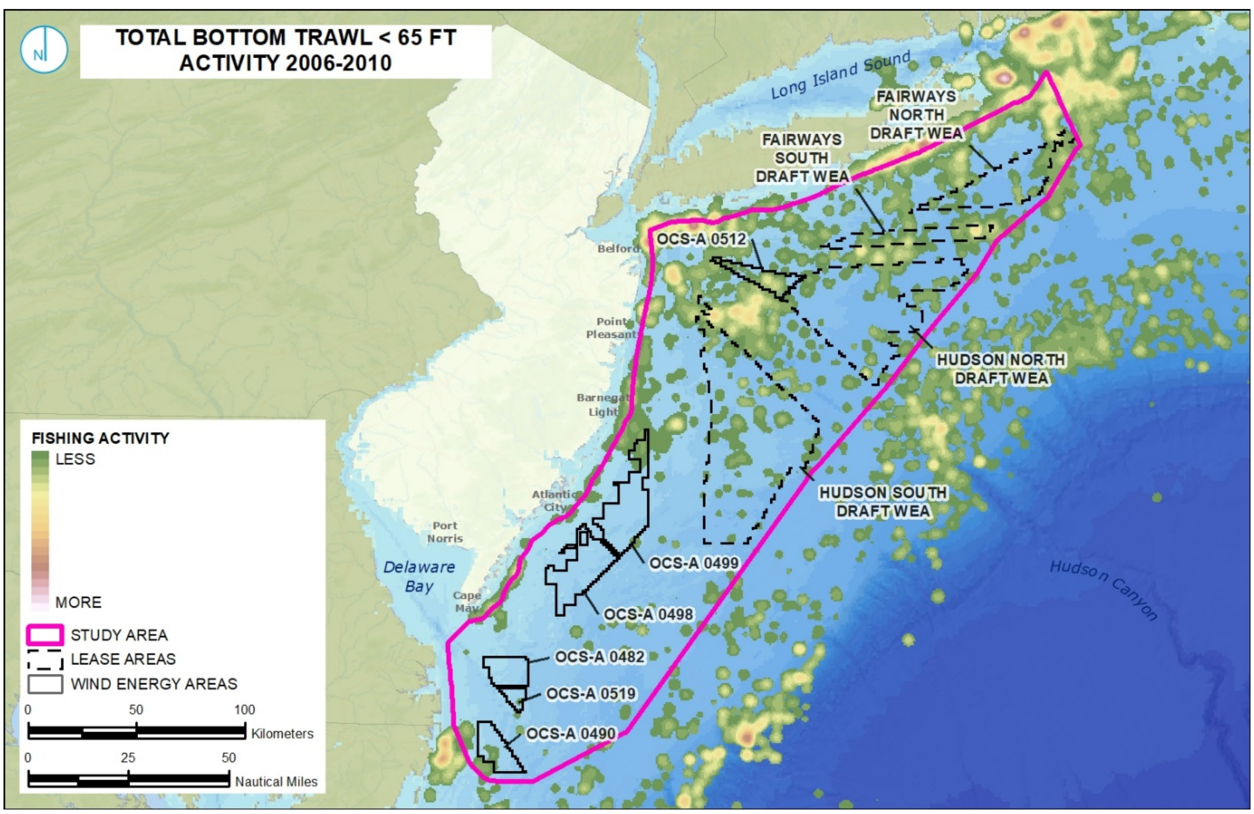

Figure 68: Total Bottom Trawl < 65 Feet Activity 2006-2010

<u>Layer Description:</u> These data are for the period from 2006-2010 and for vessels less than 65 feet in length using the following gear types: otter trawl, haddock separator; otter trawl, beam; otter trawl, bottom, Atlantic sea scallop; otter trawl, bottom, fish; otter trawl, bottom, other; otter trawl, Ruhle; pair trawl, bottom; seine, Scottish.

<u>Key Points:</u> The 2006-2010 VTR total bottom trawl data from vessels less than 65 feet in length suggest that most of this activity occurs either within 10 miles of the shoreline, along the edge of the continental shelf break, or within the Hudson Canyon and north of this canyon off the shoreline of Long Island. These data show little bottom trawl activity within the study area in the lease areas.

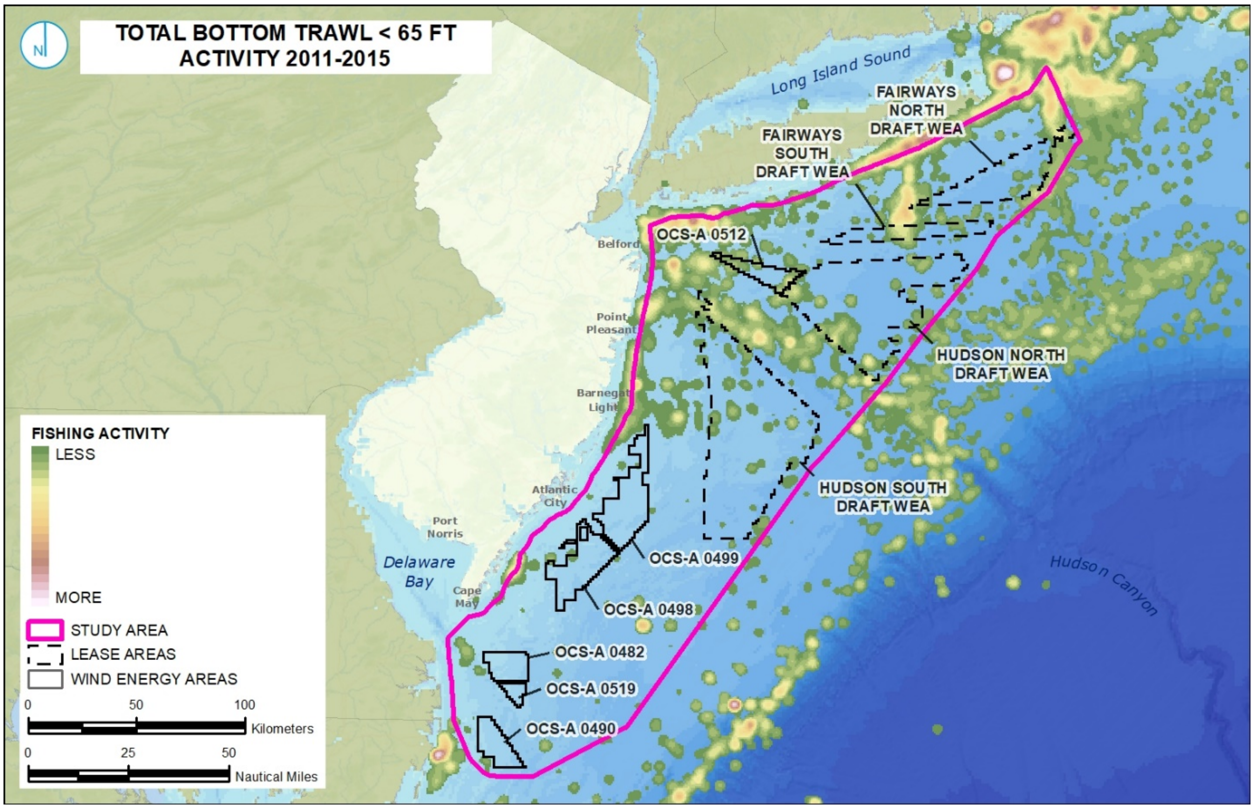

Figure 69: Total Bottom Trawl < 65 Feet Activity 2011-2015

Layer Description: These data are for the period from 2011-2015 and for vessels less than 65 feet in length using the following gear types: otter trawl, haddock separator; otter trawl, beam; otter trawl, bottom, Atlantic sea scallop; otter trawl, bottom, fish; otter trawl, bottom, other; otter trawl, Ruhle; pair trawl, bottom; seine, Scottish.

Key Points: Similar to the 2006-2010 data, the 2011-2015 VTR total bottom trawl data (<65 feet) suggest that most of this activity is close to the New Jersey and Maryland shorelines, along the edge of the continental shelf break and in the Hudson Canyon. Limited activity is observed in the New Jersey wind lease areas.

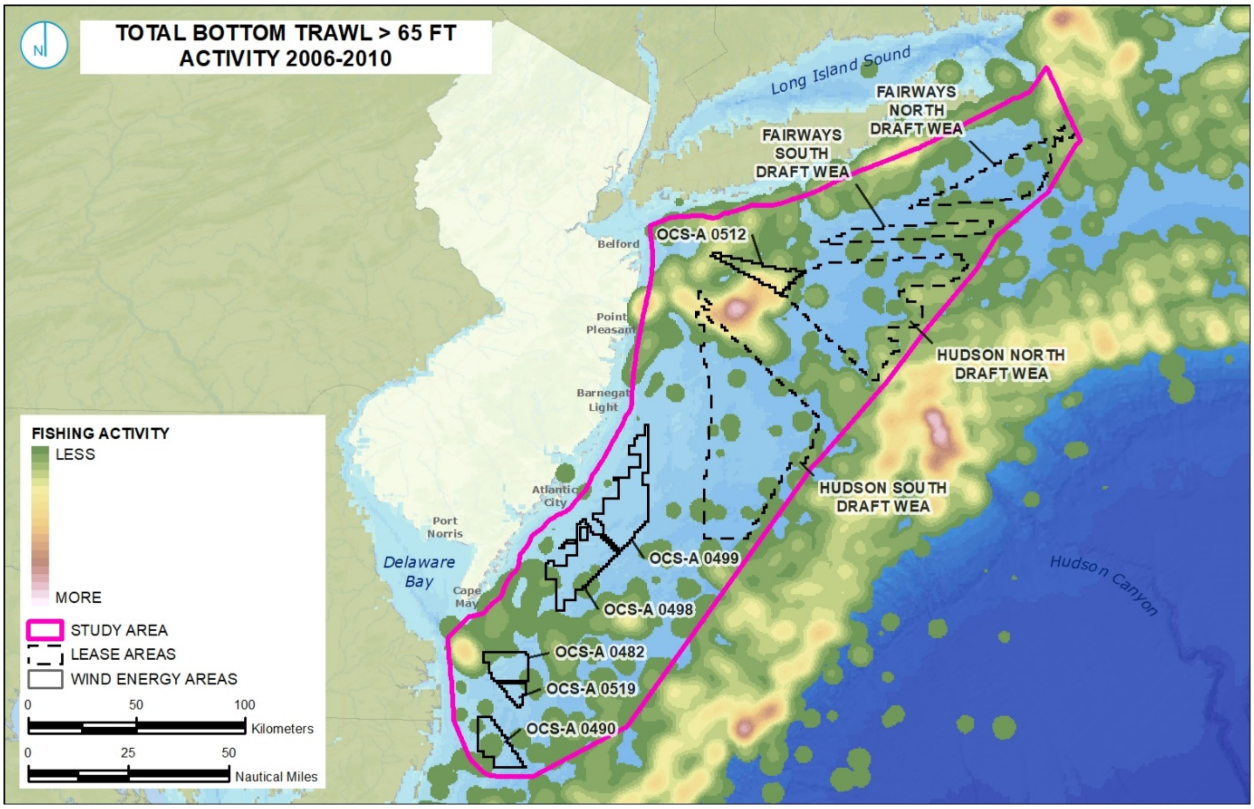

Figure 70: Total Bottom Trawl > 65 Feet Activity 2006-2010

<u>Layer Description:</u> These data are for the period from 2006-2010 and for vessels greater than 65 feet in length using the following gear types: otter trawl, haddock separator; otter trawl, beam; otter trawl, bottom, Atlantic sea scallop; otter trawl, bottom, fish; otter trawl, bottom, other; otter trawl, Ruhle; pair trawl, bottom; seine, Scottish.

<u>Key Points:</u> The 2006-2010 VTR data suggest that the areas comprising OCS-A 0498 and OCS-A 0499 have the lowest amount of total bottom trawling. The highest level of activity takes place along the edge of the continental shelf break and along the Hudson Canyon.

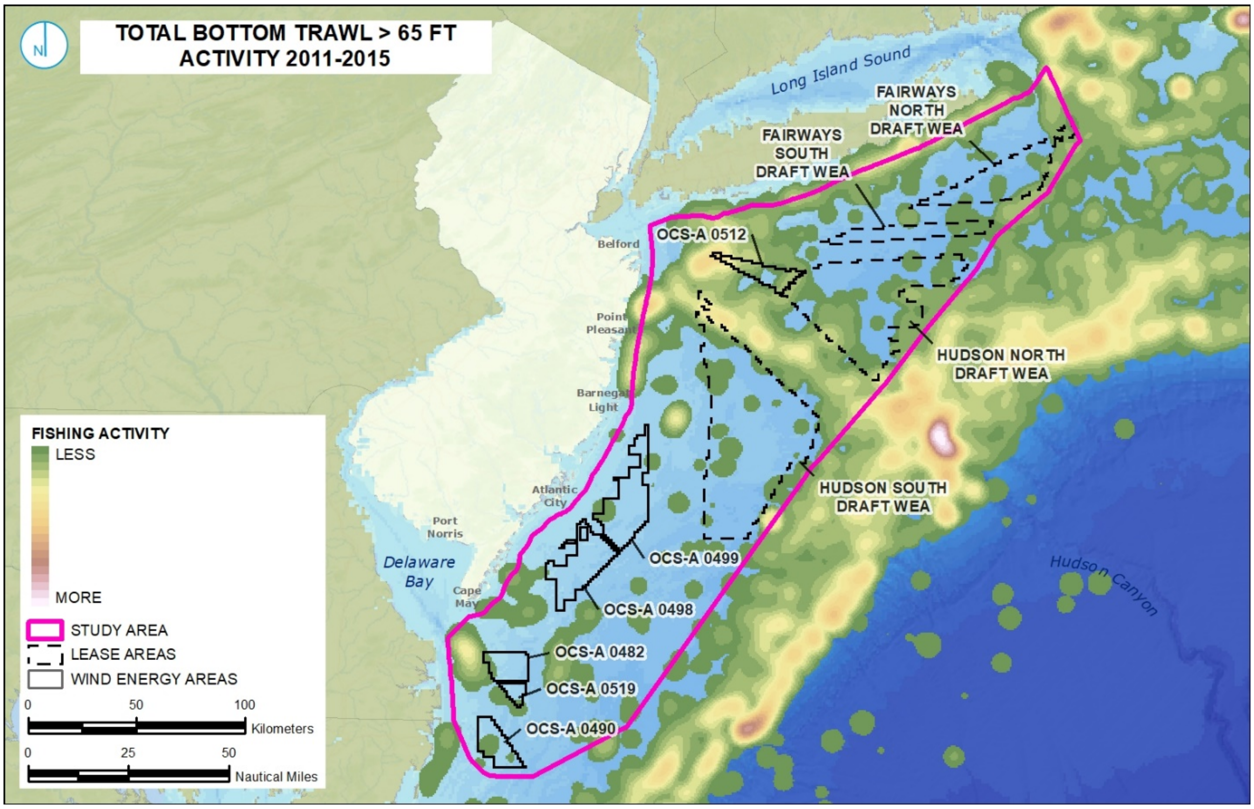

Figure 71: Total Bottom Trawl > 65 Feet Activity 2011-2015

<u>Layer Description:</u> These data are for the period 2011-2015 and for vessels greater than 65 feet in length using the following gear types: otter trawl, haddock separator; otter trawl, beam; otter trawl, bottom, Atlantic sea scallop; otter trawl, bottom, fish; otter trawl, bottom, other; otter trawl, Ruhle; pair trawl, bottom; seine, Scottish.

<u>Key Points:</u> Similar to the 2006-2010 data, the 2011-2015 VTR total bottom trawl data (>65-foot vessel) suggest that the areas of highest activity are along the edge of the continental shelf break, within the Hudson Canyon, and in proximity to the shore of Long Island. Sporadic activity is identified in the study area south of the Hudson Canyon, with only limited overlap with identified lease areas.

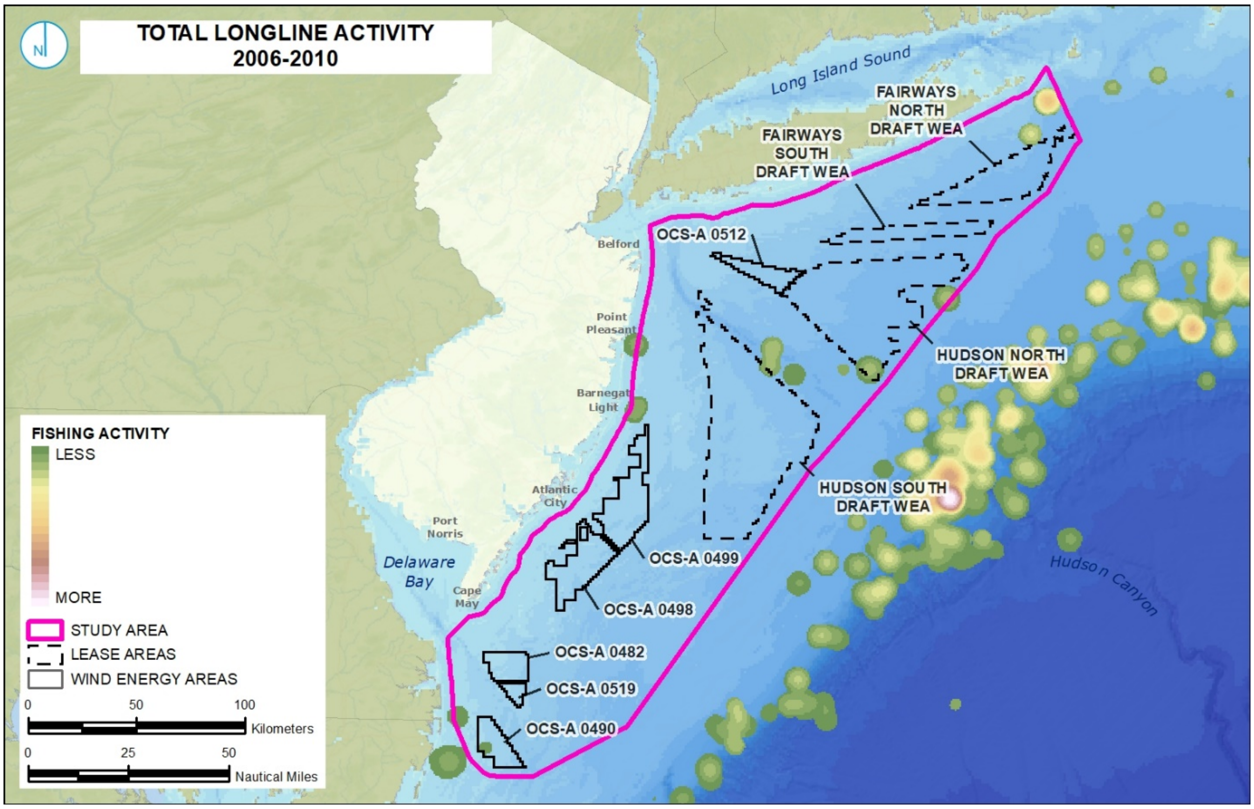

Figure 72: Longline Activity 2006-2010

Layer Description: These data are for the period from 2006-2010 using fishing longline gear type (longline, bottom and longline, pelagic).

Key Points: The 2006-2010 VTR total longline activity data suggest minimal activity within the study area, with nearly all activity taking place along the continental shelf break.

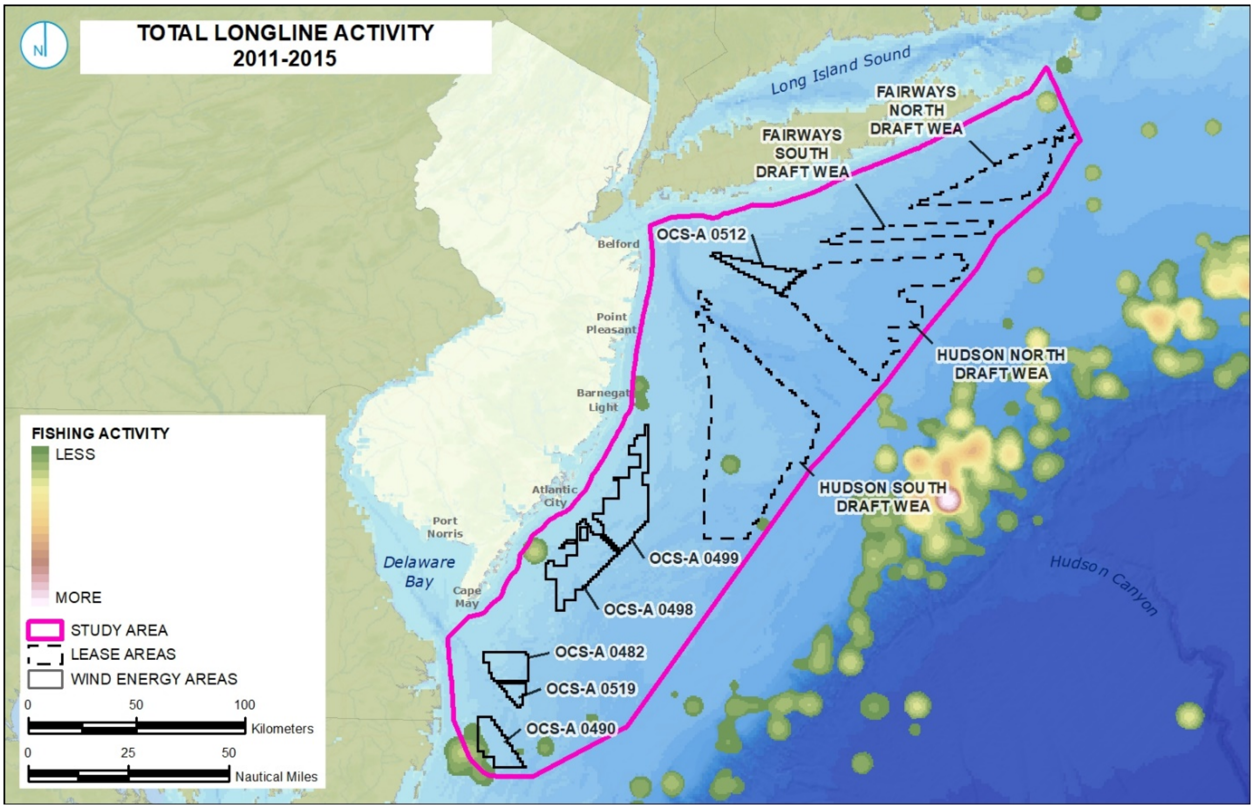

Figure 73: Longline Activity 2011-2015

Layer Description: These data are for the period from 2011-2015 using fishing longline gear type (longline, bottom and longline, pelagic).

Key Points: The 2011-2015 VTR total longline activity data suggest only a small amount of this activity within the study area, with the majority of activity taking place along the edge of the continental shelf break.

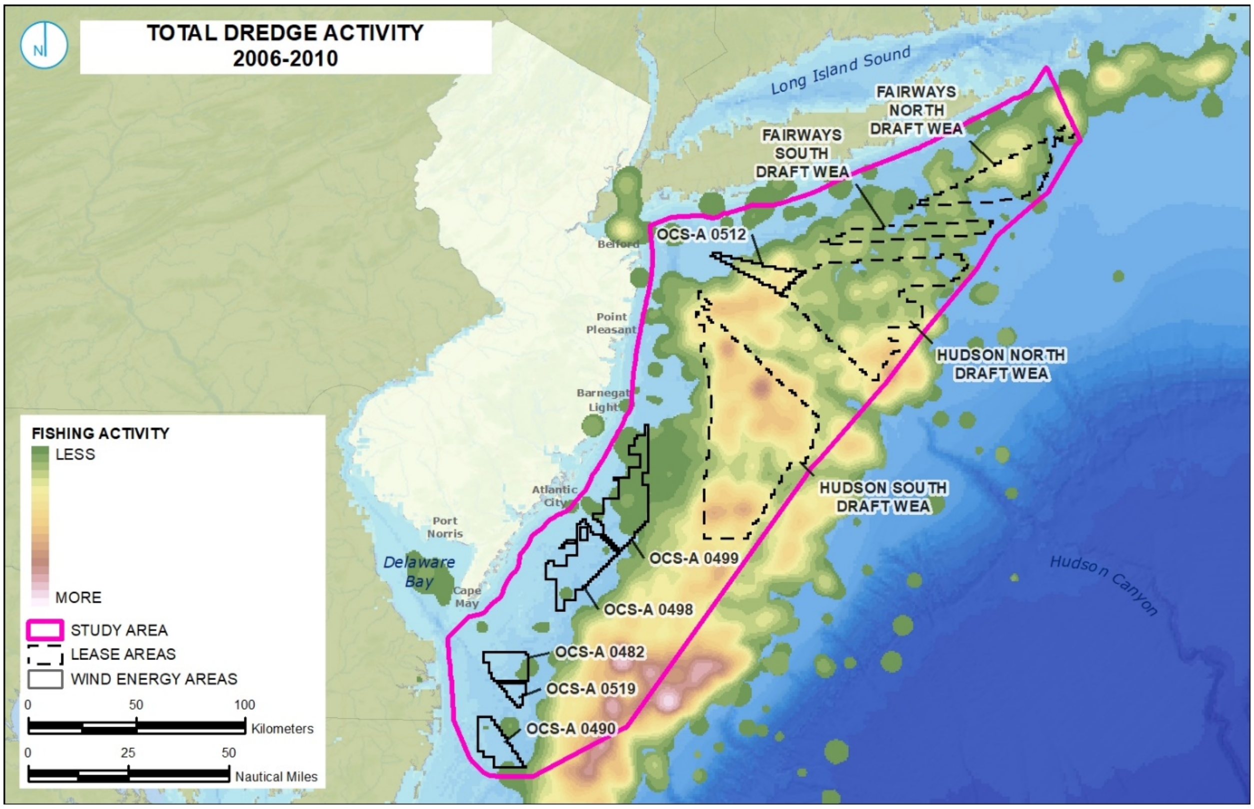

Figure 74: Dredge Activity 2006-2010

Layer Description: These data are for the period from 2006-2010 using the following fishing dredge gear types: dredge, ocean quahog/Atlantic surfclam; dredge, mussel; dredge, other; dredge, Atlantic sea scallop, standard; dredge, urchin.

Key Points: The 2006-2010 VTR data were consistent with the other bottom-focused fishing activity (e.g., Atlantic sea scallop VMS data [Figures 58, 59 and 60]), suggesting low amounts of activity lease areas OCS-A 0490, OCS-A 0519, OCS-A 0482, OCS-A 0498. Highest levels of activity are observed in the southeastern most portions of the study area, largely outside of southern lease areas. Overlap with lease areas and WEAs is more prevalent in northern portions of the study area, and generally farther offshore.

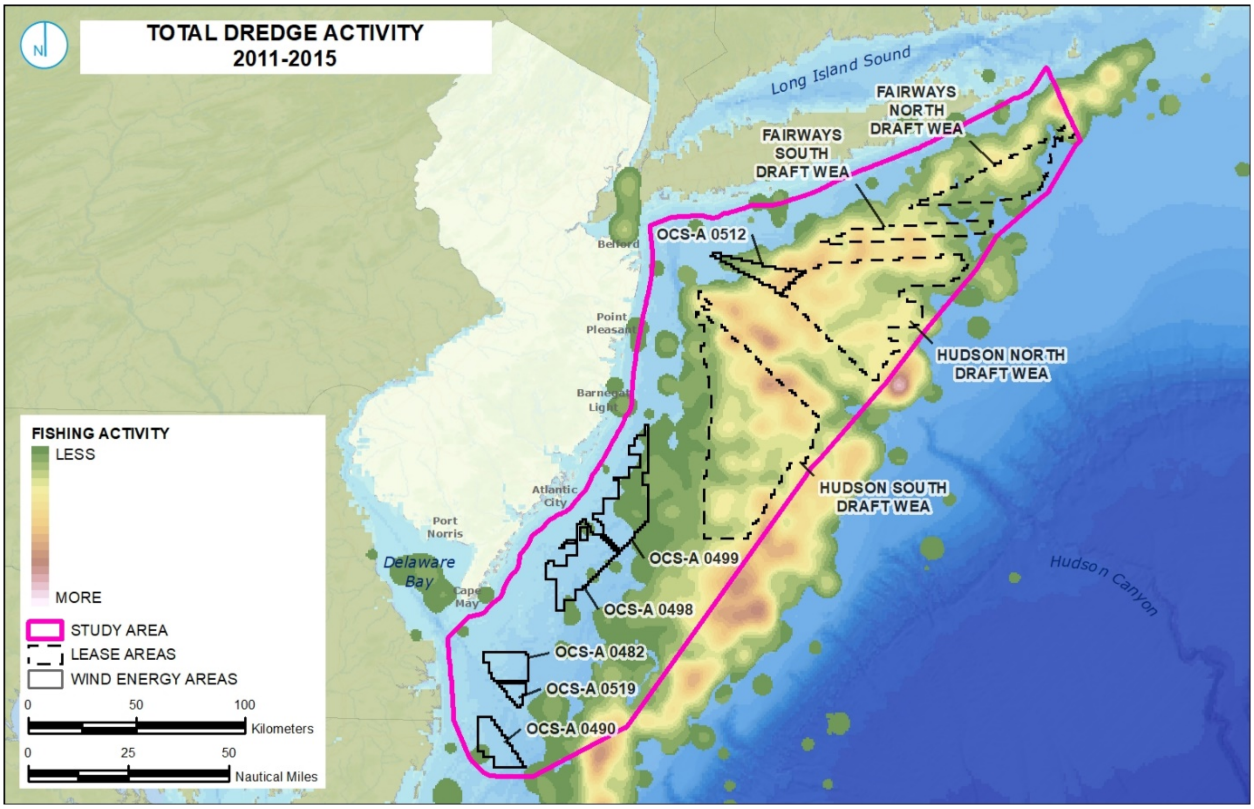

Figure 75: Dredge Activity 2011-2015

Layer Description: These data are for the period 2011-2015 using the following fishing dredge gear types: dredge, ocean quahog/Atlantic surfclam; dredge, mussel; dredge, other; dredge, Atlantic sea scallop, standard; dredge, urchin.

Key Points: The 2011-2015 total dredge activity VTR data show a distribution similar to that of the 2006-2010 VTR data for this activity (i.e., lower southern lease areas, higher to the east and north, particularly along the Hudson Canyon and in waters more near the continental shelf break).

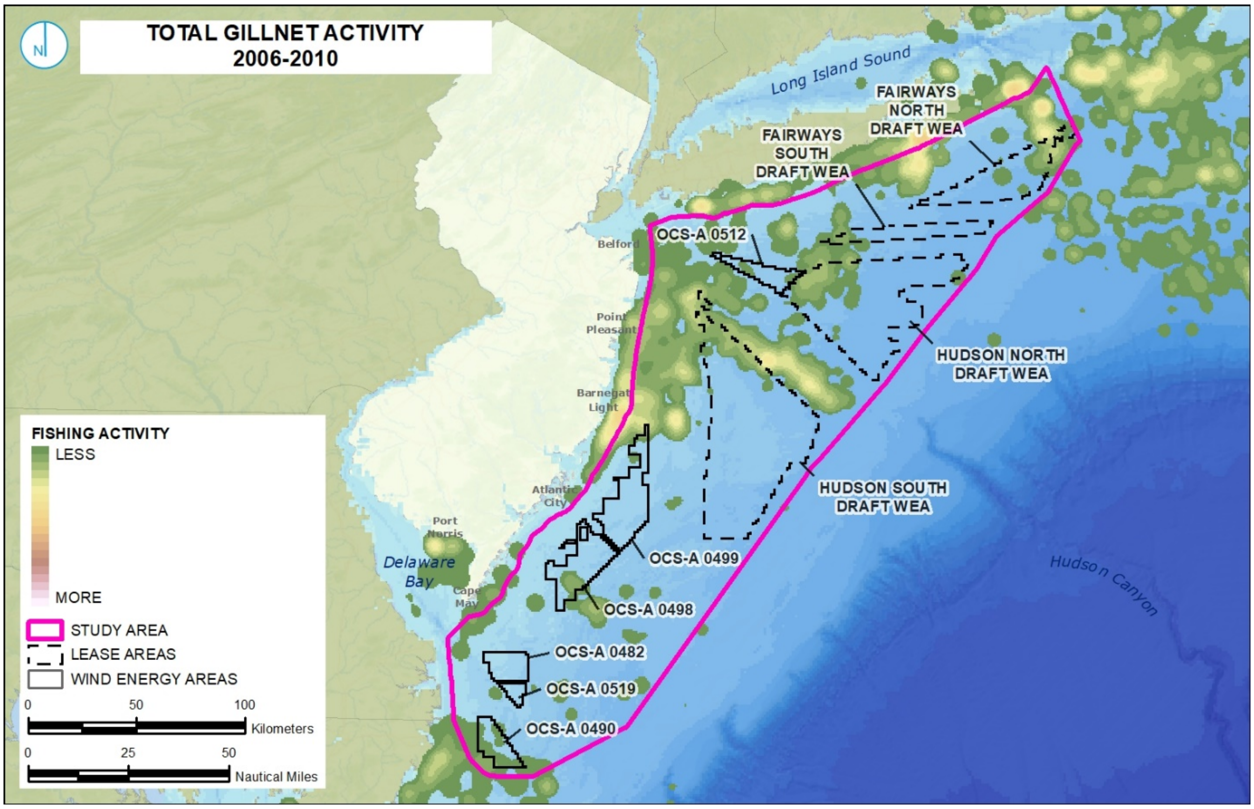

Figure 76: Gill Net Activity 2006-2010

Layer Description: These data are for the period from 2006-2010 using the following fishing gill net gear types: gill net, drift, large mesh; gill net, other; gill net, runaround; gill net, sink; gill net, drift, small mesh.

Key Points: The 2006-2010 total gill net activity VTR data suggest minimal activity within the majority of the study area. Areas of highest gill net activity include the Hudson Canyon, the southern coast of Long Island, and in proximity to the New Jersey coast from Belford to Atlantic City. Lease areas OCS-A 0519, OCS-A 0482, and OCS-A 0499 have the lowest conflicts with gill net activity.

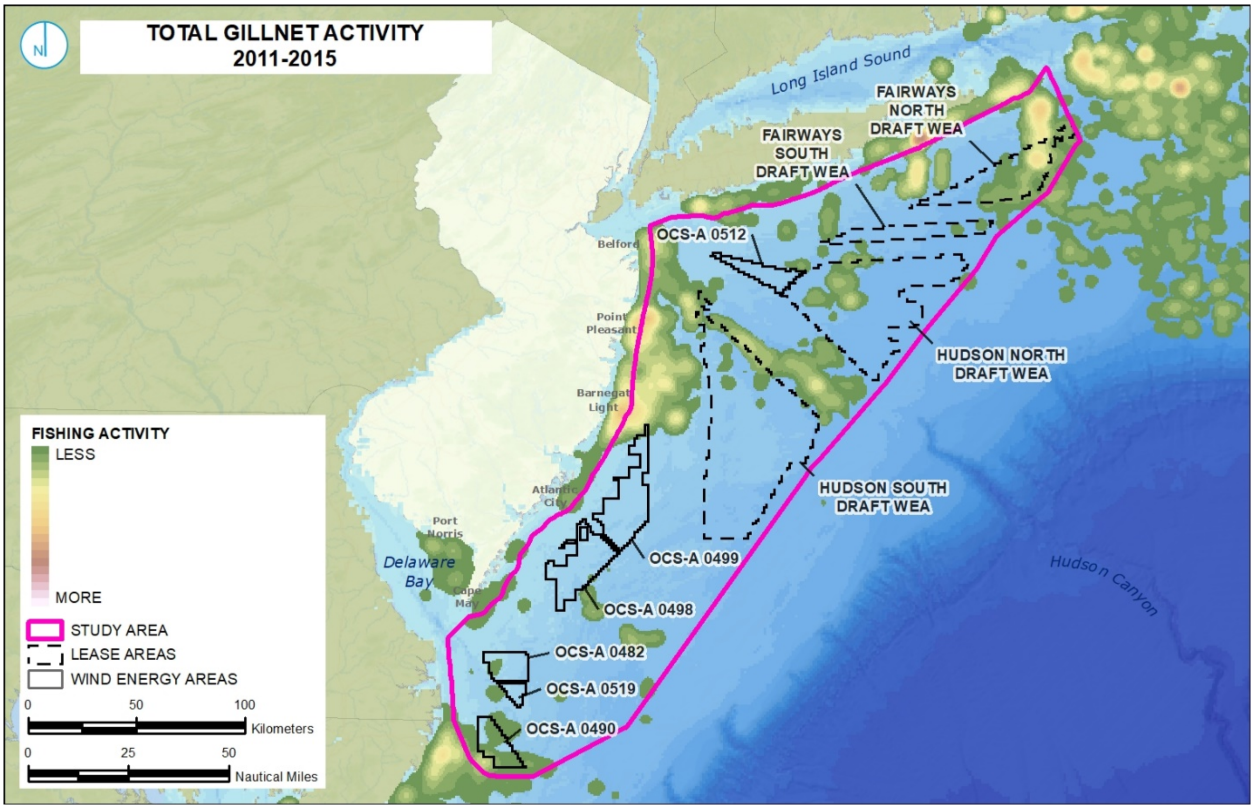

Figure 77: Gill Net Activity 2011-2015

Layer Description: These data are for the period from 2011-2015 using the following fishing gill net gear types: gill net, drift, large mesh; gill net, other; gill net, runaround; gill net, sink; gill net, drift, small mesh.

Key Points: The 2011-2015 total gill net activity VTR data are similar to the 2006-2010 VTR data for this activity (i.e., low in the majority of the study area, higher in the Hudson Canyon and near the coasts of northern New Jersey and Long Island). Lease areas OCS-A 0519, OCS-A 0482, OCS-A 0498, OCS-A 0499, and OCS-A 0512 suggest the lowest conflicts with gill net activity.

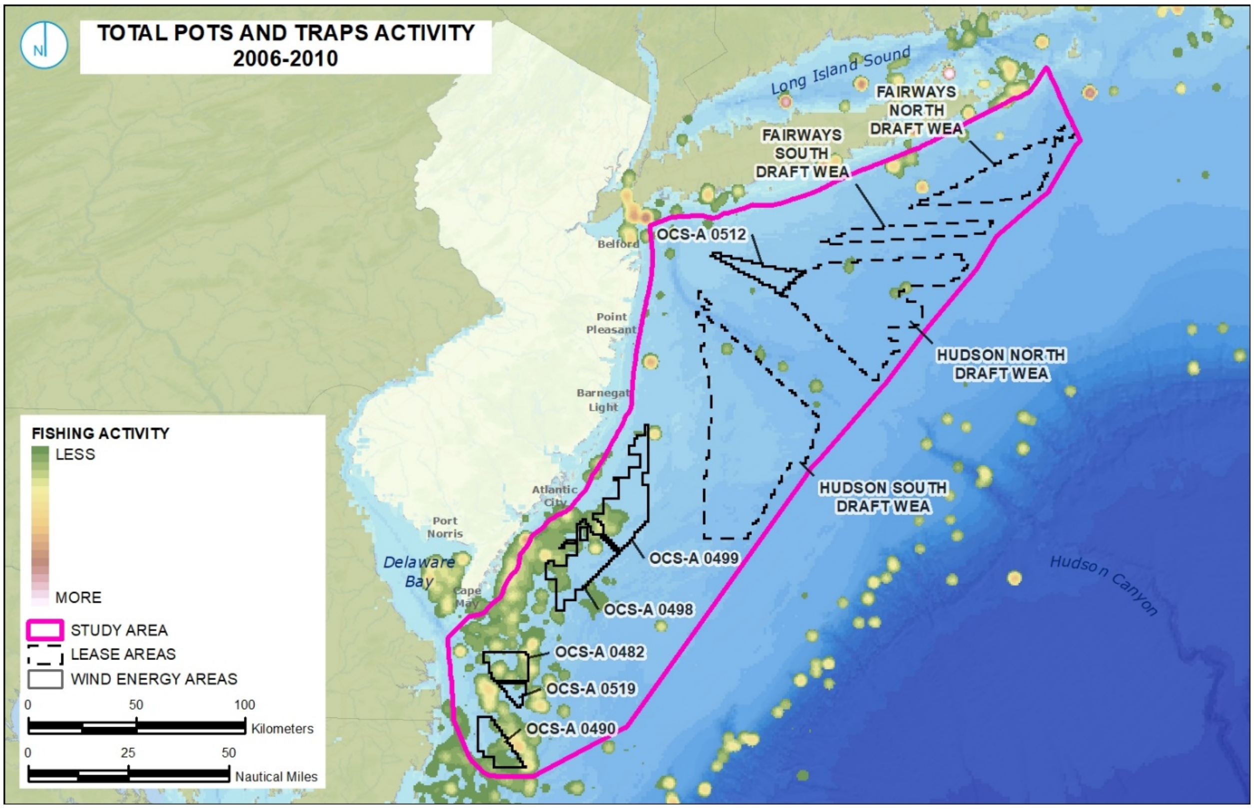

Figure 78: Pots and Traps Activity 2006-2010

Layer Description: These data are for the period from 2006-2010 using the following fishing pots and traps gear types: pot, crab; pot, fish; pot, hag; pot, other; pot, shrimp; pot, conch/whelk; pot, mixed; trap.

Key Points: The 2006-2010 total pots and traps activity VTR data suggest minimal activity within the majority of the study area. Areas of highest pot and trap fishing activity are located along the coastline of Maryland, Delaware, and southern New Jersey and there is overlap with most of the lease areas in that region.

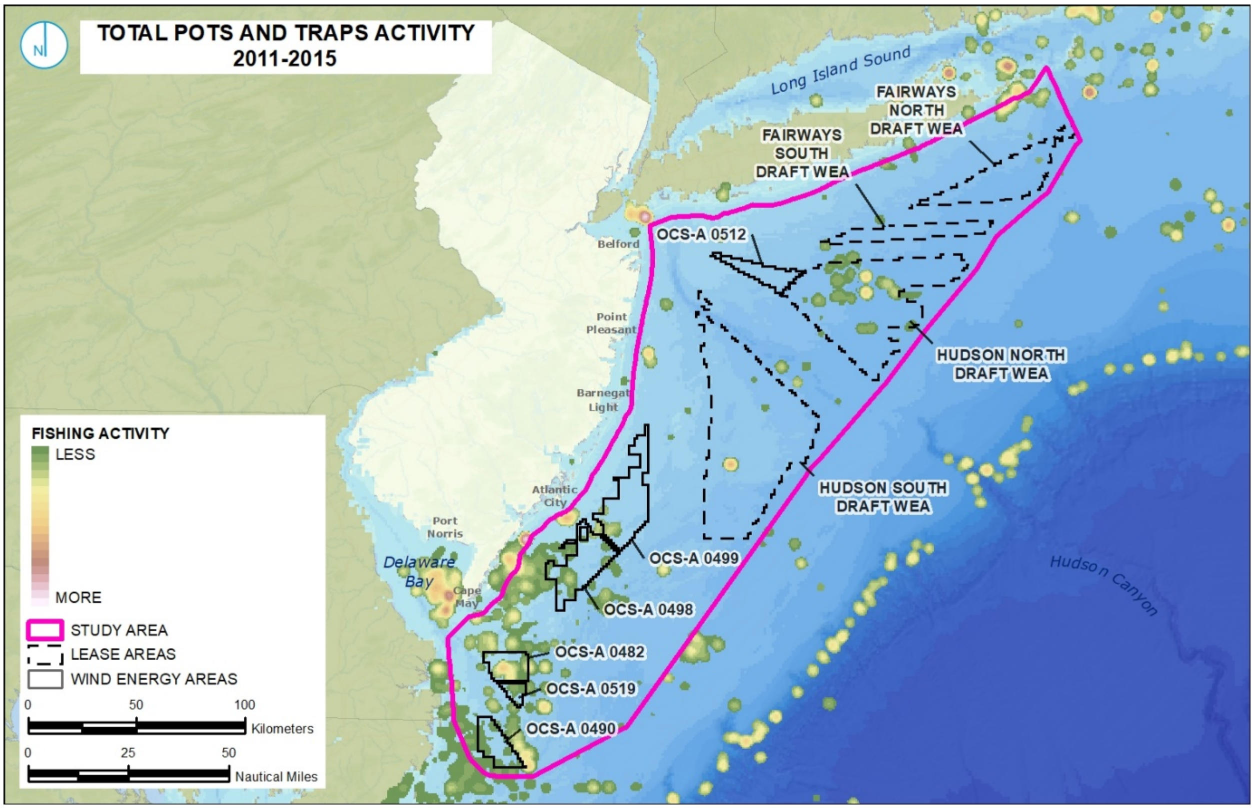

Figure 79: Pots and Traps Activity 2011-2015

Layer Description: These data are for the period from 2011-2015 using the following fishing pots and traps gear types: pot, crab; pot, fish; pot, hag; pot, other; pot, shrimp; pot, conch/whelk; pot, mixed; trap.

Key Points: The 2011-2015 total pots and traps activity VTR data are similar to the 2006-2010 VTR data for this activity (i.e., the highest activity is along the coastline of Maryland, Delaware, and southern New Jersey and within the southernmost lease areas). Additional activity is observed in the Hudson North draft WEA in this figure.

3.1.3 Mean Annual Revenue

A raster dataset was built by NOAA Fisheries NEFSC Social Sciences Branch (Kirkpatrick et al. 2017) to illustrate revenue intensity offshore. The revenue intensity raster was developed by merging spatial data on fishery catch with data collected by at-sea observers and interpolated using cumulative distribution functions. The spatial data on fishery catch are derived from VTRs, VMS data, and the Northeast Fisheries Observer Program database (NEFOP). The price data were drawn from commercial fisheries dealer reports. The research group developed spatial footprints of fishing locations based off of variables such as gear type and length of trip. The revenue calculated for the study area was determined by "exposure," which quantifies the amount of fishing that occurs in the area and represents the total fishing activity that *may be affected* by offshore wind development; it is not a measure of economic impact or loss. The actual economic impact will depend on whether the vessel is able to adapt its fishing area—if alternative fishing grounds are near, the economic impact will be lower.

The following fishery management plans were included for 2007-2012:

- Atlantic Herring
- Bluefish
- Golden Tilefish
- Large-Net Northeast Multispecies
- Highly Migratory Species
- Mackerel, Squid, Butterfish
- Monkfish
- Small-Net Northeast Multispecies

- River Herring
- Sea Scallop
- Skates
- Spiny Dogfish
- Summer Flounder/Scup/Black Sea Bass
- Surfclam/Ocean Quahog

The following gear categories were included for 2007-2012:

- Dredge
- Scallop Dredge
- Gill Net
- Hand
- Longline
- Pot
- Seine
- Bottom Trawl
- Scallop Bottom Trawl
- Midwater Trawl
- Lobster Pot

3.1.3.1 Mean Annual Revenue Analysis

Figure 80 shows the mean annual revenue (MAR) raster within the OWSP study area. The analysis includes data from 2007 to 2012 for the following fisheries industries:

- Atlantic Herring
- Bluefish
- Golden Tilefish
- Large-Net Northeast Multispecies
- Highly Migratory Species
- Mackerel, Squid, Butterfish
- Monkfish
- Small-Net Northeast Multispecies
- River Herring
- Sea Scallop
- Skates
- Spiny Dogfish
- Summer Flounder/Scup/Black Sea Bass
- Surfclam/Ocean Quahog

The areas with the highest MAR exist outside of the OWSP study area. Table 7 shows a summary of the MAR within the OWSP areas. The Hudson North draft WEA and the northern portion of the Hudson South draft WEA are located within areas of higher MAR. The Hudson North draft WEA has the highest average MAR over its area of $3,042 per 0.25 km^2 (mean annual revenue between 2007 and 2012). The Hudson South draft WEA has the highest total mean annual revenue of $31,785,550, which is expected due to its size and the prevalence of fisheries in and around the Hudson Canyon. The lease areas off New Jersey have considerably lower MAR average values. OCS-A 0499 has the highest value of the southern lease areas, with an average mean annual revenue value of $758.60 per km^2. These results are consistent with the results from VMS and VTR that show greater fishing activity within the more northern lease areas and draft WEAs. Consistency between the MAR data and the VMS/VTR data is expected because the MAR dataset is derived from the VMS/VTR datasets. Therefore, the limitations that apply to the VMS/VTR datasets should also be applied to these results.

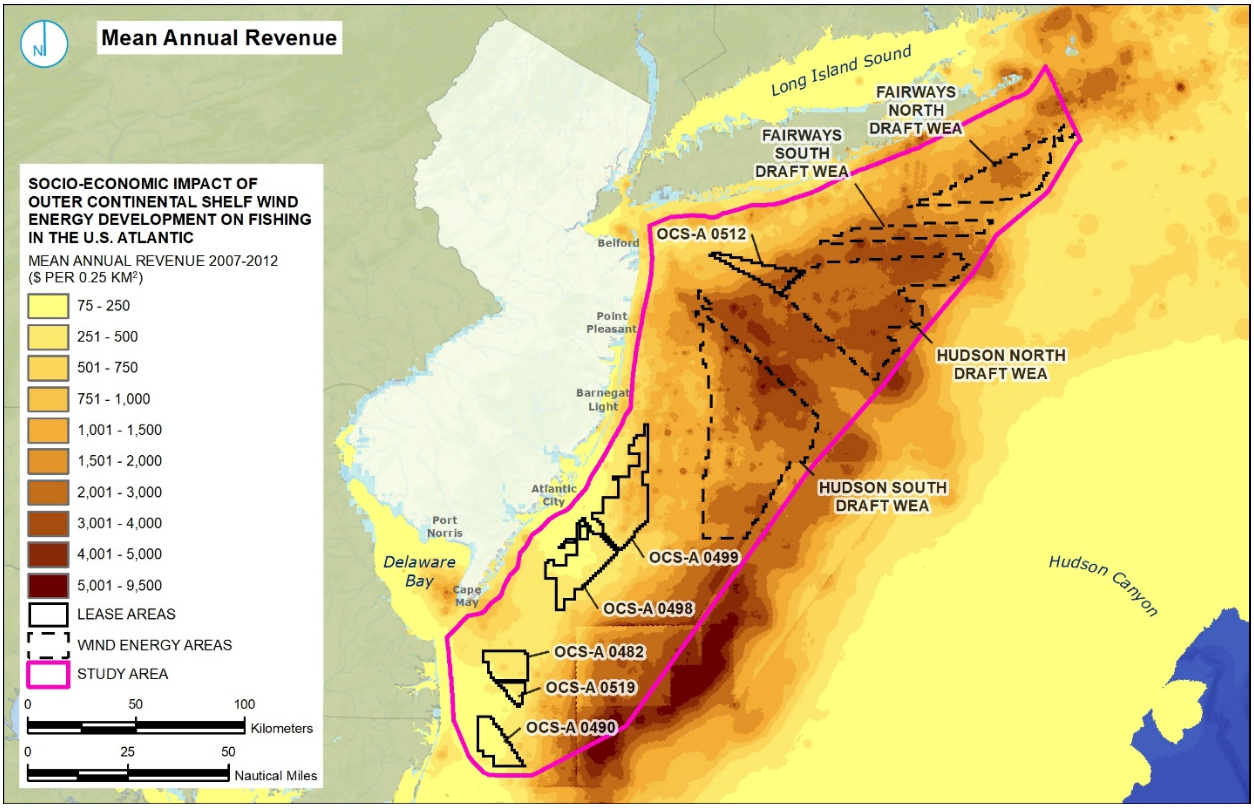

Figure 80: Mean Annual Revenue 2007-2012

Table 7: Mean Annual Revenue in OWSP Study Area

Mean Annual Revenue	Average ($/0.25 sq km)	Total ($)
OSC-A 0490 (US Wind)	$ 216.34	$ 279,079.11
OCS-A 0519 (Skipjack Wind)	$ 286.10	$ 121,306.32
OCS-A 0482 (GSOE I, LLC)	$ 333.54	$ 379,236.44
OCS-A 0498 (Ocean Wind)	$ 271.50	$ 704,258.41
OCS-A 0499 (Atlantic Shores)	$ 758.60	$ 2,248,486.00
OCS-A 0512 (Boardwalk/Empire Wind)	$ 2,013.45	$ 2,579,231.03
Hudson South Draft WEA	$ 2,379.16	$ 31,785,550.35
Hudson North Draft WEA	$ 3,042.43	$ 29,116,058.54
Fairways South Draft WEA	$ 2,335.07	$ 4,051,338.10
Fairways North Draft WEA	$ 1,710.42	$ 5,856,474.12
Entire OWSP Study Area	$ 1,713.81	$ 222,517,309.25

3.2 Recreational Fishing

Recreational fishing was assessed based on three layers: prime fishing grounds of New Jersey (polygons), prime fishing grounds of New Jersey (points), and artificial reefs. These layers are publicly available on the NJDEP Open Data. The Division of Fish and Wildlife Marine Fisheries Administration created the updated digital Prime Fishing Grounds Map through direct interviews with recreational fishing boat captains during the summer of 2003 (28 party boat captains, 47 charter boat captains, and 22 private boat captains from each fishing port along the coast of New Jersey). The interview method consisted of having the captains edit previously prepared prime recreational fishing grounds (identified by various sources) and commercially prepared sport fishing ground charts (home port charts and charter boat charts) that were transferred onto NOAA nautical charts. Generally, the editing of the fishing grounds usually expanded upon or added new areas. In 2018, the Prime Fishing Grounds Map was updated to include 17 artificial reef sites and updated Home Port charts. Species represented by this dataset are summer flounder, sea bass/tautog, cod/pollock, bluefish, weakfish, striped bass, tuna, sharks, billfish, bonito/albacore, scup, red hake, American lobster, and various others (shortfin mako, bluefin, mahi/dorado, and skippie).

3.2.1 Analysis

Figure 81 shows the prime fishing grounds of New Jersey (polygons), prime fishing grounds of New Jersey (points), and artificial reefs layers. The OWSP study area is 13% covered by recreational fishing areas.[10] In Figure 81, the polygons are reflective of known fishing target locations and areas frequented by recreational fishermen. Table 8 shows the percentage of each lease area covered by recreational fisheries, and the number of prime fishery points within each lease area and the study area. An approximately 28,000-acre recreational fishing area (called "Lobster Hole") intersects OCS-A 0499, which is overall 14% covered by recreational fisheries. OCS-A 0482 is intersected by several recreational fishing areas and is 29% covered. OCS-A 0498 is intersected by several small recreational fisheries and one dump site. The Hudson South draft WEA is intersected by several recreational fisheries. The majority of the recreational fishing layers exist further offshore, outside of the OWSP study area. Off the New Jersey coast, 6% of the total recreational fisheries area intersects with lease areas.

The artificial reefs layer was also used in the WSA. OCS-A 0498 and OCS-A 0499 were intentionally drawn to avoid artificial reefs in the area. There are 14 artificial reefs within the OWSP study area, none of which intersect the lease areas or WEAs. Artificial reefs occupy a limited area relative to the size of the lease and WEAs.

[10] A 0.25 nautical mile buffer was added to the prime fishing ground points and artificial reefs to ensure discrete locations are captured at the resolution of this analysis and as a measure of conservatism.

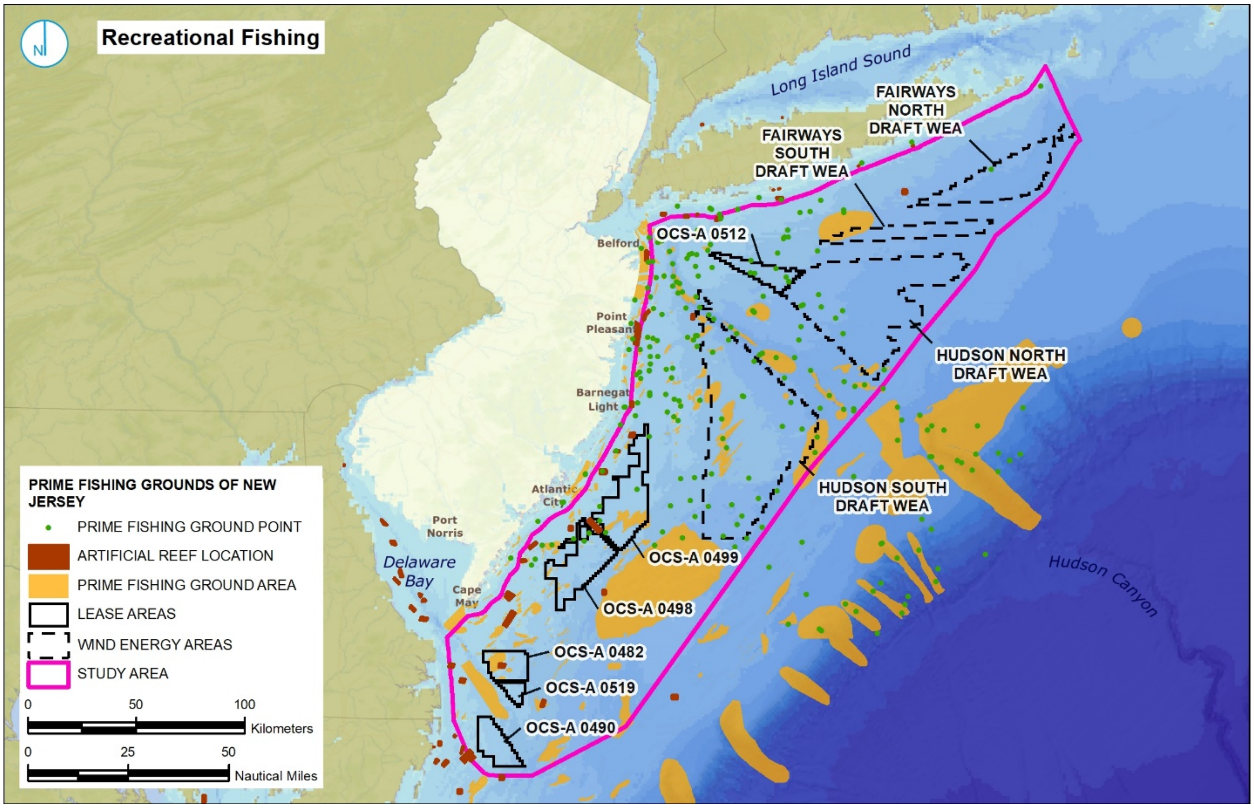

Figure 81: Recreational Fishing

Table 8: Recreational Fishing in OWSP Study Area

Lease Area	Prime Fishing Grounds (% coverage)	Prime Fishing Grounds (# of points)
OSC-A 0490 (US Wind)	0%	0
OCS-A 0519 (Skipjack Wind)	2%	0
OCS-A 0482 (GSOE I, LLC)	29%	0
OCS-A 0498 (Ocean Wind)	6%	3
OCS-A 0499 (Atlantic Shores)	14%	3
OCS-A 0512 (Boardwalk/ Empire Wind)	1%	7
Hudson South Draft WEA	9%	20
Hudson North Draft WEA	1%	7
Fairways South Draft WEA	10%	0
Fairways North Draft WEA	0%	1
Entire OWSP Study Area	13%	169

The commercial and recreational/sportfishing industry has high cultural and economic value in the region. Offshore wind development in New Jersey is generally in the preconstruction (planning) phase. While the implications of offshore wind development on commercial and recreational/sportfishing fisheries are not well understood, it is expected that specific gear types and target species will be more affected than others, as generally described below.

Recreational fishing is associated with lower economic value relative to commercial fishing. Recreational/sportfishing is also generally executed with smaller vessels than many of the commercial fishing fleet. Therefore, recreational/sportfishing grounds may be less susceptible to offshore wind development effects than commercial fishing areas. It is also possible that, because of reefing effects associated with offshore turbines, recreational fishers will see some benefits (i.e., potential for increases in localized fish abundance). However, it should be noted that the long-term effects of offshore wind development on recreational fisheries, like the effects on commercial fisheries, are largely unknown.

3.3 Social Uses

Social uses include commercial whale watching areas, scuba sites, and marine protected areas. As New Jersey's coastal ocean is renowned for its beauty, landscape, and viewshed, social use of the coastal ocean also includes the enjoyment of these attributes by millions of people each year including residents, business owners, and tourists.

The commercial whale watching and recreational scuba layers were collected as a part of the Northeast Coastal and Marine Recreational Use Characterization Study (conducted by SeaPlan and Point 97) under the Northeast Regional Planning Body. The commercial whale watching areas layer depicts activity areas mapped by whale watch industry experts, however it is not comprehensive and contains known gaps (e.g., whale watching activities that take place in Cape May, NJ region). Experts consisted of whale watch owners, operators, naturalists, and data managers, and information was collected at participatory mapping workshops. The recreational scuba diving areas layer is a composite of data collected through outreach to the scuba community and existing data sources. The sources included state-based online GIS data portals, scuba guide documents, online survey data, participatory geographic information systems workshops, and consultations with scuba experts. The parks and protected areas data were obtained from the National Oceanic and Atmospheric Administration Marine Protected Areas Center and consist of Natural Estuarine Research Reserves, Natural Recreation Areas, National Seashore, National Wildlife Refuges, Natural Areas, State Parks, and Wildlife Management Areas. While many of these parks and protected areas occur outside of the study area, they were reviewed to evaluate their occurrence within the study area.

The development of offshore wind requires the installation of above ground infrastructure that could theoretically be visible from shore and affect viewshed for some observers (viewshed impacts from offshore wind projects are subjective). The term 'theoretical visibility' refers to the potential for and extent of visibility of a given offshore wind development project. The theoretical visibility of structures within a given wind lease area to an observer located onshore is generally governed by:

- the layout and design of the proposed development, including turbine size, and spatial relationship with turbines in adjoining lease areas;
- rotational speed of turbine rotors;

- the color of turbines and utilization of non-reflective paints as well as any lighting (e.g., safety);
- the relative distance and direction of observers to the proposed development;
- the relative height of observers and the structure;
- the degree of openness or interruption of views towards the proposed development as a result of intervening buildings, vegetation or topography;
- the curvature of the earth;
- sensitivity of the seascape (industrial seascapes are less sensitive than recreational or natural);
- atmospheric conditions, meteorological visibility and light levels; and
- the visual acuity of observers.

Research suggest that with good visibility, most offshore wind structures are visible at 20-40km from land, depending upon the above factors (Sullivan et al. 2013). As many of the above factors are variable, so are the expected impacts to the viewshed of New Jersey's coastal ocean. Table 9 presents the distance from land to lease areas and WEAs.

Table 9: Distance from Land to Lease Areas and WEAs in Coastal New Jersey

WEA or Lease Area	Closest Point to NJ (miles)	Closest Point to Any Land (miles)
OCS-A 0482	14	14
OCS-A 0519	26	16
OCS-A 0490	34	9
OCS-A 0499	9	9
OCS-A 0498	7	7
FAIRWAYS NORTH DRAFT WEA	78	17
FAIRWAYS SOUTH DRAFT WEA	52	17
HUDSON NORTH DRAFT WEA	41	32
HUDSON SOUTH DRAFT WEA	17	17
OCS-A 0512	21	13
AVERAGE	**30**	**15**

3.3.1 Analysis

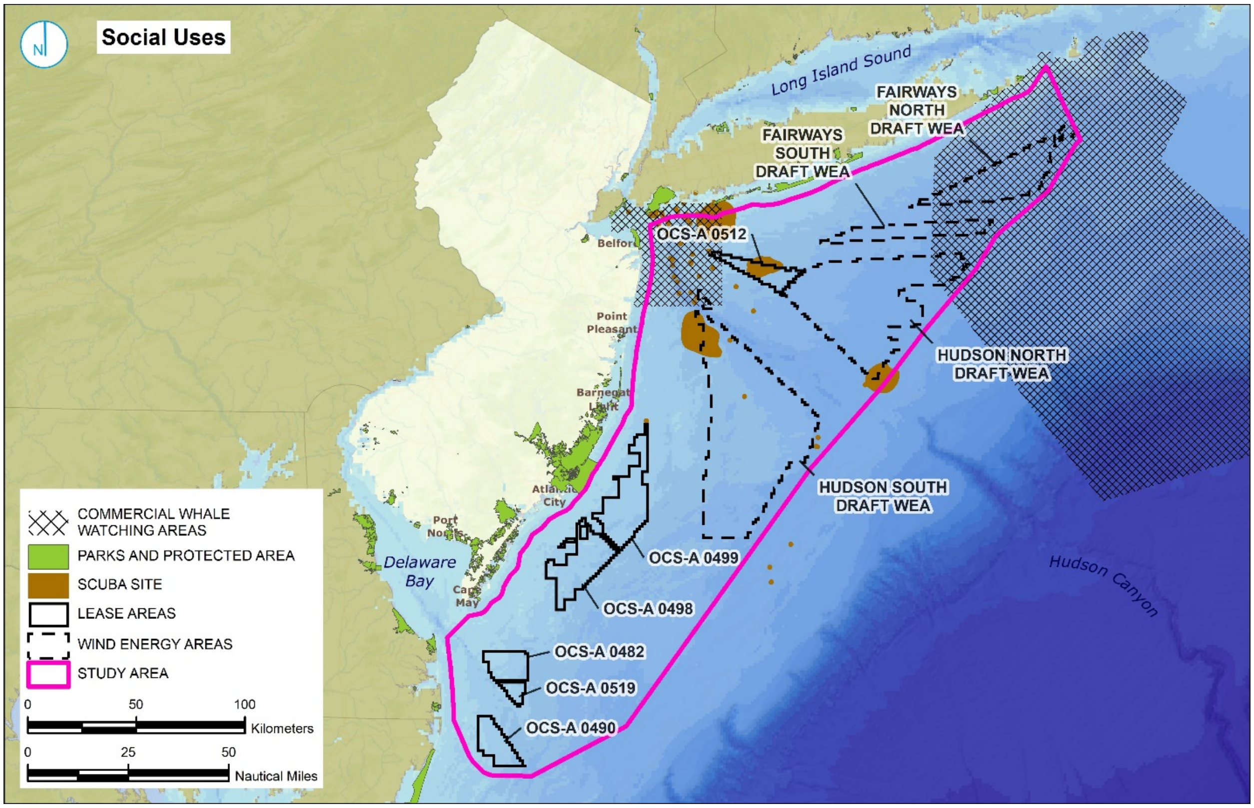

Figure 82: Social Uses

The social uses map is shown in Figure 82. Commercial whale watching areas exist off the coast of northern New Jersey and southern Long Island (as well as southern NJ, not shown). The areas intersect with the westernmost tips of the Hudson South draft WEA and OCS-A 0512. Parks and protected areas do not exist within the OWSP study area. However, it is possible that vessels traveling to and from the lease areas and WEAs will be in the vicinity of the commercial whale watching and/or protected parks areas. Scuba areas exist within the Hudson South draft WEA, the Hudson North draft WEA, and OCS-A 0512. Scuba activities may be affected by the construction phase of offshore wind development, but they will likely be less affected by other phases. Visual impacts of an offshore wind facility will be project-specific and therefore these impacts are evaluated on a case-by-case basis during the state and federal permitting process.

3.4 Utility Resources

The utilities dataset includes submarine cables and various ocean uses. The submarine cables information source is NOAA Charted Submarine Cables. Pilot boarding areas and anchorage areas are sourced from the NOAA NMFS Office of Coastal Management. Information on wrecks is from the NOAA National Ocean Service (NOS).

3.4.1 Analysis

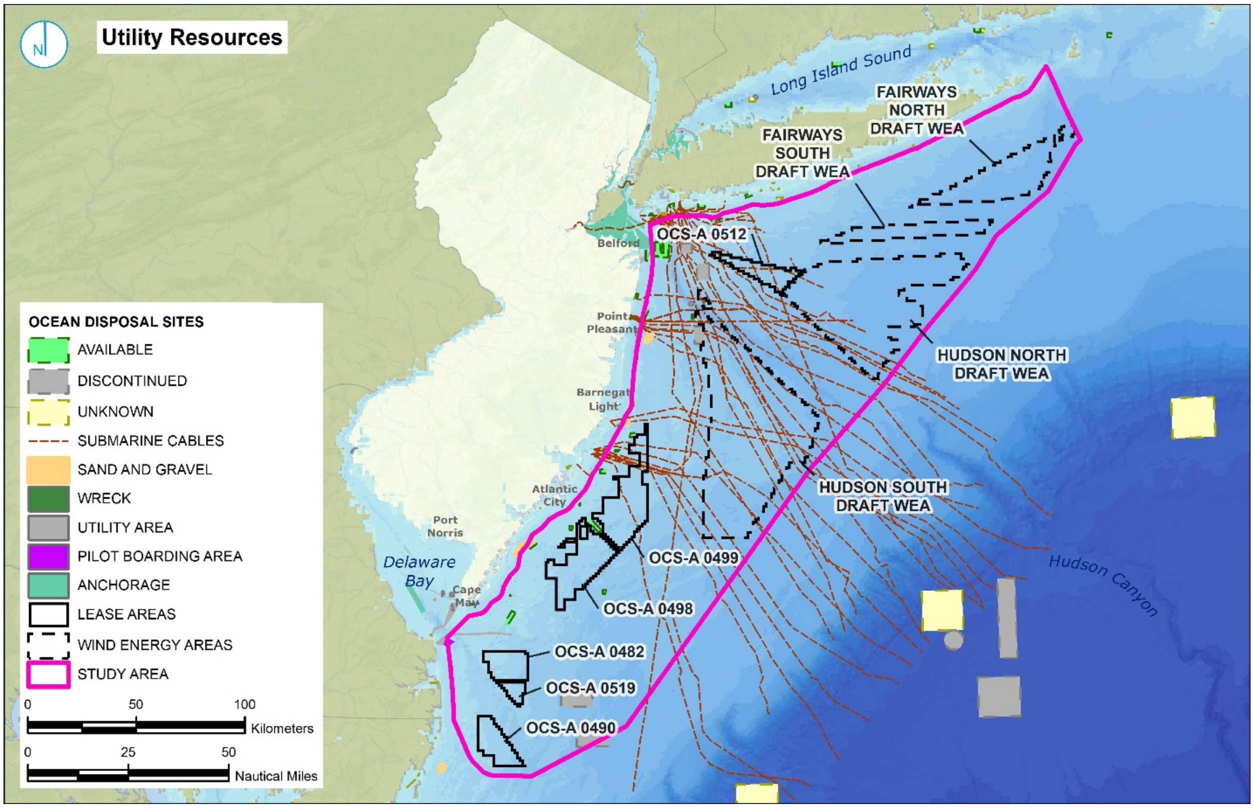

Figure 83: Utility Resources

Figure 83 shows the utility resources layers. Submarine cables are present throughout the Hudson South draft WEA and cross through OCS-A 0499 and the Hudson North draft WEA. The submarine cables will need to be considered when survey activities and turbine layouts in these areas are planned. Sand and gravel lease areas exist within the lease areas and WEAs but have de minimis spatial footprints. The wrecks are visible as small points on Figure 83 and are not expected to notably affect lease areas or WEAs, although these do not reflect all known wrecks in the study area. Utility areas exist off Cape May but are not significant within the study area. Anchorages exist off Staten Island and in the Delaware Bay, but they are not significant within the study area.

3.5 Restricted Use

The restricted use data include a danger zones and restricted areas layer, an unexploded ordnance layer, and military use restricted areas. The danger zones and restricted areas data and the unexploded ordnances data come from the United States Department of Defense. The military use restricted areas data come from the Naval Facilities Engineering Command Atlantic and Ecology and Environment, Inc. The military use areas include operating areas, which are defined by geographic coordinates. They have defined sea surface and subsurface training areas and associated special use airspace, and they include danger zones and restricted areas. Naval Undersea Warfare Centers are also represented in the military use restricted areas.

3.5.1 Analysis

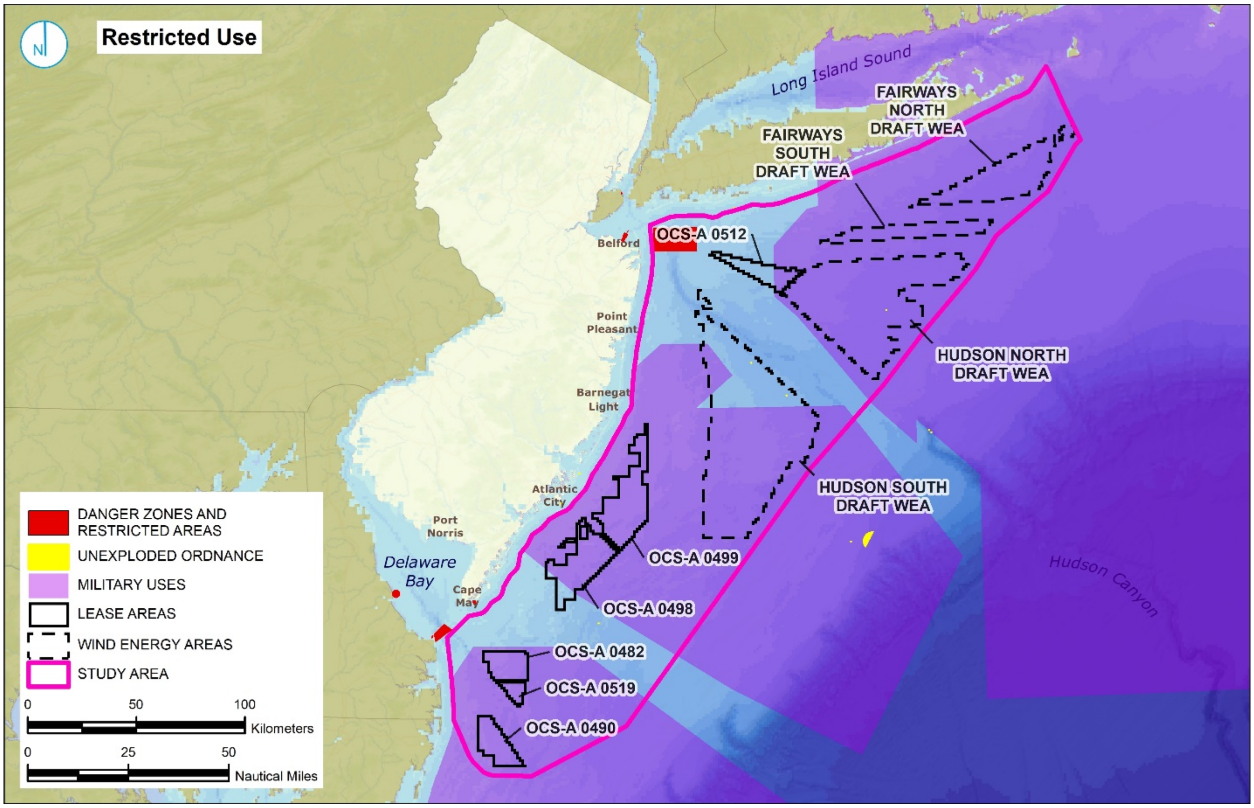

Figure 84: Restricted Use

The restricted use areas are shown on Figure 84. There are no danger zones within the lease areas or WEAs. A danger zone exists off the coast of northern New Jersey. Military use covers 86.9% of the WEAs and 74.0% of the OWSP study area. Individually, all the lease areas are 100% covered by military use zones, aside from OCS-A 0498 (83.8%), Hudson South draft WEA (72.2%), and OCS-A 0512 (36.3%).

3.6 Vessel Density

Automatic identification systems (AISs) are navigation devices that transmit and monitor the location and movement of many vessels in US and international waters, such as ships, commercial fishing vessels, and so-equipped recreational vessels. Vessel movement is tracked and processed to a 100 m x 100 m raster, with a count for each time a vessel passes through, stops, or starts. The 2019 all-vessel transit counts are used to give an overall understanding of the traffic and density of vessels at sea.

3.6.1 Analysis

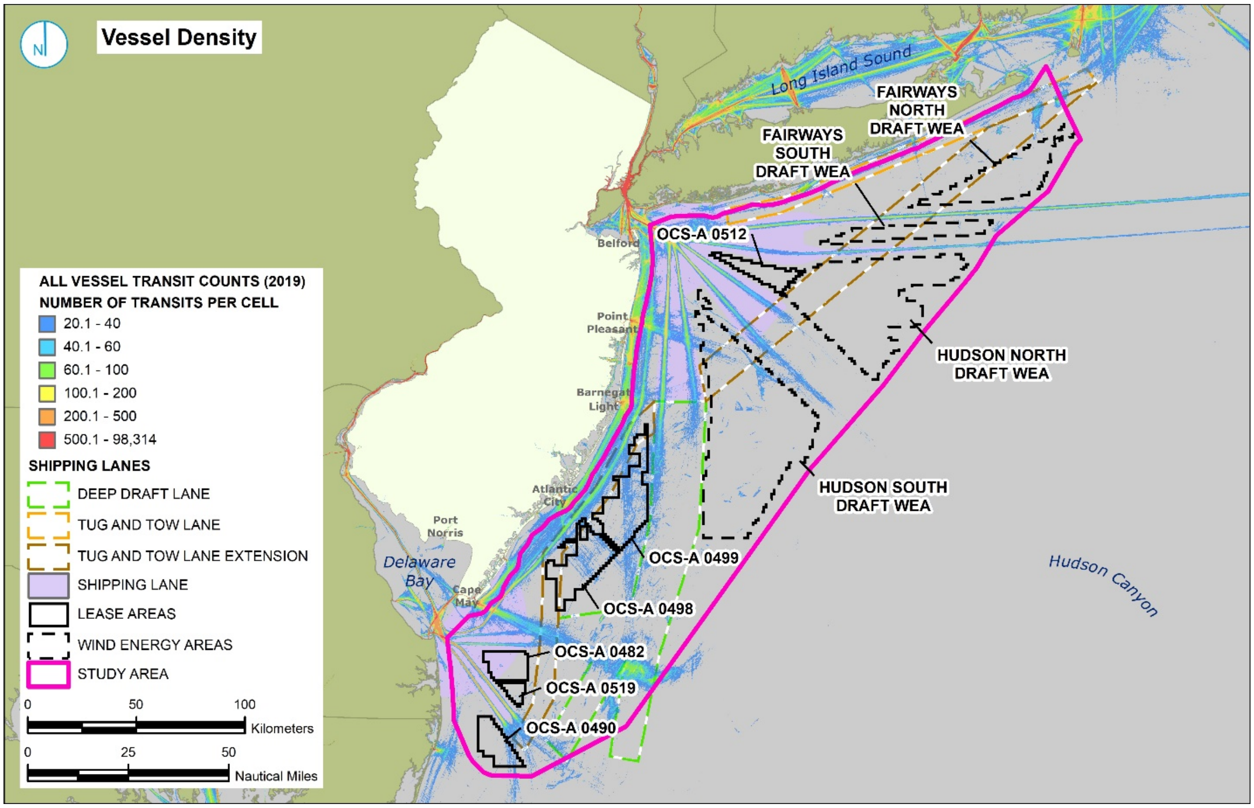

Figure 85: Vessel Density

The highest levels of vessel traffic are within shipping lanes and along the coast of New Jersey, as well as in Long Island Sound. The Hudson and Fairways draft WEAs were intentionally drawn to avoid highly utilized shipping lanes. Shipping lane areas intersect the northwestern portion of OCS-A 0482. Tug and tow extension lanes run through the Hudson and Fairways draft WEAs and through OCS-A 0498. There are moderate levels of vessel traffic within the Hudson North draft WEA and the Fairways North draft WEA, as well as within OCS-A 0499.

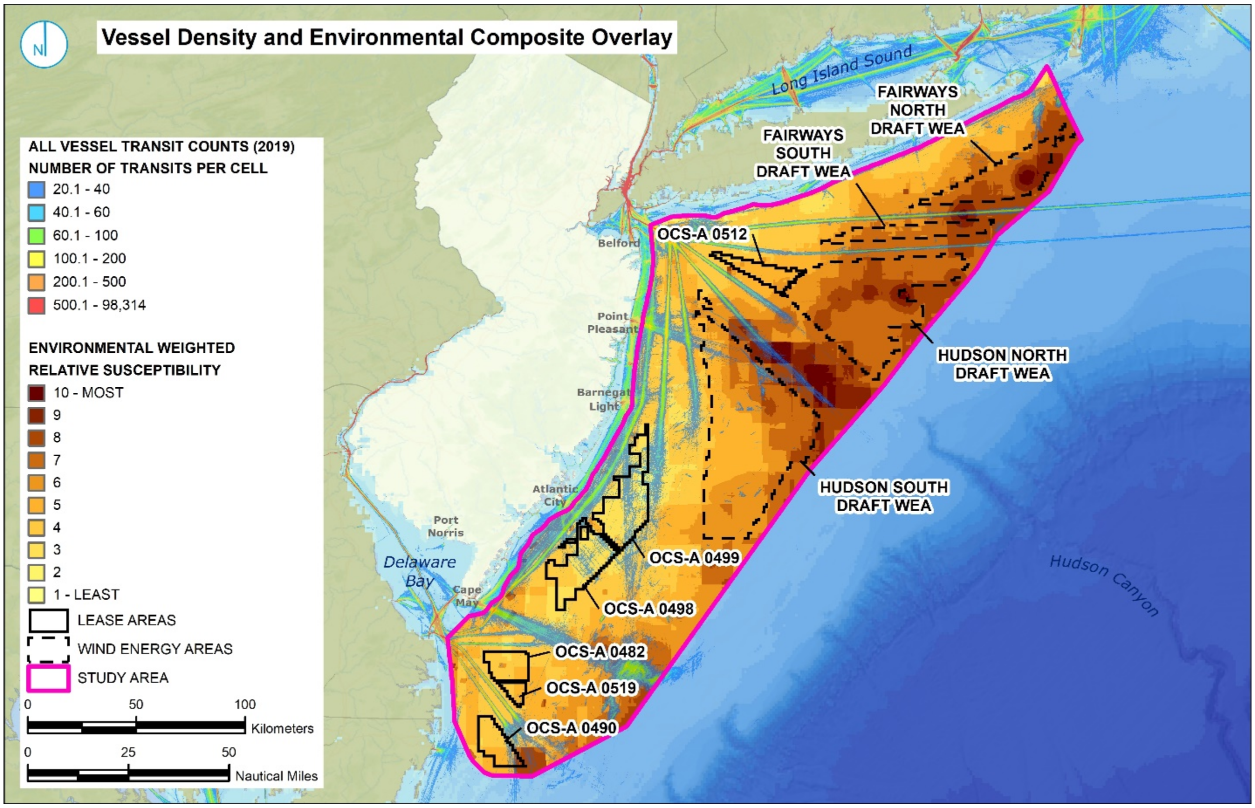

Figure 86: Vessel Density and Environmental Composite Overlay

Further examination of vessel traffic was conducted by overlaying transit areas with the overall environmental susceptibility figure produced in the WSA. This exercise facilitates identification of collocated environmentally susceptible areas and the presence of vessel traffic (Figure 85). In general, most traffic does not overlap with the areas of greatest environmental susceptibility. Areas of overlap of higher susceptibility and vessel traffic include the Hudson Canyon and the northeast part of the study area. Additional traffic may be expected with implementation of offshore wind projects off the New Jersey coast; however, there is a possibility for an increased diversity of vessel types utilizing major traffic schemes to avoid offshore wind activities or installations. Major contributions to vessel traffic from offshore wind projects will be during construction of the wind farms, which is typically over a 2-year period, and during operations, which span the 20 plus year lifespan of a project. Offshore wind vessels for construction would generally transit between a marshaling/manufacturing port and the lease area, which could include ports located along the Delaware River or in the New York Harbor area in New Jersey. For operations, vessels would generally transit between New Jersey operation ports such as Cape May, Atlantic City, or Point Pleasant. Increased vessel traffic associated with offshore wind projects will likely be concentrated between New Jersey ports and lease areas, where vessel traffic is already high, and within the lease areas. There is little overlap between areas of high environmental susceptibility and vessel traffic expected as a result of offshore wind projects.

4. RESULTS AND CONCLUSIONS

This environmental and natural resources technical appendix examined the relative susceptibility of biological resources in the WSA (Section 2) and the potential for conflicts with other ocean uses, including commercial and recreational fishing, in the URE (Section 3). The goals of the evaluation included identifying areas of higher and lower relative susceptibility to offshore wind in the study area inclusive of candidate development areas (leases and WEAs) and developing recommendations and/or best management practices based on the results, data gaps, and priorities for the state to achieve its goal of 7,500 MW of offshore wind energy by 2035. The study area was expanded relative to the NJDEP 2010 ecological baseline assessment (NJDEP 2010) to include six wind lease areas, four draft WEAs, and more than 12,500 square miles of New Jersey's coastal waters.

4.1 Weighted Susceptibility Analysis Results

The WSA was conducted to evaluate the relative susceptibility of biological resources and specific taxa to offshore wind development. Resources were separated into the following resource subgroups: birds, fish, sea turtles, cetaceans, habitat, and benthic invertebrates. Major findings for each of these resource groups and the overall environmental susceptibility are presented below.

The birds subgroup showed relatively low susceptibility due to very low relative abundance of bird species in offshore environs. Analysis of susceptibility in the context of the fish subgroup showed an increase in potential susceptibility in the northern portions of the study area. This trend aligns with those observed in the URE, which show heavier fishing activity for many fisheries in the northern portion of the study area. The cetaceans subgroup showed higher susceptibility within the Hudson Canyon and along the coast of southern New Jersey near Cape May, but largely outside of lease areas. Vessels traveling to and from the lease areas and WEAs may need to cross these zones of higher susceptibility, although review of vessel transit data relative to the overall environmental susceptibility results suggest low potential for conflict. The sea turtles subgroup showed relatively low susceptibility throughout the majority of the study area; however, an area of higher relative susceptibility was identified adjacent to lease area OCS-A 0490. This zone of higher relative susceptibility is primarily driven by the abundance of loggerhead sea turtle. The habitat subgroup showed relatively uniform low to moderate susceptibility throughout the study area, suggesting that the majority of the study area has a similar amount of designated EFHs. Artificial reefs are highly susceptible areas and should be avoided by offshore wind development. The benthic invertebrates subgroup showed higher susceptibility further offshore and further north within the study area, with low relative susceptibility identified for the southern lease areas.

Overall, the areas of highest environmental susceptibility are within the Hudson Canyon and the northern portion of the study areas, specifically WEAs of Hudson South, Hudson North, Fairways South and Fairways North, as well as OCS-A 0512. The primary drivers of elevated susceptibility in these areas include the subgroups of fish, cetaceans, and benthic invertebrates. The lowest areas of overall environmental susceptibility occur within and directly adjacent to lease areas OCS-A 0498 and OCS-A 0499.

Model sensitivity analysis shows that altering the susceptibility weightings has appropriate effects on the results and provides insight into model robustness, sources of uncertainty, and errata identification. No alteration of the assessment of biological resource susceptibility is suggested based on the results of the model sensitivity analysis. Data gaps for the WSA are important to consider when evaluating environmental susceptibility for offshore wind development. Readily available information suitable for use in the WSA was not identified for piping plover, red knot, pinnipeds, bats, hawksbill turtle, Kemp's ridley turtle, or shortnose sturgeon, species and taxa that are important to New Jersey and potentially affected by offshore wind development. Additionally, certain datasets did not have full coverage throughout the study area, affecting fish and benthic invertebrate subgroups (refer to Section 2.5 for a visualization of data coverage).

4.2 Unweighted Resource Evaluation Results

The URE depicted occurrence data for commercial and recreational fishing activity and other ocean uses, in order to inform the Environmental Protection and Commercial and Recreational Fisheries chapters of the OWSP. VMS and VTR data were used to evaluate certain commercial fisheries and largely showed higher densities of fishing activity within the northern portion of the study area and east of the study area boundaries, along the continental shelf break. This finding aligns with the fishing subgroups layer created by the WSA, which shows a greater abundance of fish species in those regions. From an economic standpoint, mean annual revenue from fishing is greatest in the northern draft WEAs and along the margins of the study area in the southern extent where important shellfisheries are located. The actual economic effect of offshore wind on commercial and recreational fishing is difficult to predict and depends on a number of factors (e.g., resource changes [described in Section 1.1.1] unrelated to offshore wind, resource changes associated with offshore wind, adaptability of fishing industries).

The recreational fishing data show that recreational fisheries exist in and near some lease areas. However, the majority of recreational fishing area coverage exists further offshore. Vessel traffic analysis confirms that the lease areas were drawn to avoid areas of high commercial vessel traffic, and vessels supporting offshore wind development are likely to follow similar paths. Where this is not the case (e.g., direct transit to a lease area), significant collocations with environmentally susceptible areas are not expected. There are small areas of social use within the draft WEAs, and coordination with industries affected (e.g., whale watching) may be necessary. Subsea cables run throughout the study area and lease areas and will require careful consideration during all phases of offshore wind development. The lease areas are within areas of potential military use, which will require ongoing coordination by projects.

4.3 Conclusion

The WSA and URE identified areas and resources with potential susceptibility to offshore wind and collocated ocean use, as well as data gaps that may be the focus of future study. These analyses also reveal the interconnectedness between resources, use priorities, and the potential for cumulative effects of offshore wind projects by multiple sponsors and by neighboring states. A spotlight is also placed on the seasonality of the ocean, its resources and their dynamic inter- and intra-year variability, a general awareness and understanding of which is important before, during, and after the construction of offshore wind farms.

It is necessary to assess the influences of this new industry and the dynamic ecology and environment on each other. In addition, other external factors must be considered over the multidecadal life span of individual offshore facilities, including other offshore industries and climate change. Existing ocean and atmospheric observation networks and data management resources, including regional expertise, are an important resource available to the research, policy, and decision-making communities, and continued, genuine engagement with all stakeholders is the key to success. These efforts benefit from and utilize the analysis conducted herein and will continue to inform the strategic direction of offshore wind development in New Jersey.

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APPENDIX C

Offshore Wind Supply Chain, Infrastructure, and Workforce Development for 7,500 MW for 2035

Commercial in confidence

Offshore Wind Supply Chain, Infrastructure and Workforce Development for 7,500 MW for 2035

An Analysis for the New Jersey Board of Public Utilities

June 2020

BVGassociates

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1. Introduction

Offshore wind is a global, rapidly maturing industry and seen by governments as a cost-effective technology for supplying low carbon energy close to demand centers. While the industry has grown most significantly in Europe, there is growing awareness in Northeastern US of the important impact that offshore wind can make to its energy generation portfolio.

On January 31, 2018, New Jersey Governor Phillip Murphy signed Executive Order No. 8 that sets forth several directives to promote and realize the development of wind energy off the coast of New Jersey and sets a goal of 3,500MW of offshore wind by 2030.

The New Jersey Board of Public Utilities (NJBPU) was given the responsibility to implement the Offshore Wind Economic Development Act's Offshore Renewable Energy Certificate program. A key part of this initiative was a desire to attract and grow a clean energy supply chain. NJBPU was charged with creating an Offshore Wind Strategic Plan to guide New Jersey to its desired offshore wind generation goals, focusing on costs of energy, job growth, supply-chain businesses, workforce development, data collection, and appropriate siting of facilities.

On November 19, 2019, New Jersey Governor Phillip Murphy signed Executive Order No. 92 raising New Jersey's offshore wind goal from 3,500 megawatts of offshore wind-generated electricity by 2030 to 7,500 megawatts by 2035.

This study was originally commissioned by the NJBPU in 2019 based on the 3.5 gigawatts (GW) of solicitations by 2030 and then extended to 7.5GW This report covers the analysis of 7.5 GW of offshore wind energy, through New Jersey solicitations, by 2035, as envisioned in 2019.

This report also addresses job growth, supply chain and workforce development. Its purpose is to establish the demand for products and services created by offshore wind developments in New Jersey and in other East Coast states to 2035. It further aims to establish how that demand could be met by companies which, or could be, based in New Jersey, considering the available coastal infrastructure in the state. If successful, New Jersey-based companies will create a significant number of jobs, as estimated in this study.

In the course of solicitating offshore wind projects for New Jersey, NJBPU must consider keeping the Levelized Cost of Energy low (a measure of the average net present cost of electricity generation over the facility's lifetime [LCOE]) and promoting local jobs and the development of a New Jersey offshore wind supply chain. The objective of this analysis is to inform the consideration of the tradeoff between low LCOE and local content to help balance between these two criteria.

The report is divided into two main sections:

- Demand for offshore wind products and services for 7.5GW by 2035, and
- Supply chain, jobs and workforce for 7.5GW by 2035.

2. Approach and Methodology

This study was predicated on the size of the New Jersey and other East Coast offshore wind (OSW) markets to 2035. These markets will create a demand for components, vessels and coastal infrastructure (for production; construction staging; and operations, maintenance and service [OMS]).

The extent New Jersey benefits economically will ultimately depend on:

- The degree to which the state prioritizes supply chain localization over cost to the ratepayer,
- The NJ and East Coast pipeline of OSW projects,
- The speed at which facilities are offered to the industry, and
- The availability of suitable coastal infrastructure.

A port infrastructure analysis was conducted by Ramboll that considered the available infrastructure in New Jersey and the preliminary cost of upgrades in each case.

The degree of establishing a local supply chain (localization) for a given scenario is dependent upon a range of factors therefore, this study encompassed a systematic assessment of the OSW supply chain. It described which activities are likely to take place in New Jersey for each scenario. In the economic impact analysis, we considered the job and value creation for each scenario to establish the number and types of jobs that are created in each scenario.

The quantitative analysis was undertaken in the following stages:

1. Demand analysis,
2. Port infrastructure analysis,
3. Supply chain analysis,
4. Economic impact analysis, and
5. Occupations analysis.

Demand analysis

The following steps were taken to complete the demand analysis:

1. Market projections,
2. Component demand analysis,
3. Vessel demand analysis, and
4. Construction staging port demand analysis

2.1. 7.5 GW by 2035 - Demand Analysis

Market Projections

Two potential supply chain-cost scenarios were developed, as approved by NJBPU, for the deployment of 7.5 GW capacity by 2035:

A. ‘Balanced’ Scenario - the trade-off between local content (i.e. materials, workers, etc., used to make a product locally versus imported) and cost is balanced with the potential supply chain, based on expert judgment, results of the first solicitation, and further engagement by NJBPU and New Jersey Economic Development Authority (NJEDA); and

B. ‘Lowest LCOE’ Scenario - where the LCOE reduction is maximized at the expense of local content.

The products and services supplied from New Jersey were defined for each of the six solicitations – see Table 1. All the solicitations are over 1.1 GW and the nearer to shore lease areas are assumed to be used first.

Table 2 presents the assumptions made about the site parameters and technology deployed. Using these, we modeled component and port demand (staging). The assumptions used are presented with the results of the analysis.

Table 1: New Jersey offshore wind solicitations now expected.

Solicitation	Capacity target MW	Issue date	Submittal date	Award date	Estimated commercial operation date	Nominal location assumed
1	1,100	Q3 2018	Q4 2018	Q2 2019	2024	A - Ocean Wind (OCS-A 0498)
2	1,200	Q3 2020	Q4 2020	Q2 2021	2027	A - BOEM near shore leases off the New Jersey coast (OCS-A 0498, OCS-A 0499, OCS-A 0482)
3	1,200	Q3 2022	Q4 2022	Q2 2023	2029	B - BOEM leases off the New Jersey coast (OCS-A 0512, OCS-A 0519, or OCS-A 0490).
4	1,200	Q2 2024	Q3 2024	Q1 2025	2031	B - BOEM leases off the New Jersey coast (OCS-A 0512, OCS-A 0519, or OCS-A 0490).
5	1,400	Q2 2026	Q3 2026	Q1 2027	2033	C - Future lease in Hudson South WEA
6	1,400	Q1 2028	Q3 2028	Q1 2029	2035	C - Future lease in Hudson South WEA

Table 2: Project assumptions by solicitation.

GW OSW	COD	Wind farm details	Definition of site	Transmission site	Marshaling (construction) port	Operations and maintenance port	Technology assumptions
1.1	2024	1100 MW site A	20 m water depth 9.3m/s AMWS at 120m	30 km cable length to landside grid interconnect	145 km distance to marshaling port (mean distance)	20 km distance to O&M port	12MW turbine; monopile foundation; 66kV array cables
1.2	2027	1200MW site A	20 m water depth 9.3m/s AMWS	30 km cable length to landside grid interconnect	145 km distance to marshaling port (mean distance)	20 km distance to O&M port	15MW 220 m diameter turbine; monopile foundation
1.2	2029	1200MW site B	30 m water depth 9.3m/s AMWS	55 km cable length to landside grid interconnect	190 km distance to marshaling port (mean distance)	45 km distance to O&M port (mean distance value)	16MW 220 m diameter turbine; monopile foundation;
1.2	2031	1200MW site B	30 m water depth 9.3m/s AMWS	55 km cable length to landside grid interconnect \	190 km distance to marshaling port (mean distance)	45 km distance to O&M port (mean distance value)	18MW 250 m diameter turbine; monopile foundation;
1.4	2033	1200MW site C	40 m water depth 9.6m/s AMWS	75 km cable length to landside grid interconnect	235 km distance to marshaling port	100 km distance to O&M port	20MW 250 m turbine; jacket foundation;
1.4	2035	1200MW site C	40 m water depth 9.6m/s AMWS	75 km cable length to landside grid interconnect	235 km distance to marshaling port	100 km distance to O&M port	20MW 250 m turbine; jacket foundation;

2.2. Port Infrastructure Analysis

New Jersey has numerous publicly and privately-owned port facilities or properties that are suitable for OSW port facility redevelopment. These include operating ports or brownfield sites such as former power plants. These facilities are well positioned to support the full lifecycle of OSW projects from manufacturing to staging, installation and OMS. However, most will require upgrades to realize the full potential of these sites, Large component manufacturing and staging, and installation ports will need higher levels of upgrades, while OMS sites will require significantly less investments.

An accompanying analysis, considered eight types of uses required for OSW production:

1. Blade production,
2. Generator production,
3. Nacelle assembly,
4. Tower production,
5. Foundation production (including transition pieces),
6. Submarine cable production,
7. Construction staging, and
8. OMS.

The following information related to OSW feasibility at each port were also analyzed:

- Water access,
- Waterfront site,
- Quay,
- On-site storage,
- Road access,
- Rail access, and
- Utilities.

2.3. Supply Chain Analysis

The supply chain analysis considered the following factors:

- Project management and development,
- Turbine nacelle and hub,
- Turbine blades,
- Turbine tower,
- Foundations,
- Subsea cables,
- Substation structure,
- Substation electrical,
- Subsea cable installation,
- Foundation installation,

- Turbine installation,
- Onshore works,
- Wind farm operations,
- Turbine maintenance, and
- Balance of plant maintenance.

A series of assessment criteria were considered to support an analysis of the likelihood with which New Jersey will capture the supply chain of each element, as follows:

- Dependency on coastal infrastructure,
- Availability of suitable NJ coastal infrastructure,
- Logistical benefit of local supply,
- Market threshold for investment,
- Interdependencies with other sectors, and
- Lower tier opportunities.

2.4. Economic Impact Analysis

The BVGA methodology's first input is the unit cost of each of the supply chain sub-elements. These forecasted costs recognize that earlier costs are likely to be higher because the U.S. industry is relatively inexperienced and that later costs will be lower as companies gain more experience and benefit more from innovations in the global industry. Before Jones Act compliant vessels are available to the industry, feeder vessels or suboptimal vessels will be used, and this will increase costs.

The next step was to estimate how much of the cost of each sub-element would be formed by the depreciated cost of these capital assets. The remaining expenditure is analogous to the direct and indirect gross value added (GVA) created. GVA is the aggregate of labor costs and operational profits. Therefore, it is possible to derive estimates of Full-Time Equivalent (FTE) employment from GVA, provided one understands some key variables. In the BVGA economic impact methodology, employment impacts are calculated using the following equation:

$FTE_a = (GVA - M)\ Y_a + W_{aa}$

where:

FTE_a = Annual FTE employment

GVA = Gross value added ($)

M = Total operating margin ($)

Y_a = Average annual wage ($)

W_a = Non-wage average annual cost of employment ($)

This report calculates employment as annual FTE employment using the above methodology but uses the terms "jobs" and "workers" to represent the forecasted annual FTEs.

To make robust assessments, each major component in the OSW supply chain was considered and typical salary levels, costs of employment, and profit margins were estimated, bringing together BVGA's specific sector knowledge and research into typical labor costs for the work undertaken in each supply chain sub-element.

The analysis considered all the jobs created in the supply chain, other than:

- Those from the construction of capital assets. The demand for workers from the construction of factories and vessels is difficult to assign to a specific year and new factory employment is highly dependent on the existing infrastructure. Jobs from the capital investments were excluded.

- Induced jobs, which are the result of personal expenditure of the labor force.

The resulting calculation represents both direct jobs, which are those of the wind farm owners and their primary contractors, and indirect jobs, which are those of suppliers and sub-suppliers to the owners and their primary contractors.

Salary levels and costs of employment in New Jersey were researched from public sources, such as the New Jersey State Department of Labor and Workforce Development. Future profit margins are highly uncertain and assumed comparable with those in the European supply chain. The job figures were validated against known employment levels in the European market.

2.5. Workforce Analysis

The study used the US Department of Labor's Standard Occupational Classification (SOC) as a framework for analyzing the workforce requirements for New Jersey OSW.

The SOC has 23 Major Groups and each of the jobs modeled in the economic impact analysis was assigned to one of these groups. Jobs were assigned in three stages:

- Direct job occupations (undertaken by workers in the principle suppliers in each of the categories in Section 2.2)
- Specialist indirect occupations (undertaken by workers in the companies supplying major components and services to the principle suppliers), and
- Generic indirect occupations (undertaken by workers in the companies supplying services to the principle suppliers that are common to most areas of the supply chain).

Direct and indirect occupations were analyzed using data held internally by BVGA based on 10 years of working in the OSW supply chain. For induced occupations, we assumed that workers expenditure patterns reflect the US economy as a whole. We therefore used Department of Labor statistics on total US employment. Some of these occupations are within the public sector because these are supported through taxation on income and personal expenditure.

2.6. Social and Economic Analysis of Two Promising Sites

The separate port infrastructure analysis identified two sites with particular interest for offshore wind development at Paulsboro and Lower Alloways Creek; located in Gloucester County and Salem County, respectively. We have compared selected social and economic characteristics of these Counties with those of New Jersey.

Conventional Economic Methodology

Conventional modeling of economic impacts for most industrial sectors relies on government statistics, for example those based on North American Industry Classification System (NAICS). These are produced at Federal level by the Department of Commerce Bureau of Economic Statistics and can be appropriate for traditional industries at a national level but are unsatisfactory for use with the OSW supply chain because the industry classifications do not map easily onto the OSW sector. The development of new codes for a maturing sector, such as OSW, takes time. This means that conventional economic analyses of OSW would need to map existing NAICS data onto OSW activities, which is a manual process and subject to error.

OSW is ideally suited to our more robust approach that considers current and future capability of local supply chains because:

- Projects tend be large and have distinct procurement processes from one another
- Projects tend to use comparable technologies and share supply chains

The BVGA model derives bespoke multipliers that convert expenditure into jobs, based on the specific features of different parts of the OSW supply chain. It is informed by BVGA's extensive experience in the US and European industry.

3. Demand Analysis for 7.5GW by 2035

3.1. Market

Our analysis based on the scenario shown in Figure 1. In addition to the 7.5GW installed as a result of the six NJ solicitations, 28GW is installed elsewhere along the US east coast.

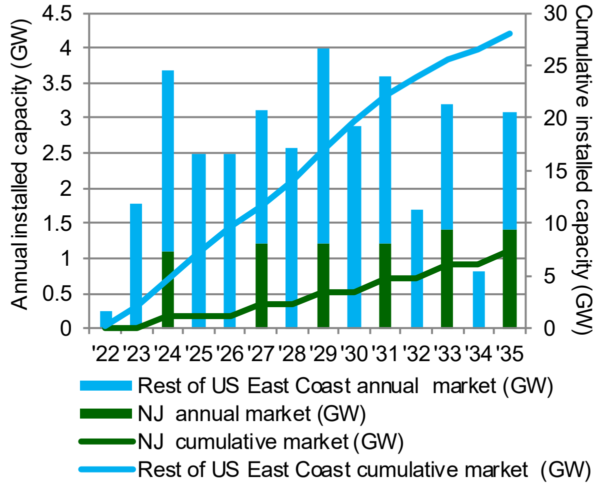

Figure 1: Market projection for NJ and the rest of the US East Coast.

3.2. Component Demand

The demand for number of turbines, foundations and length of array cables is primarily dependent on turbine rating. We assumed that in 2022, a typical turbine rating is 12 MW and this increases in steps to 20MW in 2032, as in Figure 2

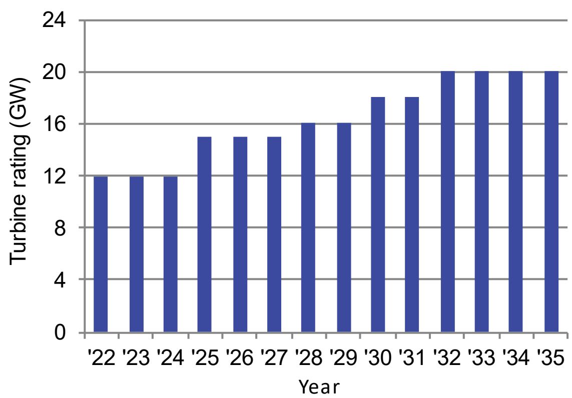

Figure 2: Projected turbine rating for US projects.

Turbines

Figure 3 shows annual demand for turbines.

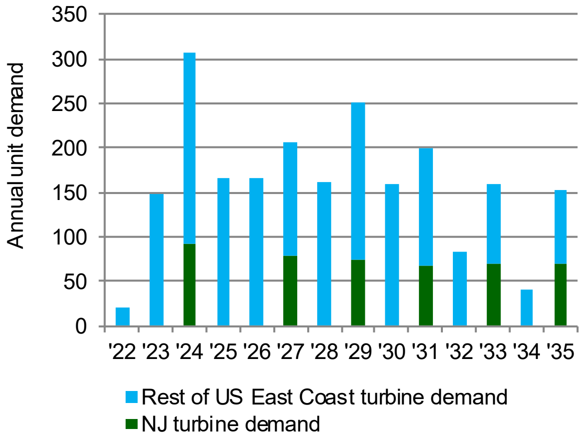

Figure 3: Annual turbine demand for NJ and the rest of the US East Coast.

The declining demand from 2031 partly reflects the peak installation that year and partly the fact that increasing turbine size reduces unit demand.

The minimum viable size for a turbine component factory is 500 MW per year, but ideally more than 1GW per year. There is therefore a potential demand for two factory 'equivalents' from 2023 and possibly three from 2026. The location of these factories is dependent on the scenario.

Foundations

Figure 4 shows the demand for foundations, which is offset one year before turbine demand. The analysis does not consider capacity installed after 2035. We expect demand to be sustained.

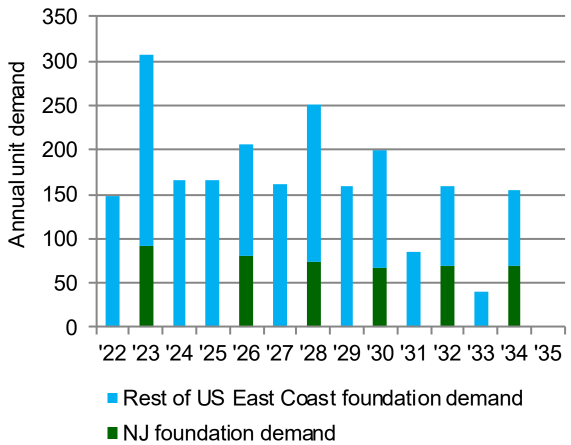

Figure 4: Annual foundation demand for NJ and the rest of the US East Coast.

The minimum viable size for a foundation production is 500 MW per year, but ideally more than 1 GW. There is therefore a potential demand for two factory 'equivalents' from 2023 and possibly three from 2026.

Subsea Cables

The demand for cables is shown in Figure 5. The forecast is based on an average turbine separation of nine rotor diameters. Up to 2030 rotor diameters were assumed to be 220m (and therefore turbines were assumed to be 1,980m apart) and 250m thereafter (and therefore turbines were assumed to be 2,250m apart). The increase in turbine size means fewer turbines per GW and lower demand for array cable that is not compensated for by the increased turbine separation.

An additional 20% was added to the cable demand to factor in the distance from the turbine tower base to the seabed and deviations from straight line cable routes.

For export cables, we assumed an average distance to shore of 55km. Projects less than 200MW were assumed to have one link, those greater than 200MW but less than 1GW were assumed to have two, and those greater than 1GW were assumed to have three. There are plans for evaluating an offshore backbone that would reduce demand but for the purposes of this analysis, we have assumed independent wind farm connections to shore.

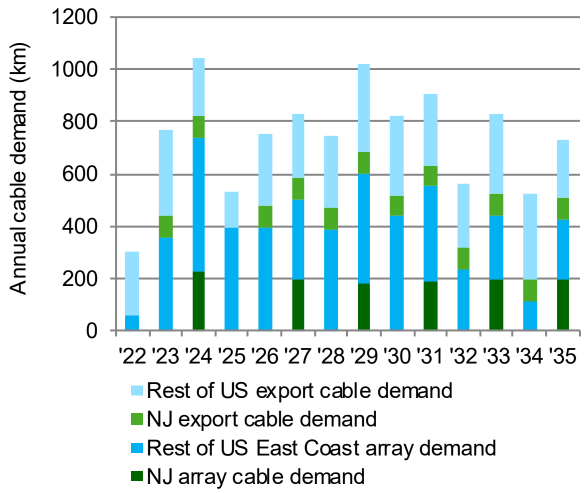

Figure 5: Annual array cable demand for NJ and the rest of the US East Coast.

The minimum viable size for cable production is 200 km per year. There is therefore a potential demand for one factory from 2022. There is no US factory capable of manufacturing array cables in this volume. The margins for array cable supply is lower than for export cables, making a new factory a less attractive investment. Array cables may be one of the last components to localize in the US. For export cables, annual demand is up to 500km. Nexans' factory in South Carolina will have capacity to produce subsea cables to meet some of this demand and they have announced plans to expand it.

Substations

The demand for substations is shown in Figure 6. We have assumed that all wind farms require at least one substation and that wind farms more than 1 GW require two.

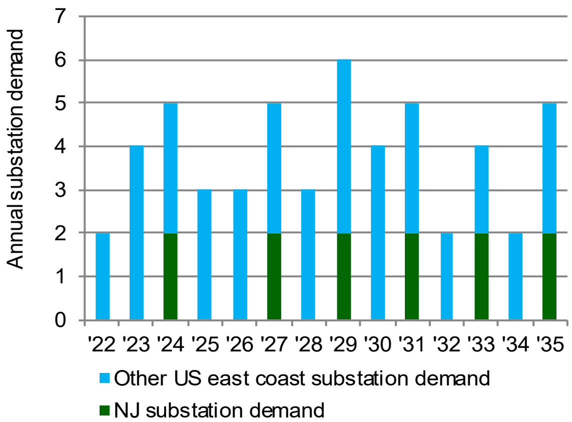

Figure 6: Annual substation demand for NJ and the rest of the US East Coast.

One substation is likely to occupy one yard for a year of manufacturing. There is a theoretical demand for four yards although production could be offset by a year so that three yards are likely to be sufficient.

3.3. Vessel Demand

The demand for vessels is complex and is intrinsically linked to the capability of the available vessels and the installation strategy being adopted.

We have assumed that as far as possible, wind farms will use the increasingly optimized installation strategies that have been developed in Europe.

In all our scenarios, we assumed there are no Jones Act compliant vessels available for the first solicitation. Feeder vessels are therefore used to supply components to globally sourced vessels for installation. For the second and third solicitations, Jones Act vessels are used and these load components in port and transport them to the wind farm site for installation.

Foundation Installation

Monopiles with transition pieces are generally installed sequentially by the same vessel. A monopile is likely to have a mass greater than 1,000t for the supply to the first solicitation and an installation vessel needs a crane with a maximum lifting capacity of 1,500t (higher than the monopile mass because the crane's capacity depends on the height of the lift and the horizontal distance from the hook to the base of the crane). As turbine capacity increases the monopiles for solicitation 4 may be greater than 1,500t and so need vessels with larger cranes. The monopile is generally hammered into the seabed, although drilling may be necessary at some locations. The transition piece is lifted and then grouted or bolted into position. A jack-up vessel is assumed for this analysis, with dimensions about 140m x 45m.

Jacket foundation generally starts with the installation of pin piles using a piling template. The jacket is lowered into position and grouted. Separate vessels may be used because pin piling may be done from a low-cost vessel and jackets take up a significant amount of deck space.

For the first New Jersey solicitation, there are no Jones Act-compliant installation vessels and feeder vessels are used. Although these enable higher rates of installation, costs are likely to be higher because of the need to mobilize at least one (and probably two) feeder vessels. Although feeder vessels can be cheaper than the main installation vessel because they do not need a crane, the vessels still need to perform in the same sea conditions as the main installation vessel so that it does not wait for components when it can be active.

Turbine Installation

Turbine installation is from a jack-up vessel and ideally achieved through five lifts:

- Tower
- Nacelle and hub, and
- Each of the three blades individually.

Many established east coast ports have air draft restrictions because they have been built upstream from the mouth of river estuaries and road bridges have been built downstream from the port. New London CT is an exception to this which will have contributed to Orsted's commitment to invest at that port. Sites like Lower Alloways Creek are attractive because they are free of air draft restrictions.

For projects in the early solicitations the vessel need not have a crane with capacity greater than 1,000 tons (t) but the nacelle masses for the 20MW envisaged for solicitations 5 and 6 may exceed this. The cranes will need to lift nacelles and blades at least 130m and 145m above the transition piece for 12 MW and 20 MW turbines, respectively. In Europe, there is increasing divergence in the turbine and foundation installation fleets. The first Jones Act compliant vessels will probably be used for both turbines and foundations because the market in the mid-2020s is unlikely to be large enough to support a specialist turbine or foundation installation vessel.

For the first solicitation, for which feeder vessels are used, the installation vessels will probably be jack-ups because the current acceleration limits of nacelles are likely to preclude lifts from a floating vessel.

Table 3: Assumptions for vessel demand analysis.

	Units Installed Per Vessel, Per Year			
	Scenario	Foundation	Turbine	Technology and strategy
Solicitation 1	1. Balanced	130	104	12MW, 220 m rotor, monopile, feeder
	2. Lowest LCOE	130	104	12MW, 220 m rotor, monopile, feeder
Solicitation 2	1. Balanced	104	81	15MW, 220 m rotor, monopile, transit
	2. Lowest LCOE	104	81	15MW, 220 m rotor, monopile, transit
Solicitation 3	1. Balanced	111	86	16MW, 220 m rotor, monopile, transit
	2. Lowest LCOE	111	86	16MW, 220 m rotor, monopile, transit
Solicitation 4	1. Balanced	106	84	18MW, 250 m rotor, monopile, transit
	2. Lowest LCOE	106	84	18MW, 250 m rotor, monopile, transit
Solicitation 5	1. Balanced	63	82	20MW, 250 m rotor, monopile, transit
	2. Lowest LCOE	63	82	20MW, 250 m rotor, monopile, transit
Solicitation 6	1. Balanced	63	82	20MW, 250 m rotor, jacket, transit
	2. Lowest LCOE	63	82	20MW, 250 m rotor, jacket, transit

Figure 7 shows foundation and turbine installation vessel demand. Four vessels will be needed from 2023.

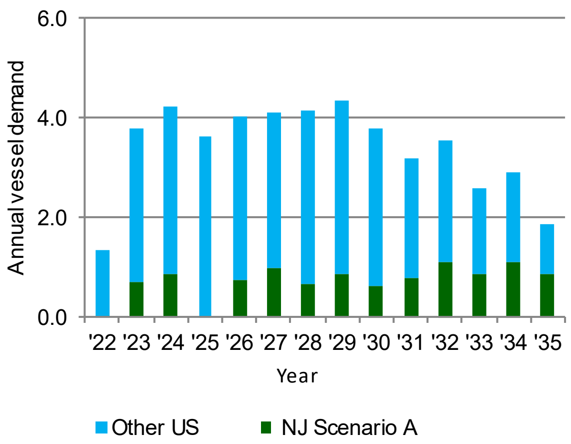

Figure 7: Foundation and turbine installation vessel demand for NJ and the rest of the US East Coast under scenario A

Cable Vessels

The cable installation strategy is highly dependent on the soil conditions. Contractors will also offer solutions based on the capabilities of their fleets and different strategies will be offered for the same wind farm. There are three main options:

- Simultaneous lay and burial using a cable plough
- Surface lay and post lay burial as separate activities, and
- Pre-cut trenching followed by lay and burial.

Contractors will offer different vessel combinations, the aim generally being to minimize the time needed for the main cable vessel. Trenching and burial can typically be undertaken by a lower cost vessel. For an array cable laying, in particular, a significant amount of time is taken up with the cable pull-in to the tower base and the termination and testing of the cable. Strategies will be developed with the aim to remove this as a limiting step by using separate vessels for the tasks.

Array and export cable laying are similar tasks but there are important differences that mean that separate vessels are often used:

- Export cable vessels ideally need to be able to work in shallow water to ensure that the pull-in to the shore is a relatively short section.
- Export cable has a significantly larger diameter (20cm compared with 14cm for a 66kV cable) and ideally is installed as a single length so the vessel needs to be wider with greater carrying capacity, and
- For array cable installation, a significant amount of time is spent positioning at each turbine location and the vessel needs excellent maneuvering capability.

The process can remain Jones Act compliant provided that the cable is not loaded from a US port.

A bottom-up analysis of vessel demand is problematic of the variation in methods and vessel strategies. Cable installation is typically focused on the summer months and one vessel is likely to be able to install array or export cables for two projects a year. Vessel demand can therefore be modeled by considering the number of active projects each year. Array cable installation is usually undertaken in the final year of construction before turbine installation. Export cable installation typically takes place the year before. Our forecast demand for vessels assumes that an installation vessel can undertake two installation campaigns (array or export cable) each year.

Figure 8 shows cable installation demand to 2035. It shows that up to four vessels will be needed. Since cable vessels need not come into port during installation, the Jones Act may not to have a significant impact on installation strategies, although the cost of mobilizing a European vessel for one project is likely to be significant. Sailing would be two weeks each way at a day rate of $100,000 would be a cost of $28 million.

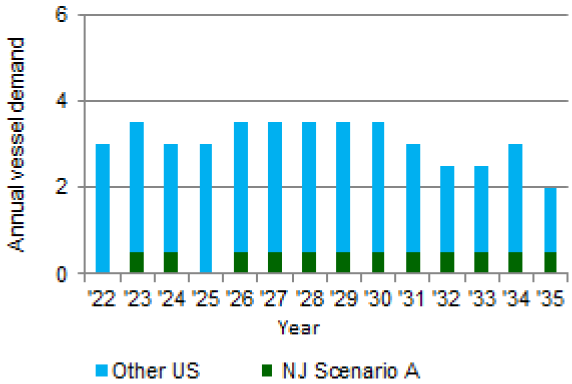

Figure 8: Cable installation vessel demand for NJ and the rest of the US East Coast.

Substation Installation Vessels

Substation platforms are typically floating out to site on a barge with a heavy lift vessel performing the lift. The foundation, usually a jacket, is likely to be installed in the same way as jacket turbine foundations, and the installation contract may include both turbine and foundation foundations.

The installation has no need for significant deck space and a wide range of vessels may be used, if they have a crane capacity of 2,000t or greater.

A wind farm is likely to charter a vessel for up to two months for a single substation to allow enough time for vessel mobilization and inclement weather delays. Depending on the capability of available vessels and the competing demand from other markets, no more than two vessels will be needed.

3.4. Port Demand

Figure 9 shows the projected construction staging port demand for both scenarios. We have assumed that there is a theoretical demand for a staging port for each New Jersey project. A staging port is used for two years for each project, regardless of size, with foundations and array cables installed in the first year, with turbines in the second year.

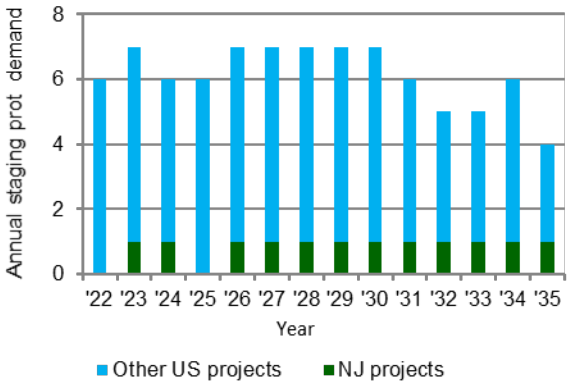

Figure 9: Annual staging port demand.

4. Port Infrastructure Evaluation

Ramboll conducted an evaluation of New Jersey port infrastructure that is provided in a separate report. Ports were evaluated for readiness to support the following seven OSW activities:

- Construction staging/Marshalling,
- OMS,
- Cables,
- Foundations,
- Tower sections,
- Blades,
- Nacelles, and
- Substations.

In early 2019, 38 different ports were assessed for suitability. Eighteen (18) ports were then excluded due to being unsuitable or unlikely to be repurposed. From the remaining 20 ports, 13 were selected for a detailed evaluation, but five of them were only suitable for OMS activities and therefore, have not been included in this report. An updated assessment was completed in early 2020 based on current information for each of the remaining 8 ports.

Complete results of the analysis are provided in the New Jersey Ports & Harbors Evaluation Report prepared by Ramboll. The report identifies several viable ports for each of the seven OSW activities evaluated, although investment of greater than $100 million dollars would be required to support offshore wind uses.

5. Social and Economic Analysis of Two Promising Sites

The separate port infrastructure analysis identified two sites with particular interest for offshore wind development at Paulsboro and Lower Alloways Creek. These are in Gloucester County and Salem County, respectively, and they boarder one another. We have compared selected social and economic characteristics of these Counties with those of New Jersey shown in Table 4. The columns entitled: “Compared to NJ average” show how the percentage in the county compares to the New Jersey average. Where this number is over 100%; the county has a greater proportion of people in that category than the New Jersey as a whole.

Although similar in geographical area Salem County has a population of 44,254 which is less than a quarter of the population of Gloucester County. Lower Alloways Creek is less than 30 miles from other counties including Gloucester so may attract a workforce from beyond the county.

While the percentage of those who are high school graduate or higher is greater than New Jersey as a whole, those with bachelor's degree or higher are lower at 82% and 54% of New Jersey average for Gloucester County and Salem County, respectively.

Both countries have more civilian veterans than New Jersey’s average with 140% and 160% for Gloucester County and Salem County, respectively.

Gloucester County has a slightly higher proportion of people involved in natural resources, construction and maintenance occupations, production, transportation, and material moving occupations than the New Jersey average while Salem County has significantly more (over 150%).

Table 4: Social and Economic characteristics of New Jersey, Gloucester County NJ, and Salem County NJ.

Subject	New Jersey		Gloucester County, NJ			Salem County, NJ		
	Estimate (People)	Percent	Estimate (People)	Percent	Compared to NJ average (Percent)	Estimate (people)	Percent	Compared to NJ average (Percent)
EDUCATIONAL ATTAINMENT								
Population 25 years and over	6,129,542		199,632			44,254		
Less than 9th grade		4.9%	4,538	2.3%	47%	2,038	4.6%	94%
9th to 12th grade, no diploma		5.5%	9,723	4.9%	89%	3,426	7.7%	140%
High school graduate (includes equivalency)		27.5%	65,856	33.0%	120%	16,680	37.7%	137%
Some college, no degree		16.6%	37,836	19.0%	114%	8,383	18.9%	114%
Associate's degree		6.5%	18,046	9.0%	138%	4,456	10.1%	155%
Bachelor's degree		23.8%	41,935	21.0%	88%	6,318	14.3%	60%
Graduate or professional degree		15.1%	21,698	10.9%	72%	2,953	6.7%	44%
Percent high school graduate or higher		89.5%	185,371	92.9%	103.8%	38,790	87.7%	98.0%
Percent bachelor's degree or higher		38.9%	63,633	31.9%	82%	9,271	20.9%	54%
VETERAN STATUS								
Civilian population 18 years and over	6,900,026		225,641	0.0%	3.3%	49,518		0.7%
Civilian veterans	331,201	4.8%	15,013	6.7%	140%	3,813	7.7%	160%
EMPLOYMENT STATUS								

Subject	New Jersey		Gloucester County, NJ			Salem County, NJ		
Civilian labor force	4,675,686		157,619		3.4%	31,676		0.7%
Unemployment Rate	285,217	6.1%	9,930	6.3%	103%	2,312	7.3%	120%
OCCUPATION								
Civilian employed population 16 years and over	4,390,602		147,707		3.4%	29,352		0.7%
Management, business, science, and arts occupations	1,860,424	42.4%	63,088	42.7%	101%	9,758	33.2%	78%
Service occupations	714,830	16.3%	21,710	14.7%	90%	4,611	15.7%	96%
Sales and office occupations	999,943	22.8%	33,666	22.8%	100%	6,294	21.4%	94%
Natural resources, construction, and maintenance occupations	313,388	7.1%	12,664	8.6%	121%	3,516	12.0%	169%
Production, transportation, and material moving occupations	502,017	11.4%	16,579	11.2%	98%	5,173	17.6%	154%
INDUSTRY								
Civilian employed population 16 years and over	4,390,602		147,707		3.4%	29,352		0.7%
Agriculture, forestry, fishing and hunting, and mining	14,060	0.3%	1,010	0.7%	233%	688	2.3%	767%
Construction	254,856	5.8%	9,779	6.6%	114%	2,327	7.9%	136%
Manufacturing	359,849	8.2%	11,257	7.6%	93%	3,318	11.3%	138%
Wholesale trade	149,359	3.4%	5,839	4.0%	118%	1,237	4.2%	124%
Retail trade	483,359	11.0%	16,857	11.4%	104%	2,975	10.1%	92%
Transportation and warehousing, and utilities	264,780	6.0%	8,340	5.6%	93%	3,060	10.4%	173%

Subject	New Jersey		Gloucester County, NJ			Salem County, NJ		
Information	122,369	2.8%	3,028	2.1%	75%	337	1.1%	39%
Finance and insurance, and real estate and rental and leasing	371,275	8.5%	10,132	6.9%	81%	1,368	4.7%	55%
Professional, scientific, and management, and administrative and waste management services	585,869	13.3%	16,480	11.2%	84%	2,054	7.0%	53%
Educational services, and health care and social assistance	1,045,599	23.8%	41,226	27.9%	117%	7,451	25.4%	107%
Arts, entertainment, and recreation, and accommodation and food services	360,170	8.2%	10,959	7.4%	90%	1,709	5.8%	71%
Other services, except public administration	194,399	4.4%	5,887	4.0%	91%	1,460	5.0%	114%
Public administration	184,658	4.2%	6,913	4.7%	112%	1,368	4.7%	112%

6. Supply Chain and Workforce Analysis

The different elements of the supply chain are analyzed in this section. A description of what makes up the supply chain, occupations involved, and seven aspects that effect the degree of supply localization in New Jersey are included for each element. These elements are rated - from 1 to 3 - with 3 signifying favorable conditions for localization, as listed below and shown in Figure 10:

1. Dependency on coastal infrastructure (1),
2. Availability of suitable NJ coastal infrastructure (3),
3. Logistical benefit of local supply (2),
4. Market threshold for investment (3),
5. Interdependencies with other sectors (2),
6. Lower tier opportunities (2), and
7. Relevant New Jersey supply chain (1).

We summarize the localization assessment by plotting the scores in a spider diagram as shown in Figure 10. The further out the bold line goes the better the likelihood of localization in New Jersey (3 = more favorable).

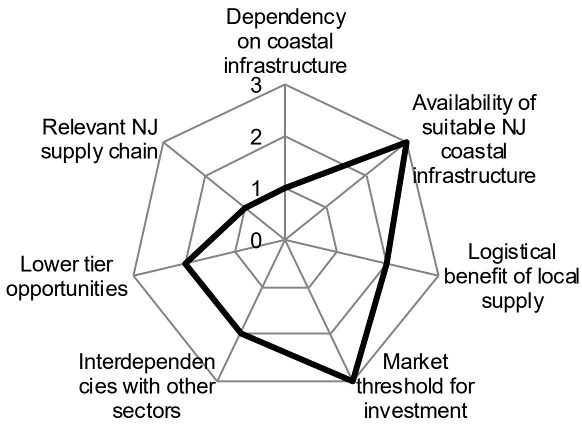

Figure 10: Example of localization results presented in a spider diagram.

6.1. Project Management and Development

Supply Chain

Development and project management makes up 3% of lifetime expenditure of a project.

Opportunities exist for companies working in the project management and development supply chain, but the lifetime spend is relatively small.

No two OSW farms are the same and specialists are therefore needed across all stages of the development process. Developers often subcontract project management and coordination of specialist tasks and services throughout the process.

During site selection, contractors carry out site investigations including geotechnical and geophysical studies to identify suitable locations for the wind farm and cable routes. These investigations identify seabed topography and locate unexploded ordnance.

Further geophysical surveys are often completed post-consent and pre-construction to determine turbines locations, foundation design and cable routes.

Environmental studies such as wildlife impact assessments make up the smallest proportion of this supply chain element and are often combined with the geophysical surveys. Initial surveys are completed during development but there are also post-construction monitoring activities. Vessels for wildlife surveys do not have a demanding specification and are often shared with other sectors.

In general, the following support services would normally be required: surveys, legal, planning, management of consent applications, financial due diligence, stakeholder engagement, and geological and economic assessments.

Workforce

The workforce for project management and development is the most diverse area of the supply chain. Within the developer team, there will be specialists in project management, procurement, consenting, engineering and finance. Occupations in the supply chain will include geologists, engineers, biologists, meteorologists and environmental scientists.

Project-specific training in this workforce is unlikely. Developers will recruit those with the necessary skills. For many suppliers, their workforce skills are what differentiate them from the competition and, therefore. may make long-term investments in increasing skills. Suppliers are reluctant to invest at new locations where a new workforce would need to be recruited therefore, existing skillsets are important.

Figure 11 shows that there is a wide range of occupations with a high proportion in general management positions and in desk-based engineering occupations. There is also a large proportion of ‘other’ occupations, reflecting the diverse range of activities that take place at this stage, including geotechnical engineers, bird experts and public relations professionals.

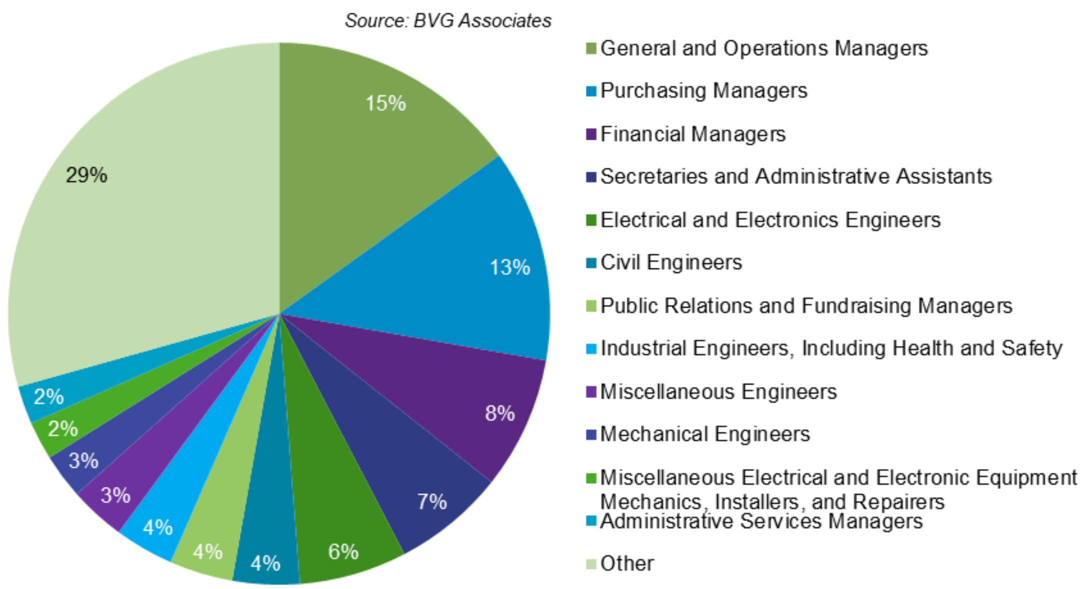

Figure 11: Occupations in project development and management.

Localization

For New Jersey wind farms, the developer is likely to set up a local project execution office, but it is likely to have a centralized engineering and procurement function. New Jersey could be an attractive location for such a central function, although for the first solicitation turbine procurement is likely to be run from Europe.

Much of the work to secure the necessary permits is likely to be done locally for all scenarios. Offshore site investigations into wind resource, environmental impacts, and metocean and seabed conditions are highly specialized activities and it is likely that the work is done by a small number of contractors for East Coast projects. Expertise from the offshore oil and gas industry is highly relevant and most relevant companies are likely to be based in the Gulf of Mexico.

Dependency on Coastal Infrastructure

There is only a limited need for coastal infrastructure. Offshore survey work requires ports to mobilize and support vessels for short periods.

Availability of Suitable NJ Coastal Infrastructure

The port requirements are low, and New Jersey has numerous locations, if needed.

Logistical Benefit of Local Supply

There is value for the developer to have a local office to give access to local stakeholders and to project manage construction. Engineering and major package procurement work can be done more remotely. There is some local benefit for New Jersey companies supplying services, particularly those for onshore aspects of the development.

Market Threshold for Investment

The main investment for companies supplying services is workforce and they can grow incrementally to meet demand.

Interdependencies with Other Sectors

Although most companies providing services will work in other sectors, companies are structured around the needs of customers and there are few interdependencies.

Lower Tier Opportunities

Most contracts awarded are small and numerous. Suppliers are often desk-based with a limited supply chain.

Relevant New Jersey Supply Chain

There are a significant number of relevant New Jersey companies. While OSW will be significant for some of these companies, the overall value of the contracts will be low, in the context of wind farms.

Figure 12 summaries the results of the above assessment factors.

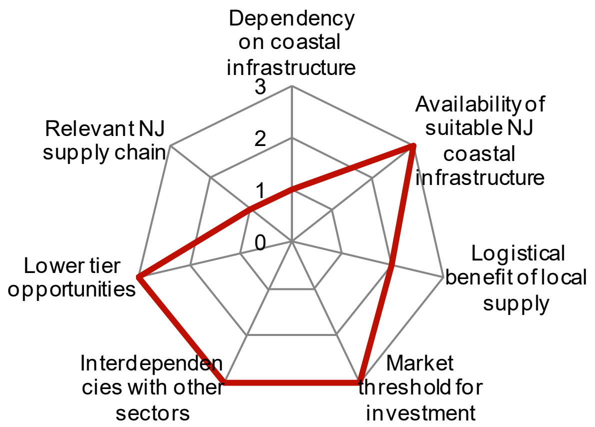

Figure 12: Assessment of project development and management.

Table 5 shows the scenarios developed as a result for 7.5 GW by 2035.

Table 5: Localization of supply chain for project management and development for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	New Jersey project office Project Procurement in New Jersey. Strategic sourcing and engineering function outside New Jersey Most specialist surveys and site investigations, such as soil analysis, wildlife surveys and wind resource assessment, undertaken by US companies outside New Jersey but with some subcontracts to New Jersey companies	New Jersey project office Project Procurement in New Jersey. Strategic sourcing and engineering function outside New Jersey Most specialist surveys and site investigations undertaken by companies outside New Jersey but with an increasing number of subcontracts to New Jersey companies	New Jersey project office Project Procurement and certain engineering functions in New Jersey. Specialist surveys and site investigations undertaken by companies outside New Jersey but with most subcontracts to New Jersey companies	As solicitation 3
B: Lowest LCOE	New Jersey project office Project Procurement in New Jersey. Strategic sourcing and engineering function outside New Jersey Most specialist surveys and site investigations, such as soil analysis, wildlife surveys and wind resource assessment, undertaken by US companies outside New Jersey but with some subcontracts to New Jersey companies	New Jersey project office Project Procurement in New Jersey. Strategic sourcing and engineering function outside New Jersey Most specialist surveys and site investigations undertaken by companies outside New Jersey but with an increasing number of subcontracts to New Jersey companies	New Jersey project office Project Procurement and certain engineering functions in New Jersey. Specialist surveys and site investigations undertaken by companies outside New Jersey but with most subcontracts to New Jersey companies	As solicitation 3

Figure 13 shows the jobs that will be created in New Jersey both as a result of its six solicitations and in supplying services to other wind farms. The jobs peak in 2029, at a time when project management and development will be underway for all wind farms built as a result of the six solicitations. The numbers drop significantly after the development work for solicitation 6 finishes. Development work would continue if there are further solicitations beyond 2035 so this drop is not really expected.

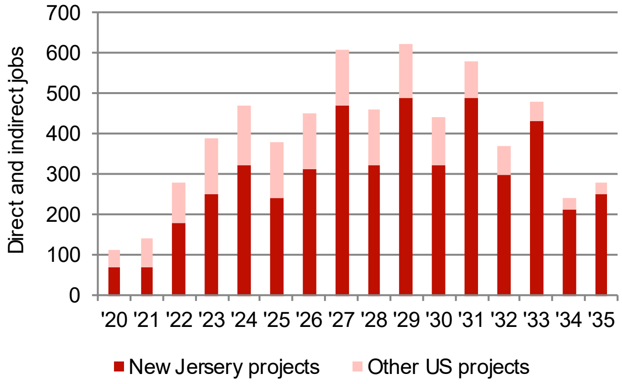

Figure 13: Direct and indirect jobs created in New Jersey for all scenarios for 7.5 GW by 2035.

Workforce Development

Project development can begin up to a decade before construction. There will already be a demand for some occupations as developers respond to known Solicitations. The successful bidders will create a demand for data acquisition and analysis occupations at an early stage.

Most of the jobs in project management and development are professional or highly technical positions, in many cases educated to postgraduate level. There is therefore a long training lead time and developers and their suppliers will recruit widely to fill positions. To maximize the participation of New Jersey workers, New Jersey universities should be encouraged to build links with the OSW industry to ensure that postgraduate provision is focused on the needs of the industry.

6.2. Turbines

Supply chain

Turbine supply makes up about 17% of the lifetime spend of an OSW farm and about 40% of the CAPEX. It is the single biggest contract placed by the developer.

The role of a wind turbine supplier is mainly one of a systems integrator, using components that are mainly externally sourced. Even where it manufactures components in-house, it will often have a second source of supply.

Turbine supply includes electrical and mechanical components and systems that make up a wind turbine nacelle, rotor and tower.

The nacelle components include the bedplate, drivetrain, power take-off, control system, yaw system, yaw bearing, auxiliary systems, frame and cover, and fasteners and conditioning monitoring system.

The rotor components include the blades, hub casting, blade bearings, blade pitch system, spinner (hub cover), auxiliary systems, and fabricated steel components and fasteners.

The tower components include steel plate, personnel access and survival equipment, electrical system including switchgear, and tower internal lighting and fasteners.

Workforce

Nacelle, Hub and Assembly

Figure 14 shows that a large proportion of the jobs are in factory assembly but also with a significant number involved in the manufacture of metal structures.

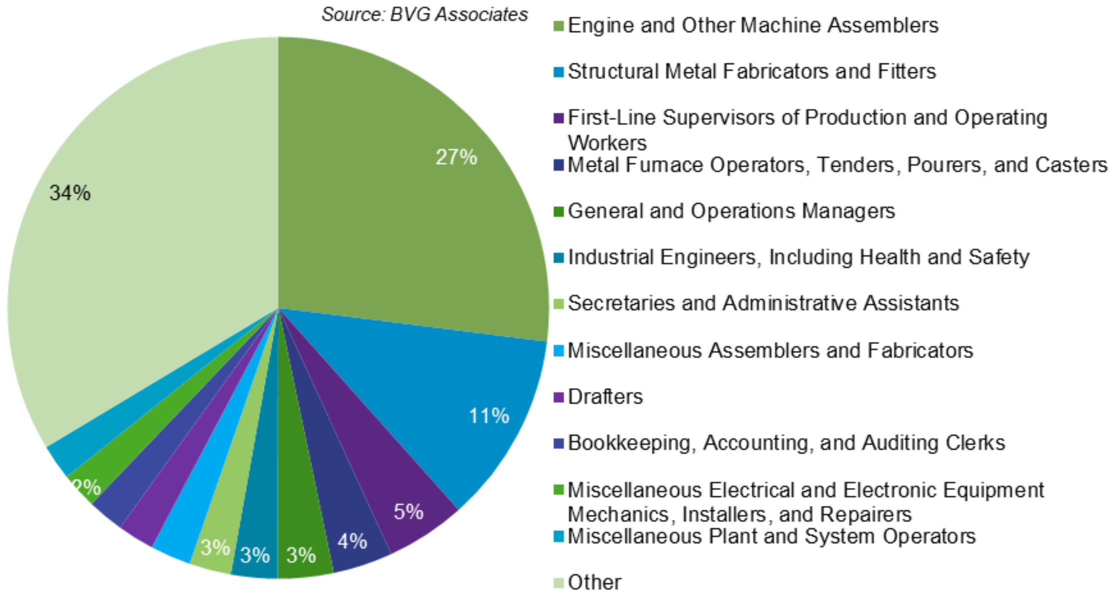

Figure 14: Occupations in nacelle, hub and assembly.

Blades

Figure 15 shows that a significant proportion are involved in factory floor manufacturing roles (miscellaneous assemblers and fabricators) reflecting the fact that blade manufacture is still largely a manual process.

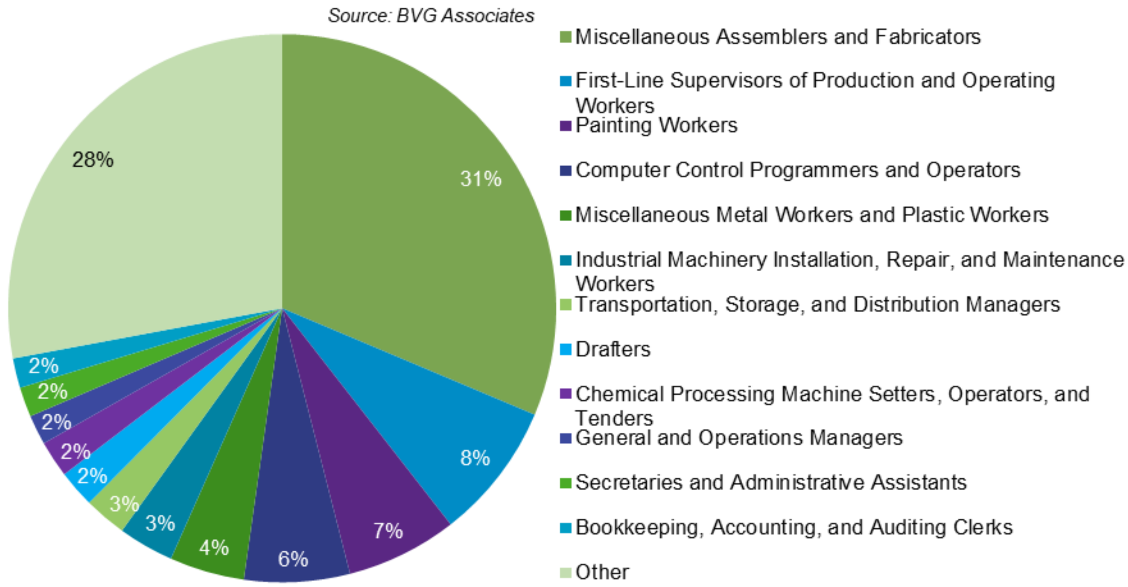

Figure 15: Occupations in blade manufacture.

Tower

Figure 16 shows that a high proportion of the jobs are in steel production and steel fabrication. Tower manufacture typically uses automated processes and the supply of steel plate is a major part of the cost.

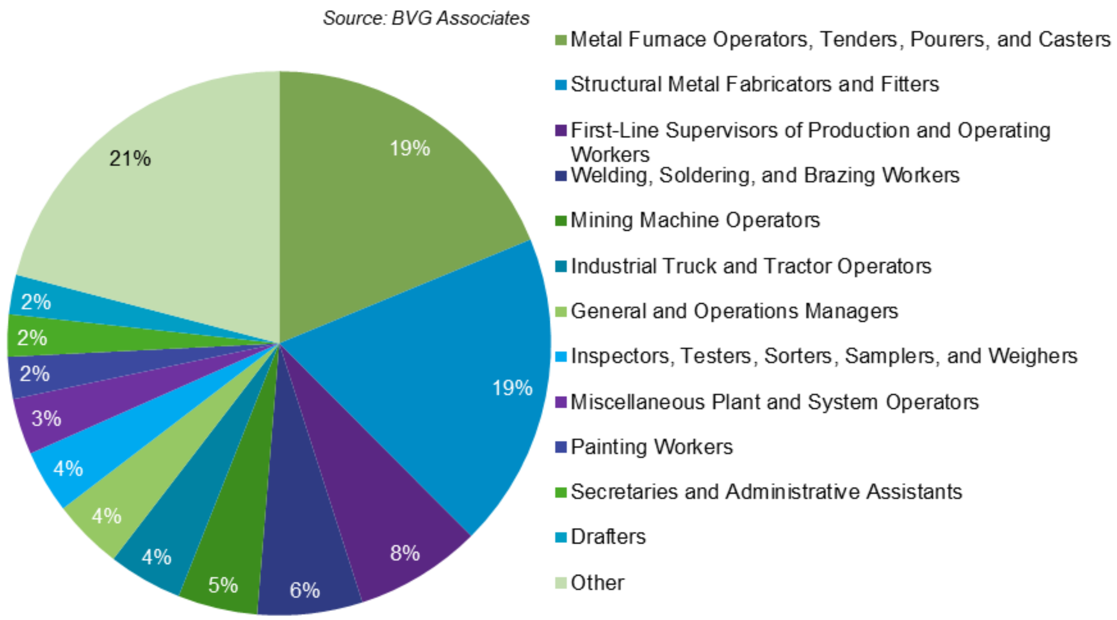

Figure 16: Occupations in tower manufacture.

Localization

To establish which parts of the turbine supply chain could be built or fabricated in New Jersey, the first stage is to establish what needs to be produced at a coastal location because components are too large to be moved by road or rail with frequency and do not serve other industrial sectors, which include the following:

- Assembled nacelles and hubs,
- Assembled generator (for direct drive turbines in particular), and
- Blades and towers.

The first US investment is likely to be a tower or blade factory. These have relatively simple supply chains and do not need to come together before the construction staging port.

Nacelles and Hubs

Nacelles, hubs and generators are likely to be assembled in adjacent facilities. Nacelles and hubs have complex supply chains. Turbine suppliers make long-term commitments to their supply chains because many of their components are critical to the turbine's reliability and in some cases an integral part of the turbine's design. The choice of turbine and hub assembly location will need to consider the logistical costs and risks associated with transporting components. The critical components for current turbine models are manufactured mainly in Europe. A decision to localize in the US is therefore likely to be part of a process in which key members of the turbine supply chain are encouraged to extend production to the US.

The supply chain scenarios for this study have been split into nacelles and hubs, blades and towers, as listed below.

Dependency on Coastal Infrastructure

A nacelles and hub assembly facility needs to be close to a quayside because these components are too large to be moved by road or rail in the numbers required by a project.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment over $100 million.

Logistical Benefit of Local Supply

An investor will look for a site from which it can supply the regional market. Such sites will normally include space for associated storage to avoid the cost of needing to transport and store elsewhere. If the factory can supply direct to the wind farm site then this reduces the need for a marshaling port, saving cost.

Market Threshold for Investment

A nacelle and hub assembly facility is a major investment. A leading manufacturer would typically wish to see an annual regional market of 2GW. In the market projection used in this study over 2 GW is installed annually from 2023 to 2035. A wind turbine supplier would need to be confident of capturing a large proportion of the market to invest in an east coast facility.

Interdependencies with Other Sectors

A nacelle and hub factory would be dedicated to OSW. Many component suppliers also serve other sectors and will make investment decisions based on demand for all these sectors.

Lower Tier Opportunities

A nacelle and hub factory creates significant long-term opportunities for local suppliers.

Relevant New Jersey Supply Chain

New Jersey has suppliers that could provide low value products. Larger components would need to be supplied by new investors.

Figure 17 summarizes our assessment.

Source: BVG Associates

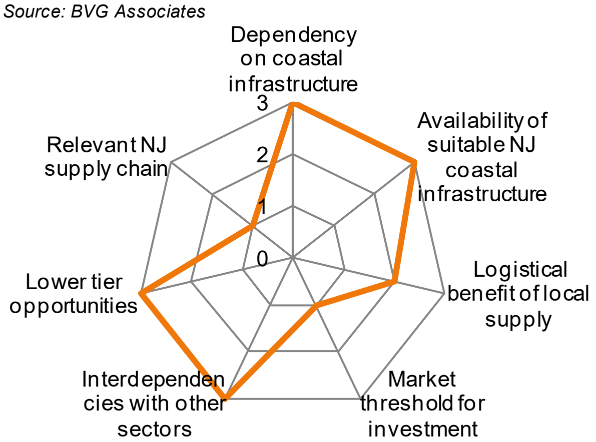

Figure 17: Assessment of turbine nacelles and hubs.

Table 6 shows the scenarios developed. In the Balanced Scenario, there is a New Jersey facility for the third solicitation, recognizing that the regional market is too small before this time for the emerging market leader to be confident of sufficient demand to make the investment. There is no supply from New Jersey for the nacelle and hub in the Lowest LCOE scenario.

Figure 18 shows that jobs peak in 2030 when the factory is supplying wind farms both inside and outside New Jersey. It shows the importance of a long-term pipeline to sustain the viability of the facility.

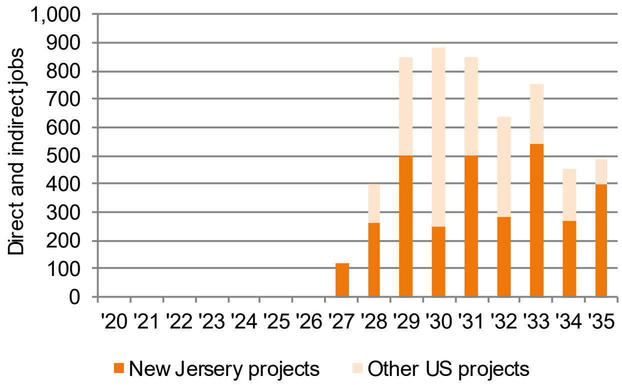

Figure 18: Job creation in New Jersey from turbine nacelle and hub under the Balanced Scenario.

Table 6: Localization of supply chain for turbine nacelle and hub for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	All component manufacture and assembly undertaken outside New Jersey with the nacelle and hub supply chain not localized in the US at this date	All component manufacture and assembly undertaken outside New Jersey with the nacelle and hub supply chain not localized in the US at this date	Nacelle and hub assembly in New Jersey.	As solicitation 3
B: Lowest LCOE	All component manufacture and assembly undertaken outside New Jersey with the nacelle and hub supply chain not localized in the US	All component manufacture and assembly undertaken outside New Jersey with the nacelle and hub supply chain not localized in the US	All component manufacture and assembly undertaken outside New Jersey with the nacelle and hub supply chain localized in the US	As solicitation 3

Turbine Blades

Leading offshore turbine suppliers typically manufacture blades in house. LM Wind Power (owned by GE) has supplied a relatively small number of blades as an independent supplier but this has usually been to smaller turbine suppliers with limited manufacturing capacity. While blades are designed as an integral part of the turbine, their supply chain is distinct.

<u>Dependency on Coastal Infrastructure</u>

A blade facility needs to close to a quayside because the blades are too large to be moved by road or rail in the numbers required by a project.

<u>Availability of Suitable NJ Coastal Infrastructure</u>

The port analysis shows several ports in New Jersey suitable with investment over $100 million.

Logistical Benefit of Local Supply

An investor will look for a site from which it can supply the regional market. If the factory can supply direct to the wind farm site then this reduces the need for a marshaling port, saving cost.

Market Threshold for Investment

A blade facility is a major investment. A leading manufacturer would typically wish to see an annual regional market of 2GW. In the market projection used in this study over 2GW is installed annually from 2023. A wind turbine supplier would need to be confident of capturing a large proportion of the market to invest in an east coast facility.

Interdependencies with Other Sectors

A blade factory would be dedicated to OSW.

Lower Tier Opportunities

Lower tier opportunities will develop over time as local expertise develops.

Relevant New Jersey Supply Chain

New Jersey companies would need to diversify to enter the blade supply chain.

Figure 19 summarizes our assessment.

Source: BVG Associates

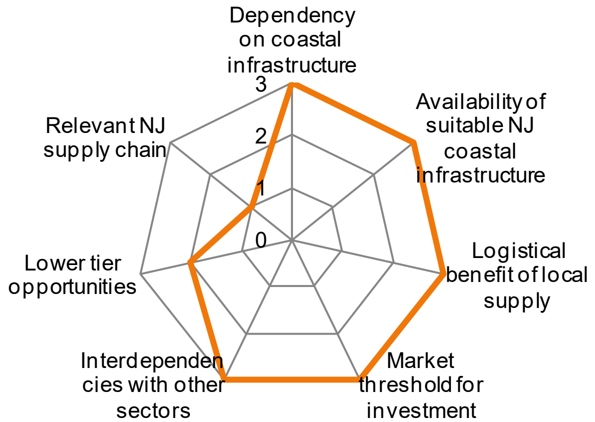

Figure 19: Assessment of turbine blades.

Table 7 shows the scenarios developed as a result of this analysis. As for nacelle and hub assembly, turbine manufacturers will look for locations along the northeast coast and there will be string competition from other states to secure a facility. In the Balanced Scenario, there is a New Jersey facility for the second solicitation, recognizing that the regional market is too small before this time.

In the Balanced Scenario, blades are made in New Jersey. Figure 20 shows peak job creation in 2029. A blade factory is likely to employ about 800 to 1,000 people but there is potential for New Jersey to supply a range of services, components and materials, creating additional employment. A significant proportion of the factory's output will be to wind farms outside New Jersey.

The Balanced Scenario has some additional jobs from blade repair.

In the Lowest LCOE Scenario the new blade factories are outside New Jersey.

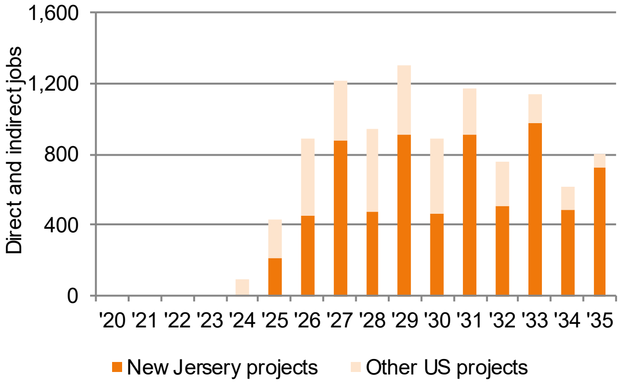

Figure 20: Job creation in New Jersey from turbine blades under the Balanced Scenario.

Table 7: Localization of supply chain for turbine blades for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	Blades manufactured outside the US with manufacture not localized.	Blades manufactured in New Jersey	Blades manufactured in New Jersey with all significant US investments made	As solicitation 3
B: Lowest LCOE	Blades manufactured outside the US with manufacture not yet localized.	Blades manufactured in the US but outside New Jersey	Blades manufactured in the US but outside New Jersey with all significant US investments already made	As solicitation 3

Turbine Towers

Dependency on Coastal Infrastructure

A tower facility needs to close to a quayside because the tower sections are too large to be moved by road or rail in the numbers required by a project.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment over $100 million.

Logistical Benefit of Local Supply

An investor will look for a site from which it can supply the regional market. If the factory can supply direct to the wind farm site then this reduces the need for a marshaling port, saving cost.

Market Threshold for Investment

A tower factory is a major investment. A leading manufacturer would typically wish to see an annual regional market of 2GW. In the market projection used in this study over 2GW is installed annually from 2023 to 2035. A tower supplier would need to be confident of capturing a large proportion of the market to invest in an east coast facility and would seek to supply whichever turbine manufacturers won supply contracts.

Interdependencies with Other Sectors

A tower factory would be dedicated to OSW. Onshore tower factories will be located to meet that market and will need good access to the road network.

Lower Tier Opportunities

The tower market has low margins and is therefore focused on high volumes. Even relatively low value components are supplied by specialist companies and these have typically not invested at new locations to meet demand from OSW.

Figure 21 summarizes our assessment.

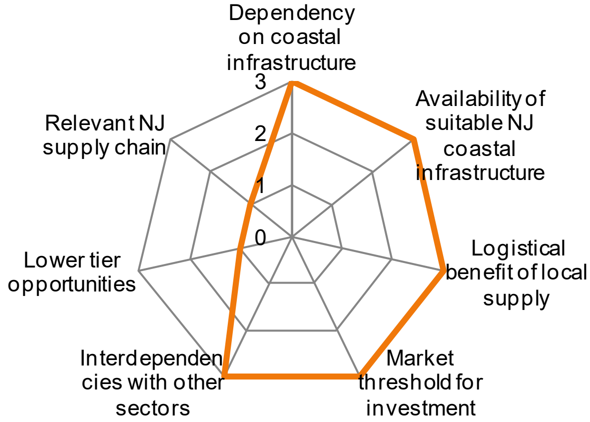

Figure 21: Assessment of turbine towers.

Table 8 shows the scenarios developed as a result of this analysis. In the Balanced scenario towers are made in New Jersey.

Figure 22 shows the turbine tower jobs created under the Balanced Scenario. A tower factory would employ about 250 people with some local employment from services to the factory after solicitation 3.

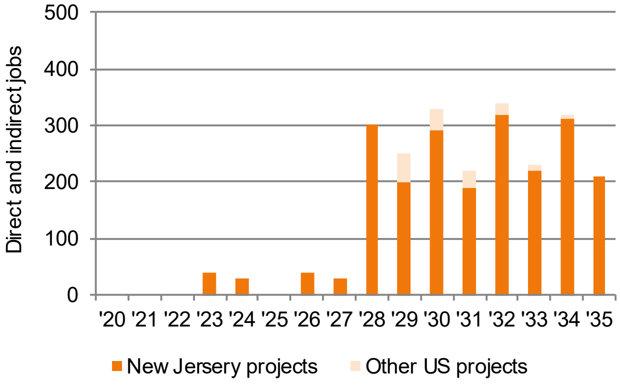

Figure 22: Job creation in New Jersey from turbine towers under the Balanced Scenario.

In the Lowest LCOE scenario, the new tower factories are outside New Jersey.

Workforce Development

Turbine component factories are serial production lines and suppliers invest in their workforce for the long-term needs of their companies. An investment decision for a new factory is likely to be made two or more years ahead of first production. In that time, companies will have time to recruit and train a new workforce, provided there is a labor pool with some experienced of production line manufacturing.

Not all the training for new workers will be undertaken in house. A new nacelle or blade factory would employ 800 or more workers and there is a role for training providers to undertake training in partnership with the companies.

Companies wishing to invest in New Jersey will look to the state to understand its training needs and have a strategy for how it can support companies in training their workforce. A tower factory that can supply the first solicitation in 2024 will need to go into production in 2023 and reach investment decision in 2021. In 2020, investors will be shortlisting sites and will at this stage wish to see evidence of state support in training. For blades and nacelle factories ready for 2026, this engagement will need to be no later than 2023.

Table 8: Localization of supply chain for turbine towers for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	Towers manufactured in US but outside New Jersey. Tower internals installed in New Jersey	Towers manufactured in US but outside New Jersey. Tower internals installed in New Jersey	Towers manufactured in New Jersey. Tower internals installed in New Jersey	As solicitation 3
B: Lowest LCOE	Towers manufactured in US but outside New Jersey Tower internals installed in US but not New Jersey	Towers manufactured in US but outside New Jersey Tower internals installed in New Jersey	Towers manufactured in US but outside New Jersey Tower internals installed in New Jersey	As solicitation 3

6.3. Foundations

Supply chain

Turbine foundations represent 8% of a project's lifetime expenditure. Developers select a foundation technology depending on the water depth, seabed conditions, wave and tidal loading, and turbine loading, mass and rotor speed. The options are summarized below:

To date, most OSW farms have used steel monopile foundations that are driven into the seabed. A transition piece is fitted over the top and fixed using grout or bolts. The development of projects in deeper water with larger turbines has led to the enlargement of designs, with units up to 1,200t currently being deployed. Monopiles, depending on seabed conditions, may have the potential to be used for the 20MW turbines in 40 m water depth envisaged solicitations 5 and 6. This is yet to be established, so the scenario in this report for solicitations 5 and 6 assumes the technically certain but more expensive jackets are used.

Jacket foundations are cross-braced, welded, space-frame structures. Other space-frame designs, such as tripods and tri-piles, have also been used on German projects but their cost means their future role is likely to be limited to deeper sites and larger turbines.

There is significant interest in suction buckets as seabed connections as a means of lowering installation costs and the impact of piling on wildlife. These maybe used as an alternative to pin-piles for jackets.

Since New Jersey has a strong concrete supply industry there is some interest in gravity base foundations (GBFs) potentially to achieve more local content. As the name suggests GBFs rely on the mass of the foundation to keep the turbine in place. They have a steel stem not that dissimilar to a short monopile with structural fins around which the reinforced concrete structure is built. Like monopiles a transition piece fits on top of the stem. GBFs have only been used in a small number of niche commercial projects in Europe. Five novel float-out and submerge GBFs were used in the Blyth Offshore Wind Farm that demonstrated installing a foundation using tugboats instead of large installation vessels. The hollow concrete structures were ballasted to lower and secure the foundations in place. This is an example of the many innovations in offshore wind that may go on to shape technology of future wind farms.

For the anticipated steel foundations, there are two main types of factories: monopiles and pin piles (for the jackets) that are produced from steel rolling factories, which are highly automated. Transition pieces and jackets are produced at steel fabrication facilities employing significant numbers of welders.

In the scenarios, monopiles are used for the first 4 solicitations, and jackets are used for solicitations 5 and 6 where turbines are larger and in deeper water.

Workforce

Figure 23 shows the occupations involved in jacket manufacturing. It shows that compared with tower manufacture, a higher proportion of jobs are in steel fabrication roles than in steel production because much of the fabrication work involves more manual welding, and the work in producing the steel plate accounts for less of the overall cost. However, there are still a significant number of jobs with occupations in steel production.

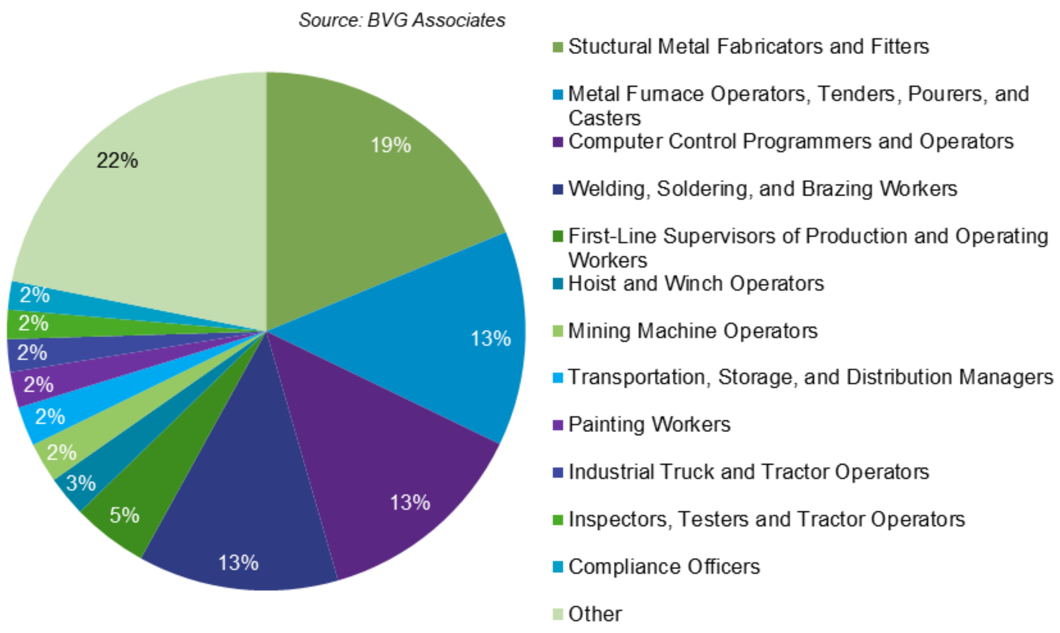

Figure 23: Occupations in jacket foundation manufacture.

Localization

Dependency on Coastal Infrastructure

A foundation facility needs to close to a quayside because foundations are too large to be moved by road or rail in the numbers required by a project.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment over $100 million.

Logistical Benefit of Local Supply

An investor will look for a site from which is can supply the regional market. If the factory can supply direct to the wind farm site then this reduces the need for a marshaling port, saving cost.

Market Threshold for Investment

A foundation factory is a major investment. A leading manufacturer would typically wish to see an annual regional market of 2GW. In the market projection used in this study over 2GW is installed annually from 2023 to 2035. A foundation supplier would need to be confident of capturing a large proportion of the market to invest in an east coast facility.

Interdependencies with Other Sectors

A foundation factory would be dedicated to OSW. No other sector has the demand for large fabricated structures in such high volumes.

Lower Tier Opportunities

Opportunities are to supply secondary steel (such as cable entry and boat-landing systems, and sacrificial anodes) and architectural steel (such as railings and the foundation platform).

Figure 24 summarizes our assessment.

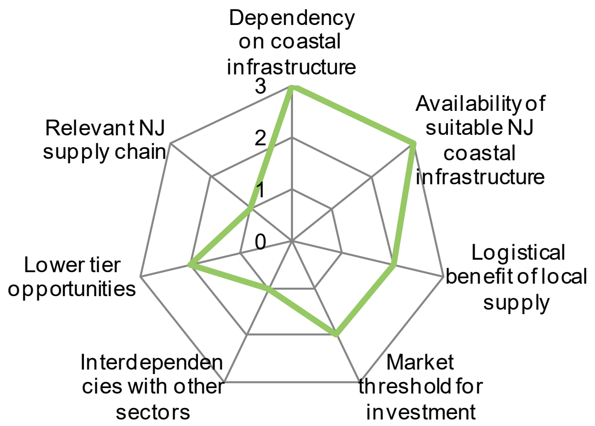

Figure 24: Assessment of foundations.

Table 9 shows our scenarios based on this analysis. In the Balanced Scenario, New Jersey undertakes monopile manufacture for solicitation 1 and extends this to include transition pieces for solicitation 2. For solicitations 5 and 6, jackets that are manufactured in US but outside NJ, are used. The TPs are manufactured in New Jersey.

In the Lowest LCOE Scenario, foundations are manufactured in low-cost jurisdictions.

Figure 25 and Figure 26 show the jobs created in the Lowest LCOE and Balanced scenarios respectively. The Lowest LCOE scenario shows that monopile manufacture creates about 900 jobs, increasing to 1400 with the addition of TPs. A risk is that if foundations are sold to projects outside New Jersey then the opportunity to sell to the projects in New Jersey maybe limited. The factory's viability is therefore linked to a longer time pipeline for New Jersey projects. The use of jackets for solicitations 5 and 6 made outside NJ reduces the jobs from 2030. If the technology does shift to jackets, then there is an opportunity to seek to manufacture in NJ. The size of site required is significantly bigger than for monopiles.

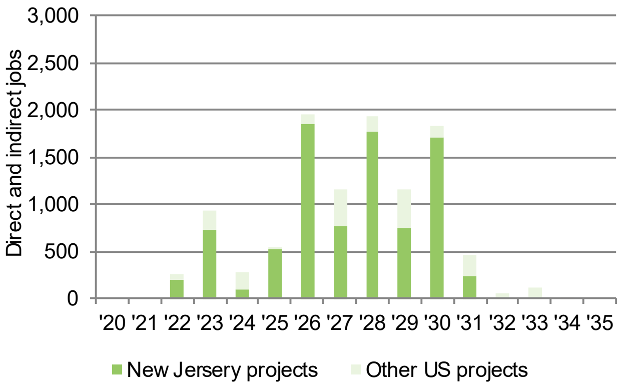

Figure 25: Job creation in New Jersey from foundations under the Lowest LCOE scenario.

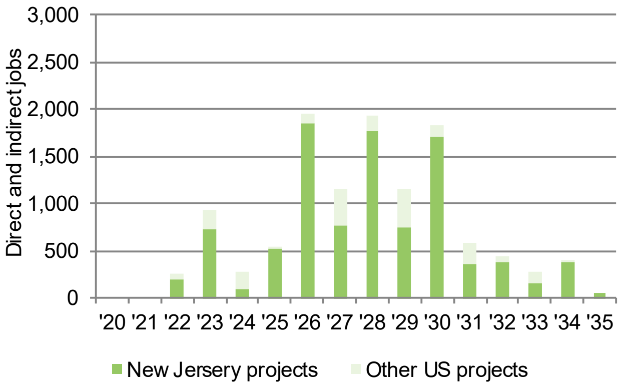

Figure 26: Job creation in New Jersey from foundations under the Balanced scenario.

Workforce Development

Monopile manufacture creates a demand for welders, and an investor in New Jersey is likely to expect a trained workforce in place. Because demand from the factory is likely to have peaks and troughs, many workers will be on short-term contracts to meet the needs of a specific contract, and on the job training is unlikely.

Table 9: Localization of supply chain for turbine foundations for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3-4	Solicitations 5-6
A: Balanced	Monopiles manufactured in New Jersey TPs manufactured in US but outside NJ	Monopiles and TPs manufactured in New Jersey	Monopiles and TPs manufactured in New Jersey	Jackets manufactured in US but outside NJ

Scenario	Solicitation 1	Solicitation 2	Solicitation 3-4	Solicitations 5-6
B: Lowest LCOE	Foundations manufactured outside US TPs manufactured in US but outside NJ	Foundations manufactured outside US but final assembly in US TPs manufactured in US but outside NJ	Monopiles manufactured in New Jersey TPs manufactured in US but outside NJ	Jackets manufactured in US but outside NJ

6.4. Subsea Cables

Subsea cables deliver the power from the turbines to the onshore grid. Array cables connect the turbines to an offshore substation from which the power is transmitted to an onshore substation via high voltage (HV) export cables.

To date, array cables have predominantly been medium voltage (MV) and rated at 33kV using copper or aluminum cores. The technology is well established and has been extensively used in the power and oil and gas industries. Contracts have recently been awarded for the supply of 66kV cables and this is expected to be a rapidly growing market over the coming years.

Export cables have a significantly higher capacity than array cables, ranging from 132kV to 245kV with copper or aluminum cores. Export cable installation takes place early in the construction schedule and there are potentially long lead times. It is therefore one of the first contracts placed.

Most export cables have been alternating current (AC) but the development of projects further from shore is likely to lead to greater use of direct current (DC) systems.

Workforce

Array and export cable supply use the same occupations. The manufacturing process is largely automated, and this is reflected in the main occupations in Figure 27, a significant proportion of which are involved in the operation of the cable assembly lines (notably Forming Machine Setters, Operators, and Tenders, Metal and Plastic).

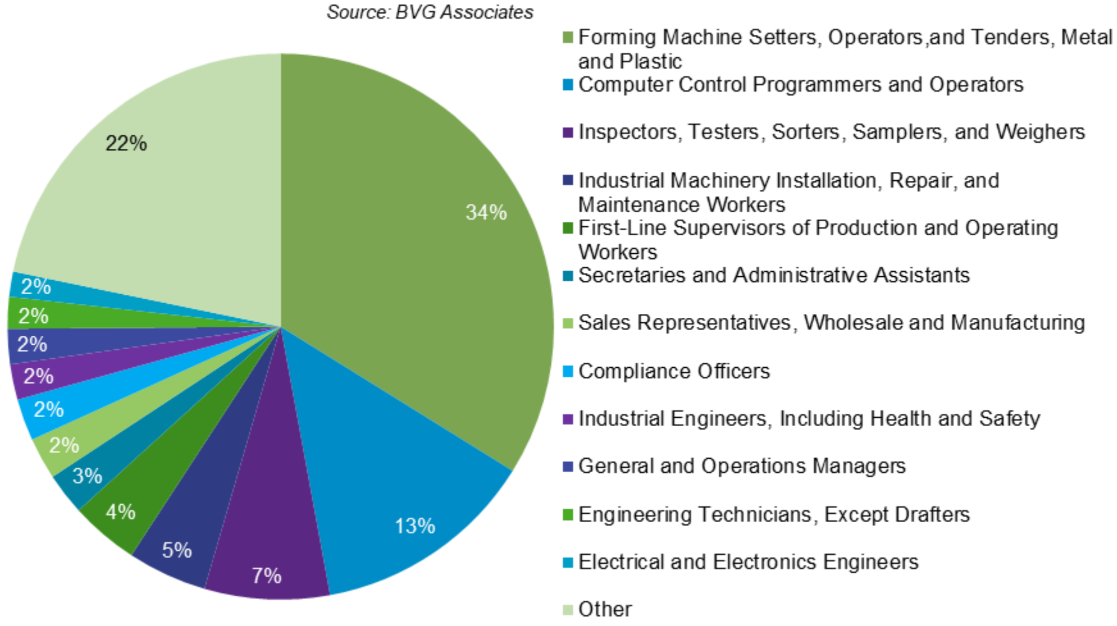

Figure 27: Occupations in subsea cable supply.

Localization

Dependency on Coastal Infrastructure

A cable facility needs to be waterside because they are too large to be moved by road or rail in the numbers required by a project. Cable is typically spooled direct onto the vessel and there is less need for a high load bearing quayside than some other OSW activities. River access is possible and can be attractive for investors if its land rent costs are lower.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment over $100 million.

Logistical Benefit of Local Supply

An investor will look for a site from which is can supply the regional market. If the factory can supply direct to the wind farm site then this reduces the need for a marshaling port, saving cost. The gain is marginal, however, because an installation vessel may be able to load all the cable for the wind farm in one port visit.

Market Threshold for Investment

A cable factory is a major investment, particularly for high voltage cables, for which a vertical extrusion tower is needed. A leading manufacturer would typically wish to see an annual regional market of 200km of three-core AC cable which is roughly equivalent to 1GW. This length is defined by the amount of cable core than can be extruded in one year.

Interdependencies with Other Sectors

A cable factory would be dedicated mainly to OSW. Oil and gas and subsea interconnectors are potential other markets.

Lower Tier Opportunities

There are limited lower tier opportunities. Most of the supply chain for cables is commodities such as copper wire, steel armoring wire and XLPE (cross-linked polyethylene). For array cables in particular, there is an opportunity to supply cable accessories such as hang-offs, joints and terminations.

Figure 28 summarizes our assessments.

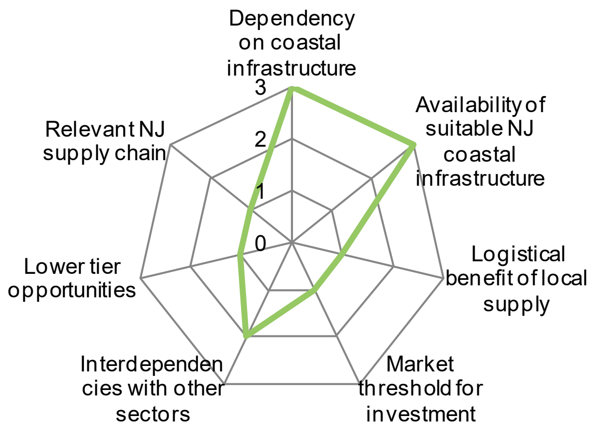

Figure 28: Assessment of subsea cables.

Table 10 shows the scenarios we have developed.

For the Balanced and Lowest LCOE Scenarios, cables are supplied from outside New Jersey. Investments at new sites by manufacturers are considered high risk because of the importance of the technical experience at the factory. Nexans's investment at its South Carolina plant to meet OSW demand illustrates this point.

Table 10: Localization of supply chain for subsea cables for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3-4	Solicitations 5-6
A: Balanced	Subsea cables manufactured in US at the site of existing factory but outside New Jersey	Subsea cables manufactured in US at new factory but outside New Jersey	Subsea cables manufactured in US at new factory but outside New Jersey	As solicitation 4
B: Lowest LCOE	Subsea cables manufactured outside US from existing European and Asian factories	Subsea cables manufactured outside US from existing European and Asian factories	Subsea cables manufactured outside US from existing European and Asian factories	As solicitation 4

Workforce Development

New cable factories have long lead times, with investment decisions typically four years ahead of production. Certification of new production lines is crucial, and this takes significant time. Companies will have time to train a new workforce, which is likely to involve time at existing manufacturing facilities. Training can be done during the time that an investment decision is made through to production.

6.5. Substations

Almost all commercial-scale OSW farms have involved at least one offshore substation, incorporating electrical components such as reactive compensation systems, switchgear, transformers, back-up generators and converters where required.

HVAC electrical systems have been the most common solution to date. For projects that are built further offshore, however; there is a cost benefit in using HVDC systems due to reduction in electricity losses.

Offshore substation platforms are large complex steel structures. An HVAC offshore substation platform weighs up to 2,000t and may include a helipad and emergency accommodation. HVDC substations are much larger, with masses of up to 15,000t. Substation manufacturing is analogous to shipbuilding and offshore oil and gas platform fabrication. Large steel modules are fabricated with complex systems then integrated. Currently HVDC is considered for projects over 100km from onshore grid connection. An HVAC connection has been made, with a midway reactive compensation platform, for a total length of 175km at the Hornsea One wind farm in the UK.

The onshore substation includes similar electrical components, although it operates at high voltages (132kV or above). Much of the equipment is installed outside on concrete bases, although the reactive compensation systems and electrical system controls are in buildings.

Workforce

Figure 29 shows that substation supports a diverse range of occupations with significant numbers in the design and manufacture of electrical components and systems, and in heavy steel fabrication. The manufacturing processes for electrical components are automated, hence the high proportion of computer control programmers and operators of factory equipment. The high steel content in the substation structure means that steel manufacturing and fabrication occupations are well represented.

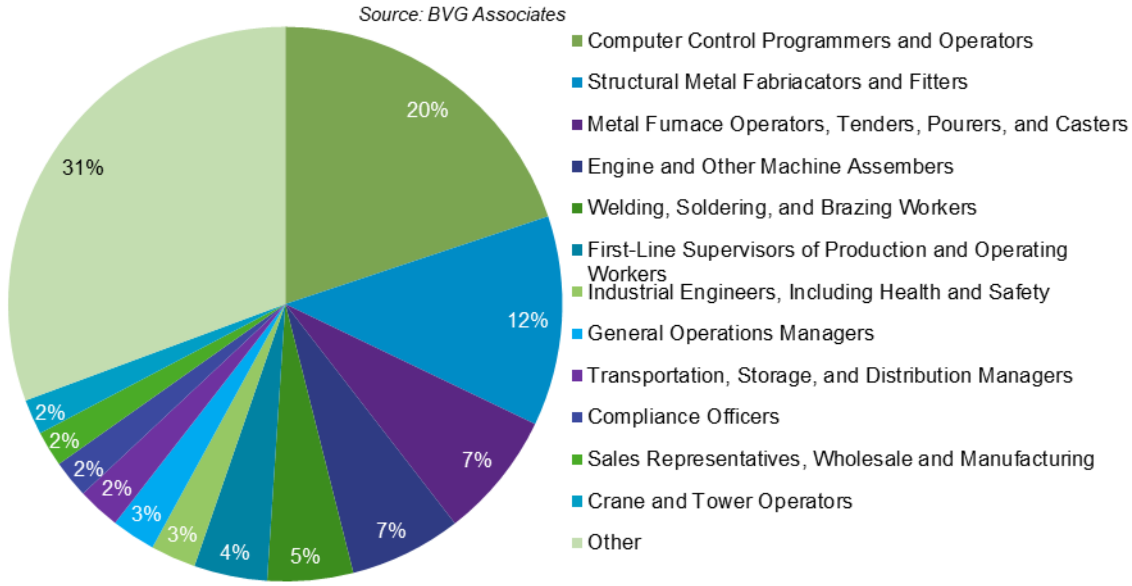

Figure 29: Occupations in substation supply.

Localization

Dependency on Coastal Infrastructure

A substation production facility needs to be waterside because the platforms and foundations are too large to be moved by road or rail.

While some electrical equipment is large, such as transformers and reactors, because a project may need no more than six, these can be moved by road if arrangements are made.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment over $100 million.

Logistical Benefit of Local Supply

Suppliers are selected largely on price. The structures can be moved over long distances by barge at low cost.

Market Threshold for Investment

Substations for OSW have typically been produced at existing yards. Demand is potentially highly intermittent and an investment at a new site would be considered high risk, even in a strong market.

Interdependencies with Other Sectors

Substations are typically built at locations for shipbuilding or oil and gas. Suppliers need to be able to supply several sectors to make facilities viable.

Lower Tier Opportunities

There are considerable opportunities in the supply chain. A substation has a significant amount of architectural steel, need low voltage systems and lighting, and emergency accommodation and safety equipment.

Figure 30 and Figure 31 summarize our assessments

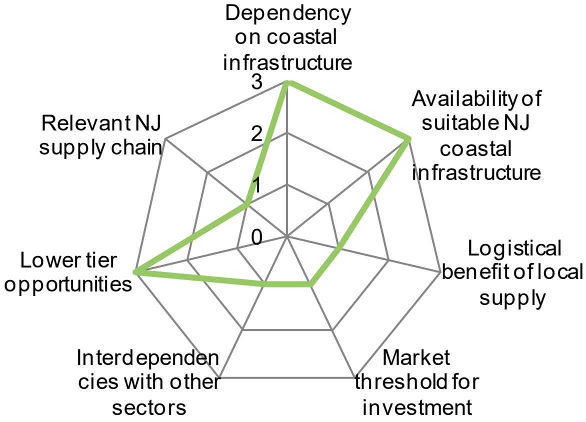

Figure 30: Assessment of substation structure.

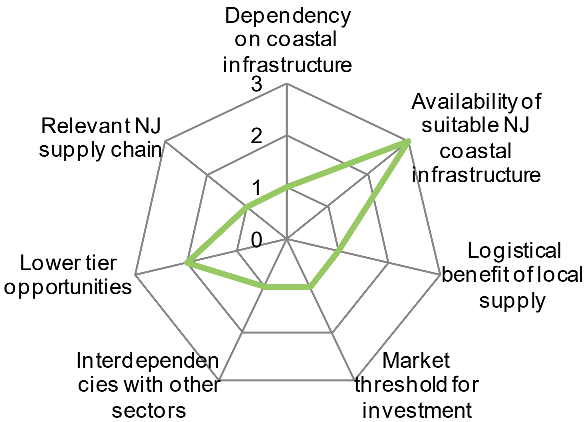

Figure 31: Assessment of substation electrical.

Table 11 shows the scenarios for the substation structure. In the Balanced Scenario, both the substation structure is manufactured at an existing NJ shipbuilding yard and structural steelwork for onshore substation made in New Jersey from solicitation 2 onwards. There is no new jersey Content in the Lowest LCOE Scenario.

Table 12 shows the scenarios for the electrical substation. In all scenarios, large electrical components are supplied from factories across the US that supply the power sector, but there is no New Jersey content.

Figure 32 show the jobs created from substations in the Balanced Scenario. The Balanced Scenarios create about 1300 jobs from the construction of the substation foundation, low voltage systems, and architectural steel. In the Lowest LCOE Scenario, we concluded that supply of substation foundations for wind farms are outside New Jersey.

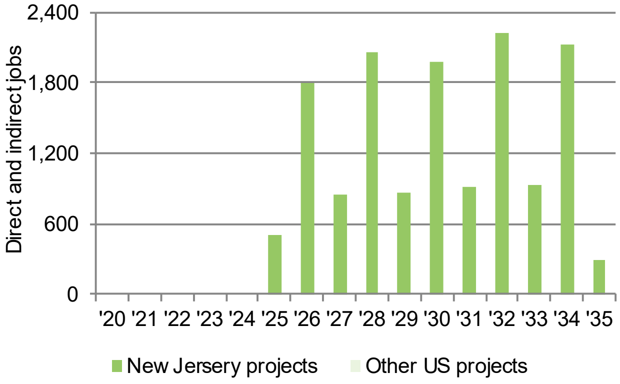

Figure 32: Job creation in New Jersey from substations under the Balanced scenario.

Table 11: Localization of supply chain for substation structure for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
1: Balanced	Offshore substation structure manufactured outside the US with manufacture not localized.	Offshore substation structure manufactured at an existing NJ shipbuilding yard. Structural steelwork for onshore substation made in New Jersey	Offshore substation structure manufactured at an existing NJ shipbuilding yard. Structural steelwork for onshore substation made in New Jersey	As solicitation 3
B: Lowest LCOE	Offshore substation structure manufactured outside the US with manufacture not localized	Offshore substation structure manufactured outside New Jersey at an existing US shipbuilding or oil platform yard. Structural steelwork for onshore substation made in New Jersey	Offshore substation structure manufactured outside New Jersey at an existing US shipbuilding or oil platform yard. Structural steelwork for onshore substation made in New Jersey	As solicitation 3

Table 12: Localization of supply chain for substation electrical for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	All electrical components manufactured outside New Jersey at existing US factories outside New Jersey because offshore wind does not a big enough market to drive new factory	All electrical components manufactured outside New Jersey at existing US factories outside New Jersey because offshore wind does not a big enough market to drive new factory	All electrical components manufactured outside New Jersey at existing US factories outside New Jersey because offshore wind does not a big enough market to drive new factory	As solicitation 3
B: Lowest LCOE	All electrical components manufactured outside New Jersey at existing US factories outside New Jersey because offshore wind does not a big enough market to drive new factory	All electrical components manufactured outside New Jersey at existing US factories outside New Jersey because offshore wind does not a big enough market to drive new factory	All electrical components manufactured outside New Jersey at existing US factories outside New Jersey because offshore wind does not a big enough market to drive new factory	As solicitation 3

Workforce Development

Substation foundation manufacturing creates a high demand for welders, and an investor in New Jersey is likely to expect a trained workforce in place. Because demand from the factory is likely to have peaks and troughs, many workers will be on short-term contracts to meet the needs of a specific contract, and on the job training is unlikely. An investing company will require either evidence that a trained workforce is in place or have a strategy in place for building a workforce.

The supply of low voltage systems from New Jersey is most likely caused by an existing company with the expertise and workforce in place elsewhere.

6.6. Subsea Cable Installation

Cable installation can be undertaken either in a single lay and burial process using a plough or via a separate surface lay-down and subsequent burial approach using a jetting tool on a remotely operated vehicle (ROV).

Installation of array cables is more challenging due to the large number of operations involved, with a pull-in at each foundation. For near-shore installations, shallow-draft barges are often used, while large scale projects further from shore typically use dynamically positioned cable ships.

Export cables are typically installed as a single length of cable and thus larger vessels are used with the necessary storage. Unlike turbine and foundation installation, success in the cable installation market is driven as much by technical capability and track record as it is by vessel capability.

Workforce

Figure 33 shows that there is a wide range of occupations with a high proportion working offshore such as engineering technicians and construction workers (included in the Miscellaneous Installation, Maintenance and Repair Workers pie segment).

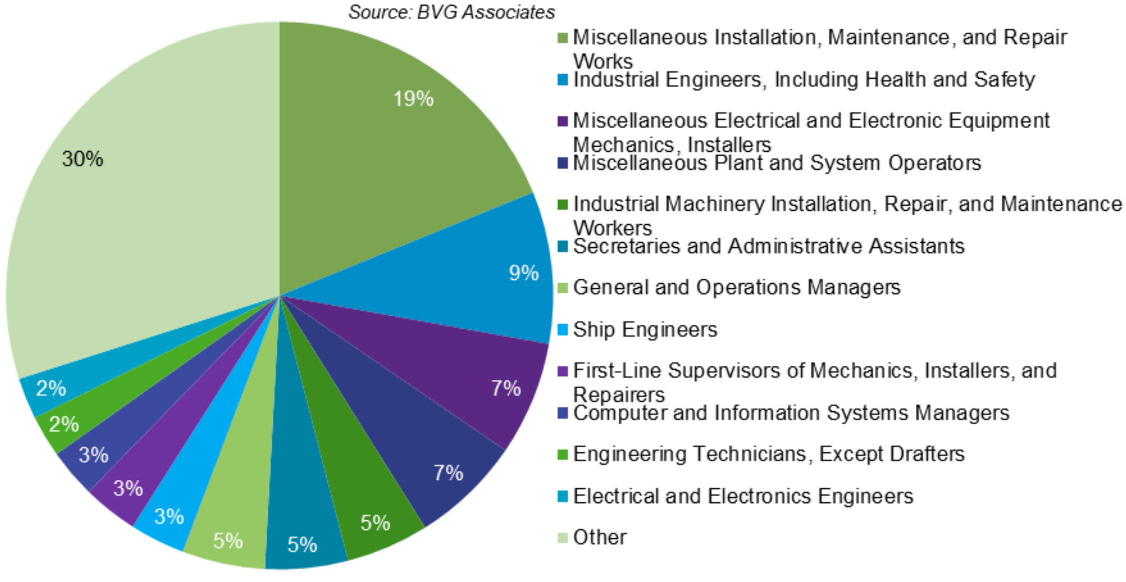

Figure 33: Occupations in subsea cable installation.

Localization

Dependency on Coastal Infrastructure

By its nature, cable installation needs coastal infrastructure, but the cable is likely to be loaded direct from the cable factory and require only limited port visits. The cable installation contractor is unlikely to be headquartered in a port because its function is administrative. It may also maintain a small operational base to store equipment and mobilize vessels.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment.

Logistical Benefit of Local Supply

There is little benefit of hiring a local contractor.

Market Threshold for Investment

A contractor is unlikely to consider new investment in onshore infrastructure. In OSW, new cable vessels were constructed once the industry had matured with large marine contractors bidding for work. While not optimal for the industry, the first Jones Act compliant cable vessels for OSW are likely to be vessel modifications, perhaps from the telecoms fleet.

Interdependencies with Other Sectors

Cable installers are likely also to supply other sectors, including oil and gas, telecoms and dredging.

Lower Tier Opportunities

There are some opportunities in the supply chain supplying cable storage and vessel and port services to the main contractor.

Our assessments are summarized in Figure 34.

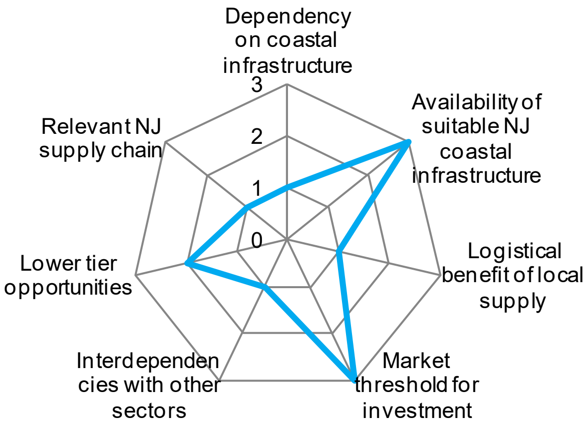

Figure 34: Assessment of subsea cable installation.

Table 13 shows the scenarios for subsea cable installation.

Table 13 Localization of supply chain for subsea cable installation for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	Installation contractor from outside New Jersey using global vessels. Cable storage and installation support from New Jersey	Installation by US marine contractor based around the Gulf of Mexico Cable storage and installation support from New Jersey	Installation by US marine contractor based around the Gulf of Mexico Cable storage and installation support from New Jersey	As solicitation 3
B: Lowest LCOE	Installation contractor from outside New Jersey using global vessels. Installation support from New Jersey	Installation contractor from outside New Jersey using global vessels. Installation support from New Jersey	Installation contractor from outside New Jersey using global vessels. Installation support from New Jersey	As solicitation 3

Figure 35 Shows that 30-40 jobs are created in New Jersey from installation support services. Because there may be limited opportunities to supply to wind farms outside New Jersey.

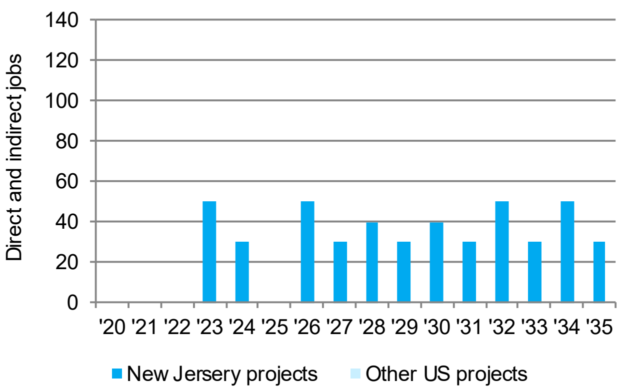

Figure 35 Job creation in New Jersey from subsea cable installation under the Lowest LCOE scenario.

Figure 36 shows that an additional 20-30 jobs are created from also providing cable storage in New Jersey.

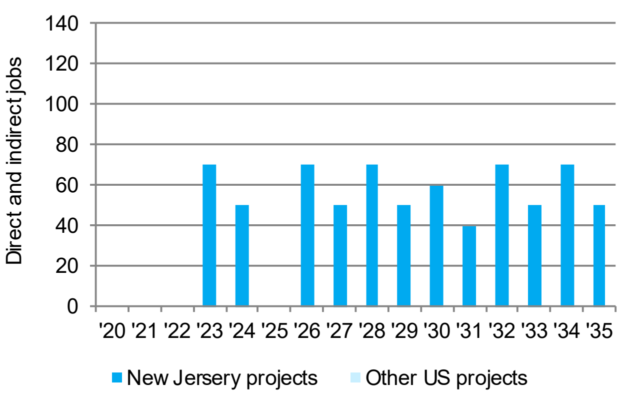

Figure 36 Job creation in New Jersey from subsea cable installation under the Balanced scenario.

Workforce Development

For cable installation contractors, workforce skills contribute significantly to their competitiveness and they will devote significant resources to skills development. Because of the nature of offshore work, the workforce can live anywhere. The jobs shown the graphs above do not consider those jobs undertaken by individuals living in New Jersey. There is an opportunity for New Jersey to maximize the opportunity for New Jersey residents by fostering links between marine training organizations in New Jersey and marine contractors in the OSW sector. This should be a long-term program because the skills needed for cable installation are gained over many years.

6.7. Foundation Installation

Monopiles with transition pieces are generally installed sequentially by the same vessel. A monopile is likely to have a mass greater than 1,000t and an installation vessel needs a crane with a maximum lifting capacity of 1,500t (because the crane's capacity depends on the height of the lift and the horizontal distance from the hook to the base of the crane). The monopile is generally hammered into the seabed, although drilling may be necessary at some locations. The transition piece is lifting and grouted or bolted into position. A jack-up vessel is assumed for this analysis, with dimensions about 140m x 45m.

Jacket foundation generally starts with the installation of pin piles using a piling template. The jacket is lowered into position and grouted. Separate vessels may be used because pin piling may be done from a low-cost vessel and jackets take up a significant amount of deck space.

For the first New Jersey solicitation, there are no Jones Act-compliant installation vessels and feeder vessels are used with installation vessels remaining at the wind farm site. Although these enable higher rates of installation, costs are likely to be higher because of the need to mobilize at least one (and probably two) feeder vessels. Although feeder vessels can be cheaper than the main installation vessel because they do not need a crane, the vessels still need to perform in the same sea conditions as the main installation vessel so that it does not wait for components when it can be active.

Workforce

Figure 37 shows that a high proportion of the jobs created are classified as installation, maintenance and repair workers, which reflects the significant use of offshore riggers.

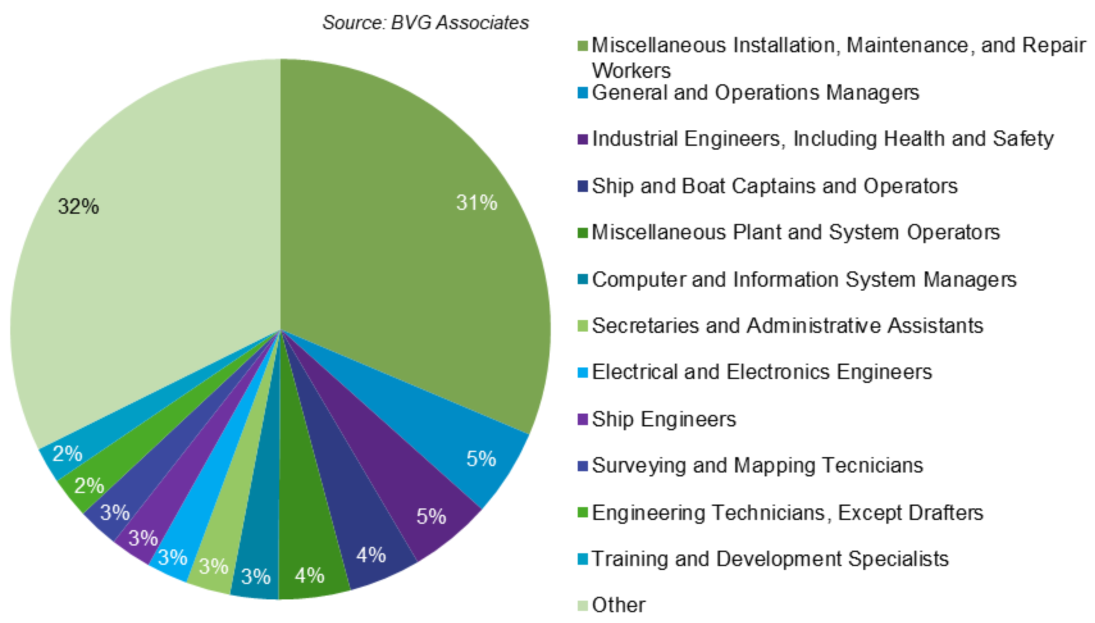

Figure 37: Occupations in foundation installation.

Localization

Dependency on Coastal Infrastructure

By its nature, foundation installation needs coastal infrastructure but if the structures are manufactured reasonably close to the wind farm site then no significant additional facilities will be needed. The foundation installation contractor is unlikely to be headquartered in a port because its function is administrative. It may also maintain a small operational base to store equipment and mobilize vessels.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment over $100 million.

Logistical Benefit of Local Supply

There is little benefit of hiring a local contractor. The use of a staging port to install foundations (if the manufacturing site is not close) is an important part of lowering project risk.

Market Threshold for Investment

A Jones Act compliant installation vessel is critical to the development of US OSW. To achieve the rates of utilization needed to support an investment decision, we have concluded that such a vessel will be available for the second solicitation.

To develop a port for foundation (and turbine) staging, an investor would need confidence that it will used over five or more years.

Interdependencies with Other Sectors

There are vessels used in oil and gas with the potential to be used in OSW, although these vessels with the necessary crane capacity are typically over specified and expensive for OSW use.

The quayside requirements for foundation are typically more demanding than other sectors, particularly in terms of quayside length, load-bearing capacity on the quayside and significant areas of laydown space. An alternative use for a port developed for OSW is as a container terminal.

Lower Tier Opportunities

There are some opportunities in the supply chain supplying staging facilities and a range of port services.

Our assessments are summarized in Figure 38.

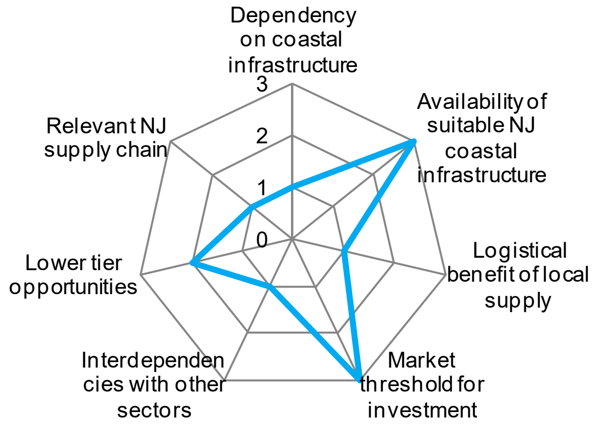

Figure 38: Assessment of foundation installation.

Table 14 shows the scenarios developed following this analysis. In all scenarios, staging facilities are in New Jersey (although in the case of the Local scenario, these facilities form part of the foundation production site). In the Local scenario, there is vessel mobilization in New Jersey.

Figure 39 shows that foundation staging creates between 40 and 90 jobs. If the same port is used for turbine staging, then about 120 jobs are sustained annually at the port.

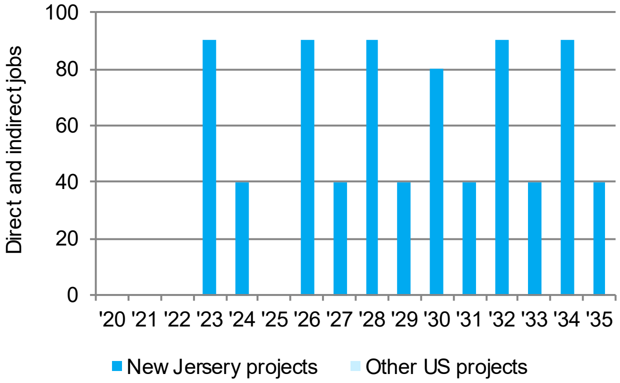

Figure 39 Job creation in New Jersey from foundation installation under the Lowest LCOE and Balanced Scenarios.

Workforce Development

Foundation installation contractors devote significant resources to skills development (although perhaps not to the same degree as cable installers). The workforce population can live anywhere because of the nature of offshore work. The jobs shown the graphs above do not consider those jobs undertaken by individuals living in New Jersey. There is an opportunity for New Jersey to maximize the opportunity for New Jersey residents by fostering links between marine training organizations in New Jersey and marine contractors in the OSW sector.

Table 14: Localization of supply chain for foundation installation for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	Installation contractor from outside New Jersey using global vessels with US feeder vessels from outside New Jersey Foundation staging in New Jersey	US contractor from outside New Jersey. Foundation staging in New Jersey	US contractor from outside New Jersey. Foundation staging in New Jersey	As solicitation 3
B: Lowest LCOE	Installation contractor from outside New Jersey using global vessels with US feeder vessels from outside New Jersey Foundation staging in New Jersey	US contractor from outside New Jersey. Foundation staging in New Jersey	US contractor from outside New Jersey. Foundation staging in New Jersey	As solicitation 3

6.8. Turbine Installation

Turbine installation is from a jack-up vessel, and ideally, achieved through the following lifts:

- Tower,
- Nacelle and hub, and
- Each blade individually.

Many east coast ports have air draft restrictions because they have been built upstream from the mouth of river estuaries where road bridges have been built downstream from the port.

For projects in the early solicitations, the vessel need not have a crane with capacity greater than 1,000t but the nacelle masses for the 20MW envisaged for solicitations 5 and 6 may exceed this. The cranes will need to lift nacelles and blades at least 130m and 145m above the transition piece for 12 MW and 20 MW turbines, respectively. In Europe, there is increasing divergence in the turbine and foundation installation fleets. The first Jones Act compliant vessels will probably be used for both turbines and foundations because the market in the mid-2020s is unlikely to be large enough to support a specialist turbine or foundation installation vessel.

For the first solicitation, for which feeder vessels are used, these vessels will probably be jack-ups because the acceleration limits of nacelles are likely to preclude lifts from a floating vessel.

Workforce

Figure 40 shows that a high proportion of the jobs created are classified as installation, maintenance and repair workers, which reflects the use of offshore riggers. There are similarities with foundation installation, but the key difference is the use of turbine technicians during the commissioning process. The SOC classification is strictly for maintenance technicians but the commissioning teams use similar skills.

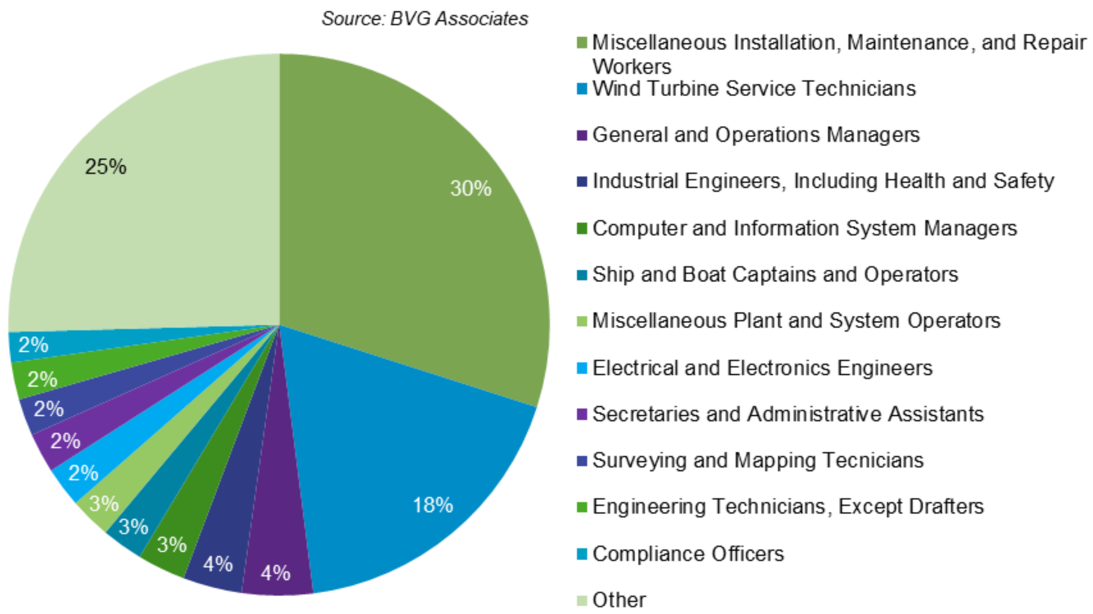

Figure 40: Occupations in turbine installation.

Localization

Dependency on Coastal Infrastructure

Turbine installation needs coastal infrastructure but if either nacelles and hubs or blades are manufactured reasonably close to the wind farm site then no significant additional facilities will be needed. The turbine installation contractor is unlikely to be headquartered in an installation port because its function is administrative. It may also maintain a small operational base to store equipment and mobilize vessels.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment over $100 million.

Logistical Benefit of Local Supply

There is little benefit of hiring a local contractor. The use of a staging port to install turbines (if the manufacturing site is not close) is an important part of lowering project risk.

Market Threshold for Investment

A Jones Act compliant installation vessel is critical to the development of US OSW. To achieve the rates of utilization needed to support an investment decision, we have concluded that such a vessel will be available for the second solicitation.

To develop a port for turbine (and foundation) staging, an investor would need confidence that it will used over five or more years.

Interdependencies with Other Sectors

Turbine installation vessels are specialist and are not typically used in other sectors. Other potential uses in OSW are as an accommodation base for substation or turbine commissioning or for large component replacement during maintenance. If a vessel's utilization is low, its owners may offer to the oil and gas sector, potentially for accommodation or decommissioning of platforms.

The quayside requirements for turbine are less demanding that for foundation that typically set the staging requirement particularly in terms of quayside length, load-bearing capacity on the quayside and significant areas of lay-down space. An alternative use for a port developed for OSW is as a container terminal.

Lower Tier Opportunities

There are some opportunities in the supply chain supplying staging facilities and a range of port services.

Our assessments are summarized in Figure 41.

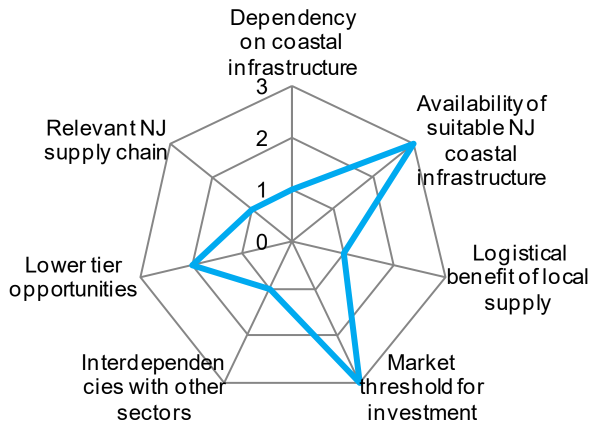

Figure 41: Assessment of turbine installation.

Table 15 shows the scenarios we developed. Wind farm location has little bearing on the construction and management of vessels. The opportunity for localization comes from subcontracted services such as mobilization, staging and installation support. The difference between solicitations is dependent on the business case and lead time for investment in new vessels.

Error! Reference source not found. shows the jobs created in the Balanced and Lowest LCOE Scenarios. It shows that between 30 and 80 jobs are created for turbine staging. If the same location is used for foundation staging, then about 120 jobs are created in the port during the period in which the New Jersey wind farms are being constructed.

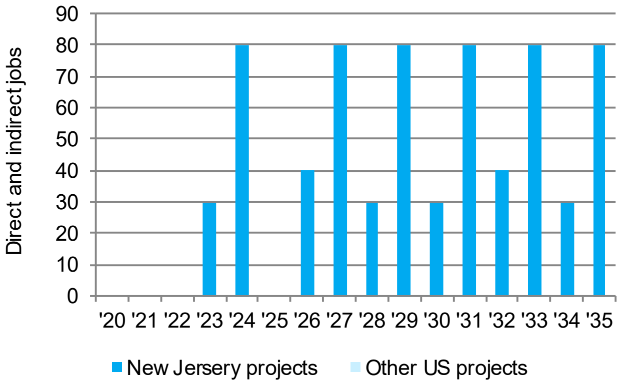

Figure 42: Job creation in New Jersey from turbine installation under the Balanced and Lowest LCOE Scenarios.

Table 15: Localization of supply chain for turbine installation for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	Installation contractor from outside New Jersey using global vessels with US feeder vessels from outside New Jersey Turbine staging in New Jersey	US contractor from outside New Jersey. Turbine staging in New Jersey	US contractor from outside New Jersey. Turbine staging in New Jersey	As solicitation 3
3: Lowest LCOE	Installation contractor from outside New Jersey using global vessels with US feeder vessels from outside New Jersey Turbine staging in New Jersey	US contractor from outside New Jersey. Turbine staging in New Jersey	US contractor from outside New Jersey. Turbine staging in New Jersey	As solicitation 3

Workforce Development

Turbine installation contractors devote significant resources to skills development. The workforce population can live anywhere because of the nature of offshore work. The jobs shown the graphs above do not consider those jobs undertaken by individuals living in New Jersey. There is an opportunity for New Jersey to maximize the opportunity for New Jersey residents by fostering links between marine training organizations in New Jersey and marine contractors in the OSW sector.

6.9. Wind Farm Operations

Wind farms typically have an operating lifetime of 25 years. The operation of a wind farm is managed from an onshore base. Typically, wind farm operators will look to use the nearest port that meets its specifications. Activities include day-to-day workflow management and data gathering and analysis. This allows the owners to respond efficiently to failures when they occur and, where possible, to identify potential failures before they occur.

The management of logistics (vessels, helicopters, personnel, specialist tooling and spare parts) is also an important part of the operations role. Maintenance services include both planned and unplanned visits to wind turbines and their foundations to inspect, maintain and repair. In some instances, replacement of large items of plant such as gearboxes or blades is required, which will usually need jack-up vessels such as those used during installation. Vessels and equipment are an essential component of this sub-element and an area where Norwegian suppliers have significant expertise.

Crew transfer vessels (CTVs) typically provide transport for technicians and spares from the onshore base to OSW farms less than about 90 minutes transfer time from port. Some wind farms supplement CTVs with full-time helicopter support, for transporting technicians when the task in hand does not require heavy tools or spares, or when sea conditions are severe. Spare parts are stocked in onshore warehouses.

Service operations vessels (SOVs) are larger and more capable than CTVs and are typically used for wind farms more than about 90 minutes transfer time from port. They are effectively a floating OMS base, accommodate between 60 and 90 passengers and contain workshops and storage for equipment, consumables and spares.

Marine coordination activities are required for efficient use of personnel and vessels moving between the onshore base and the OSW farm. Weather conditions, visibility, and tides are monitored daily in order to coordinate efficiently, on a 24-hour service.

Workforce

Figure 43 shows that there is a wide range of occupations with a high proportion in vessel operations and in general operations.

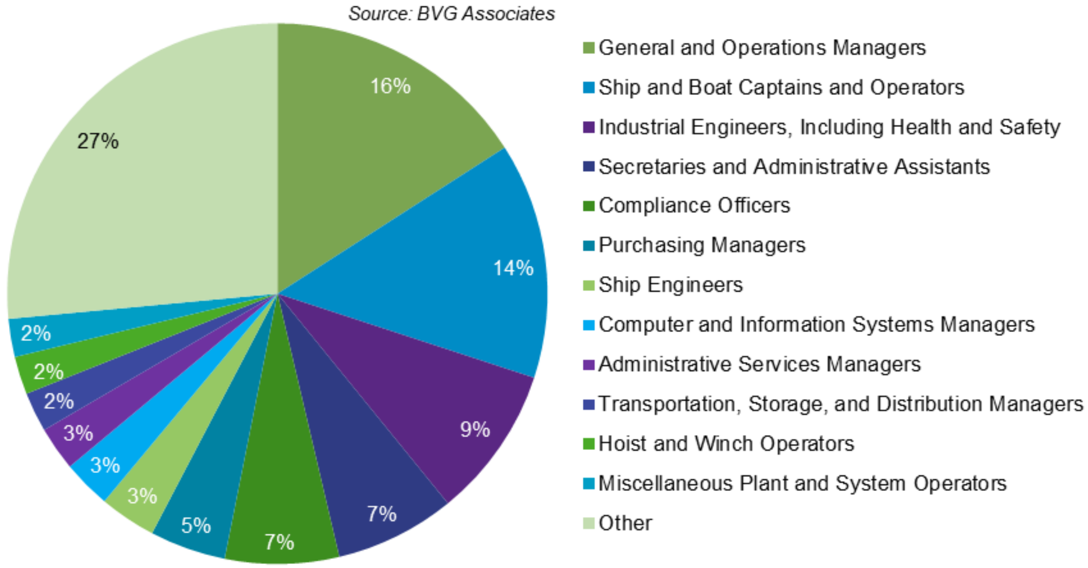

Figure 43: Occupations in wind farm operations.

Localization

Dependency on Coastal Infrastructure

As significant proportion of wind farm operations requires coastal infrastructure, although some asset management will be done centrally by the developer and the turbine supplier as part of the service agreement.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment less than $25 million.

Logistical Benefit of Local Supply

Local provision is essential.

Market Threshold for Investment

A wind farm must have operational infrastructure and therefore there is no market threshold.

Interdependencies with Other Sectors

There are no interdependencies as wind farm operations requires dedicated resource.

Lower Tier Opportunities

There are significant opportunities in the supply chain supplying a range of services to support the onshore and offshore logistics.

Our assessments are summarized in Figure 44.

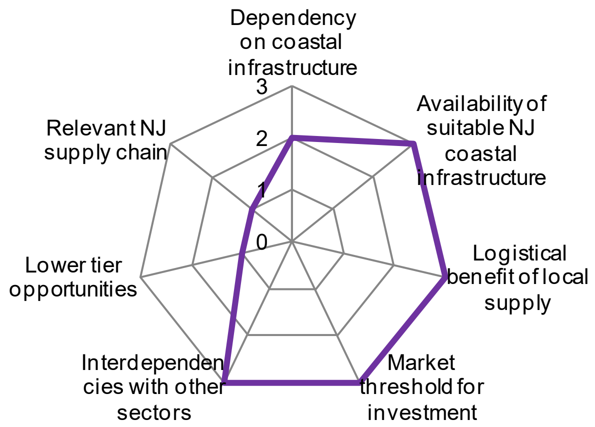

Figure 44: Assessment of wind farm operations.

Table 16 shows the scenarios we developed. The location of wind farm operations is driven by wind farm location and there are therefore no differences between scenarios and solicitations.

Table 16: Localization of supply chain for wind farm operations for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	Operations base in New Jersey Asset management in New Jersey Dedicated vessels operating out of New Jersey	Operations base in New Jersey Asset management in New Jersey Dedicated vessels operating out of New Jersey	Operations base in New Jersey Asset management in New Jersey Dedicated vessels operating out of New Jersey	As solicitation 3
B: Lowest LCOE	Operations base in New Jersey Asset management in New Jersey Dedicated vessels operating out of New Jersey	Operations base in New Jersey Asset management in New Jersey Dedicated vessels operating out of New Jersey	Operations base in New Jersey Asset management in New Jersey Dedicated vessels operating out of New Jersey	As solicitation 3

Figure 45 shows that jobs increase with cumulative installed capacity in New Jersey for both scenarios, which are therefore long-term jobs for the state.

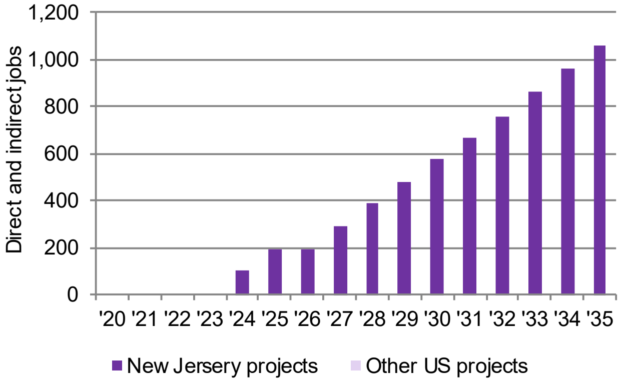

Figure 45: Job creation in New Jersey from wind farm operations under both scenarios.

Workforce development

The operational management of the wind farm will be undertaken by labor directly or indirectly, through a special purpose vehicle employed by the developer. The skills lie in management, finance, procurement and engineering. For senior positions, developers typically recruit internally or externally if internal capability is lacking. More junior positions will be recruited locally.

For a wind farm using crew transfer vessels, there are usually five jobs per vessel (two for each shift with a fifth to cover absentees). For the three solicitations, demand for vessel crews could reach 200, which will generally be employed by the vessel operator. It is likely that with New Jersey's significant maritime industry, suitably skilled individuals will be recruited locally. Some specific training for the industry will be needed, but this can be undertaken following recruitment.

6.10. Turbine Maintenance and Service

Typically, wind turbines are supplied with a five-year service agreement and wind turbine manufacturers provide full turbine maintenance services during this period. Sometimes the service agreement can last as long as 15 years. At the end of the service agreement, the wind farm owner may negotiate an extension, undertake the wind turbine maintenance itself or contract to a third-party services company.

Turbine maintenance typically involves a planned visit to each turbine once or twice a year. During these visits, technicians carry out inspection and maintenance activities including checks on oil and grease levels and a change of filters; checks on instruments, electrical terminations, and the tightness of bolts; and statutory safety inspections. Unplanned service calls involve a technician visit to a turbine in response to an alarm reported on the wind farm supervisory control and data acquisition (SCADA) systems or component-specific condition monitoring systems (CMSs). Such visits can entail the simple resetting of a circuit breaker on a piece of auxiliary plant such as a cooling fan or as serious as replacing the main gearbox or generator following a failure that cannot be repaired offshore.

Workforce

Figure 46 shows that the occupations are mainly wind turbine service technicians, although significant numbers of jobs are also created through the manufacture of replacement components and in the repair or refurbishment of components.

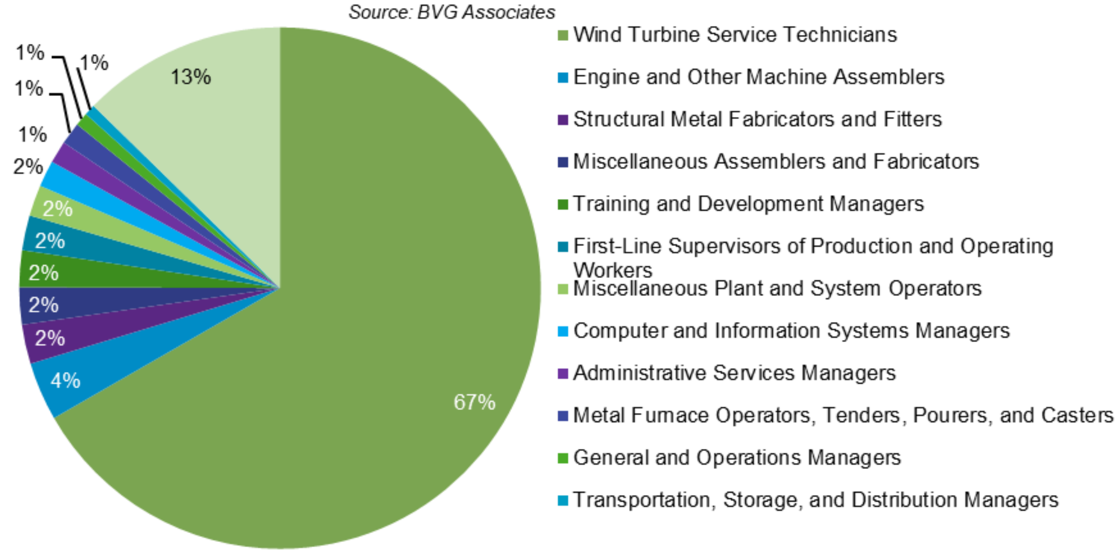

Figure 46: Occupations in turbine maintenance and service.

Localization

Dependency on Coastal Infrastructure

Routine maintenance and service requires a dedicated team based at the operations port. Infrastructure is typically made available by the developer. Unplanned maintenance and service, including major component replacement, will require some additional infrastructure. If the work involves large vessels, it is likely to use a different port than the main operations port.

Availability of Suitable NJ Coastal Infrastructure

The port analysis shows several ports in New Jersey suitable with investment less than $25 million.

Logistical Benefit of Local Supply

Local provision is essential for routine maintenance service.

Market Threshold for Investment

A wind farm must have operational infrastructure and therefore there is no market threshold.

Interdependencies with Other Sectors

There are no interdependencies as turbine maintenance and service requires dedicated resource.

Lower Tier Opportunities

There are significant opportunities in the supply chain supplying a range of services to support the onshore and offshore logistics.

Our assessments are summarized in Figure 47.

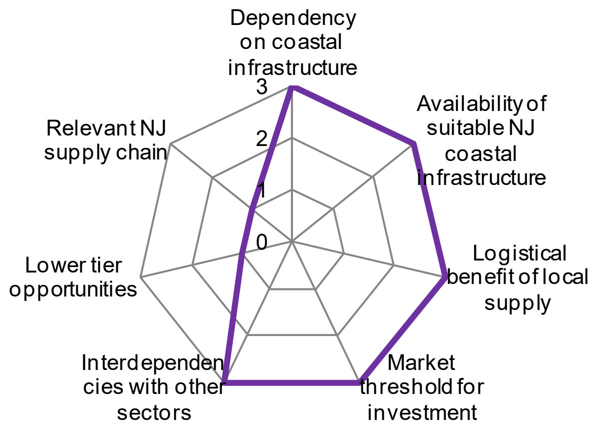

Figure 47: Assessment of wind turbine maintenance and service.

The scenarios based on our analysis are shown in Table 17. In the Lowest LCOE Scenarios, the core, routine maintenance and service activities are undertaken from New Jersey. In the Balanced scenario, blades are manufactured for the second solicitation onwards and this capability also enables the state to provide blade repairs.

Table 17: Localization of supply chain for turbine maintenance for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	Planned maintenance undertaken from New Jersey from crew transfer vessels Unplanned maintenance from outside New Jersey Maintenance jack-ups from outside New Jersey Spares and consumables from outside New Jersey	Planned maintenance undertaken from New Jersey from crew transfer vessels Unplanned maintenance from outside New Jersey Maintenance jack-ups from outside New Jersey Blade repair from New Jersey Other spares and consumables from outside New Jersey	Planned maintenance undertaken from New Jersey from crew transfer vessels Unplanned maintenance from outside New Jersey Maintenance jack-ups from outside New Jersey Blade repair from New Jersey Other spares and consumables from outside New Jersey	Planned maintenance undertaken from New Jersey from service operations vessels Unplanned maintenance from outside New Jersey Maintenance jack-ups from outside New Jersey Blade repair from New Jersey Other spares and consumables from outside New Jersey
B: Lowest LCOE	Planned maintenance undertaken from crew transfer vessels Unplanned maintenance from outside New Jersey Maintenance jack-ups from outside New Jersey Spares and consumables from outside New Jersey	Planned maintenance undertaken from crew transfer vessels Unplanned maintenance from outside New Jersey Maintenance jack-ups from outside New Jersey Spares and consumables from outside New Jersey	Planned maintenance undertaken from crew transfer vessels Unplanned maintenance from outside New Jersey Maintenance jack-ups from outside New Jersey Spares and consumables from outside New Jersey	Planned maintenance undertaken from New Jersey from service operations vessels Unplanned maintenance from outside New Jersey Maintenance jack-ups from outside New Jersey Spares and consumables from outside New Jersey

Figure 48 shows the cumulative impact of the six solicitations. Because the jobs are dedicated to the New Jersey wind farms, there is little potential to supply other states' projects.

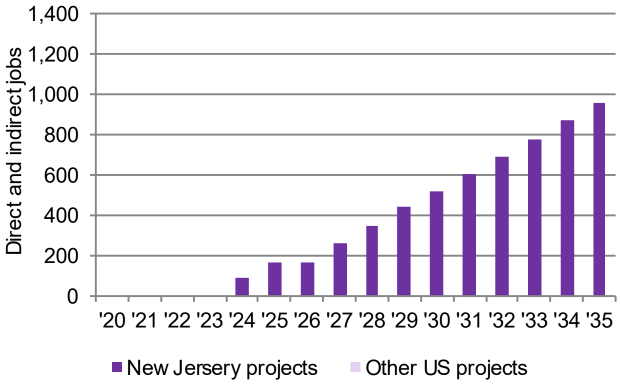

Figure 48: Job creation in New Jersey from turbine maintenance and service under the Lowest LCOE scenario.

Figure 49 shows that the presence of a blade factory creates local jobs. Most of these will because the factory supports a local capability in composites and so blade repair, which will find a market outside New Jersey.

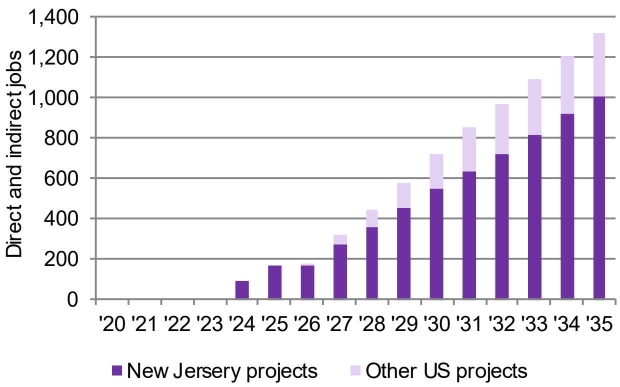

Figure 49: Job creation in New Jersey from turbine maintenance and service under the Balanced scenario.

Workforce Development

In most cases the turbine supplier employs technicians locally for the duration of its service agreement with the developer. On expiry, the agreement may be extended, or the technicians transferred to the developer.

Since these skills are unlikely to be available currently in New Jersey, workforce development is a high priority. The turbine contract will be placed about three years before operation, which will give adequate time to recruit and train. The turbine supplier and developer will both be keen to ensure that a local workforce is recruited to help ensure long term continuity in the wind farm team. They will want to work with local training providers to help build a skills base. They will see military veterans as individuals well suited to the work.

6.11. Balance of Plant Maintenance and Service

Subsea cable faults are a major concern for developers because of the impact they have on wind farm production. They are the single biggest source of insurance claims in the industry. The source of the problem may be handling during installation or damage from fishing or mechanical loads on cables exposed due to seabed movements.

For array cables, the time taken to identify the fault and repair it usually means that it is cost effective to replace the whole cable. For export cables, once the fault location is found, the cable is cut and lifted onto the vessel deck where a new section of cable is inserted with a joint at each end. It is then carefully lowered and buried.

Foundations for wind turbines and offshore substations require structural inspection and maintenance on a regular basis. The mix of atmospheric, marine, and biological corrosion can cause damage that is both expensive and difficult to repair. Inspections map the thickness of the foundations, check seals and corrosion projects, take silt samples and check scour (erosion of the seabed around the foundations). Inspections can be completed by commercial divers, fixed video cameras or remotely operated vehicles (ROVs) fitted with camera and other remote sensing instruments. Secondary steel structures, for example boat landing systems, ladders and railings, are inspected in addition to the main foundation structure, and these may need regular cleaning of bird guano.

Workforce

Figure 50 shows that there are a wide range of occupations. Cable repair is the biggest source of employment and the work needs a range of roles from the manufacture of replacement cables and joints to the work involved in replacing or repairing the cables offshore.

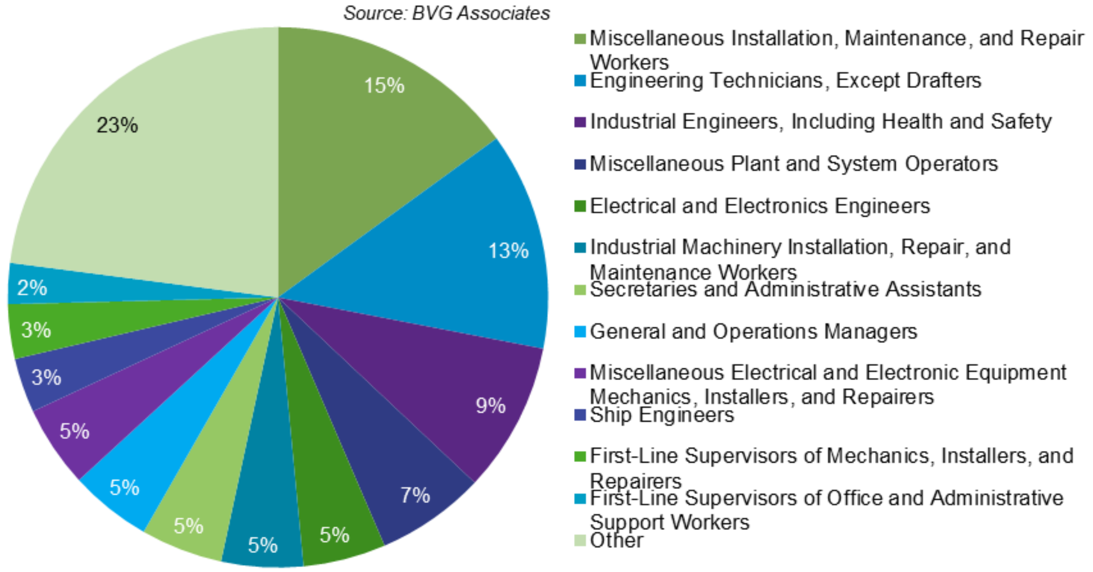

Figure 50: Occupations in balance of plant maintenance and service.

Localization

Dependency on Coastal Infrastructure

Contractors will need quayside access to undertake the work, but they do not need permanent facilities within a port.

Availability of Suitable NJ Coastal Infrastructure

The operations base will provide the necessary infrastructure.

Logistical Benefit of Local Supply

Suppliers will value being close to their customers but there is no significant logistical benefit.

Market Threshold for Investment

Suppliers can invest incrementally to meet demand. They may need to invest in ROVs, which can be a significant outlay for a small business.

Interdependencies with Other Sectors

Suppliers will also be active in the offshore oil and gas and telecoms markets.

Lower Tier Opportunities

There are some opportunities in the supply chain supplying a range of services to support the work offshore.

Our assessments are illustrated in Figure 51.

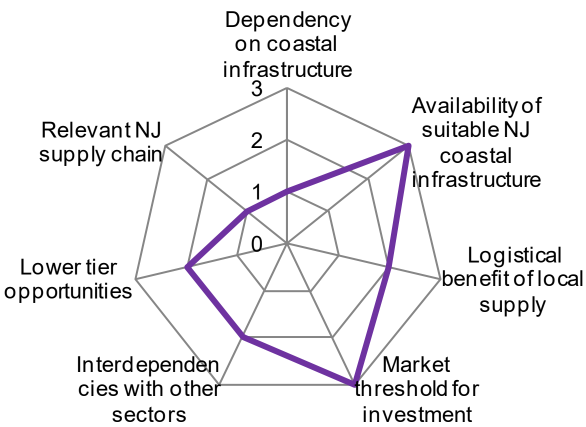

Figure 51: Assessment of balance of plant maintenance and service.

The scenarios developed from this analysis are shown in Table 18. For both scenarios, the work is undertaken from New Jersey using suppliers elsewhere.

Table 18: Localization of supply chain for balance of plant maintenance for 7.5GW at 2035.

Scenario	Solicitation 1	Solicitation 2	Solicitation 3	Solicitations 4-6
A: Balanced	Substation maintenance undertaken from New Jersey from crew transfer vessels Cable maintenance from outside New Jersey Foundation maintenance from outside New Jersey	Substation maintenance undertaken from New Jersey from crew transfer vessels Cable maintenance from outside New Jersey Foundation maintenance from New Jersey from crew transfer vessels	Substation maintenance undertaken from New Jersey from crew transfer vessels Cable maintenance from outside New Jersey Foundation maintenance from New Jersey from crew transfer vessels	Substation maintenance undertaken from New Jersey from Service Operations Vessels Cable maintenance from outside New Jersey Foundation maintenance from New Jersey from Service Operations Vessels
B: Lowest LCOE	Substation maintenance undertaken from New Jersey from crew transfer vessels Cable maintenance from outside New Jersey Foundation maintenance from outside New Jersey	Substation maintenance undertaken from New Jersey from crew transfer vessels Cable maintenance from outside New Jersey Foundation maintenance from outside New Jersey	Substation maintenance undertaken from New Jersey from crew transfer vessels Cable maintenance from outside New Jersey Foundation maintenance from outside New Jersey	Substation maintenance undertaken from New Jersey from crew transfer vessels Cable maintenance from outside New Jersey Foundation maintenance from outside New Jersey from crew transfer vessel

Figure 52 shows that there are a small number of jobs associated with substation maintenance and support provided by New Jersey companies to contractors undertaking other balance of plant maintenance.

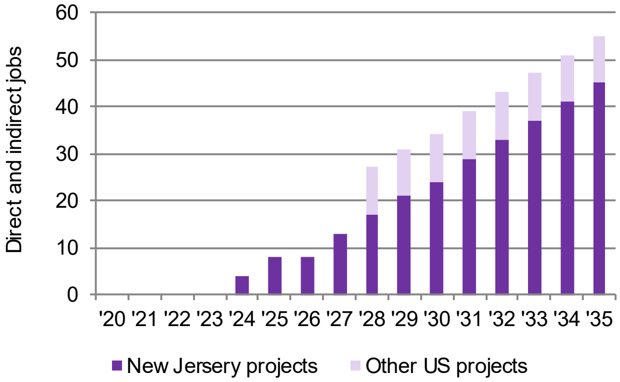

Figure 52: Job creation in New Jersey from balance of plant maintenance and service under the Lowest LCOE scenario.

Workforce Development

The primary demand for workforce development would be associated with cable repairs in the Local scenario and would form part of the workforce development of the cable factory (see Section 6.4).

6.12. Summary 7.5GW by 2035

Some supply elements such as project management and development, onshore works, wind farm operation, turbine maintenance and BOP maintenance are likely to have high local content without any state investment. Some state investments may improve their local content. The supply elements were state investment is most likely to make a significant difference in local content are in manufacturing of turbine nacelles and hubs, turbine blades, turbine towers, and especially foundations. Table 19 shows when state investment might result in New Jersey manufacturing.

Table 19: Summary of New Jersey supply chain elements supply that might be achieved through New Jersey state investments.

Key:	
	No New Jersey supply
	Supply establishing or supply of part of supply chain element in New Jersey
	Supply from New Jersey significant in East Coast market for full supply chain element

	2022-2024	2025-2027	2028-2029	2030-2031	2032-2033	2034-2035
Solicitation	1	2	3	4	5	6
Turbine nacelles & hubs						
Turbine blades						
Turbine towers						
Foundation						

Below we summarize the amount of local content arising from the two scenarios. For local content to be 100% all activities in the supply chain including raw material extraction and even the tooling and energy used to do that would need to happen in New Jersey however, this is seldom the case. For example, the materials for blades account for about half of their content. If no materials are sourced from New Jersey, the maximum that the blade development and manufacturing process can achieve would be a local content of 50%. New Jersey has an established composites industry, so some material supply is possible. Where the material is steel there is less opportunity to get material supplies in state.

Scenario A: Balanced

Table 20 summarizes the amount of New Jersey supply that would be expected under Scenario A. It shows that most of the New Jersey content is in the wind farms built as a result of the New Jersey solicitations. The main opportunity to supply other projects comes from the construction of a blade factory that will be built to supply the whole US east coast market. New Jersey manufactured monopiles and towers will also supply other projects. The New Jersey solicitations make up about a fifth of solicitations to 2035 and so even a 10% New Jersey content in other East Coast projects will translate to significant supply chain activity in New Jersey.

Figure 53 shows that the main sources of jobs under this scenario are from project management and development and turbine blades. Because there is little supply to other states' projects, other than OMS, the employment levels are not sustained at the end construction of the sixth solicitation.

Table 21 summarizes the job years for New Jersey to the end of 2035. jobs endure for the lifetime of the wind farm, at least 25 years to 2060. Operations, maintenance and service jobs will endure for the lifetime of the wind farm, at least 25 years so out to 2060 for solicitation 6.

Table 20: Summary of New Jersey supply chain for Scenario A – Balanced.

Key:	
	No New Jersey supply
	Low New Jersey content (0-10%)
	Medium New Jersey content (>10%-30%)
	High New Jersey content (>30%)

In period	2022-2024		2025-2027		2028-2029		2030-2031		2032-2033		2034-2035	
Solicitation	1		2		3		4		5		6	
Main supply element	NJ	Other EC	NJ	Other EC	NJ	Other EC	NJ	Other EC	NJ	Other EC	NJ	Other EC
Project M&D	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Turbine nacelle & hub	None	None	Low	None	High	Medium	High	Medium	High	Medium	High	Medium
Turbine blades	None	None	High	High	High	High	High	High	High	High	High	High
Turbine tower	Low	Low	Low	Low	High	Low	High	Low	High	Low	High	Low
Foundations	Medium	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Subsea cables	None	None	None	None	None	None	None	None	None	None	None	None
Substation structure	Low	None	Low	None	Low	None	Low	None	Low	None	Low	None
Substation electrical	None	None	None	None	None	None	None	None	None	None	None	None
Subsea cable install	Low	None	Low	None	Low	None	Low	None	Low	None	Low	None
Foundation install	Low	None	Low	None	Low	None	Low	None	Low	None	Low	None
Turbine installation	Low	None	Low	None	Low	None	Low	None	Low	None	Low	None
Onshore works	High	None	High	None	High	None	High	None	High	None	High	None
Wind farm operations	High	None	High	None	High	None	High	None	High	None	High	None
Turbine maintenance	High	None	High	None	High	None	High	None	High	None	High	None
BOP maintenance	Medium	Low	Medium	Low	Medium	Low	Medium	Low	Medium	Low	Medium	Low

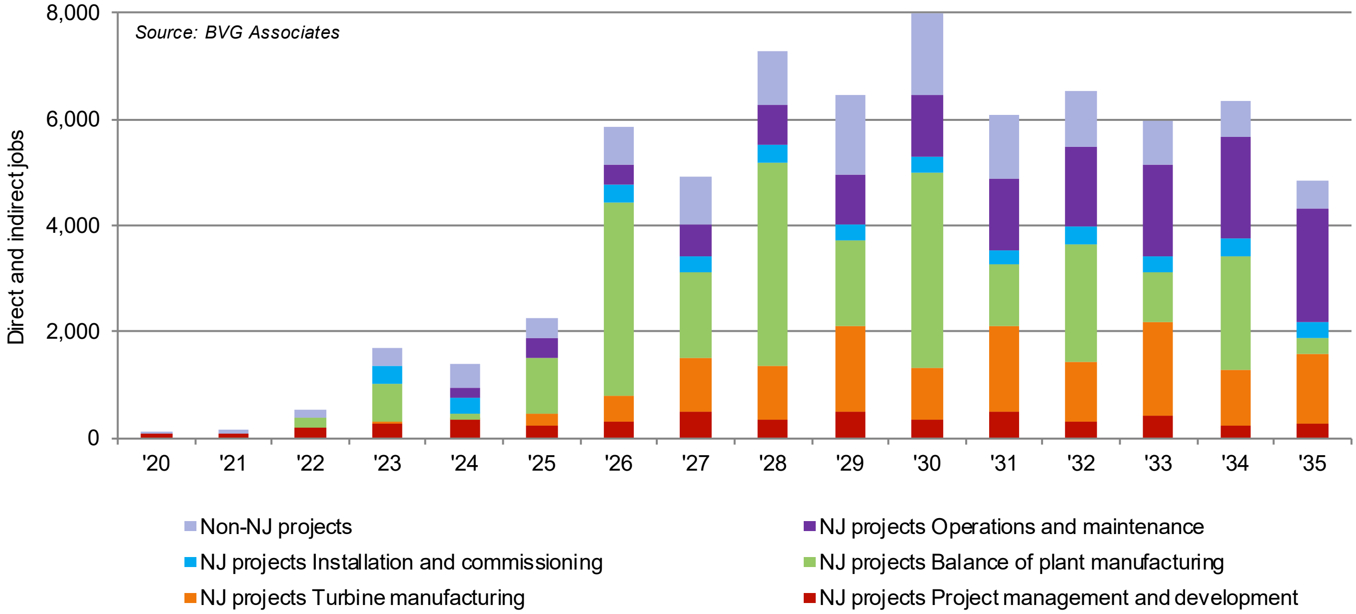

Figure 53: Jobs created under the Balanced scenario to end 2035 by main supply element.

Table 21: Jobs created under the Balanced scenario by standard occupational job type.

Job type	Total jobs to end 2035 (FTE job years)	Average FTE jobs (2020-2035)
Production Occupations	29,026	1,814
Management Occupations	11,038	690
Installation, Maintenance, and Repair Occupations	8,757	547
Architecture and Engineering Occupations	5,469	342
Business and Financial Operations Occupations	3,227	202
Transportation and Material Moving Occupations	3,842	240
Office and Administrative Support Occupations	2,815	176
Life, Physical, and Social Science Occupations	534	33
Sales and Related Occupations	967	60
Other	2,564	160
Total	**68,240**	**4,265**

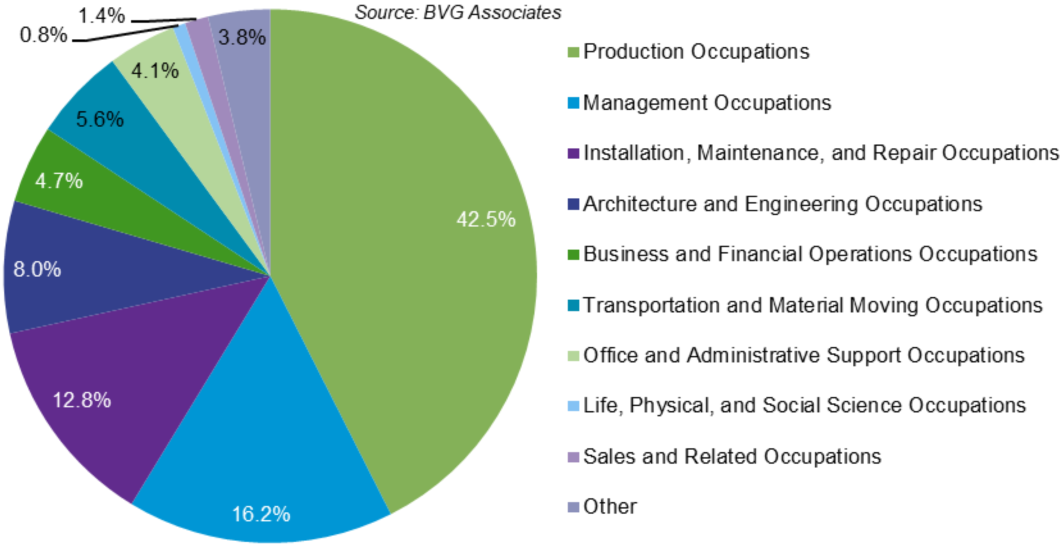

Figure 54: Split of jobs created under the Balanced Scenario.

Scenario B: Lowest LCOE

Table 22 summarizes the amount of New Jersey supply that would be expected under the Lowest LCOE Scenario. New Jersey supply is primarily in those areas where the logistical benefit of local supply is paramount, particularly during construction and operation. There is no manufacturing apart of the infrastructure associated with the onshore substation.

Figure 55 shows that most of the jobs are associated with OMS. Although these are not significant compared with the manufacturing jobs created under the Local Scenario, these jobs endure for the lifetime of the wind farm, at least 25 years so out to 2060 for solicitation 6.

Figure 56 shows the split of jobs by type out to end 2035.

Table 22: Summary of New Jersey supply chain for Scenario B – Lowest LCOE.

Key:	
	Least likely New Jersey supply
	Low New Jersey content (0-10%)
	Medium New Jersey content (>10%-30%)
	High New Jersey content (>30%)

In period	**2022-2024**		**2025-2027**		**2028-2029**		**2030-2031**		**2032-2033**		**2034-2035**	
Main supply element	NJ	Other EC	NJ	Other EC	NJ	Other EC	NJ	Other EC	NJ	Other EC	NJ	Other EC
Project M&D												
Turbine nacelle & hub												
Turbine blades												
Turbine tower												

In period	2022-2024		2025-2027		2028-2029		2030-2031		2032-2033		2034-2035	
Foundations												
Subsea cables												
Substation structure												
Substation electrical												
Subsea cable install												
Foundation install												
Turbine installation												
Onshore works												
Wind farm operations												
Turbine maintenance												
BOP maintenance												

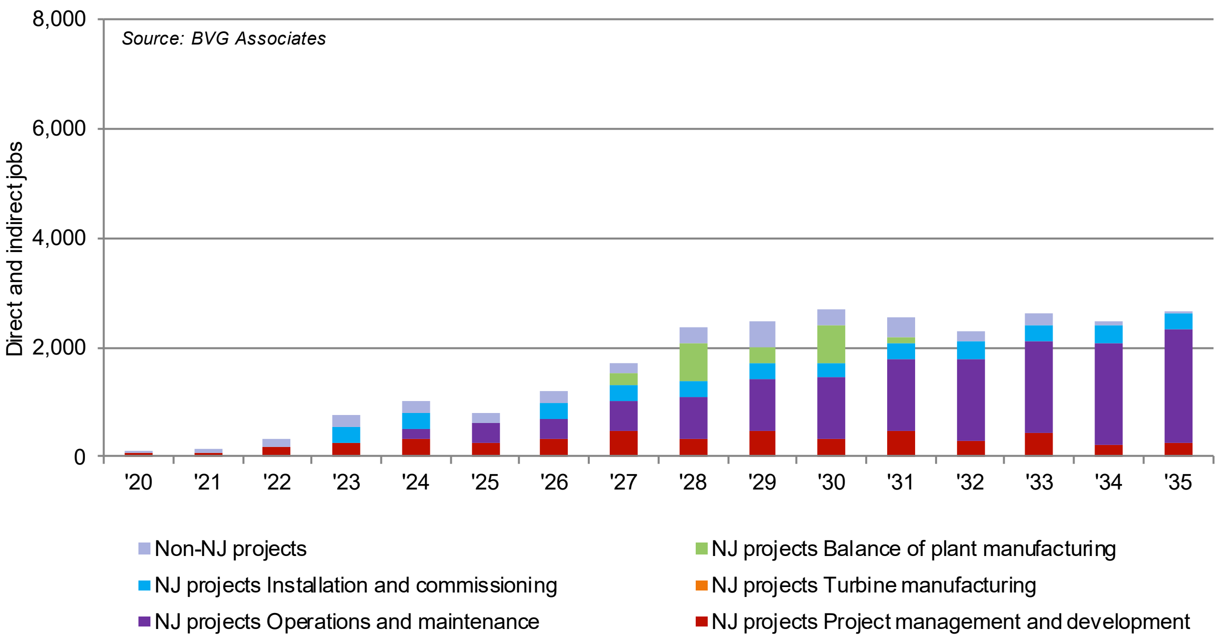

Figure 55: Jobs created under the Lowest LCOE scenario.

Table 23: Jobs created under the Lowest LCOE scenario to end 2035.

Job type	Total jobs to end 2035 (FTE job years)	Average FTE jobs (2020-2035)
Production Occupations	3,392	212
Management Occupations	6,778	424
Installation, Maintenance, and Repair Occupations	6,224	389
Architecture and Engineering Occupations	2,981	186
Business and Financial Operations Occupations	1,577	99
Transportation and Material Moving Occupations	1,993	125
Office and Administrative Support Occupations	1,446	90
Life, Physical, and Social Science Occupations	399	25
Sales and Related Occupations	251	16
Other	1,269	79
Total	22,918	1,432

Source: BVG Associates

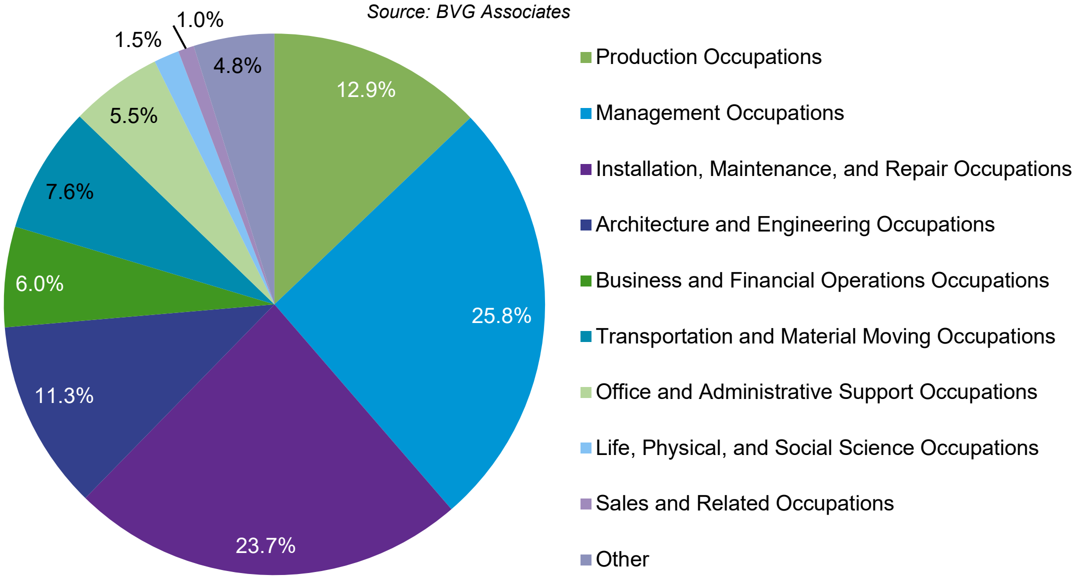

Figure 56: Split of jobs created under the Lowest LCOE Scenario.

Appendix A: Standard Occupational Classification Major Groups

- Production Occupations
- Installation, Maintenance, and Repair Occupations
- Life, Physical, and Social Science Occupations
- Construction and Extraction Occupations
- Architecture and Engineering Occupations
- Transportation and Material Moving Occupations
- Management Occupations
- Business and Financial Operations Occupations
- Office and Administrative Support Occupations
- Sales and Related Occupations
- Computer and Mathematical Occupations
- Educational Instruction and Library Occupations
- Legal Occupations
- Arts, Design, Entertainment, Sports, and Media Occupations
- Community and Social Service Occupations
- Healthcare Practitioners and Technical Occupations
- Healthcare Support Occupations
- Protective Service Occupations
- Food Preparation and Serving Related Occupations
- Building and Grounds Cleaning and Maintenance Occupations
- Personal Care and Service Occupations
- Farming, Fishing, and Forestry Occupations
- Military Specific Occupations

APPENDIX D

New Jersey Ports and Harbors Evaluation

> > >

DRAFT

Intended for:
New Jersey Board of Public Utilities

Prepared By:
Ramboll US Corporation
Newark, New Jersey

Date:
June 2020

NEW JERSEY PORTS AND HARBORS EVALUATION

OFFSHORE WIND SUPPLY CHAIN

RAMBOLL

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APPENDICES

Appendix A: Preliminary New Jersey Port Matrix

1. EXECUTIVE SUMMARY

At the request of New Jersey Board of Public Utilities (NJBPU), Ramboll conducted a Preliminary Ports and Harbors Evaluation Report (Preliminary Report) in early 2019 to assist the New Jersey Economic Development Agency (NJEDA) in identifying potential properties suitable for marshaling, manufacturing, and operations & maintenance (O&M) facilities to support the offshore wind energy industry in the State of New Jersey. This initial assessment was also to support NJBPU's initial 1,100-megawatt (MW) solicitation and Offshore Wind Strategic Plan (OWSP) to develop 3,500 MW of offshore wind energy.

In November 2019, the NJBU was tasked by Governor Murphy to complete the OWSP based on New Jersey's new offshore wind goal—7,500 MW of offshore wind energy by 2035. Based on the new goal, Ramboll has updated the Preliminary Report and added relevant analyses in this New Jersey Ports and Harbor Evaluation (Evaluation). The Evaluation includes an update to New Jersey port assessments based on the current plans for offshore wind and port development in the state. It includes updates to the Preliminary Report in regard to current potential ports available for supporting the OWSP for 7,500 MW by 2035.

This report is based on current publicly available information at the time of each assessment. As the offshore wind market develops, port availability may change accordingly. Inclusion or exclusion of potential sites in this Evaluation does not preclude other alternative development or sites from consideration.

Ramboll evaluated potential properties for future port and harbors development based on:

- Waterfront access
- Size of property
- Depth of existing berth
- Depth of nearby navigational channel
- Air draft (i.e. bridges causing vertical limitations)
- Availability for future development as an offshore wind port

Ramboll initially examined 38 properties to be potentially developed for offshore wind use and screened out 18 of these shoreline properties based on the six selection criteria listed above. Twenty sites were then evaluated in more detail. Of the twenty sites, several sites were selected for deeper evaluation based on their potential for use in marshaling, manufacturing, and operations and maintenance (O&M). The following 13 properties were selected for further evaluation:

- Werner Generating Station located in South Amboy (Northern New Jersey)
- Chemours Chamber Works/Carney's Point located in Pennsville Township (Southern New Jersey).
- Paulsboro Marine Terminal in Paulsboro (Southern New Jersey)
- Lower Alloways Creek site (Hope Creek - Artificial Island) in Lower Alloway Creek Township (Southern New Jersey
- Military Ocean Terminal at Bayonne (MOTBY) in Bayonne (Northern New Jersey)

- Chemours site in Linden (Northern New Jersey)
- Former DuPont site (Repauno) in Greenwich Township (Southern New Jersey)
- Gardner's Basin in Atlantic City (Atlantic Coast)
- Cape May-Lewes Ferry in Cape May (Atlantic Coast)
- North New Jersey Ave in Atlantic City (Atlantic Coast)
- North & McLester in Elizabeth (Northern New Jersey)
- Construction & Marine Equipment in Elizabeth (Northern New Jersey)
- Naval Weapons Station Earle (Northern New Jersey)

For each of the above sites, this report summarizes existing site conditions, discusses potential offshore wind use, and provides estimated costs associated with reuse scenarios. Several sites were identified as potential marshaling and/or manufacturing ports, while others may be more suited for O&M support. Most, if not all sites, require significant upgrades to accommodate offshore wind uses and it unlikely that many of these sites would be available for full use for the construction of New Jersey's first major offshore project – Ørsted's Ocean Wind project for 1,100 MW of energy.

The Evaluation looks at both existing and undeveloped port sites. The principal advantages of focusing on existing terminals are: 1) these properties already have terminal operators who understand the business of port operations and are in a better position to expand the operations to include offshore wind; 2) marine terminal operators already have existing relationship with the regulatory agencies that issue the permits, licenses, and other approvals necessary to allow for future expansion; and 3) existing ports have trained workforces experienced in port operations. However, existing ports typically have ongoing operations for other industries, and may not be readily available for large scale offshore wind related uses. Building new port and harbor infrastructure on properties with no current port terminal operations would be very difficult to meet the expedited schedule for this initial 1,100 MW tranche. However, new sites create the opportunity to develop for offshore-specific uses over the long term and also avoid conflict with ongoing uses at existing ports.

It is important to note that the development of any port will require a full assessment of potential environmental impacts from activities such as waterfront construction, dredging and site disturbance. Environment assessments will be done as each specific site is developed and environmental assessments for each offshore project development impacts will also be required. This Evaluation does not assess potential environmental impacts of developing each port site.

The Evaluation focuses on the current New Jersey goal of 7,500 MW and the state's plans to identify ports which will support offshore wind projects. New Jersey has currently identified two major ports for initial offshore wind and supply chain development. The Port of Paulsboro, located in Southern New Jersey along the Delaware River, has been identified as a potential staging and manufacturing site for foundation or other components used in the initial phase of New Jersey offshore wind development. The port is currently being upgraded to potentially accommodate these anticipated uses.

Governor Murphy has also recently announced that the Lower Alloways Creek Site will be developed by New Jersey and others as a manufacturing and marshaling site. The Lower Alloways Creek site is a vacant artificial island located near Hancock Bridge on the Delaware River in Southern New Jersey.

The site is a former US Army Corps of Engineer's dredge spoil site with approximate 320 acres and is owned by the Public Service Enterprise Group (PSEG). Because of its size, location, and, importantly, its unlimited air draft restrictions, NJBPU and NJEDA have identified Lower Alloways Creek as a likely site to be developed into a major offshore wind manufacturing and marshaling site.

2. INTRODUCTION

Per the request of the NJBPU, the purpose of this report is to provide an initial evaluation of facilities which could be potentially utilized as marshaling, manufacturing, and /or operations and maintenance (O&M) ports for developing the New Jersey offshore wind (OSW) market sector. Ramboll completed the original assessment in 2019 and updated this report to consider New Jersey's revised goal of 7,500 MW of offshore wind energy by 2035, which was announced by Governor Murphy in November 2019. Ramboll evaluated publicly available resources on New Jersey ports/facilities together with OSW supply chain infrastructure requirements and consulted with NJBPU and NJEDA regarding the development of offshore wind port support in the state.

2.1 East Coast Offshore Wind Port Development

Although this Evaluation only assesses New Jersey sites, it is important to note that the expanded interest in offshore wind across most Mid-Atlantic and New England States has resulted in several ports outside of New Jersey being identified for offshore wind use and development. Other ports along the East Coast region have either received funding or are seeking investment to become purpose-build offshore wind ports. Development of New Jersey ports will support projects in other states, and conversely, other state ports may be used to support New Jersey offshore wind solicitations. Potential regional ports for offshore wind include, but are not limited to:

Massachusetts

- New Bedford Marine Commerce Terminal
- Brayton Point

Connecticut

- New London
- Bridgeport

Rhode Island

- Quansett

New York

- Port of Albany
- Port of Coeymans
- South Brooklyn Marine Terminal
- Port Ivory
- Arthur Kill Terminal

Maryland

- Sparrow's Point

Delaware

- Port of Wilmington

Virginia

- Hampton Roads Ports

2.2 Offshore Wind Foundation Technology

The type and size of offshore wind foundation that will be used for New Jersey project is important when evaluating which ports can support manufacturing, assembling and staging od foundations. Because foundations are large and require manufacturing and assembly processes, ports that can accommodate this activity are desired. Port requirements and specifications will vary depending on the type of foundations utilized by the developer. This report does not evaluate port requirements for floating foundation concepts which have different requirements. The three most common types of fixed bottom foundations are monopiles, jackets and gravity-based structures (GBS). Figure 1 below depicts each.

Monopiles - The first East Coast offshore wind project approved for federal waters will use monopiles. Monopiles are fabricated by rolling steel plate, typically in a highly efficient automated manufacturing facility. A crane installation vessel is used to transport and position the monopiles, which are then driven into the seabed by a large hydraulic hammer. The transition piece is mounted on top of the monopile foundation. The pile driving installation method emits noise, which can impact marine wildlife. Scour protection, such as rock, is typically placed around the base of the monopile. Local content for monopiles could include rolling and welding of large diameter steel tubulars, final assembly of pre-fabricated can sections, scour protection, and fabrication of secondary steel.

Jacket - Jacket fabrication can vary between assembling one complete side of the jacket at a time and then assembling the jacket lying down or assembling the jacket in an upper and lower part and then mating the two parts. This process is typically more labor intensive than monopile manufacturing. For installation, the piles are driven using a hydraulic hammer and then a heavy lift crane vessel is used to position the jacket onto the piles. The hydraulic hammer used to install jacket piles is smaller than that used for monopiles, thus, less noise is emitted. However, the noise emission can still impact local wildlife and noise mitigation methods can be utilized. Scour protection is typically placed around the base of the jacket. Local content for jackets could include scour protection, rolling and welding of piles and steel tubulars for jacket lattice; and fabrication and welding of jacket, transition piece, and other secondary steel.

Gravity-based structure (GBS) - The most recent GBS foundation project was commissioned in 2013. Earlier offshore wind farms used smaller turbines and were generally in shallower waters. GBS have now been proposed for use projects in deeper water with larger turbines. The fabrication of GBS is labor intensive and time consuming but does not require a specialized manufacturing facility. The GBS is typically either floated and pulled by tugs or placed on a semi-submersible barge to be transported from manufacturing location to installation site. The seabed must be prepared by excavation and installation of a stone bedding. When the GBS reaches its final location, the conical void is filled with ballast material. The installation of GBS creates less noise than pile driving required for other structures but may require a larger area of disturbance on the sea floor. Local content for GBS could include: fabrication of the concrete structures and secondary steel, scour protection, and ballasting operations.

There are also other promising variants of monopile and jacket foundation concepts that use large buckets at the base of the structure to suck them silently into the seabed instead of using a large noisy hammer to drive piles. Floating foundation technology is also being developed for offshore wind and will likely become the preferred technology for deeper waters.

Figure 1: Foundation Concepts Including Jacket, Monopiles, and Gravity-based

2.3 OSW Facility Requirements

Table 1 below summaries the port parameters required by OSW use.

Table 1: High-Level Port Requirements for Each Use

Activity/Use	Size (acres)	Air Draft[1] (feet)	Depth of Channel[2] (feet)	Depth at Berth (feet)	Quayside Length (feet)	Quayside Load Bearing Capacity (psf)
Marshaling	30 to 100	430 to unlimited[3]	20 to 50	20 to 40	660 to 1,200	4,000 to 5,000
O&M	2 to 15	20 to 30	18 to 23	20 to 25	165 to 330	N/A
Cables	15 to 30	100 to 250	20 to 34	20 to 34	300 to 400	1,500 to 3,000
Monopiles	20 to 50	100 to 250	20 to 34	20 to 34	290 to 660	1,500 to 4,000
Jacket Foundations	35 to 100	130 to 300	20 to 34	20 to 35	600 to 1,200	3,000 to 5,000
Gravity Foundations	25 to 100	80 to 195	13 to 55	13 to 55	200 to 600	2,000 to 4,000
Tower Sections	30 to 50	100 to 250	20 to 34	22 to 34	330 to 660	1,500 to 3,500
Blades	35 to 75	70 to 100	20 to 34	22 to 34	550 to 800	1,000 to 4,000
Nacelles	15 to 30	75 to 120	24 to 36	22 to 34	330 to 1,000	1,500 to 4,000
Substation	30 to 50	100 to 430	20 to 50	20 to 40	200 to 550	3,000 to 4,000

Notes: psf-pounds per square foot

2.4 Initial Facility Screening

As part of this preliminary evaluation, Ramboll examined 38 properties to be potentially developed for OSW use and screened out 18 of these shoreline properties based on the selection criteria listed above. Only ports within 50 nautical miles of an OSW lease area were considered for O&M-use

[1] Due to Jones Act issues, the ports / facilities for the early projects will not likely support use of jack up vessels as such US-flagged vessels will not be available. As such, the early projects will likely be serviced via a feeder barge system which negates air-gap issues. However, later OSW projects will likely be supported by US-flagged vessels and air-gap restriction issues become more critical

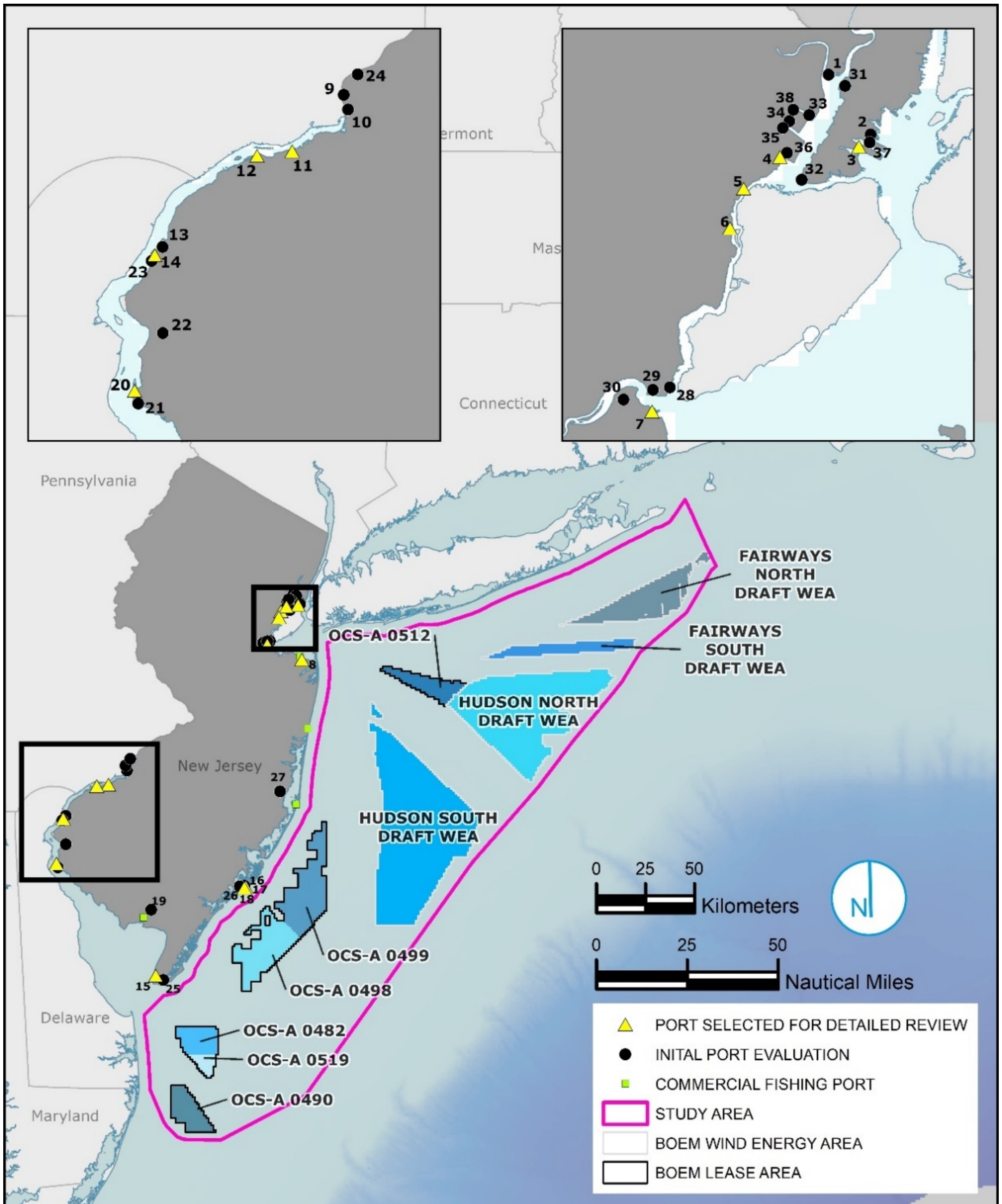
[2] 20 ft draft required for barges, 34 ft draft required for cargo vessels

[3] Air draft required for multiple tower sections to be transported upright and connected

development. As indicated in Figure 2, the offshore wind lease areas considered in this study included:

- OCS-A 0498 – leased by Ocean Wind LLC (Ørsted)
- OCS-A 0499 – leased by Atlantic Shores Offshore Wind, LLC (a 50:50 joint venture between Shell New Energies US LLC and EDF Renewables North America)
- OCS-A 0512 – leased by Equinor Wind US LLC; location of the Boardwalk Wind and Empire Wind projects
- OCS-A 0482 – leased by Garden State Offshore Energy, LLC (GSOE I, LLC), a joint venture between Ørsted and PSEG
- OCS-A 0519 – leased by Skipjack Offshore Energy, LLC, a joint venture between Ørsted and PSEG
- OCS-A 0490 – leased by US Wind, Inc
- Fairways North Draft WEA
- Fairways South Draft WEA
- Hudson North Draft WEA
- Hudson South Draft WEA

Figure 2 also depicts the 38 sites originally assessed and those selected for detailed review.



1- Veckridge Chemical
2- Weeks Marine
3- Military Ocean Terminal, Bayonne
4- North & McLester
5- Construction & Marine Equipment
6- Chemours Co., Linden
7- Werner Power Station
8- Naval Weapons Station Earle
9 - Balzano Marine Terminal
10- Broadway Marine Terminal
11- Port of Paulsboro
12- Dupont Repauno
13- Chemours Carney's Point
14- Chemours Chambers Works
15- Cape May Ferry
16- Atlantic City Marina District
17- Gardner's Basin
18- Atlantic City NNJ Ave
19- Dorchester Shipyard
20- Lower Alloways Creek
21- Hope Creek Generating Station
22- Salem Terminal
23- Calpine Power Plant
24- Petty Island
25- Schellengers Landing
26- Golden Nugget
27- Oyster Creek Nuclear Power Plant
28- Port of Perth Amboy
29- Perth Amboy Point
30- Chevalier Avenue Brownfield
31- Bayfront
32- Bayonne Bridge Point
33- Foreign Auto Preparation
34- Port Newark Container Terminal
35- Maher Terminals
36- APM Terminals
37- GCT Port Jersey
38- Red Hook Newark

Figure 2: Ports Overview

The 18 ports that were initially screened out as unsuitable or unlikely to be repurposed for OSW use are listed in Table 2 below.

Table 2: Ports Not Selected for Further Review

Site Name	Location	Rationale
Chevalier Avenue Brownfield	Chevalier Avenue, Sayreville, NJ	Not viable due to location upstream of a narrow swing bridge.
Bayonne Bridge Point	Avenue A & West 1st Street, Bayonne, NJ	Site is not available; being redeveloped for residential and parkland use.
Global Container Terminal (GCT), Bayonne (Port Jersey)	302 Port Jersey Boulevard, Jersey City, NJ	Site is unlikely to be repurposed; currently used as a busy container terminal.
Bayfront	60 Kellogg Street, Jersey City, NJ	Site is unlikely to be repurposed; being developed for residential use.
Foreign Auto Preparation	371 Craneway Street, Newark, NJ	Site is unlikely to be repurposed; currently used as a busy international Roll-On/Roll-Off terminal.
Red Hook Newark	138 Marsh Street, Newark, NJ	Site is unlikely to be repurposed; currently used as a busy container terminal.
Port Newark Container Terminal	241 Calcutta Street, Newark, NJ	Site is unlikely to be repurposed; currently used as a busy container terminal.
Maher Terminals (Port Elizabeth)	1210 Corbin Street, Elizabeth, NJ	Site is unlikely to be repurposed; currently used as a busy container terminal.
APM Terminals (Port Elizabeth)	5080 McLester Street, Elizabeth, NJ	Site is unlikely to be repurposed; currently used as a busy container terminal.
Hope Creek Generating Station Deepwater Point	Alloway Creek Neck Rodd, Hancock's Bridge, NJ	Nuclear power plant present makes development of this site unrealistic. There do not appear to be plans to decommission this plant.
Port of Perth Amboy	260B Front Street, Perth Amboy, NJ	Appears to be small marina. Due to size and use, unlikely that it can be redeveloped for OSW use.

Site Name	Location	Rationale
Perth Amboy Point	Foot of Elm Street, Perth Amboy, NJ	Swing bridge will make this location difficult to redevelop for OSW use.
Schellengers Landing, Cape May, NJ	1111-1115 Route 109; 1121 Route 109; 1129 Route 109; 1139 Route 109; 1145 Route 109; 1149 Route 109, Lower Township, NJ	Marina; would need quayside improvements to handle larger vessels. Too many recreational boats to be viable for offshore wind.
Golden Nugget	North of Absecon Boulevard Bridge, Atlantic City, NJ	Channel is too shallow (2-4 feet deep) and bridges/power cables are too low (26 feet).
Oyster Creek Nuclear Power Plant	741 US 9, Lanoka Harbor, NJ	Route 9 overpasses are very low. Additionally, Fork River and Oyster Creek are both narrow and shallow, making navigation difficult. Note: Ørsted may use this site as a grid connection point.
Salem Terminal	Salem, New Jersey at Exit 1 of the New Jersey Turnpike	Overhead power cables are too low (66 feet). Salem River Channel is too narrow and shallow (150 feet wide by 16 feet deep mean lower low water (MLLW))
Calpine New Jersey Generation, Deepwater Point, NJ	401 North Broadway, Pennsville Township, NJ	Existing closed power plant, not currently available for OSW purposes.
Port of Pennsauken (Petty's Island)	1 Betsy Ross Bridge Plaza, Pennsauken, NJ	Citgo plans to turn over property to New Jersey Natural Lands Trust in 2020, upon remediation completion. New Jersey Lands Trust has been granted a conservation easement for the entire property.

The 20 sites that were selected for further review are summarized with specific evaluation details in Appendix A.

2.5 Ports Selected for Evaluation

Of the 20 ports summarized in Appendix A, the following 13 ports/facilities were selected for a detailed evaluation as part of this report (shown in Figure 3) based on port characteristics and likelihood of development:

- Werner Generating Station located in South Amboy (Northern New Jersey)
- Chemours Chamber Works/Carney’s Point located in Pennsville Township (Southern New Jersey).
- Paulsboro Marine Terminal in Paulsboro (Southern New Jersey)
- Lower Alloways Creek site (Hope Creek - Artificial Island) in Lower Alloway Creek Township (Southern New Jersey
- Military Ocean Terminal at Bayonne (MOTBY) in Bayonne (Northern New Jersey)
- Chemours site in Linden (Northern New Jersey)
- Former DuPont site (Repauno) in Greenwich Township (Southern New Jersey)
- Garner’s Basin in Atlantic City (Atlantic Coast)
- Cape May-Lewes Ferry in Cape May (Atlantic Coast)
- North New Jersey Ave in Atlantic City (Atlantic Coast)
- North & McLester in Elizabeth (Northern New Jersey)
- Construction & Marine Equipment in Elizabeth (Northern New Jersey)
- Naval Weapons Station Earle (Northern New Jersey)

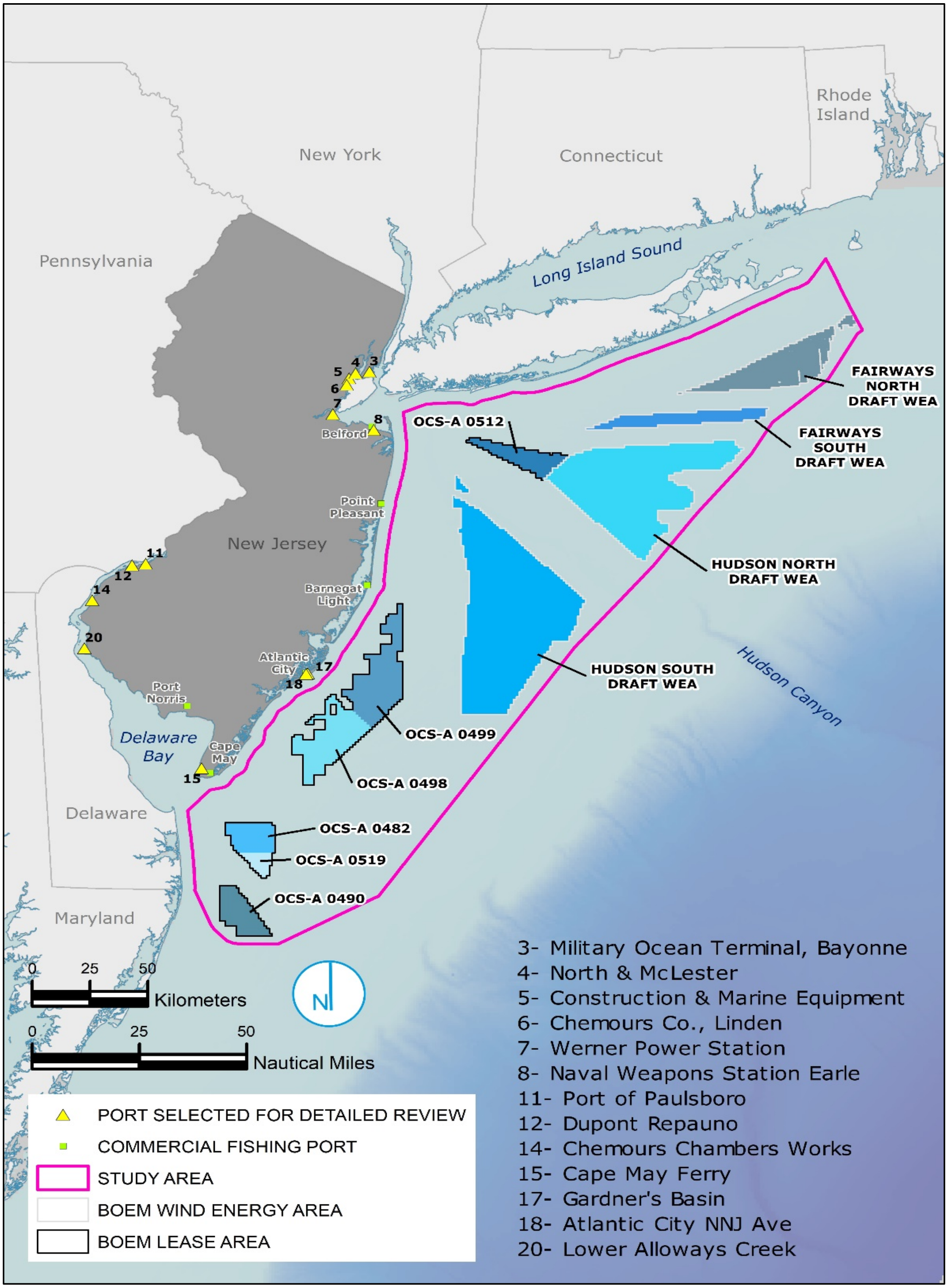


Figure 3: Ports Evaluation Map

The 13 ports selected for further detailed analysis were compared to the suitability parameters provided in Table 1. Table 3 below summarizes each facility's suitability and readiness to support the various OSW components. The readiness of each port/facility was rated green, light green, yellow, orange, or red for each of the eight OSW activities. Sites rated red have hard constraints such as inadequate space, vertical restrictions (bridge or overhead cables), or distance from OSW lease areas. Sites rated orange could be suitable with major improvements (greater than $100M). Sites rated yellow could be suitable with moderate improvements ($25M to $100M). Sites rated light green are suitable with some improvements ($5M to $25M). Sites rated green are suitable with few or no upgrades (less than $5M).

Table 3: Summary of Port Suitability and Readiness

	Werner Generating Station	Chemours Chamber Works (Deepwater)	Paulsboro Marine Terminal	Lower Alloways Creek (Hope Creek)	MOTBY	Chemours (Linden)	Former Dupont – Repauno	Gardners Basin	Cape May-Lewes Ferry	North New Jersey Ave	North & McLester	CME	NWS Earle
Marshaling	O	O	O	O	R	R	O	R	R	R	O	R	R
O&M	LG	R	R	LG	G	LG	R	LG	LG	LG	LG	G	LG
Cables	O	O	Y	O	O	O	Y	R	R	R	O	R	O
Foundations	O	O	Y	O	O	R	Y	R	R	R	O	R	O
Tower Sections	O	O	Y	O	O	R	Y	R	R	R	O	R	O
Blades	O	O	Y	O	O	O	Y	R	R	R	O	R	O
Nacelles	O	O	Y	O	O	O	Y	R	R	R	O	R	O
Substations	O	O	O	O	O	R	O	R	R	R	O	R	O

The suitability for various uses and redevelopment and reuse costs for each port are further discussed in Sections 3 to 15 of this report. Redevelopment costs include preliminary estimated costs to construct a suitable quayside, improve upland load bearing capacity, and dredging, if needed. Reuse scenario costs include additional costs for the site to be suitable for a specific use. Reuse scenario costs include buildings and specialized equipment for a specific use. Costs were estimated in late 2018 and early 2019.

3. PAULSBORO MARINE TERMINAL– PAULSBORO, NJ

3.1 Existing Conditions

The Paulsboro Marine Terminal totals approximately 200 acres and is located at 50A Universal Rd, Paulsboro, NJ (Figure 4). The site is owned by South Jersey Port Corporation and operated by Holt Logistics, LLC. The Paulsboro Marine Terminal is located along the eastern shore of the Delaware River in the southern portion of New Jersey. It is the first major port to be constructed on the Delaware River in over 50 years. The site has a long industrial history including former use as a BP Oil Terminal and Dow Chemical Plant. A wastewater treatment facility is located along the western property boundary. An approximately 5,500 square foot building is located at the site's entrance on Universal Road. A solar panel field is located in the southeastern portion of site. The site is currently being developed by Holt Logistics for use as a cargo terminal. The site layout (Figure 4) and proposed development layouts are provided below.

Figure 4: Paulsboro Marine Terminal - Site Location Map

The site is located across the Delaware River from Philadelphia International Airport. A residential area is located west of the site. Beyond the residential area is the Paulsboro Refinery. A canal, following by an oil terminal are located east of the site. An industrial facility and wetlands are located south of the site. Rail access is available on-site. Route I-295 is located within one mile east of the site.

Water approaches to the site are via the Billingsport Range and Mifflin Range (See Figure 5). The Billingsport Range and Mifflin Range are 40 feet deep MLLW and 800 feet wide. The channels through the Delaware River continue as the Tinicum Range, Eddystone Range, Chester Range, Marcus Hook Range, Bellevue Range, Cherry Island Range, Deepwater Point Range, Bulkhead Bar Range, New Castle Range, Reedy Island Range, Baker Range, and Liston Range, all of which are at least 800 feet wide and 40 feet deep. The 850 quayside is fully utilized. A new 1,500-foot quayside with 1,500 psf uniform live load with reinforced landing pads for mobile harbor crane is being constructed. Approximately 100 acres of the property could potentially be available for OSW use.

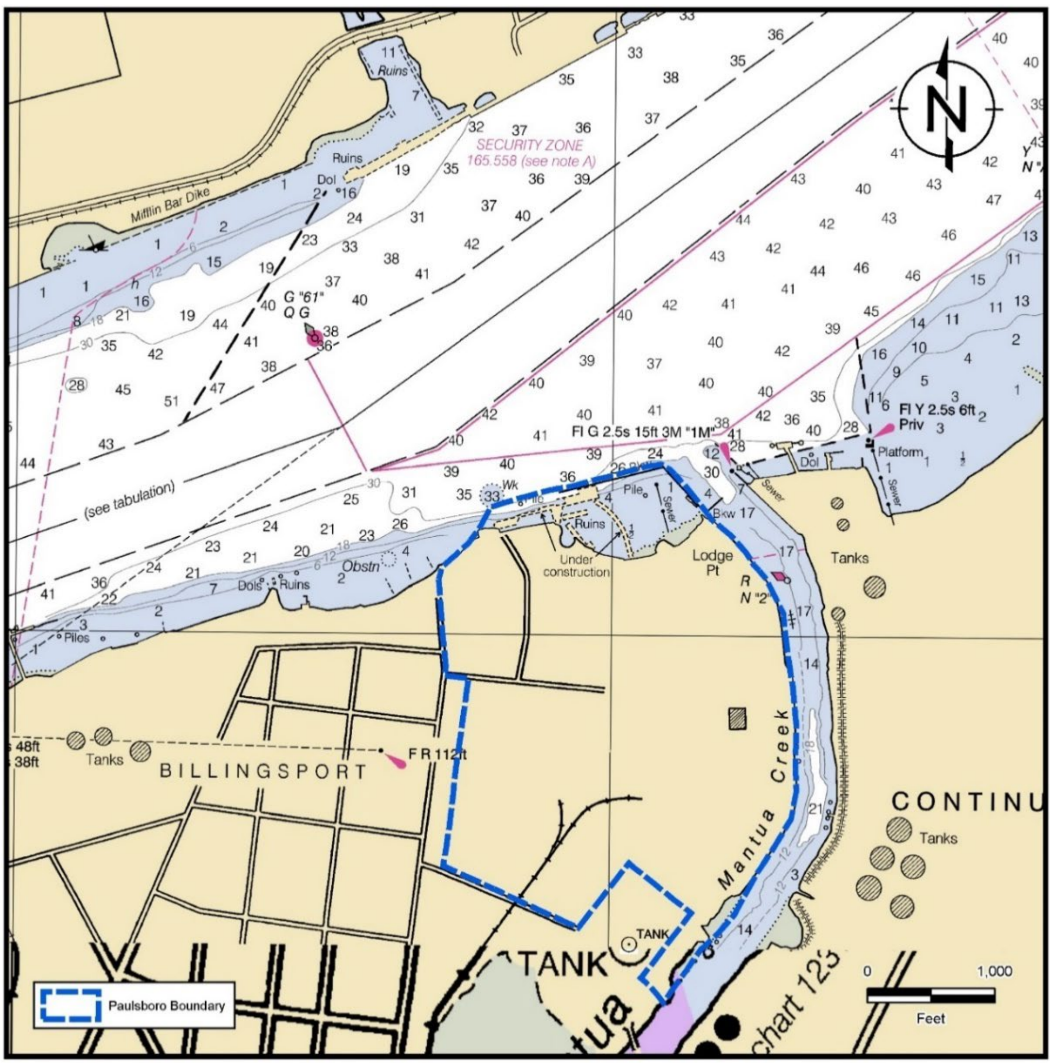


Figure 5: **Paulsboro Marine Terminal - NOAA Depth Chart**

3.2 Limitations

Vertical restrictions between the site and open water include the Commodore Barry Bridge, Delaware Memorial Bridge and overhead cables. The Commodore Barry Bridge has vertical clearances of 190 feet (middle 822 feet) and 181 feet (remainder) and a horizontal clearance of 1,600 feet. The Delaware Memorial Bridge has vertical clearances of 188 feet (middle 800 feet), 175 feet (middle 1,500 feet), and 166 feet (Main Towers) and a horizontal clearance (beam) of 2,000 feet. There are overhead cables which have a vertical clearance of 223 feet. The closest airport is the Philadelphia International Airport located directly across the Delaware River.

3.3 Environmental Conditions

In addition, the site is listed on the New Jersey active sites with confirmed contamination (NJEMS IDs 14643 and 45934).

- NJEMS Site ID 14643; Preferred ID 004975 (BP Oil Inc Paulsboro Terminal) – Remedial actions were initiated on November 1, 1995. The remedial investigation was completed on May 7, 2014. Remedial action essential completed.
- NJEMS Site ID 45934; Preferred ID 005438 (Essex Chemical Corporation) – Remedial actions were initiated on May 1, 1989. The site is required to submit a Remedial Action Protectiveness/Biennial Certification next on December 9, 2020.

Wetlands are present in the northeast corner of the property (Figure 6). Smaller areas of wetlands are located in the southern portion of the property. The southeast portion of the property has areas with habitat-specific requirements. The majority of the site contains threatened habitats. These environmental conditions will need to be considered during development of this property.

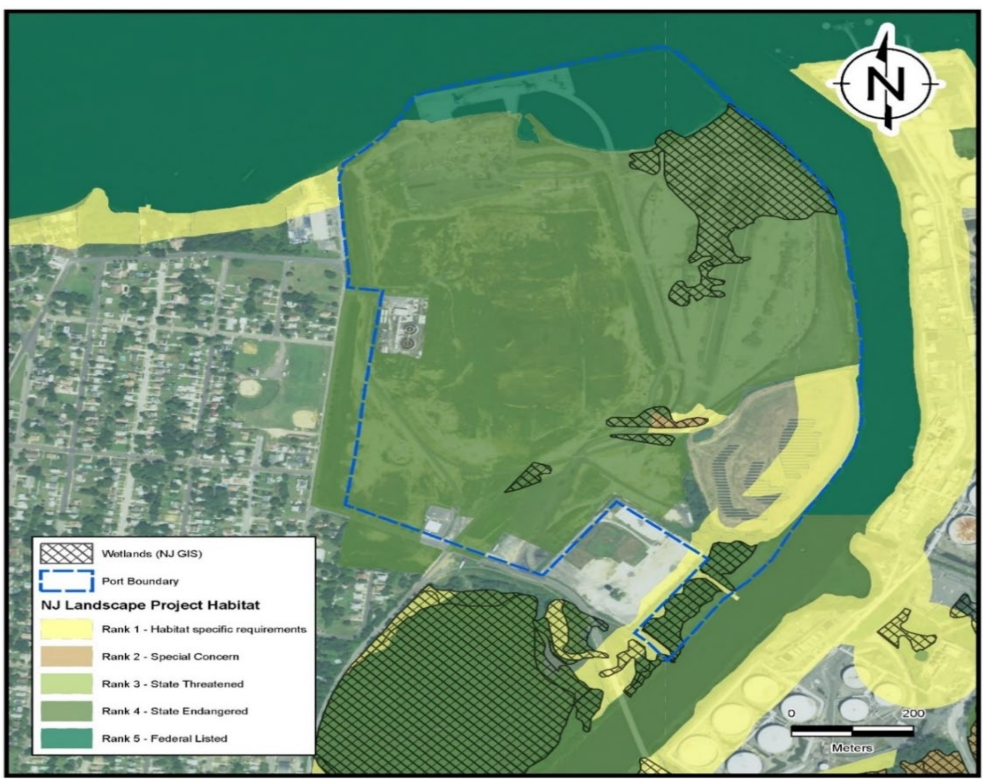


Figure 6: Paulsboro Marine Terminal - Wetlands and Habitat Map

Table 4: Paulsboro Marine Terminal - Summary of Existing Conditions

Size	~200 acres	Up to 200 acres may be available for monopiles or other components, minimal acreage for other uses
Buildings	Solar panels on southeastern parcel. Apparent wastewater settling basins on the western portion of the property. One structure on the southern boundary. Former oil storage and fueling structures have been demolished.	
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	Marginal wharf	
Quayside Length	850 feet (fully utilized); additional 1,500 feet being constructed	
Quayside Load Bearing Capacity*	1,500 psf	
Depth at Potential Quayside locations	40 feet MLLW	
Channel Dimensions	800-1,000 ft wide by 40 ft deep Mifflin Range, Billingsport Range, Tinicum Range, Eddystone Range, Chester Range, Marcus Hook Range, Bellevue Range, Cherry Island Range, Deepwater Point Range, Bulkhead Bar Range, New Castle Range, Reedy Island Range, Baker Range, and Liston Range - 800 feet wide by 40 feet deep MLLW	
Distance to OSW Lease Areas	OCS-A 0490 – 103 nautical miles OCS-A 0519 – 98 nautical miles OCS-A 0482 (Ørsted/PSEG) - 90 nautical miles OCS-A 0498 (Ørsted) – 111 nautical miles OCS-A 0499 (EDF/Shell) - 130 nautical miles Hudson South Draft WEA – 150 nautical miles OSC-A 0512 (Equinor) – 201 nautical miles Hudson North Draft WEA – 202 nautical miles Fairways South Draft WEA – 218 nautical miles Fairways North Draft WEA – 240 nautical miles	
Rail Connection	Rail on-site	

Table 4: Paulsboro Marine Terminal - Summary of Existing Conditions		
Restrictions	Delaware Memorial Bridge: Vert Cl 188 feet (middle 800 feet); Vert Cl 175 feet (middle 1,500 feet); Vert Cl 166 feet (Main Towers); Horizontal Clearance 2,000 feet	
Environmental Conditions	NJEMS Site ID 14643; Preferred ID 004975 (BP Oil Inc Paulsboro Terminal) NJEMS Site ID 45934; Preferred ID 005438 (Essex Chemical Corporation)	
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.		

To meet the needs of marshaling or OSW manufacturing, certain improvements are necessary. Table 9 below provides a cost summary to construct a suitable quayside, complete the required dredging, and improve upland load bearing capacity (50 acres). Given that expansion beyond the 50 acres required by marshaling is possible, a cost to improve the upland load bearing capacity per acre is also provided. Disposal costs are variable, so low and high costs are provided. Cost estimates were completed prior to ongoing work being done at Paulsboro.

Table 5: Paulsboro Marine Terminal - Summary of Redevelopment Costs

	Low Disposal Cost Scenario	High Disposal Cost Scenario
New quayside (1,500 linear feet) – assumes a new quayside is required by the facility to support OSW operations	$57,000,000	$57,000,000
Dredge around quayside to 35 feet	$12,635,760	$44,225,160
Transportation and disposal costs of upland soils, including excavation	$27,225,000	$72,600,000
Placement and compaction of 3 feet of DGA	$18,150,000	$18,150,000
Upland load bearing capacity improvements per acre	$907,500/acre	$1,815,000/acre
20% Contingency	$23,002,152	$38,395,032
Total	**$138,012,912***	**$230,370,192**

*Paulsboro is currently being upgraded to potentially accommodate some offshore wind uses. These upgrades could support port use for cables, foundations, towers, blades, or nacelles. Completion of ongoing upgrades would significantly reduce the above costs.

3.4 Potential Offshore Wind Uses

The Port of Paulsboro is currently being upgraded to potentially accommodate additional offshore wind manufacturing. An additional 1,500 ft quayside is under construction and will have a bearing capacity of 1,500 PSF and roll-off capabilities. With the addition of roll-off capabilities, Paulsboro now has the potential to serve as a manufacturing facility for certain foundations, tower sections, blades, nacelles and cables. A likely use for Paulsboro would be for staging and manufacturing of monopile foundations. Paulsboro may be available for marshaling activities in 2021-2022, and some manufacturing uses in 2023. Paulsboro could be available as early as 2024-25 for full manufacturing of certain offshore wind components. Because of its size, location, and ongoing investments and improvements, the port is a primary site for marshaling and manufacturing.

4. LOWER ALLOWAYS CREEK (HOPE CREEK – ARTIFICIAL ISLAND)

4.1 Existing Conditions

Governor Murphy has recently announced that the 320-acre New Jersey Wind Port (Lower Alloways Creek site) will be developed by New Jersey and others as a manufacturing and marshaling site. Because of its size, location, and, importantly, its unlimited air draft restrictions, this site has been identified to be developed into a major offshore wind port. Construction is planned in two phases, beginning in 2021. Phase 1 will develop a 30-acre site to accommodate marshaling activities and a 25-acre component manufacturing site. Phase 2 adds another 150+ acres to accommodate expanded marshaling activities and extensive manufacturing facilities for turbine components like blades and nacelles. The New Jersey Economic Development Authority (NJEDA) is leading development and is currently considering a range of public, private, and public-private partnership (P3) financing options This first phase of development is expected to be completed in 2023 to support the first phase of offshore wind construction. Because Lower Alloways Creek has a total of 320 acres, New Jersey expects future phases of investment will attract additional manufacturing and marshaling activity at this site, to support full build-out of offshore projects to deliver 7,500 MW by 2035.

Figure 7: New Jersey Wind Port Rendering

The site is located on the eastern shores of the Delaware River. North of the site is the continuation of Artificial Island, owned by the USACE. To the east of the site are wetlands. To the south of the site is the Hope Creek Nuclear Generating Station. No major highways are located in proximity to the site.

Water approaches to the site are via the Baker Range and Liston Range (Figure 8). The Baker Range and Liston Range are 40 feet deep MLLW and 800 feet wide. There is not active quayside at the property; however, there are approximately 8,000 feet of water frontage which could be developed into a quayside to support OSW operations.

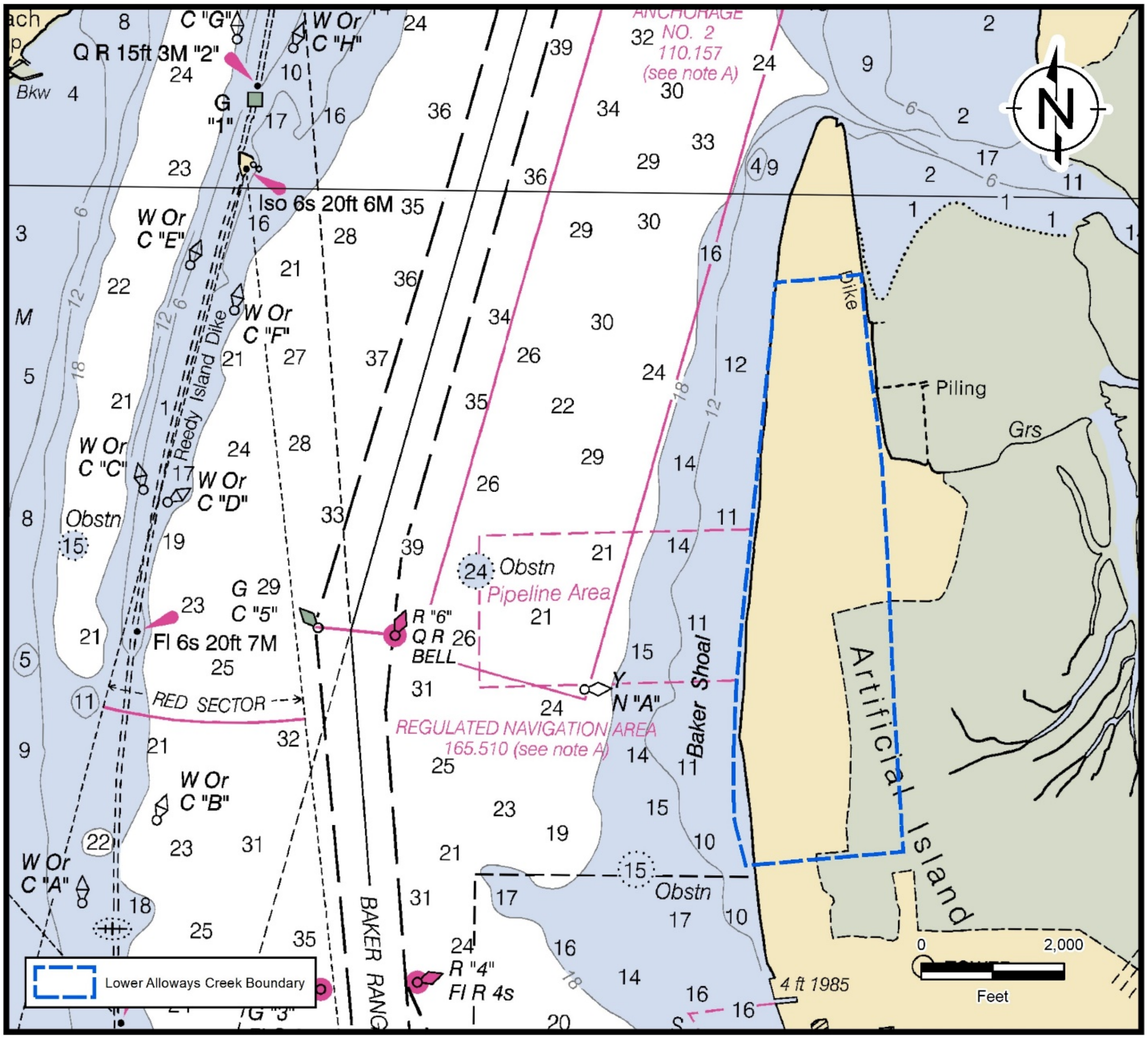


Figure 8: **Lower Alloways Creek - NOAA Depth Chart**

4.2 Limitations

There are no vertical restrictions between the site and open ocean. The closest airport is the New Castle Airport located approximately 12.5 miles northwest of the site.

The site was used by the USACE for dredge spoil disposal. A change in use will be required for port development.

4.3 Environmental Conditions

The site operated as three CDF cells. The site is not listed on NJDEP's database of sites with known contamination. The site is mostly comprised of wetlands (Figure 9). There are habitat specific requirements that will need to be considered during the planning phase of development.

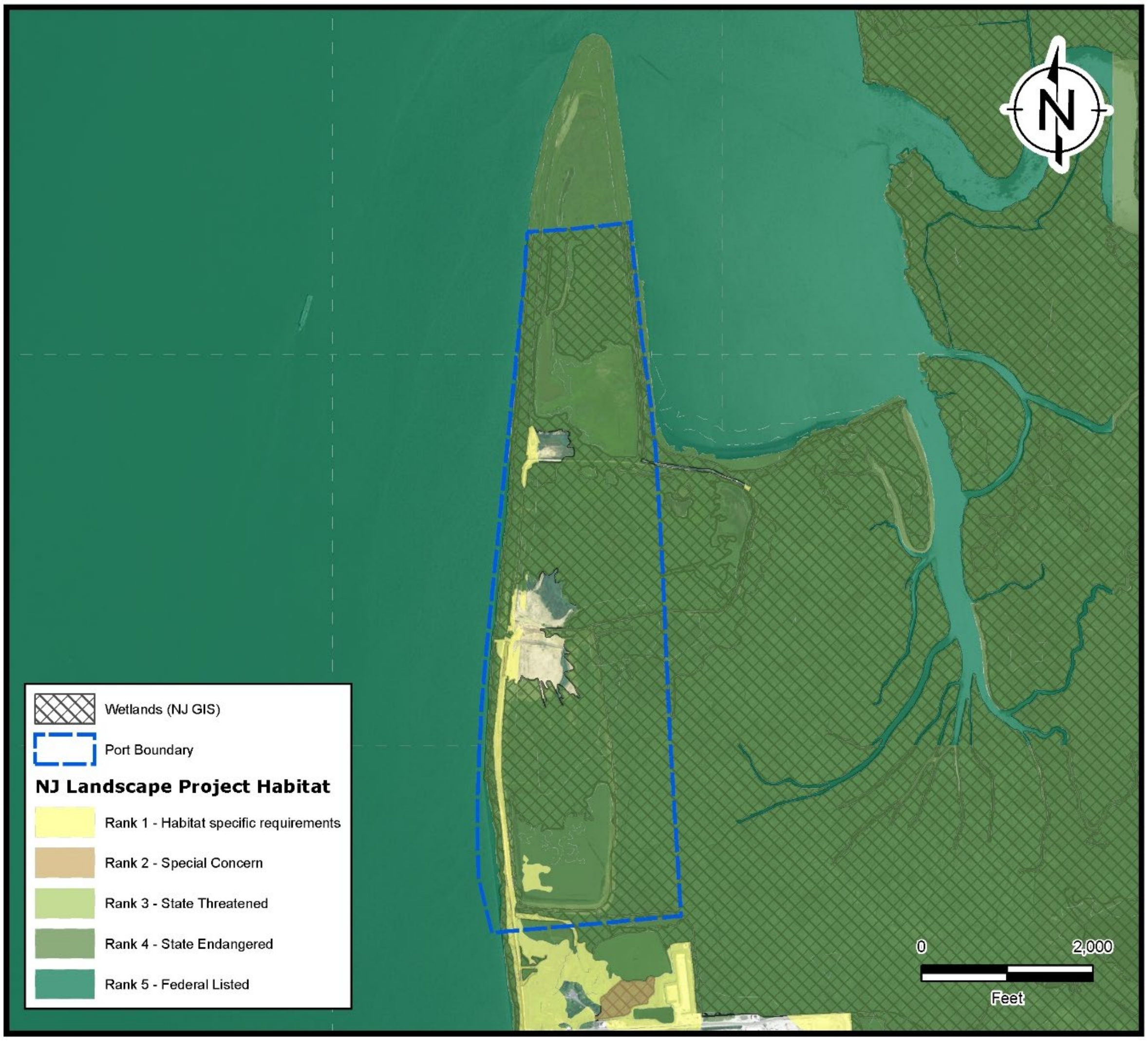


Figure 9: Lower Alloways Creek - Wetlands and Habitat Map

Table 6: Lower Alloways Creek - Summary of Existing Conditions		
Size	~320 acres	Majority of site has been classified as wetlands.

Table 6: Lower Alloways Creek - Summary of Existing Conditions		
Buildings	No structures; site was historically used for confined disposal facilities for Delaware River dredging.	
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	N/A	
Quayside Length	N/A; ~8,000 feet of water frontage	
Quayside Load Bearing Capacity*	N/A	
Depth at Potential Quayside locations	10-12 feet MLLW	
Channel Dimensions	Baker Range and Liston Range - 800 feet wide by 40 feet deep MLLW	
Distance to OSW Lease Areas	OCS-A 0490 – 71 nautical miles OCS-A 0519 – 66 nautical miles OCS-A 0482 (Ørsted/PSEG) - 57 nautical miles OCS-A 0498 (Ørsted) – 76 nautical miles OCS-A 0499 (EDF/Shell) - 95 nautical miles Hudson South Draft WEA – 121 nautical miles OSC-A 0512 (Equinor) – 169 nautical miles Hudson North Draft WEA – 170 nautical miles Fairways South Draft WEA – 186 nautical miles Fairways North Draft WEA – 208 nautical miles	
Rail Connection	None identified	
Restrictions	No overhead restrictions	
Environmental Conditions	No known contamination; majority of site is wetlands	
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.		

Governor Murphy's announcement about the New Jersey Wind Port development estimated a cost of $300-$400 million. The costing estimated for the site was conducted prior to the announcement and does not directly reflect the costs provided in the announcement. Table 7 below provides a cost summary to construct the quayside, increase upland load bearing capacity (50 acres), and complete the required dredging. Given that expansion beyond the 50 acres required by marshaling is possible, a cost to improve the upland load bearing capacity per acre is also provided. Disposal costs are variable, so low and high costs are provided.

Table 7: Lower Alloways Creek - Summary of Redevelopment Costs		
	Low Disposal Cost Scenario	**High Disposal Cost Scenario**
New quayside (1,200 linear feet) including relieving platform	$45,600,000	$45,600,000
Dredge around quayside to 35 feet	$21,333,333	$74,666,667
Dredge to Baker Range channel to 35 feet	$49,866,667	$174,533,333
Transportation and disposal costs of upland soils, including excavation	$27,225,000	$72,600,000
Placement and compaction of 3 feet' of DGA	$18,150,000	$18,150,000
Upland load bearing capacity improvements per acre	$907,500/acre	$1,815,000/acre
20% Contingency	$32,435,000	$77,110,000
Total	**$194,610,000**	**$462,660,000**

4.4 Potential Offshore Wind Uses

The site's large acreage, lack of vertical restrictions, and potential for sole use make it adaptable for manufacturing of OSW components and marshaling. The site's large acreage and generous water frontage make it potentially suitable for multiple OSW uses. For example, marshaling could be conducted on the southern portion of the property, and the northern portion of the property could be developed for manufacturing of various components. There are no overhead restrictions between the site and the open ocean, making the site in an ideal location for marshaling. The site does not currently have a suitable quayside, so a new quayside will need to be designed and constructed. Additionally, dredging is required to connect the site quayside (to be constructed) to the deep-water channel. The site is currently owned by PSEG and has been selected for development as a manufacturing and marshaling port.

4.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site could be adapted to handle monopile, transition piece, tower section components and jacket foundations, including manufacturing, fabrication, and lay down. Upland soil load bearing capacities would need to be improved and the new quayside constructed to support these operations. Dredging is required at the quayside (to be constructed).

Nacelles, Blades, Rotors, Generators:

These components could be manufactured or finished at this site. Upland soil load bearing capacity would need to be improved over portions of the site for the efficiency of this operation to meet serial production standards. Similar to the requirements for other components, a new quayside will need to be designed and constructed. Dredging is required at the quayside (to be constructed).

O&M, Service, Cables, Secondary Steel:

The site could be used for O&M operations from a layout perspective but is further from most of the lease areas than ideal. Manufacture of secondary steel components (ladders, platforms, railings, racks) could be easily conducted at this site. The site has the potential for cable storage, as a cable service port, and as a cable manufacturing facility. Similar to the requirements for other components, a new quayside will need to be designed and constructed. Dredging is required at the quayside (to be constructed).

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of marshaling or offshore wind production, certain site improvements would be required. These would include: closure of USACE CDFs, improvement of upland load bearing capacity; development of quayside; dredging of berth; addition of production buildings (for manufacturing/fabrication scenarios); and installation of crane pads or relieving platform where extreme heavy lift operations might occur

4.4.2 Reuse Scenario - Marshaling

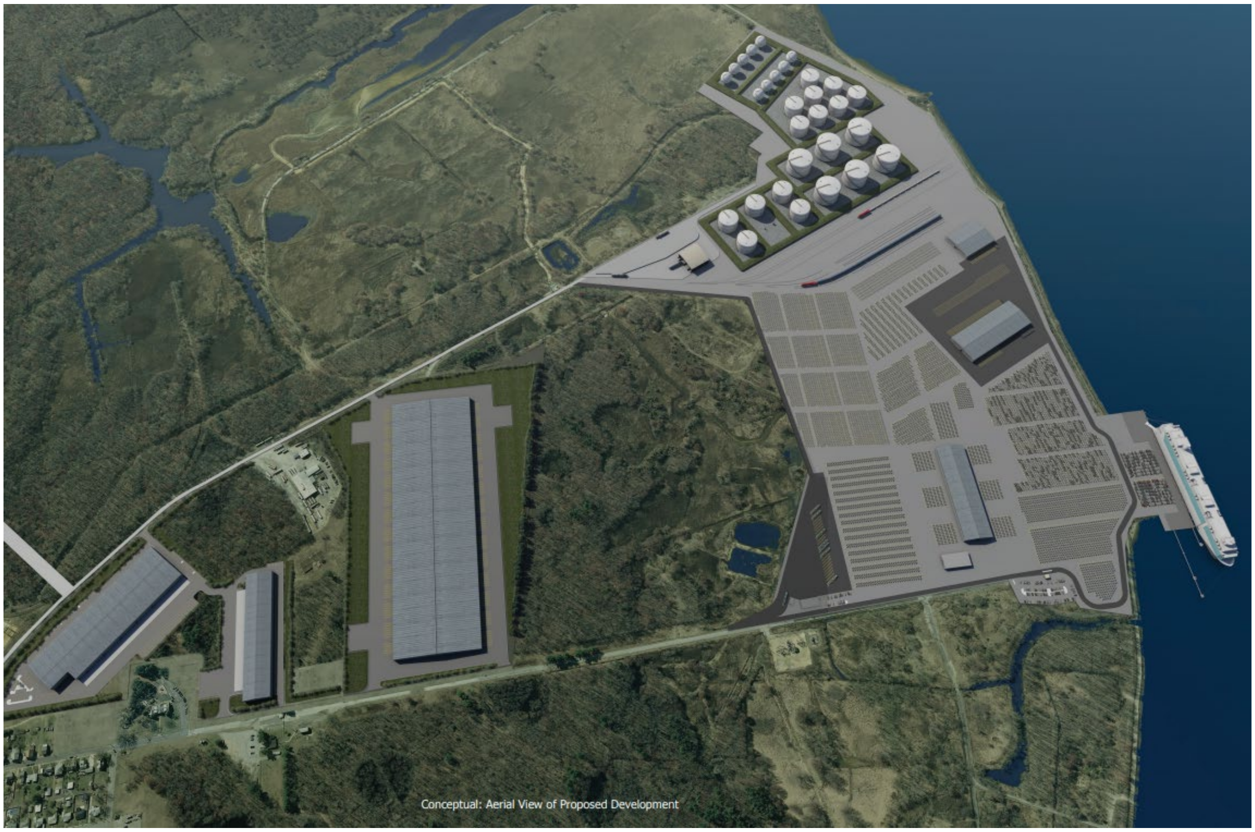
The site’s large acreage, lack of vertical restrictions, and potential for sole use make the site adaptable for marshaling. The redevelopment costs provided above include constructing the quayside (including relieving platform), increasing upland load bearing capacity (50 acres; including laydown areas), and completing the required dredging.

5. FORMER DUPONT SITE (REPAUNO) – GREENWICH, NJ

5.1 Existing Conditions

The former Chemours (DuPont) facility totals approximately 1,600 acres (356 acres for the red parcel) and is located at 200 North Repauno Avenue in Greenwich Township, New Jersey (Figure 10). The site has a long industrial history dating back to 1880. The former DuPont chemical plant manufactured a variety of products including dynamite, acids, nitrobenzene, and other organic compounds. The explosive manufacturing and ammonia manufacturing operations were discontinued in the 1960s. In 1998, Repauno Products LLC acquired sodium nitrite and nitrosylsulfuric acid manufacturing operations. From 1999 to 2002, Spring AG operated the industrial diamond refining process. The property was sold to Delaware River Partners LLC in 2016. The majority of the site is comprised of wetlands. The site is currently being developed to create a deep-water marine terminal for vessels with a maximum length of 870 feet. Based on available information the port is currently being redeveloped for multiple uses including, energy products Roll-On/Roll-Off (RO-RO) cargo, project cargo, bulk cargo, warehousing and logistics (Conceptual future rendering Figure 11).

Figure 10: Repauno - Site Location Map



Conceptual rendering. Source: Greenwich Township (https://www.greenwichtwp.com/2202/Proposed-Port-Development)

Figure 11: Repauno - Site Development Map

The Delaware River bounds the site to the north. Wetlands and the former Hercules chemical plant are located adjacent east of the site. A residential area is located south of the site. Wetlands and a raceway are located west of the site. Rail access is available on-site. Philadelphia International Airport is located north of the site, across the Delaware River. Route I-295 is located within two miles east of the site.

Water approaches to the site is via the Tinicum Range (See Figure 12). The Tinicum Range is 40 feet deep MLLW and 800 feet wide. The channels through the Delaware River continue as the Eddystone Range, Chester Range, Marcus Hook Range, Bellevue Range, Cherry Island Range, Deepwater Point Range, Bulkhead Bar Range, New Castle Range, Reedy Island Range, Baker Range, and Liston Range, all of which are at least 40 feet deep and 800 feet wide.

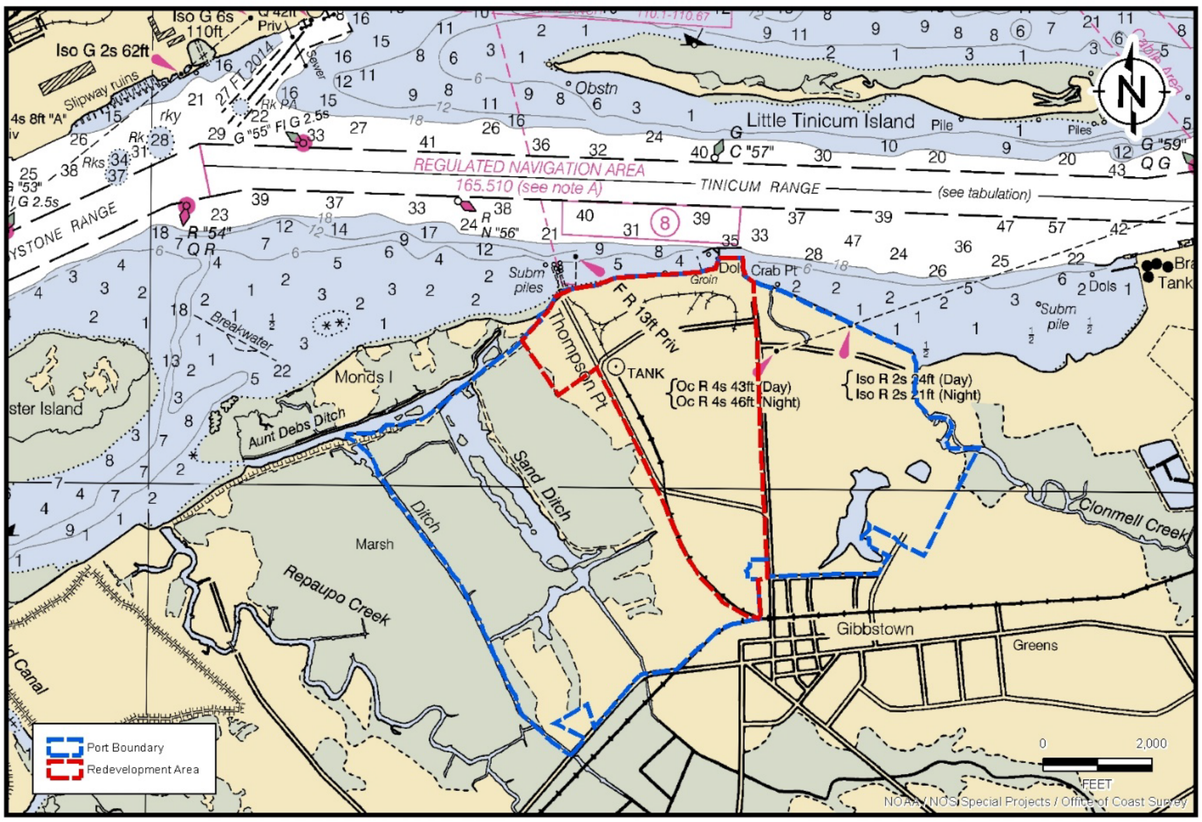


Figure 12: Repauno - NOAA Depth Chart

5.2 Limitations

Vertical restrictions between the site and open water include the Commodore Barry Bridge, Delaware Memorial Bridge and overhead cables. The Commodore Barry Bridge has vertical clearances of 190 feet (middle 822 feet) and 181 feet (remainder) and a horizontal clearance of 1,600 feet. The Delaware Memorial Bridge has vertical clearances of 188 feet (middle 800 feet), 175 feet (middle 1,500 feet), and 166 feet (Main Towers) and a horizontal clearance (beam) of 2,000 feet. There are overhead cables which have a vertical clearance of 223 feet. The closest airport is the Philadelphia International Airport located directly across the Delaware River.

5.3 Environmental Conditions

The site is listed on NJDEP's database for sites with known contamination (NJEMS IDs 36417 and 26416). The site is under investigation and a soil remedial action permit (RAP190002) has been issued.

According to NJDEP GIS data, the majority of the site is classified as wetlands (Figure 13). Additionally, there are habitat-specific requirements that will need to be considered during the planning phase of development.

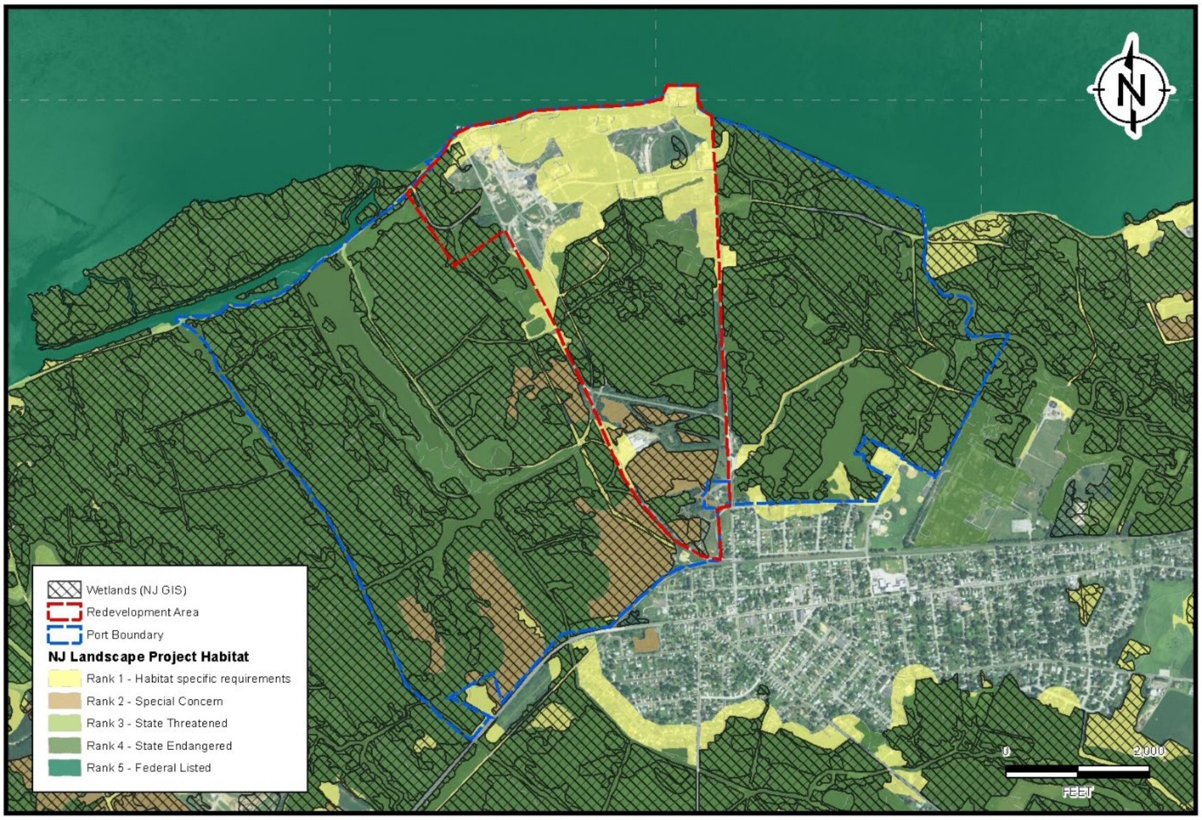


Figure 13: Repauno - Wetlands and Habitat Map

Table 8: Repauno - Summary of Existing Conditions		
Size	~1,600 acres (356 acres for redevelopment)	Majority of site is wetlands.
Buildings	Most buildings associated with former Dupont operations have been demolished. Site is currently being redeveloped.	
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	Concrete decking supported by steel piles.	
Quayside Length	751 feet	
Quayside Load Bearing Capacity*	<2,500 psf	
Depth at Potential Quayside locations	40 feet deep MLLW; dredging completed	

Table 8: Repauno - Summary of Existing Conditions		
Channel Dimensions	Tinicum Range, Eddystone Range, Chester Range, Marcus Hook Range, Bellevue Range, Cherry Island Range, Deepwater Point Range, Bulkhead Bar Range, New Castle Range, Reedy Island Range, Baker Range, and Liston Range - 800 feet wide by 40 feet deep MLLW	
Distance to OSW Lease Areas	OCS-A 0490 – 100 nautical miles OCS-A 0519 – 95 nautical miles OCS-A 0482 (Ørsted/PSEG) - 86 nautical miles OCS-A 0498 (Ørsted) – 107 nautical miles OCS-A 0499 (EDF/Shell) - 126 nautical miles Hudson South Draft WEA – 146 nautical miles OSC-A 0512 (Equinor) – 197 nautical miles Hudson North Draft WEA – 199 nautical miles Fairways South Draft WEA – 215 nautical miles Fairways North Draft WEA – 237 nautical miles	
Rail Connection	Rail on-site	
Restrictions	Delaware Memorial Bridge: Vert Cl 188 feet (middle 800 feet); Vert Cl 175 feet (middle 1,500 feet); Vert Cl 166 feet (Main Towers); Horizontal Clearance 2,000 feet	
Environmental Conditions	Known contaminated site under investigation and remediation NJEMS Site ID 36417; Preferred ID 008225 (Repauno Plant) NJEMS Site ID 26416; Preferred ID 016891 (Cardox Corp) Site contains extensive wetlands	Soil Remedial Action Permit issued 7/11/2019
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.		

To meet the needs of OSW manufacturing, certain improvements are necessary. Table 9 below provides a cost summary to construct the quayside, improve upland load bearing capacity (30 acres), and complete the required dredging. Disposal costs are variable, so low and high costs are provided. Costs for existing building demolition are not included.

Table 9: Repauno - Summary of Redevelopment Costs

	Low Disposal Cost Scenario	High Disposal Cost Scenario
New quayside (1,000 feet); including a relieving platform	$38,000,000	$38,000,000
Dredge around quayside to 35 feet	$21,481,481	$75,185,185
Dredge to deep water channel to 35 feet	$888,889	$3,111,111
Transportation and disposal costs of upland soils, including excavation	$16,335,000	$43,560,000
Placement and compaction of 3 feet of DGA	$10,890,000	$10,890,000
20% Contingency	$17,519,074	$34,149,259
Total	**$105,114,444***	**$204,895,556**

*Repauno has recently been upgraded, including dredging. Although not designated for offshore wind at this time, the upgrades could support potential port use for cables, foundations, towers, blades, or nacelles. Completion of ongoing upgrades would significantly reduce the above costs.

5.4 Potential Offshore Wind Uses

The site's large acreage makes it adaptable for manufacturing of OSW components and potentially marshaling. The port is currently being developed as a RO-RO facility, so any additional development for offshore wind would need to accommodate current use. This analysis assumes that a new quayside will be constructed, as the existing quayside will be fully utilized and may not meet the required load bearing capacity for OSW components. The Delaware Memorial Bridge with a vertical clearance of 188 feet will present challenges for marshaling which will likely need to be addressed via barge feedering. Coordinating with RO-RO operations could make marshaling challenging.

5.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site could be adapted to handle monopile, transition piece, tower section components and jacket foundations, including manufacturing, fabrication, and lay down. Upland soil load bearing capacity would need to be improved. A new quayside will need to be constructed. Dredging at the site is being conducted as part of the RO-RO facility development.

Nacelles, Blades, Rotors, Generators:

These components could be manufactured or finished at this site. Upland soil load bearing capacity would need to be improved over portions of the site for the efficiency of this operation to meet serial production standards. Similar to the requirements for other components, a new quayside will need to be constructed.

O&M Service, Cables, Secondary Steel:

The site is well suited for O&M operations from a layout perspective but is too far of a distance from the OSW lease areas to be viable. Manufacture of secondary steel components (ladders, platforms, railings, racks) could be easily adapted at this site. The site is well suited for cable storage, as a cable service port, and as a cable manufacturing facility. In all cases, a robust quayside will need to be constructed.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of marshaling or OSW manufacturing, certain site improvements would be required. These would include: improvement of upland load bearing capacity; development of quayside and dredging; addition of production buildings (for manufacturing/fabrication scenarios); and installation of crane pads or relieving platform where extreme heavy lift operations might occur.

5.4.2 Reuse Scenario – Nacelle Manufacturing

The site's large acreage, access to deep water channels, and use as an existing port make the site adaptable for nacelle manufacturing. The redevelopment costs provided above include constructing the quayside (1,000 feet; including relieving platform), increasing upland load bearing capacity (30 acres; including laydown areas), and completing the required dredging. Additional reuse costs may include construction of production and assembly buildings.

Table 10: Repauno - Summary of Reuse Costs –Nacelle Manufacturing

	Estimated Costs
Production building (180,000 square feet); includes overhead crane	$9,682,000
Assembly building (120,000 square feet); includes overhead crane	$6,788,000
20% Contingency	$3,294,000
Total	**$19,764,000**

6. WERNER GENERATING STATION

6.1 Existing Conditions

The decommissioned Werner Generating Station (WGS) is located at 106 Pupek Road, South Amboy, NJ. The property encompasses approximately 97 acres on the west bank of Raritan Bay (Figure 14). The WGS was constructed circa 1929 by the Jersey Central Power & Light Company (JCP&L). The facility was originally powered by coal and then modified to burn either coal or oil after a large explosion occurred at the plant in the 1950s. The main power-generating building has been demolished circa 2014. Several structures associated with the former power plant infrastructure, including out-of-service oil storage tanks, electrical transformers, and several smaller buildings remain on-site. The remaining infrastructure is currently being demolished. Based on discussions with the New Jersey Economic Development Authority and other local stakeholders, the planned development for the site does not include OSW. Currently, the site is targeted as a potential ferry terminal and as a site for residential condos and not for heavy industrial development. Although the site is adequate in size and has unlimited air draft, its current plans and significant required investment and improvement make offshore wind use unlikely.

Figure 14: Werner Generating Station - Site Location Map

A railroad swing bridge crosses the Raritan River west of the site and the Arthur Kill is located to the north of the site. Residential areas are located to the south, southeast, and southwest of the property. Industrial properties border the site to the west. Rail lines are located along the site's western boundary. The Garden State Parkway is located approximately one mile west of the site.

According to available NOAA information, water approaches to the site are via the South Amboy Reach and Great Beds Reach (Figure 15). The South Amboy Reach and Great Beds Reach are 25 feet deep at MLLW and 300 feet wide. The channel widens and deepens at the Ward Point Secondary Channel, which is 30 feet deep MLLW and 400 feet wide. The channel widens and deepens again at Ward Point East, which is 35 feet deep MLLW and 600 to 800 feet wide. An approximately 220 to 350-foot-wide and 920-foot long pier is located on the southeastern portion of the site. The construction details of the pier are unknown, although NOAA charts indicate quay side depths of 21 feet MLLW. Additionally, a smaller pier of approximately 100 feet wide and 235 to 400 feet long is located north of the main pier. Depths at the smaller pier range from 3 to 17 feet MLLW.

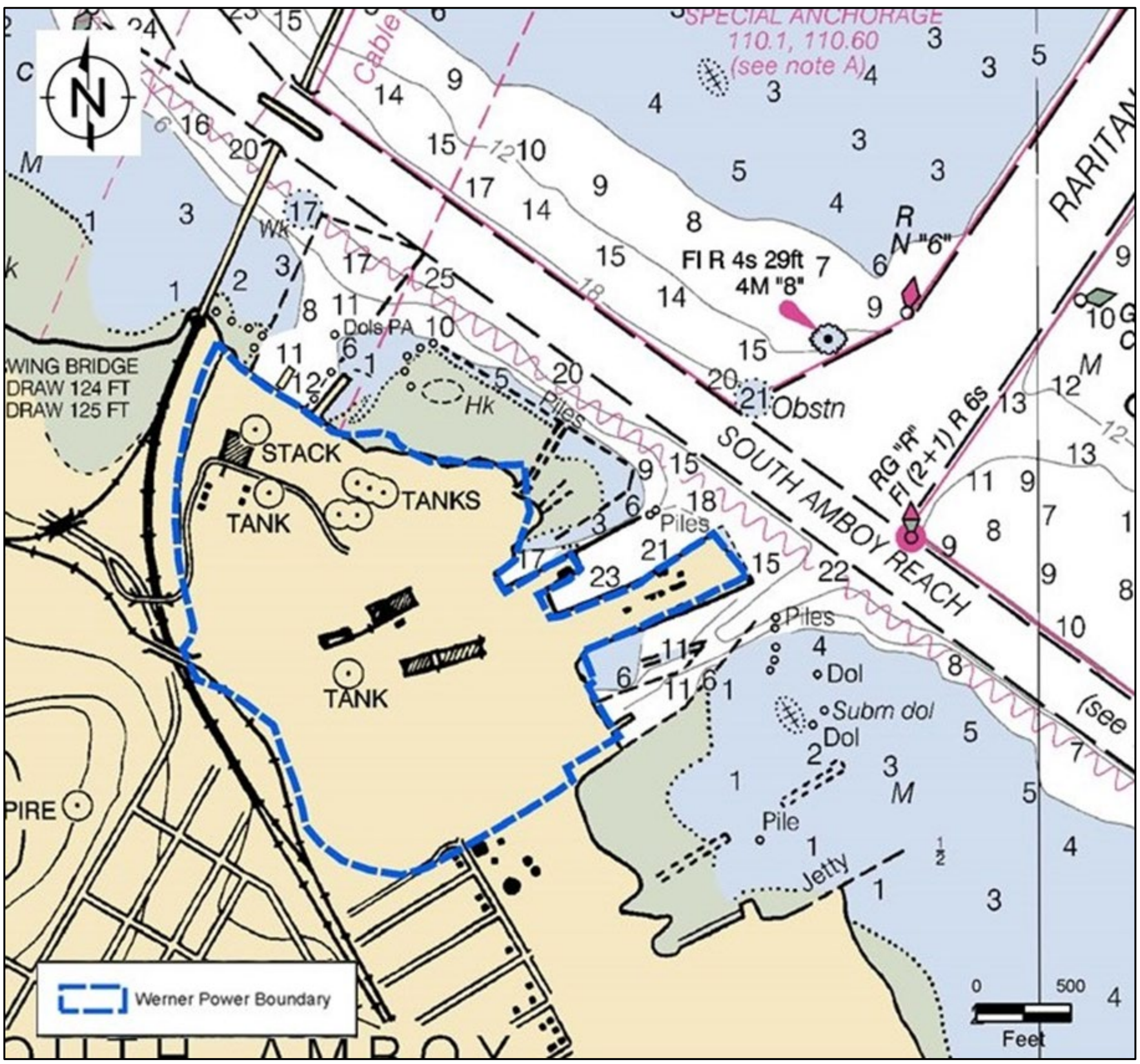


Figure 15: Werner Generating Station - NOAA Depth Chart

6.2 Limitations

There are no bridges between the facility and the open ocean. The closest airports are the Newark International Airport located approximately 13.5 miles to the north-northeast of the site and the Old Bridge Airport (a small, public-use airport) located approximately 11.4 miles southwest of the site.

6.3 Environmental Conditions

According to New Jersey Department of Environmental Protection (NJDEP) online databases, remediation was required to be initiated on the property on January 1, 1992 under activity LSR120001. The Remedial Action Report is due May 6, 2021. In addition, the site is listed on the New Jersey active sites with confirmed contamination (NJEMS IDs 15970 and 94273). Contaminants of concern include gasoline, sodium hydroxide, lube oil, transmission fluid, #2 fuel oil, and sodium hypochlorite. The site is also listed on environmental databases for numerous spills and releases on the property. There are limited areas of wetlands and areas that require habitat-specific requirements that would need to be considered during the planning phase of redevelopment (Figure 16).

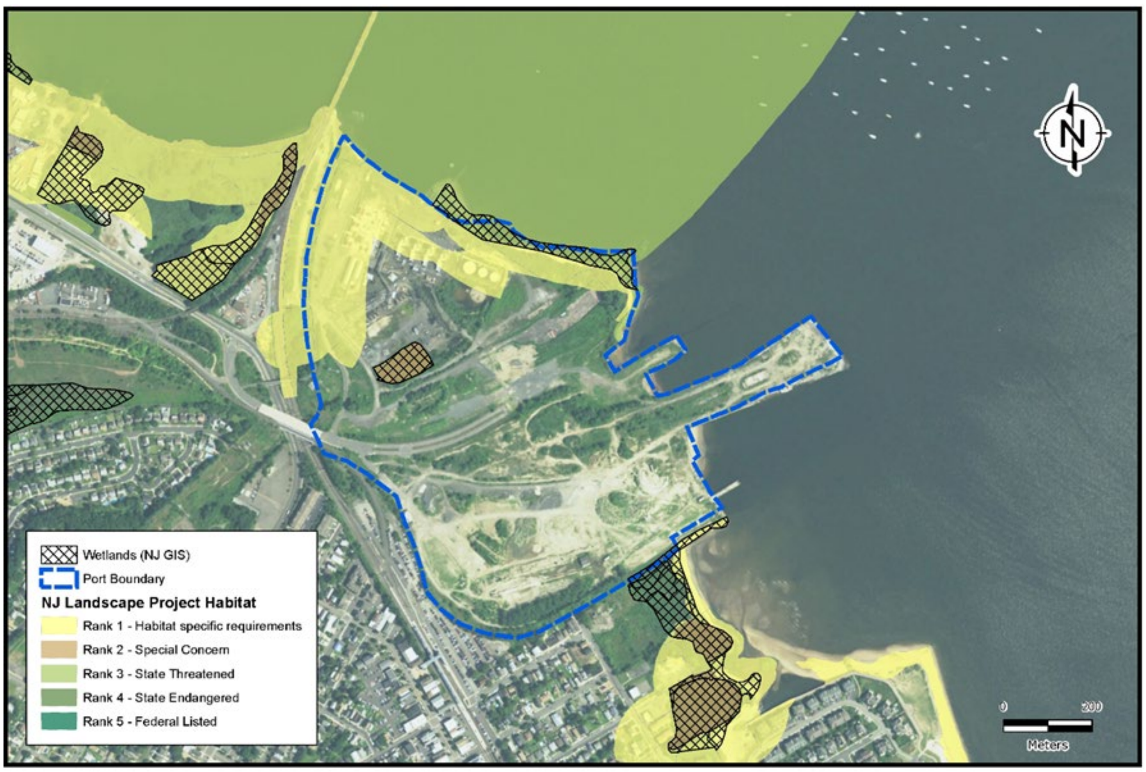


Figure 16: Werner Generating Station - Wetland and Habitat Map

Table 11: WGS - Summary of Existing Conditions		
Size	~97 acres total	
Buildings	Several structures remain from power generating operations.	Plant infrastructure is currently being demolished.
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	Piers	Piers are in disrepair
Quayside Length	Main Pier: ~920 feet Pier face: ~350 feet	
Quayside Load Bearing Capacity*	<1,000 psf	
Depth at Berth	No existing berth; water depth is 15 feet	
Channel Dimensions	South Amboy Reach and Great Beds Reach- 300 feet wide by 25 feet deep MLLW* Ward Point Secondary Channel - 400 feet wide by 30 feet deep MLLW Ward Point Bend East, Red Bank Reach, Seguine Point Reach, Raritan Bay West Reach, Raritan Bay East Reach - 600-800 feet wide by 35 feet deep MLLW *recent surveys show that these reaches may be shallower than project depth (15-20 ft)	Dredging would be required at berth to deepen the channel and quaysides to 35 feet MLLW to support typical OSW marshaling operations
Distance to OSW Lease Areas	OCS-A 0490 – 155 nautical miles OCS-A 0519 – 148 nautical miles OCS-A 0482 (Ørsted/PSEG) - 132 nautical miles OCS-A 0498 (Ørsted) – 91 nautical miles OCS-A 0499 (EDF/Shell) - 64 nautical miles Hudson South Draft WEA – 42 nautical miles OSC-A 0512 (Equinor) – 35 nautical miles Hudson North Draft WEA – 57 nautical miles Fairways South Draft WEA – 59 nautical miles Fairways North Draft WEA – 81 nautical miles	
Rail Connection	Adjacent; Rail runs along the northwestern site boundary	
Restrictions	No overhead restrictions	

Table 11: WGS - Summary of Existing Conditions		
Environmental Conditions	Wetlands (~0.8 acres) are located in the southeastern portion of the site. Additionally, wetlands are located along the waterfront. NJEMS ID 15970; Preferred ID 009964 (E H Werner Generating Station) NJEMS ID 94273; Preferred ID 132954 (Conrail & McKean Property)	Site has subsurface impacts from former power plant operations.
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.		

To meet the needs of marshaling or OSW manufacturing uses, certain improvements would be necessary. Table 12 below provides a redevelopment cost summary to improve the quayside, increase upland load bearing capacity (50 acres) and complete the required dredging. Given that expansion beyond the 50 acres required by marshaling is possible, a cost to improve the upland load bearing capacity per acre is also provided. Disposal costs are variable, so low and high costs are provided. Costs to demolish existing structures are not included.

Table 12: Werner Generating Station - Summary of Redevelopment Costs[4]

	Low Disposal Cost Scenario	**High Disposal Cost Scenario**
Harden current quayside (2,100 linear feet) and install relieving platform	$79,800,000	$79,800,000
Dredge around quayside to 35 feet	$31,111,111	$108,888,889
Dredge to South Amboy channel to 35 feet	$4,444,444	$15,555,556
Transportation and disposal costs of upland soils, including excavation	$27,225,000	$72,600,000
Placement and compaction of 3 feet of dense-grade aggregate (DGA)[5]	$18,150,000	$18,150,000
Upland load bearing capacity improvements per acre	$907,500/acre	$1,815,000/acre
20% Contingency	$32,146,111	$58,998,889
Total	**$192,876,667**	**$353,993,333**

[4] Detailed cost-breakdown sheets are available upon request.

[5] Most OSW developers prefer installation of DGA to support their site operations. The costs for a developers specific infrastructure improvements are typically borne by the developer.

6.4 Potential Offshore Wind Uses

The site's relatively large acreage and lack of vertical restrictions make the site adaptable for manufacturing of OSW components and marshaling. The existing structures would require demolition and the entire site redeveloped for the site to be suitable to support manufacturing, staging of components and/or marshaling (e.g., erection). The quaysides would also require complete rebuilding. Additionally, to serve as a marshaling port, the berth and channels will need to be dredged to 35 feet MLLW. Redevelopment would also need to take into account any NJDEP-required environmental remediation requirements.

6.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site could be adapted to handle manufacturing/fabrication of monopiles, transition pieces, tower section components and jacket foundations, including lay down. Upland soil load bearing capacities would need to be improved and the quayside will need complete redevelopment to support these operations. Dredging is required at the quaysides as well as the approach channels.

Nacelles, Blades, Rotors, Generators:

These components could be manufactured or finished at this site. Upland soil load bearing capacity would need to be improved over portions of the site for the efficiency of this operation to meet serial production standards. Similar to the requirements for other components, the quaysides will require complete redevelopment and dredging at the quaysides and channels would be required.

O&M, Service, Cables, Secondary Steel:

The site could be used for O&M operations from a layout perspective and is within 50 nautical miles of Hudson South Draft WEA and OCS-A 512 (Equinor's Empire Wind). The channel is suitable for O&M, but the quayside would require dredging. Manufacture of secondary steel components (ladders, platforms, railings, racks) could be easily conducted at this site. The site is well suited for cable storage, as a cable service port, and as a cable manufacturing facility with moderate modification needed.

Upgrades and Improvements Opportunity for Full Utility:

For full utility, certain site improvements would be required. These would include:

- Demolition of existing structures;
- Improvement of upland soil bearing capacities;
- Complete redevelopment of quayside;
- Dredging of berth and channel;
- Addition of production buildings (for manufacturing/fabrication scenarios); and
- Installation of crane pads or relieving platform where extreme heavy-lift operations might occur.

The depth of the channel (currently 25 feet MLLW) represents a limiting factor of the site's redevelopment as a marshaling facility as a minimum of 35 feet MLLW is typically required to OSW marshaling operations.

6.4.2 Reuse Scenario - Marshaling

The site's relatively large acreage, lack of vertical restrictions, and potential for sole use make the site adaptable for marshaling. The bulk of the redevelopment costs for marshaling are associated with hardening the quayside, increasing upland load bearing capacity (50 acres), and completing the required dredging. The redevelopment cost to harden the quayside includes the cost to construct a relieving platform. Additional costs may include office trailer rentals (approximately $20,000).

7. CHEMOURS CHAMBER WORKS – DEEPWATER, NJ & CARNEY'S POINT, NJ

7.1 Existing Conditions

The approximately 1,545-acre Chemours Chamber Works Complex is located at 67 Canal Road, Pennsville Township, New Jersey and 600 Shell Road, Carney's Point, New Jersey. The Chemours Chambers Works Complex, composed of the Chambers Works manufacturing area (Deepwater Site) and the former Carneys Point Works (Carney's Point Site), is located along the eastern shore of the Delaware River (Figure 17) in the southern portion of New Jersey. The site has a long industrial history with operations initiating as early as 1892 and included the manufacture of gunpowder, dyes, freon, tetraethyl lead, and aromatic chemicals. During World War II, the site was used for research and development of chemicals for the production of radiological materials. By the early 1980s, the manufacture of explosives and dyes ended, leaving only chemical manufacturing. Currently, there are several active waste-management areas on the site, including a secure landfill and a wastewater treatment plant. Portions of the site remain in operation by Chemours for chemical manufacturing purposes. Up to 405 acres are available for redevelopment, of which approximately 101 acres are located along the Delaware River on the Deepwater site. The approximately 412-acre Deepwater site is paved or developed for chemical manufacturing purposes. Approximately 175 acres of the Carney's Point site are available for redevelopment. The remaining portions of the Carney's Point site are wetlands or currently being utilized by Chemours for their own operations.

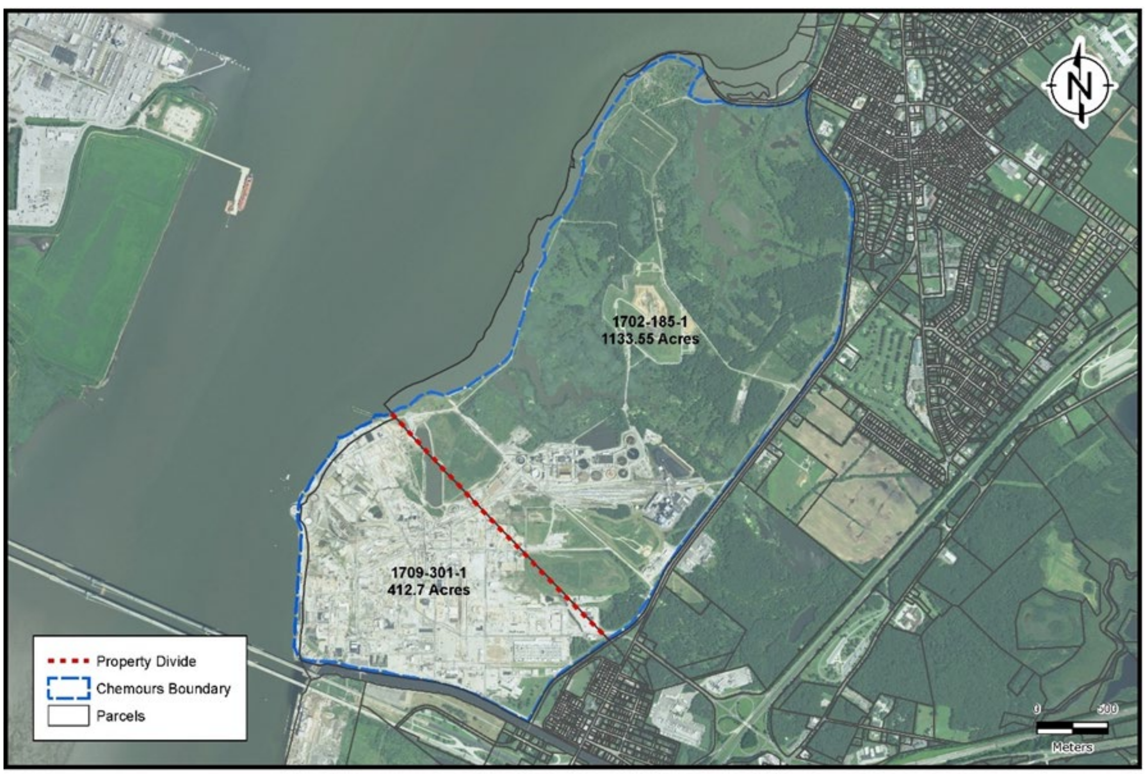


Figure 17: Chemours Chamber Works - Site Location Map

A canal and the Delaware Memorial Bridge are located immediately south of the site, beyond which is the Calpine Power Plant. Residential areas are located east and north of the site. The Delaware River bounds the site to the west. The Port of Wilmington is across the Delaware River. Rail access is available on-site. The New Jersey Turnpike and Route I-295 are located within one mile east of the site.

Water approaches to the site is via the Cherry Island Range and Deepwater Point Range (Figure 18). The Cherry Island Range and Deepwater Point Range are 40 feet deep MLLW and 800 feet wide. The channels through the Delaware River continue as the Bulkhead Bar Range, New Castle Range, Reedy Island Range, Baker Range, and Liston Range, all of which are at least 800 feet wide and 40 feet deep. There is not active quayside at the property; however, there are approximately 16,300 feet of water frontage which could be developed into a quayside to support multiple OSW operations.

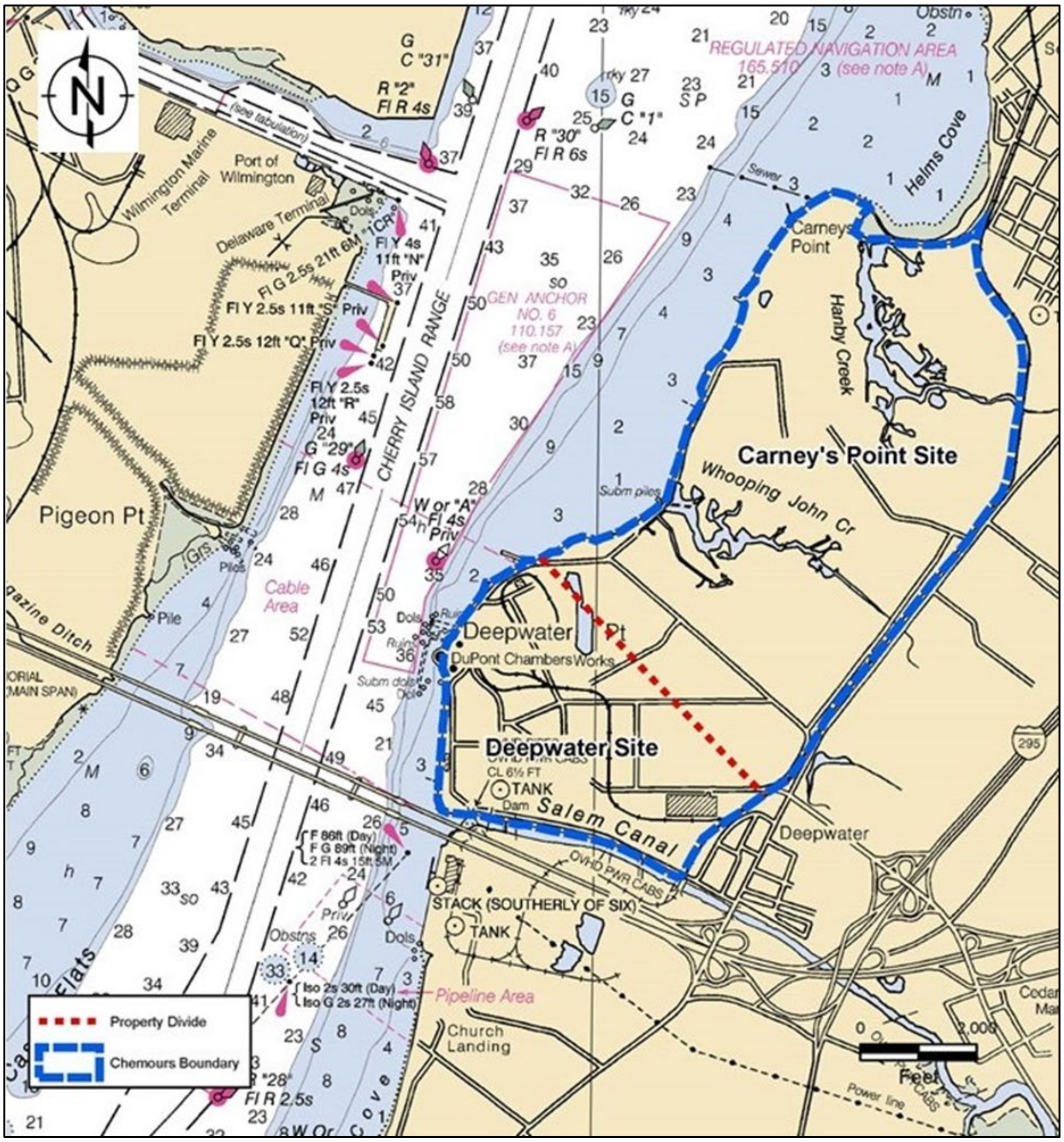


Figure 18: Chemours Chamber Works - NOAA Depth Chart

7.2 Limitations

Vertical restrictions between the site and open water include the Delaware Memorial Bridge and overhead cables. The Delaware Memorial Bridge has vertical clearances of 188 feet (middle 800 feet), 175 feet (middle 1,500 feet), and 166 feet (Main Towers) and a horizontal clearance (beam) of 2,000 feet. There are overhead cables which have a vertical clearance of 223 feet. The closest airport is the New Castle Airport located approximately 4.5 miles southwest of the site.

7.3 Environmental Conditions

Historical chemical manufacturing and waste management at the site have resulted in impacts to the site subsurface. Contaminants of concern include aniline, benzene, chlorobenzene, trichloroethene, tetrachloroethene, lead, and other organic and inorganic chemical constituents such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), perfluorooctanoic acid (PFOA), and radiological materials.

Chemours is required to conduct site-wide groundwater monitoring and remediation. In addition, the U.S. Army Corps of Engineers (USACE) is evaluating the areas utilized for the radiological material research and development.

Two rounds of site-wide investigation have been completed to date, and several interim remedial measures (removal of source materials, installation of caps over contaminated areas, and fences) have been completed to address immediate environmental concerns. An interceptor Well System (IWS) was installed in the 1970s to pump and treat contaminated groundwater at an on-site wastewater treatment plant. A site-wide groundwater monitoring program has been implemented to monitor the effectiveness of the system. The closures of three basins and two ditches were completed in the early 1990s.

As of 2016, remedial actions were being implemented at the Salem Canal to address a groundwater plume of volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) migrating into and beneath the adjacent canal; an investigation was performed for the dense non-aqueous phase liquid (DNAPL) found under Delaware River near the AOC-1 area; a vapor intrusion investigation was conducted at more than 200 buildings and structures at the site; and an investigation was performed to determine the extent of PFOA contamination in the groundwater on-site and off-site.

Chemours and the USACE are continuing to evaluate additional contaminant sources that might be contributing to the subsurface impacts. The groundwater pump and treat system will continue to operate in conjunction with a cut-off sheet pile barrier wall system, and the site-wide groundwater monitoring program to ensure that contaminated groundwater does not migrate off-site. NJDEP will impose a deed notice on the site to restrict future use to industrial purposes, such as OSW support operations.

Additionally, the majority of the Carney's Point site are wetlands and areas of both sites have habitat specific requirements (Figure 19).

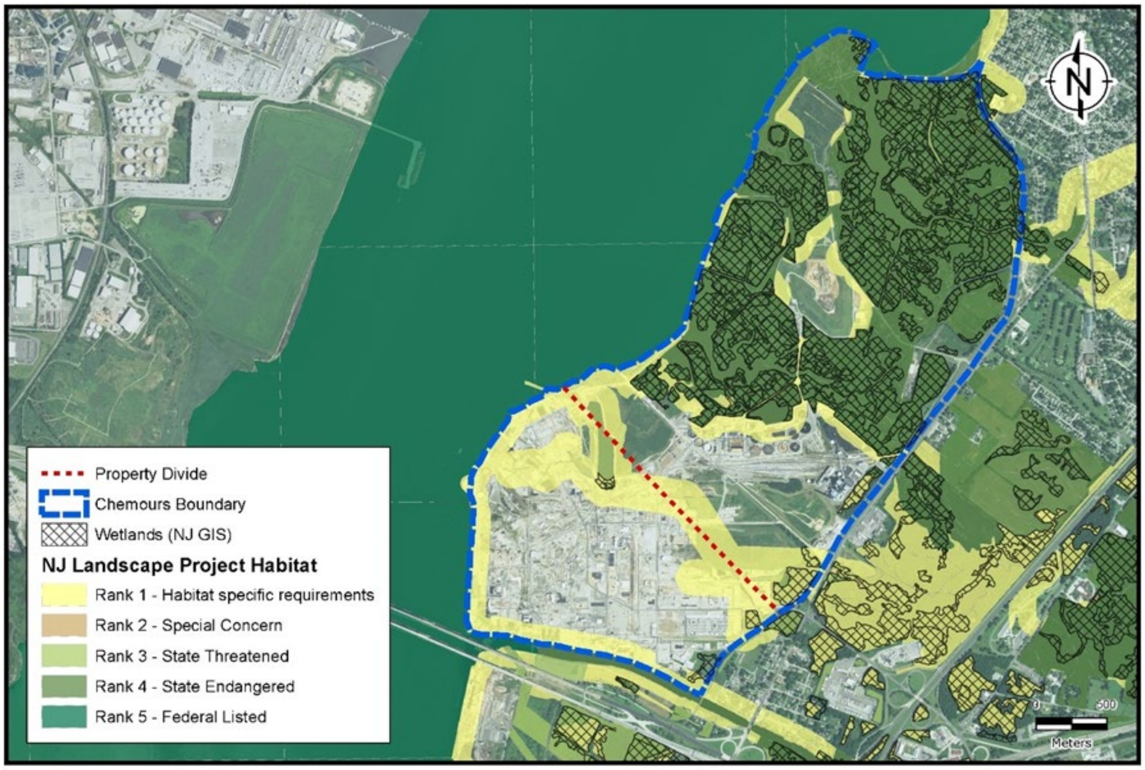


Figure 19: Chemours Chamber Works - Wetlands and Habitat Map

Table 13: Chemours Chamber Works - Summary of Existing Conditions

Size	Deepwater: ~412 acres total; up to 230 acres available for development. Carney's Point: ~1,133.55 acres total; 175 acres available for development	Majority of Carney's Point site is wetlands.
Buildings	Deepwater: Several structures associated with former manufacturing. Majority of site is paved or improved with buildings. Carney's Point: Wastewater treatment plant is located on southern portion of parcel. Majority of the site is undeveloped.	Complete redevelopment is required.
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	N/A	
Quayside Length	N/A; ~16,300 feet of water frontage	
Quayside Load Bearing Capacity*	N/A	

Table 13: Chemours Chamber Works - Summary of Existing Conditions		
Depth at Potential Quayside locations	1-314 feet MLLW	
Channel Dimensions	Cherry Island Range, Deepwater Point Range, Bulkhead Bar Range, New Castle Range, Reedy Island Range, Baker Range, and Liston Range - 800 feet wide by 40 feet deep MLLW	
Distance to OSW Lease Areas	OCS-A 0490 – 85 nautical miles OCS-A 0519 – 80 nautical miles OCS-A 0482 (Ørsted/PSEG) - 74 nautical miles OCS-A 0498 (Ørsted) – 95 nautical miles OCS-A 0499 (EDF/Shell) - 112 nautical miles Hudson South Draft WEA – 145 nautical miles OSC-A 0512 (Equinor) – 187 nautical miles Hudson North Draft WEA – 184 nautical miles Fairways South Draft WEA – 200 nautical miles Fairways North Draft WEA – 222 nautical miles	
Rail Connection	Rail on-site	
Restrictions	Delaware Memorial Bridge: Vert Cl 188 feet (middle 800 feet); Vert Cl 175 feet (middle 1,500 feet); Vert Cl 166 feet (Main Towers); Horizontal Clearance 2,000 feet Overhead Cables Vertical Clearance 223 feet	
Environmental Conditions	NJEMS Site ID 15645; Preferred ID 008221 (The Chemours Company FC LLC) Majority of Carney's Point site is wetlands	Subsurface impacts from long industrial history. Remediation is on-going.
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.		

To meet the needs of marshaling or OSW manufacturing, certain improvements are necessary. Table 14 below provides a cost summary to improve the quayside, improve upland load bearing capacity (50 acres) and complete the required dredging. Given that expansion is possible, a cost to improve the upland load bearing capacity per acre is also provided. Disposal costs are variable, so low and high costs are provided. Costs for existing building demolition are not included.

Table 14: Chemours Chamber Works - Summary of Redevelopment Costs		
	Low Disposal Cost Scenario	**High Disposal Cost Scenario**
New quayside (1,200 linear feet) including relieving platform	$45,600,000	$45,600,000

Table 14: Chemours Chamber Works - Summary of Redevelopment Costs		
	Low Disposal Cost Scenario	**High Disposal Cost Scenario**
Dredge around quayside to 35 feet	$29,333,333	$102,666,667
Dredge to Cherry Island Range channel to 35 feet	$4,444,444	$15,555,556
Transportation and disposal costs of upland soils, including excavation	$27,225,000	$72,600,000
Placement and compaction of 3 feet of DGA	$18,150,000	$18,150,000
Upland load bearing capacity improvements per acre	$907,500/acre	$1,815,000/acre
20% Contingency	$24,950,556	$50,914,444
Total	**$149,703,333**	**$305,486,667**

7.4 Potential Offshore Wind Uses

The site's large acreage makes the site adaptable for manufacturing of OSW components and potentially marshaling. The existing structures will need to be demolished and the entire site redeveloped for the site to be suitable to support manufacturing or staging of components. The Delaware Memorial Bridge with a vertical clearance of 188 feet will present challenges for marshaling which will likely need to be addressed via barge feedering, especially for early projects. The site does not currently have a suitable quayside, so a new quayside will need to be designed and constructed. Additionally, to serve as a marshaling port, dredging is required to connect the site quayside (to be constructed) to the deep-water channel. The site could also be well suited for use as a component lay down facility.

7.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site could be adapted to handle monopile, transition piece, tower section components and jacket foundations, including manufacturing, fabrication, and lay down. Upland soil load bearing capacity would need to be improved and the quayside would need to be constructed. Dredging is required at the future quayside to connect to the deep-water channel.

Nacelles, Blades, Rotors, Generators:

These components could be manufactured or finished at this site. Upland soil load bearing capacity would need to be improved over portions of the site for the efficiency of this operation to meet serial production standards. Similar to the requirements for other components, the quayside will need to be built and dredging is necessary.

O&M Service, Cables, Secondary Steel:

The site is well suited for O&M operations in terms of available acreage but is located away from the OSW lease areas to be viable. Manufacture of secondary steel components (ladders, platforms, railings, racks) could be easily adapted at this site. The site is well suited for cable storage, as a cable service port, and as a cable manufacturing facility with moderate modification needed. In all cases, a robust quayside would need to be constructed.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of marshaling or offshore wind production, certain site improvements would be required. These would include: demolition of existing structures; improvement of upland load bearing capacity; development of quayside; dredging of berth; addition of production buildings (for manufacturing/fabrication scenarios); and installation of crane pads or relieving platform where extreme heavy-lift operations might occur.

7.4.2 Reuse Scenario - Marshaling

The site's large acreage and potential for sole use make the site adaptable for marshaling. The majority of the redevelopment costs for marshaling are associated with constructing the quayside, increasing upland load bearing capacity (50 acres), and completing the required dredging. The cost to construct the quayside includes a relieving platform suitable for marshaling. Additional costs may include office trailer rentals (approximately $20,000).

8. MILITARY OCEAN TERMINAL AT BAYONNE (MOTBY) – BAYONNE, NJ

8.1 Existing Conditions

The Military Ocean Terminal at Bayonne (MOTBY) totals approximately 427 acres is located at 630 Avenue C, Bayonne, New Jersey (Figure 20). The site is an active port and shipyard with portions of the site currently being redeveloped for residential/commercial use (over 1,500 new apartments) and industrial warehousing. Current tenants include GMD Shipyard, Cape Liberty Cruise Port, City of Bayonne Police Department and Fire Department, and US Coast Guard. GMD Shipyard and Cape Liberty Cruise Port appear to use the northeast, east, and southeast berthing areas. A portion of the site along Route 440 was recently developed for a Costco retail store. Based on Ramboll's current understanding of the planned residential/commercial/industrial development at MOTBY, up to 150 contiguous acres may be available for redevelopment for OSW use.

MOTBY was formed using dredged material in as early as 1939. In 1941, the US Navy acquired the terminal and used it as the primary East Coast distribution point for ordnance and electronic materials and stored war reserve materials. The site was also used for petroleum storage. In 1967, the US Navy transferred the site to the US Army. In 1995, MOTBY was designated for closure under the Base Realignment and Closure Act (BRAC). In 1999, MOTBY was officially closed under BRAC.

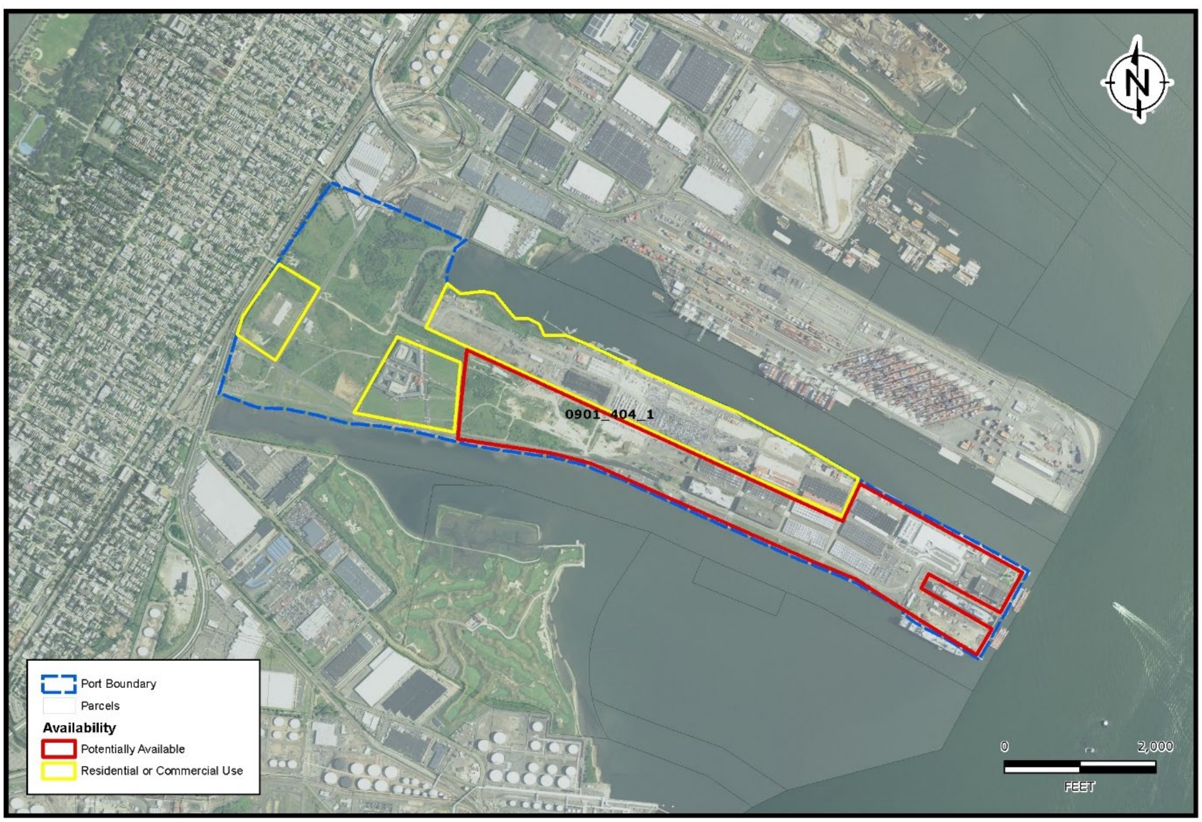


Figure 20: MOTBY - Site Location Map

Global Container Terminal (GCT) is located north of the site. The Upper Bay bounds the site to the east. Across the Upper Bay is Brooklyn, NY. South of the site are a golf course and shopping center. Route 440 bounds the site to the west, beyond which are mixed residential and commercial areas. Rail access is available within 0.5 miles of the site. The New Jersey Turnpike Extension can be accessed via Route 440.

Water approaches to the site are via the Ambrose Channel Reach D (53 feet deep by 2,000 feet wide) and the Anchorage Channel (51 feet deep by 500 feet wide) (Figure 21). The site has several active berths located along the northern, eastern, and southeastern sides of the peninsula. GMD Shipyard and Cape Liberty Cruise Port appear to use the northeast, east, and southeast berthing areas. It is unclear if any of the existing berths are available. The depths along the southwestern side of the peninsula (non-berthing areas) range from 11 to 13 feet.

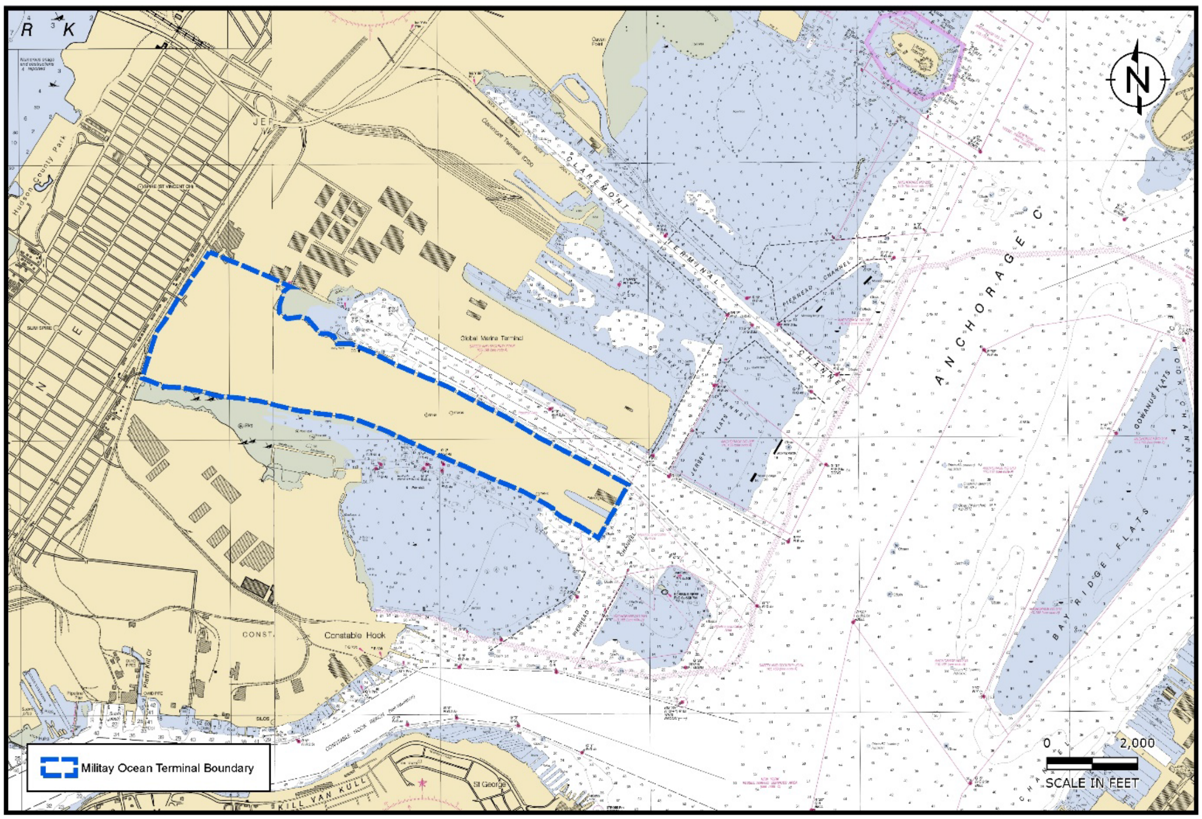


Figure 21: MOTBY - NOAA Depth Chart

8.2 Limitations

Vertical clearance between the site and open water is restricted by the Verrazano-Narrows Bridge. The Verrazano-Narrows Bridge has vertical clearances of 198 feet (middle 2,000 feet), 183 feet (piers), and 215 feet (center). The closest airport is the Newark International Airport located approximately 3.5 miles southwest of the site. No rail is available on-site; however, rail is available within 0.5 miles of the site.

8.3 Environmental Conditions

The site is listed in NJDEP's database for known contamination sites (NJEMS Site IDs 14201, 602237, 621075, 621105, and 601158). Additionally, the site is listed in the USEPA's Hazardous Waste Cleanup program. Subsurface impacts were caused by releases from underground storage tanks (USTs), possible releases from a sanitary sewer, spills from former transformers (PCBs), contaminated fill used to construct the Military Ocean Terminal Bayonne peninsula, and the possible migration of petroleum contamination on-site from off-site sources. The releases resulted in impacts to site soil (metals, organics, pesticides and PCBs), and site groundwater (arsenic, mercury, volatile organic compounds and pesticides). According to the USEPA, corrective actions have been completed for 551 acres of MOTBY (MOTBY was formerly 652 acres, a parcel larger than the current study area). In 2001, NJDEP granted a no further action determination for site cleanup.

A small area of wetlands is present in the southwest corner of the property, along the water (Figure 22). There are habitat-specific requirements that will need to be considered during the planning phase of development.

Figure 22: MOTBY - Wetlands and Habitat Map

Table 15: MOTBY - Summary of Existing Conditions		
Size	Parcel: ~427 acres; ~150 contiguous acres available for development	
Buildings	Warehouse Area: ~1,200,000 sf (10 - 200 feet by 600 feet One apartment complex complete; several apartment complexes under development Costco along Route 440	
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	Piers	
Quayside Length	Berth A: 225 feet Berths B and C: 348 feet total L-shaped Pier: 120 feet + 100 feet +110 feet + 90 feet Drydock: 1,092 feet by 148 feet	
Quayside Load Bearing Capacity*	<1,000 psf	
Depth at Potential Quayside locations	Berth - 48 feet The southwest side of the site is not currently used for berthing. Depths along the southwest side range from 11 to 13 feet.	
Channel Dimensions	Ambrose Channel Reach D: 2,000 feet wide by 53 feet deep MLLW Anchorage Channel - 51 feet to 54 feet deep MLLW 500 foot of channel dredged to 45 feet MLLW	
Distance to OSW Lease Areas	OCS-A 0490 – 155 nautical miles OCS-A 0519 – 135 nautical miles OCS-A 0482 (Ørsted/PSEG) - 132 nautical miles OCS-A 0498 (Ørsted) – 97 nautical miles OCS-A 0499 (EDF/Shell) - 68 nautical miles Hudson South Draft WEA – 36 nautical miles OSC-A 0512 (Equinor) – 30 nautical miles Hudson North Draft WEA – 56 nautical miles Fairways South Draft WEA – 59 nautical miles Fairways North Draft WEA – 80 nautical miles	
Rail Connection	Rail is available within 0.5 miles	

Table 15: MOTBY - Summary of Existing Conditions		
Restrictions	Verrazano-Narrows Bridge: Vert Cl 198 feet (middle 2,000 feet); Vert Cl 183 feet (piers); Vert Cl 215 feet (center)	
Environmental Conditions	NJEMS Site ID 14201; Preferred ID 011992 (Military Ocean Terminal – Bayonne) NJEMS Site ID 602237; Preferred ID 788099 (Bayonne Bay Residential Development) NJEMS Site ID 621075; Preferred ID 788103 (Harbor Pointe & Alexan City View Apartments) NJEMS Site ID 621105; Preferred ID 788144 (Port Authority @ Maritime District) NJEMS Site ID 601158; Preferred ID 788093 (151 Centre Street Urban Development)	NJDEP issued a No Further Action required in 2001
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.		

To meet the needs of offshore wind component manufacturing, certain improvements are necessary. Table 16 below provides a cost summary to replace 1,000 feet of the quayside and improve upland load bearing capacity (50 acres). Disposal costs are variable, so low and high costs are provided. Given that expansion beyond the 50 acres is possible, a cost to improve the upland load bearing capacity per acre is also provided. It is assumed that an existing quayside with access to a deep-water berth will be replaced, so no dredging will be required. Costs to demolish existing buildings are not included.

Table 16: MOTBY - Summary of Redevelopment Costs

	Low Disposal Cost Scenario	High Disposal Cost Scenario
Replace quayside (1,000 feet); including relieving platform	$38,000,000	$38,000,000
Transportation and disposal costs of upland soils, including excavation	$27,225,000	$72,600,000
Placement and compaction of 3 feet of DGA	$18,150,000	$18,150,000
Upland load bearing capacity improvements per acre	$907,500/acre	$1,815,000/acre
20% Contingency	$16,675,000	$25,750,000
Total	**$100,050,000**	**$154,500,000**

8.4 Potential Offshore Wind Uses

The site's large acreage and access to deep water channels make it adaptable for manufacturing of OSW components. Some of the existing structures will need to be demolished for the site to be suitable to support manufacturing or staging of components. Depending on the condition of the existing buildings, it is possible some of the buildings can be repurposed for storage or fabrication of OSW components. The Verrazano-Narrows Bridge with a vertical clearance of 198 feet (middle 2,000 feet) or 183 feet (piers) will present challenges for larger wind components without utilizing a feeder barge system. Coordinating with other operations at the terminal will make marshaling challenging. Depending on availability and OSW use, the existing quaysides will either need to be strengthened or replaced. Additionally, if the southern side is used, dredging will be required. If the existing quaysides on the north, east, or southeast are available, then dredging will not be required.

8.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site could be adapted to handle monopile, transition piece, tower section components and jacket foundations, including manufacturing, fabrication, and lay down. Upland soil load bearing capacity would need to be improved and a replacement quayside constructed.

Nacelles, Blades, Rotors, Generators:

These components could be manufactured or finished at this site. Upland soil load bearing capacity would need to be improved over portions of the site for the efficiency of this operation to meet serial production standards. For heavier components including nacelles, rotors, and generators, a replacement quayside will need to be constructed to handle the heavy loads. For blades, strengthening the existing quayside may meet the load bearing capacity requirements.

O&M Service, Cables, Secondary Steel:

The site is well suited for O&M operations from a layout perspective and is within 50 nautical miles of the Hudson South Draft WEA and OCS-A 0512 (Equinor's Empire Wind). The existing quayside is suitable for O&M. Manufacture of secondary steel components (ladders, platforms, railings, racks) could be easily adapted at this site. The site is well suited for cable storage, as a cable service port, and as a cable manufacturing facility with moderate modification needed. The existing quayside will likely need to be strengthened for cables and secondary steel.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of offshore wind production, certain site improvements would be required. These would include: demolition of existing structures; improvement of upland load bearing capacity; strengthening or development of quayside; dredging of berth (southern side only); addition of production buildings (for manufacturing/fabrication scenarios); and installation of crane pads or relieving platform where extreme heavy lift operations might occur.

8.4.2 Reuse Scenario – Cable Manufacturing

The site's large acreage and access to deep water channels make the site adaptable for cable manufacturing. The redevelopment costs provided above include replacing the quayside (including installing a relieving platform) and increasing upland load bearing capacity (50 acres; including laydown areas). If the site were to be redeveloped for cable manufacturing, only 30 acres of upland soil capacity would need to be improved. Additional costs may include construction of warehouse/office building, construction of manufacturing building, and installation of a transfer crane.

Table 17: MOTBY - Summary of Reuse Costs – Cable Manufacturing

	Estimated Costs
Construction of warehouse/offices (50,000 square feet)	$1,010,000
Construction of manufacturing building (100,000 square feet); including two overhead cranes	$6,090,000
Transfer crane	$3,000,000
20% Contingency	$2,020,000
Total	**$12,120,000**

9. CHEMOURS – LINDEN, NJ

9.1 Existing Conditions

The former Chemours (also formerly known as DuPont Grasselli) chemical manufacturing facility totals approximately 98 acres (Figure 23). The site has a long industrial history dating back to 1800s. From 1885 to 1928, the site was used for chemical manufacturing by Grasselli. In 1928, the plant was acquired by DuPont for manufacture of chemicals and pesticides. DuPont operated at the site until 1990. The long industrial history resulted in chemical releases to the subsurface. Site environmental remediation is now complete, and the site is reportedly ready for development. The site is currently for sale with a listing price of $70M. According to NJ state planning documents, the site is the longest contiguous available waterfront parcel in the NJ & NY port area with rail access. All former chemical manufacturing buildings have been demolished and the site has undergone pre-consolidation with fill material and is graded for development above the base flood elevation (BFE) line. The site is equipped with three dolphins along the southeastern boundary.

Figure 23: Chemours (Linden, NJ) - Site Location Map

The site is located on the western shore of the Arthur Kill. Pralls Island divides the Arthur Kill east of the site. Beyond the Arthur Kill is Staten Island, NY. A wastewater treatment facility and petroleum terminal are located south of the site. An apparent warehouse is located on the parcel west of the site. North of the site is a canal, beyond which is the PSEG Linden Generating Station. The majority of the adjacent west parcel is undeveloped wetlands. Route I-95 is located within three miles of the site and the Garden State Parkway is located within five miles of the site. Rail access is available along the western property boundary.

Water approaches to the site is via the Pralls Island Reach (Figure 24). Deep water channels are available to the north and south of the site. To the north, the Pralls Island Reach and Gulfport Reach are 35 feet deep and 500 feet wide. The channel deepens to 50 feet through the Elizabethport Reach, North of Shookers Island Reach, Bergen Point West Reach, Bergen Point East Reach, and Constable Hook Reach. To the south, the channels are 35 feet deep and at least 500 feet wide via the Pralls Island Reach, Tremley Point Reach, Fresh Kills Reach, Port Reading Reach, Port Socony Reach, Outerbridge Reach, Ward Point Bend West, Ward Point Bend East, Red Bank Reach, Seguine Point Reach, Raritan Bay West Reach, and Raritan West Reach. There are three dolphins along the southeastern site boundary. There is not a suitable quayside at the property; however, there are approximately 3,175 feet of water frontage which could be developed into a quayside to support OSW operations.

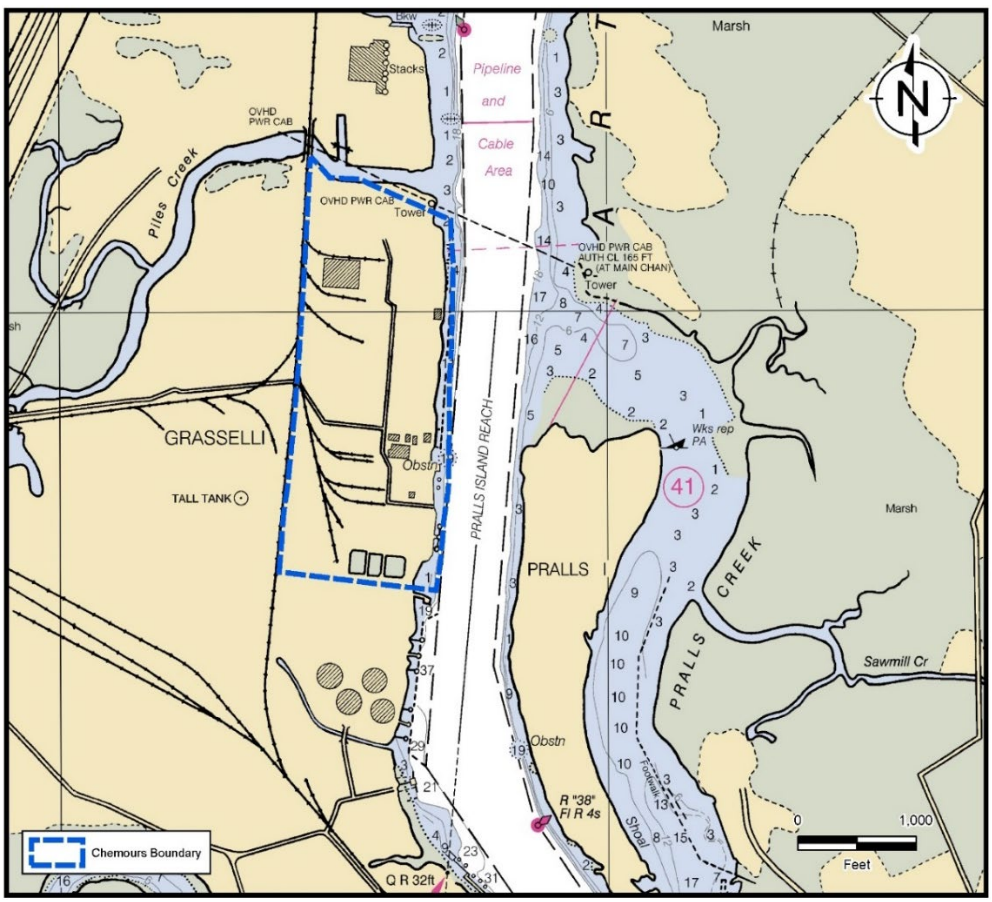


Figure 24: Chemours (Linden, NJ) - NOAA Depth Chart

9.2 Limitations

Vertical restrictions between the site and open water include overhead power cables, the Goethals Bridge, Arthur Kill Railroad Bridge, Bayonne Fixed Bridge, and the Verrazano-Narrows Bridge to the north. The vertical clearance along the northern route is restricted by the Arthur Kill Railroad Bridge at 135 feet (up), and 31 feet (down). The Arthur Kill Railroad Bridge has a horizontal (beam) clearance of 500 feet. To the south, the Outerbridge Crossing restricts the vertical clearance at 143 feet. The Outerbridge Crossing has a horizontal clearance of 675 feet. The closest airport is the Newark International Airport located approximately 4.5 miles north of the site.

9.3 Environmental Conditions

The site is listed on the NJDEP's database for sites with known contamination (NJEMS ID 930). Site soil and groundwater were impacted with solvents and pesticides from the long industrial history. Site environmental remediation is reportedly complete. Additionally, there are habitat-specific requirements that will need to be considered during the planning phase of development (Figure 25).

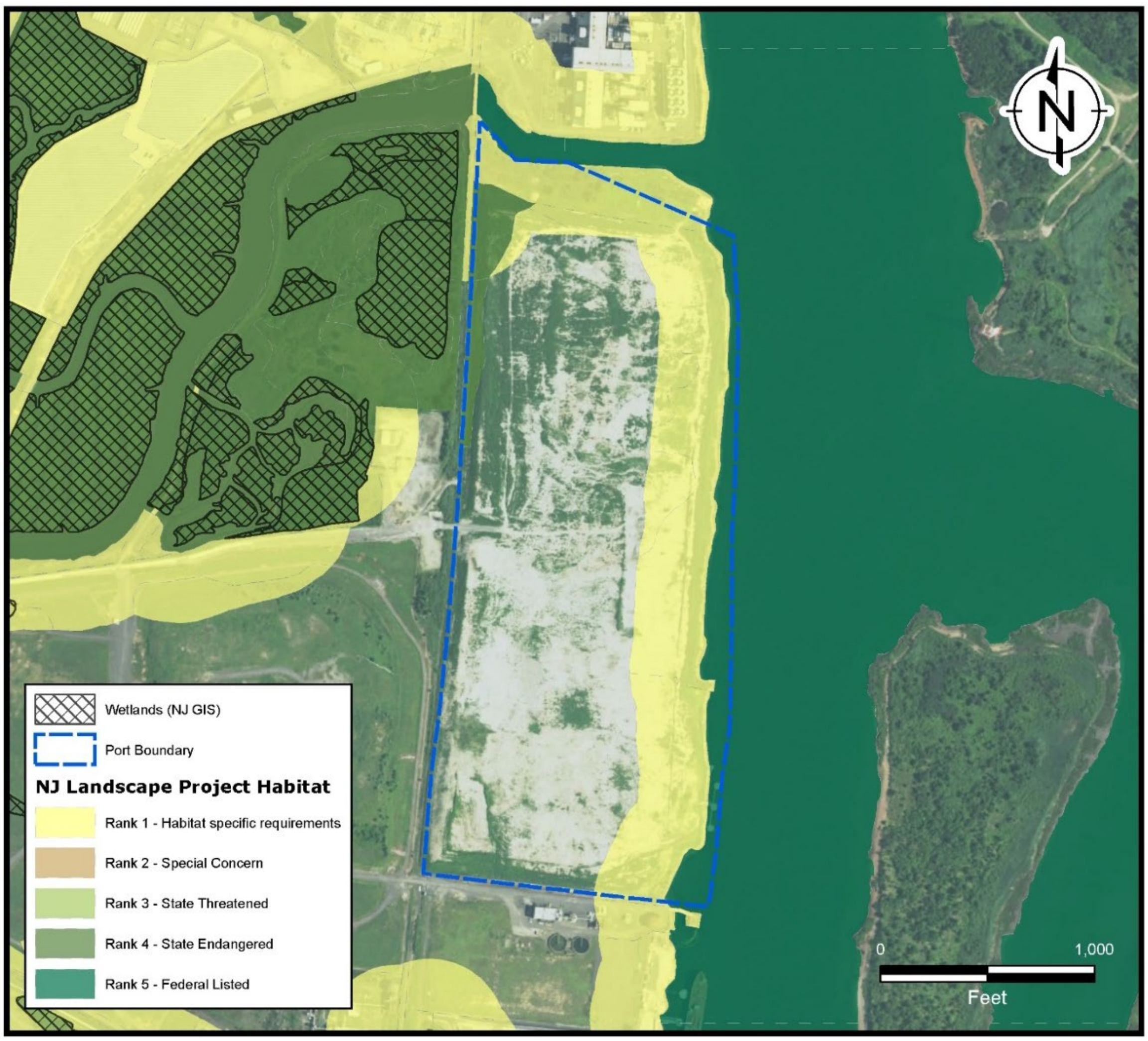


Figure 25: Chemours (Linden, NJ) - Wetlands and Habitat Map

Table 18: Chemours (Linden, NJ) - Summary of Existing Conditions		
Size	~98 acres total	
Buildings	Buildings associated with former chemical manufacturing have been demolished.	
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	Three dolphins; not a suitable quayside	
Quayside Length	N/A; ~3,176 feet of water frontage	
Quayside Load Bearing Capacity*	N/A	
Depth at Potential Quayside locations	1-19 feet MLLW	
Channel Dimensions	Route North: Pralls Island Reach and Gulfport Reach - 35 feet deep MLLW by 500 feet wide Elizabethport Reach, North of Shookers Island Reach, Bergen Point West Reach, Bergen Point East Reach, and Constable Hook Reach - 50 feet deep MLLW by at least 500 feet wide Route South: Pralls Island Reach, Tremley Point Reach, Fresh Kills Reach, Port Reading Reach, Port Socony Reach, Outerbridge Reach, Ward Point Bend West, Ward Point Bend East, Red Bank Reach, Seguine Point Reach, Raritan Bay West Reach, and Raritan Bay East Reach - 35 feet deep MLLW by at least 500 feet wide	
Distance to OSW Lease Areas	OCS-A 0490 – 159 nautical miles OCS-A 0519 – 153 nautical miles OCS-A 0482 (Ørsted/PSEG) - 138 nautical miles OCS-A 0498 (Ørsted) – 98 nautical miles OCS-A 0499 (EDF/Shell) - 70 nautical miles Hudson South Draft WEA – 50 nautical miles OSC-A 0512 (Equinor) – 42 nautical miles Hudson North Draft WEA – 62 nautical miles Fairways South Draft WEA – 63 nautical miles Fairways North Draft WEA – 85 nautical miles	
Rail Connection	Rail at western site boundary	

Table 18: Chemours (Linden, NJ) - Summary of Existing Conditions		
Restrictions	North: Arthur Kill Railroad Bridge: Vert Cl 135 feet (up); Vert Cl 31 feet (down); Hor Cl 500 feet South: Outerbridge Crossing (Cantilever Bridge) Vert Cl 143 feet; Hor Cl 675 feet	
Environmental Conditions	NJEMS Site ID 930; Preferred ID G000001666 (El Dupont Denemours & Co)	Remediation is reportedly complete
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.		

To meet the needs of OSW manufacturing, certain improvements are necessary. Table 19 below provides a cost summary to construct the quayside, improve the upland load bearing capacity (50 acres), and complete the required dredging. Given that expansion beyond 50 acres is possible, a cost to improve the upland load bearing capacity per acre is also provided. Disposal costs are variable, so low and high costs are provided.

Table 19: Chemours (Linden, NJ) - Summary of Redevelopment Costs

	Low Disposal Cost Scenario	High Disposal Cost Scenario
New quayside (800 linear feet) including relieving platform	$30,400,000	$30,400,000
Dredge around quayside to 35 feet	$2,844,444	$9,955,556
Transportation and disposal costs of upland soils, including excavation	$27,225,000	$72,600,000
Placement and compaction of 3 feet of DGA	$18,150,000	$18,150,000
20% Contingency	$15,723,889	$26,221,111
Total	**$94,343,333**	**$157,326,667**

9.4 Potential Offshore Wind Uses

The site's large acreage and potential for sole use make it adaptable for manufacturing of OSW components. The upland load bearing capacity of the site will need to be improved. The Arthur Kill Railroad Bridge with a vertical clearance of 135 feet make the site unsuitable for marshaling or manufacture of larger components without utilizing a feeder barge system. The site does not currently have a suitable quayside, so a new quayside will need to be designed and constructed. Additionally, dredging at the quayside (to be constructed) will be necessary.

9.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The vertical clearance of 135 feet will make it challenging to manufacture or fabricate monopile, transition piece, tower section components and jacket foundations without utilizing a feeder barge system.

Nacelles, Blades, Rotors, Generators:

These components could be manufactured or finished at this site. Upland soil load bearing capacity would need to be improved over portions of the site for the efficiency of this operation to meet serial production standards. Similar to the requirements for other components, the quayside will need to be built and dredging is necessary.

O&M Service, Cables, Secondary Steel:

The site is well suited for O&M operations from a layout perspective and is within 50 nautical miles of the Hudson South Draft WEA and OCS-0512 (Equinor's Empire Wind). Manufacture of secondary steel components (ladders, platforms, railings, racks) could be easily adapted at this site. The site is well suited for cable storage, as a cable service port, and as a cable manufacturing facility. In all cases, a robust quayside would need to be constructed.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of offshore wind production, certain site improvements would be required. These would include: improvement of upland load bearing capacity; development of quayside; dredging of berth; addition of production buildings (for manufacturing/fabrication scenarios); and installation of crane pads or relieving platform where extreme heavy lift operations might occur.

9.4.2 Reuse Scenario – Blade Manufacturing

The site's large acreage and access to deep water channels make the site adaptable for blade manufacturing. The bulk of the reuse costs for blade manufacturing are associated with the redevelopment costs presented above. The redevelopment costs include quayside construction (including relieving platform), upland load bearing capacity improvement (including laydown areas) and dredging. Additional costs may include construction of warehouse building, and construction of fabrication building.

Table 20: Chemours (Linden, NJ) - Summary of Reuse Costs – Blade Manufacturing

	Estimated Costs
Construction of warehouse building (20,000 square feet)	$524,000
Construction of fabrication building (180,000 square feet); includes two overhead cranes	$10,682,000
20% Contingency	$2,241,200
Total	**$13,447,200**

10. GARDNER'S BASIN – ATLANTIC CITY, NJ

10.1 Existing Conditions

The approximately 10-acre site is currently vacant and located at Carson Avenue in Atlantic City, New Jersey (Figure 26). Portions of the site are used for parking for visitors accessing the water. The site has approximately 1,400 feet of water frontage along Absecon Inlet.

Figure 26: Gardner's Basin - Site Location Map

Absecon Inlet bounds the site to the north and east. To the southeast are a recreational beach and residences. To the west are residences and the Atlantic City Aquarium. No rail is available on-site. The Atlantic City International Airport is located approximately nine miles northwest of the site. The Atlantic City Expressway is located within two miles southwest of the site.

Water approaches to the site are via the Absecon Inlet (See Figure 27). The channel is 29 feet to 46 feet deep and 400 feet wide. Depth along the property is approximately 15 feet deep. The Absecon Inlet leads to open water.

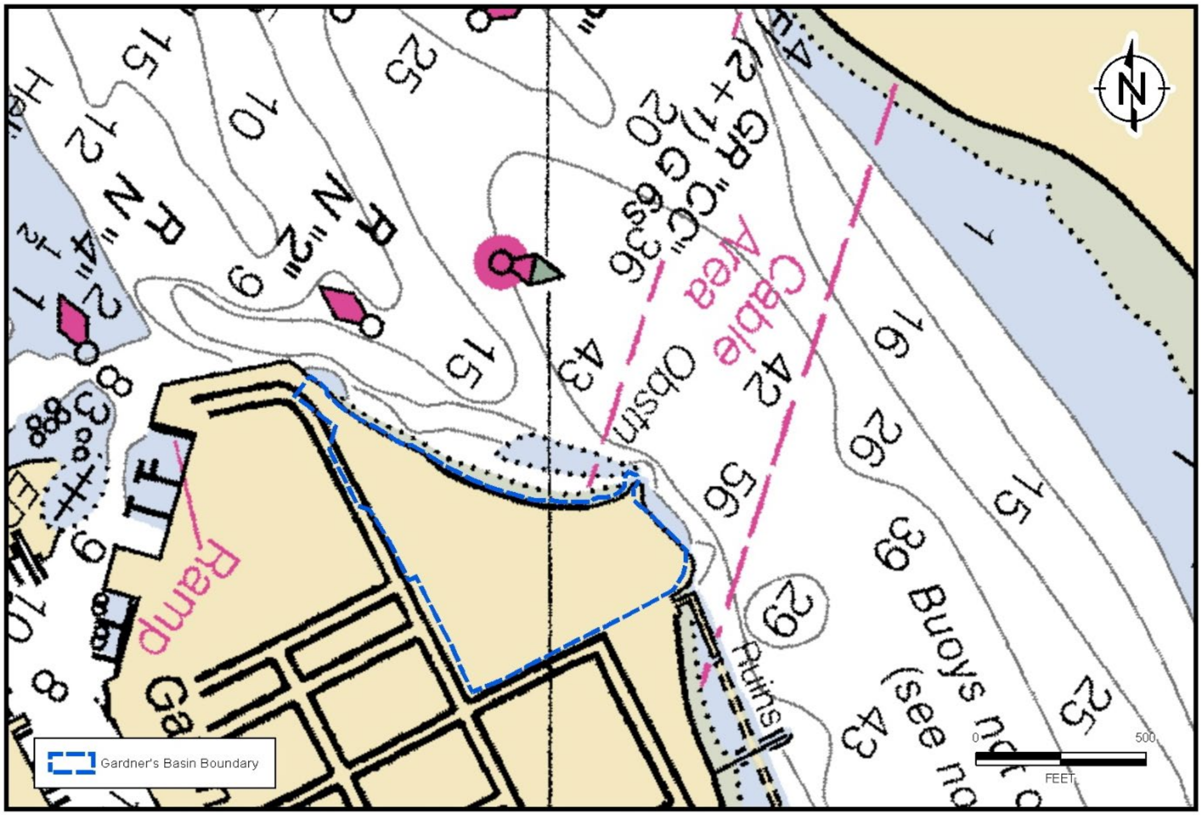


Figure 27: Gardner's Basin - NOAA Depth Chart

10.2 Limitations

There are no overhead restrictions between the site and open water.

10.3 Environmental Conditions

The site address is not listed on NJDEP's database for sites with known contamination; however, Captain Starns Fuel Service Inc (801 New Hampshire Ave N) is mapped on the database within site boundaries. No wetlands were identified on-site. The site does have habitat-specific requirements that will need to be considered if redeveloped (Figure 28).

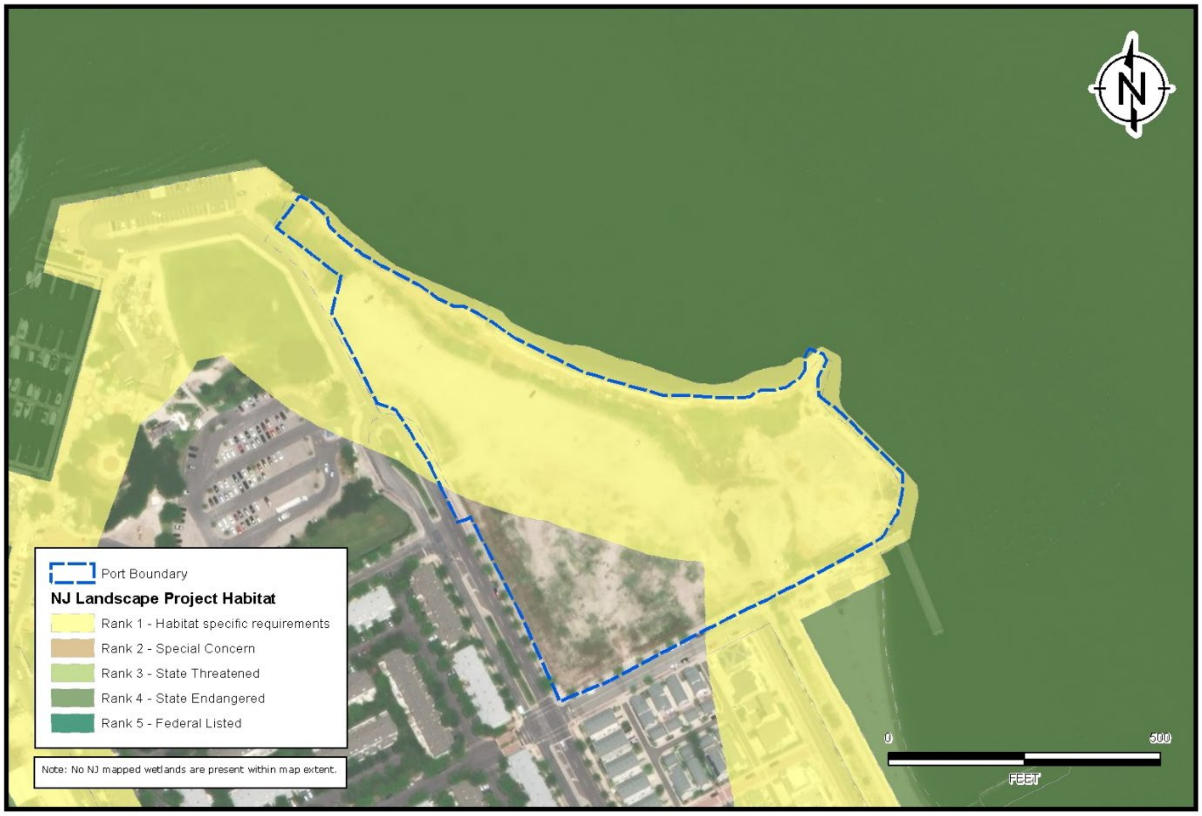


Figure 28: Gardner's Basin - Wetlands and Habitat Map

Table 21: Gardner's Basin - Summary of Existing Conditions		
Size	~10 acres	
Buildings	No buildings present	
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	N/A; riprap	
Quayside Length	N/A; ~1,400 feet of water frontage	
Quayside Load Bearing Capacity*	N/A	
Depth at Potential Quayside locations	9-15 feet deep MLLW	
Channel Dimensions	400 feet wide by 29-46 feet deep MLLW	

Table 21: Gardner's Basin - Summary of Existing Conditions		
Distance to OSW Lease Areas	OCS-A 0490 – 69 nautical miles OCS-A 0519 – 65 nautical miles OCS-A 0482 (Ørsted/PSEG) - 42 nautical miles OCS-A 0498 (Ørsted) – 9 nautical miles OCS-A 0499 (EDF/Shell) - 10 nautical miles Hudson South Draft WEA – 37 nautical miles OSC-A 0512 (Equinor) – 76 nautical miles Hudson North Draft WEA – 79 nautical miles Fairways South Draft WEA – 94 nautical miles Fairways North Draft WEA – 117 nautical miles	
Rail Connection	None identified	
Restrictions	No overhead restrictions	
Environmental Conditions	NJEMS Site ID 44393; Preferred ID 010045 (Captain Starns Fuel Service Inc)	Unclear if this is on-site. The Known Contaminated Site listing is for 801 New Hampshire Ave N.
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.		

This location is well-suited to support O&M operations but not for other OSW-related uses. To meet the needs of an O&M facility, certain improvements are necessary. Table 22 below provides a redevelopment cost summary to construct the quayside (pontoon), improve upland load bearing capacity, and complete the required dredging. Disposal costs and pontoon construction costs are variable, so low and high costs are provided.

Table 22: Gardner's Basin - Summary of Redevelopment Costs		
	Low Cost Scenario	**High Cost Scenario**
New quayside (pontoon)	$3,000,000	$4,000,000
Dredge around quayside to 20 feet	$550,000	$1,925,000
Transportation and disposal costs of upland soils, including excavation	$3,630,000	$9,680,000
Placement and compaction of 1 foot of coarse granular aggregate (CGA)	$847,000	$847,000
Placement and compaction of 1 foot of DGA	$1,210,000	$1,210,000
20% Contingency	$1,847,400	$3,532,400
Total	**$11,084,400**	**$21,194,400**

10.4 Potential Offshore Wind Use

The site's proximity to offshore wind lease areas make it in an ideal location for an O&M facility. The site is less than 10 miles from OCS-0498 (Ørsted's Ocean Wind) and OCS-0499 (EDF and Shell's joint venture, Atlantic Shores Offshore Wind). Additionally, the site is within 50 nautical miles of Hudson South Draft WEA and OCS-0482 (Ørsted and PSEG's joint venture, Garden State Offshore Energy). There are no vertical restrictions between the site and open ocean. The site does not currently have a suitable quayside, so a new quayside (likely pontoon) will need to be designed and constructed. Additionally, dredging is required to connect the site quayside (to be constructed) to the deep-water channel.

10.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site's acreage makes it unsuitable for fabrication or manufacture of foundation and tubular components.

Nacelles, Blades, Rotors, Generators:

The site's acreage makes it unsuitable for fabrication or manufacture of nacelles, blades, rotors, and generator components.

O&M Service, Cables, Secondary Steel:

The site is ideal for O&M operations from a layout perspective and proximity to OSW lease areas. Due to the relatively small size, manufacture of secondary steel components (ladders, platforms, railings, racks) and cables would be challenging. Additionally, given the surrounding land use (residential) and recreation vessel traffic, OSW component manufacturing would be challenging at this site. A suitable pontoon-type quayside and dredging would be needed.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of O&M, certain site improvements would be required. These would include: improvement of upland load bearing capacity; development of quayside; dredging of berth; and addition of storage buildings.

10.4.2 Reuse Scenario – O&M

The site's layout and proximity to OSW lease areas make it adaptable for O&M. The bulk of the redevelopment costs for O&M are associated with constructing the quayside, increasing upland load bearing capacity (10 acres; includes laydown areas), and completing the required dredging. Additional costs may include construction of warehouse/office building (20,000 square feet).

Table 23: Gardner's Basin - Summary of Reuse Costs –O&M

	Estimated Costs
Construction of warehouse/office building (20,000 square feet)	$524,000
20% Contingency	$104,800
Total	**$628,800**

11. CAPE MAY-LEWES FERRY – CAPE MAY, NJ

11.1 Existing Conditions

The approximately 250-acre site is owned by the Delaware River and Bay Authority and located in Cape May, New Jersey (Figure 29). The southwest portion of the site is operated by the Cape May-Lewes Ferry Terminal, including quayside, support structures, and parking areas. An apparent industrial facility is located on the southeast corner of the site. The majority of the site consists of wetlands and undeveloped land. There are over 6,000 feet of water frontage.

Figure 29: Cape May-Lewes Ferry - Site Location Map

The Cape May Canal bounds the site to the south. Residential properties and a vineyard are located east of the site. To the north of the site is Route 9, beyond which is a mixed residential and commercial area. A beach and the Delaware Bay are located west of the site. The Garden State Parkway is located within two miles east of the site. No rail is available on-site. The Cape May Airport is located approximately 3.5 miles northwest of the site.

Water approaches the site via the Cape May Canal and Delaware Bay (See Figure 30). The Cape May Canal is approximately 100 feet wide and 12 feet deep. The Cape May Canal provides direct access to the Delaware Bay.

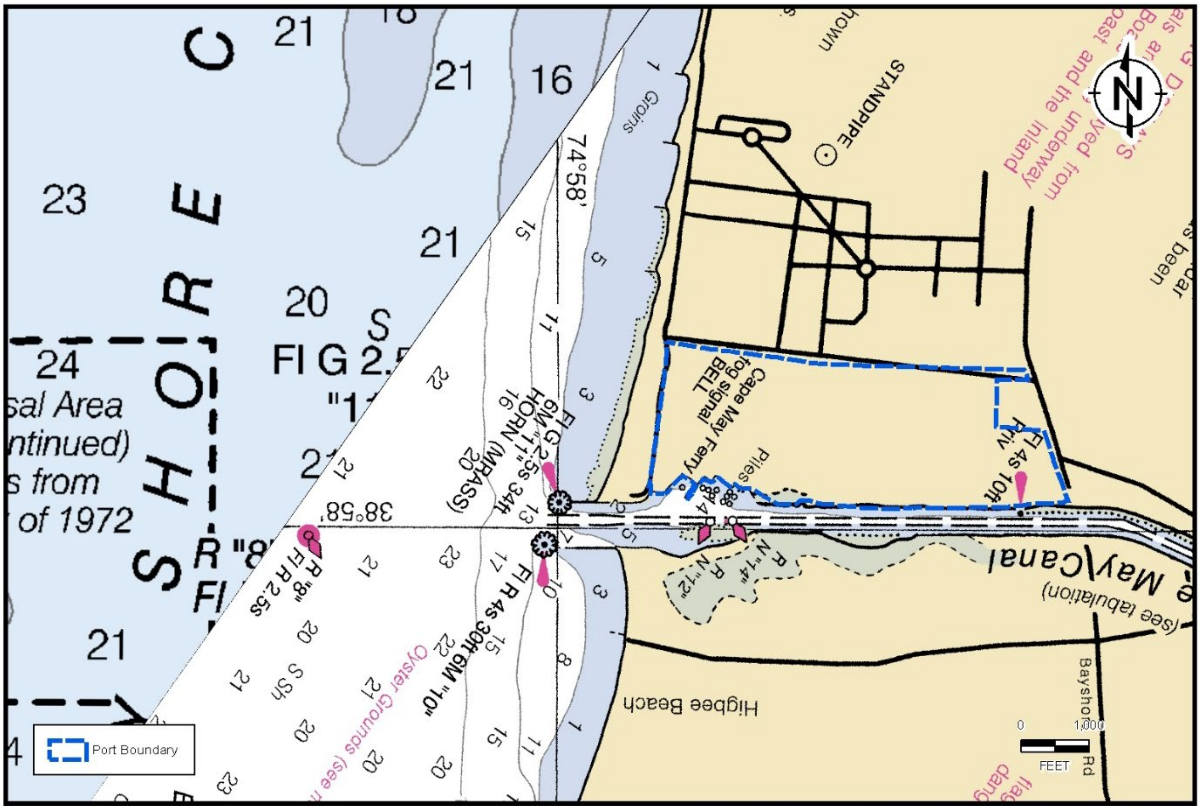


Figure 30: Cape May-Lewes Ferry - NOAA Depth Chart

11.2 Limitations

There are no vertical restrictions between the site and open water. The Cape May Canal is 12 feet deep, so dredging is necessary to accommodate OSW support vessels.

11.3 Environmental Conditions

The site is not listed on NJDEP's database of sites with known contamination sites. The majority of the site is comprised of wetlands and habitat-specific requirements that will need to be considered during the planning phase of development (Figure 31).

Figure 31: Cape May-Lewes Ferry - Wetlands and Habitat Map

Table 24: Cape May-Lewes Ferry - Summary of Existing Conditions

Size	~250 acres; 160 acres potentially available for redevelopment	Majority of site is wetlands.
Buildings	Five buildings and parking areas associated with ferry terminal located in the southwestern portion of the property; One building located in the southeastern corner of the property; the majority of the site is undeveloped.	
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	Piers; five berthing areas associated with ferry terminal	
Quayside Length	Five berthing areas totaling ~1,300 feet	
Quayside Load Bearing Capacity*	<1,000 psf	

Table 24: Cape May-Lewes Ferry - Summary of Existing Conditions		
Depth at Potential Quayside locations	2-14 feet MLLW	
Channel Dimensions	Cape May Canal (Spicer Creek Canal to Inner End of Ferry Basin) - 100 feet wide by 12 feet deep MLLW Cape May Canal (Ferry Basin to Delaware Bay) - 100-150 feet wide by 12 feet deep MLLW	
Distance to OSW Lease Areas	OCS-A 0490 – 35 nautical miles OCS-A 0519 – 28 nautical miles OCS-A 0482 (Ørsted/PSEG) - 22 nautical miles OCS-A 0498 (Ørsted) – 37 nautical miles OCS-A 0499 (EDF/Shell) - 56 nautical miles Hudson South Draft WEA – 78 nautical miles OSC-A 0512 (Equinor) – 129 nautical miles Hudson North Draft WEA – 135 nautical miles Fairways South Draft WEA – 152 nautical miles Fairways North Draft WEA – 172 nautical miles	
Rail Connection	None identified	
Restrictions	No vertical restrictions; dredging in Cape May Canal is likely necessary	
Environmental Conditions	No known contamination; majority of undeveloped land is wetlands	
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.		

This location is well-suited to support O&M operations but not for other OSW-related uses. To meet the needs of an O&M or fabrication facility, certain improvements are necessary. Table 25 below provides a cost summary to construct the quayside, improve upland load bearing capacity (4 acres), and complete the required dredging. Given that expansion beyond four acres is possible, a cost to improve the upland load bearing capacity (O&M use) per acre is also provided. Disposal costs and pontoon construction costs are variable, so low and high costs are provided.

Table 25: Cape May-Lewes Ferry - Summary of Redevelopment Costs		
	Low Cost Scenario	**High Cost Scenario**
New quayside (pontoon)	$3,000,000	$4,000,000
Dredge around quayside to 20 feet	$550,000	$1,925,000
Dredge to deep water channel to 20 feet	$5,163,704	$18,072,963
Transportation and disposal costs of upland soils, including excavation	$1,452,000	$3,872,000
Placement and compaction of 1 foot of CGA	$338,800	$338,800
Placement and compaction of 1 foot of DGA	$484,000	$484,000
Cost to improve upland per acre (excavation, CGA, and DGA)	$568,700/acre	$1,173,700/acre
20% Contingency	$2,197,701	$5,738,533
Total	**$13,186,204**	**$34,431,316**

11.4 Potential Offshore Wind Use - O&M

The site's proximity to offshore wind lease areas make it suitable for O&M. There are no overhead restrictions between the site and open ocean. The Cape May Canal is shallow at 12 feet and will need to be deepened to be suitable for OSW components. The Cape May Canal has a limiting horizontal (beam) clearance of 100 feet, making the site unsuitable for larger OSW components. The majority of the site is comprised of wetlands, so permitting for developing large areas will be challenging. The site's current quayside is used by the Cape May-Lewes Ferry. It is unclear if the existing quayside could be available for OSW use.

11.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

Due to the permitting challenges and Cape May Canal depth and horizontal restrictions, the site cannot be adapted to handle monopile, transition piece, tower section components and jacket foundations.

Nacelles, Blades, Rotors, Generators:

Due to the permitting challenges and Cape May Canal depth and horizontal restrictions, the site is not suitable for manufacturing or finishing of these components.

O&M Service, Cables, Secondary Steel:

The site's proximity to offshore wind lease areas make it a suitable location for an O&M facility. The site is within 50 nautical miles of OCS-0498 (Ørsted's Ocean Wind) and OCS-0482 (Ørsted and PSEG's joint venture, Garden State Offshore Energy). The site's current quayside is used by the Cape May-Lewes Ferry. It is unclear if the existing quayside could be available for OSW use. If the current quayside is available, it could be used for O&M. If a new quayside is required, a pontoon design would be suitable for O&M. The permitting challenges associated with wetlands will be more easily managed in the development of an O&M facility due to the small acreage required. Additionally, dredging is required to connect the site quayside (to be constructed) to the deep-water channel. The Cape May Canal itself will also need to be dredged to 25 feet. Due to the Cape May Canal restrictions and required permitting, this site is not suitable for manufacture of secondary steel components (ladders, platforms, railings, racks) and cables.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of O&M, certain site improvements would be required. These would include: improvement of upland load bearing capacity; development of quayside; dredging of berth and Cape May Canal; and addition of storage buildings.

11.4.2 Reuse Scenario – O&M

The site's layout and proximity to OSW lease areas make it adaptable for O&M. The bulk of the redevelopment costs for O&M are associated with constructing the pontoon quayside, increasing upland load bearing capacity (four acres; includes laydown areas), and completing the required dredging. Additional costs may include construction of warehouse/office building (20,000 square feet).

Table 26: Cape May-Lewes Ferry - Summary of Reuse Costs –O&M

	Estimated Costs
Construction of warehouse/office building (20,000 square feet)	$524,000
20% Contingency	$104,800
Total	**$628,800**

12. NORTH NEW JERSEY AVE – ATLANTIC CITY, NJ

12.1 Existing Conditions

The approximately 3.2-acre site is owned by OCD, Inc and located at 614 North New Jersey Avenue in Atlantic City (Figure 32). The site is improved with an approximately 6,200 square foot warehouse. The majority of the site is undeveloped. The site does not have suitable quayside; however, the site has approximately 460 feet of water frontage. The quayside currently consists of a retaining wall and riprap.

Figure 32: North New Jersey Ave - Site Location Map

An inlet off of Absecon Inlet bounds the site to the west and north. Magellan Ave bounds the site to the south, beyond which are residences. To the east are Kirby Shore Mechanical Contractors and residences. To the southeast are a recreational beach and residences. To the west are residences and the Atlantic City Aquarium. No rail is available on-site. The Atlantic City International Airport is located approximately nine miles northwest of the site. The Atlantic City Expressway is located within two miles southwest of the site.

Water approaches to the site is via an inlet off of Absecon Inlet (See Figure 33). The inlet approaching the site is approximately 7 to 14 feet deep and 350 feet wide. The Absecon Inlet is 29 feet to 46 feet deep and 400 feet wide. Depth along the property is approximately 11-13 feet deep. The Absecon Inlet leads to open water.

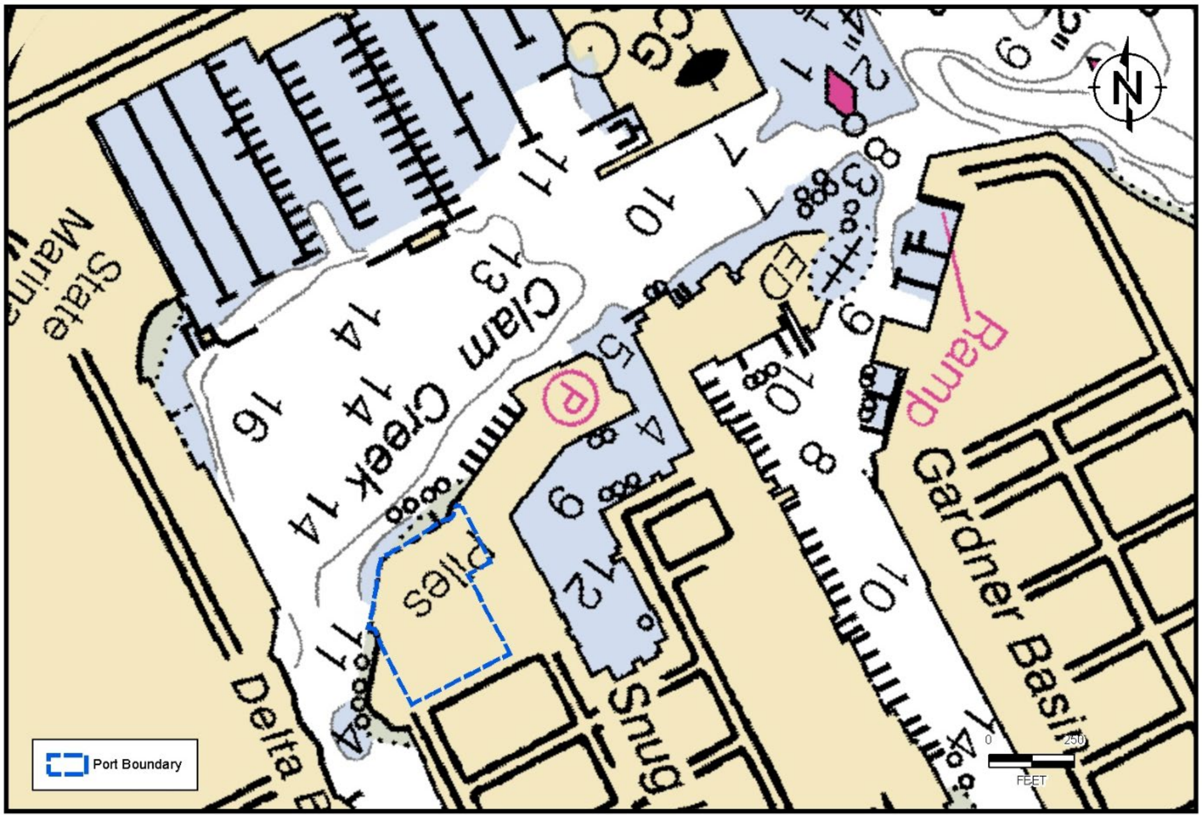


Figure 33: North New Jersey Ave - NOAA Depth Chart

12.2 Limitations

There are no overhead restrictions between the site and open water.

12.3 Environmental Conditions

Wetlands are present on a small section of the western property boundary (Figure 34). The site has habitat-specific requirements that will need to be considered if redeveloped. The site is listed on the NJDEP's database for sites with known contamination. The database listing is for Exxon Company USA.

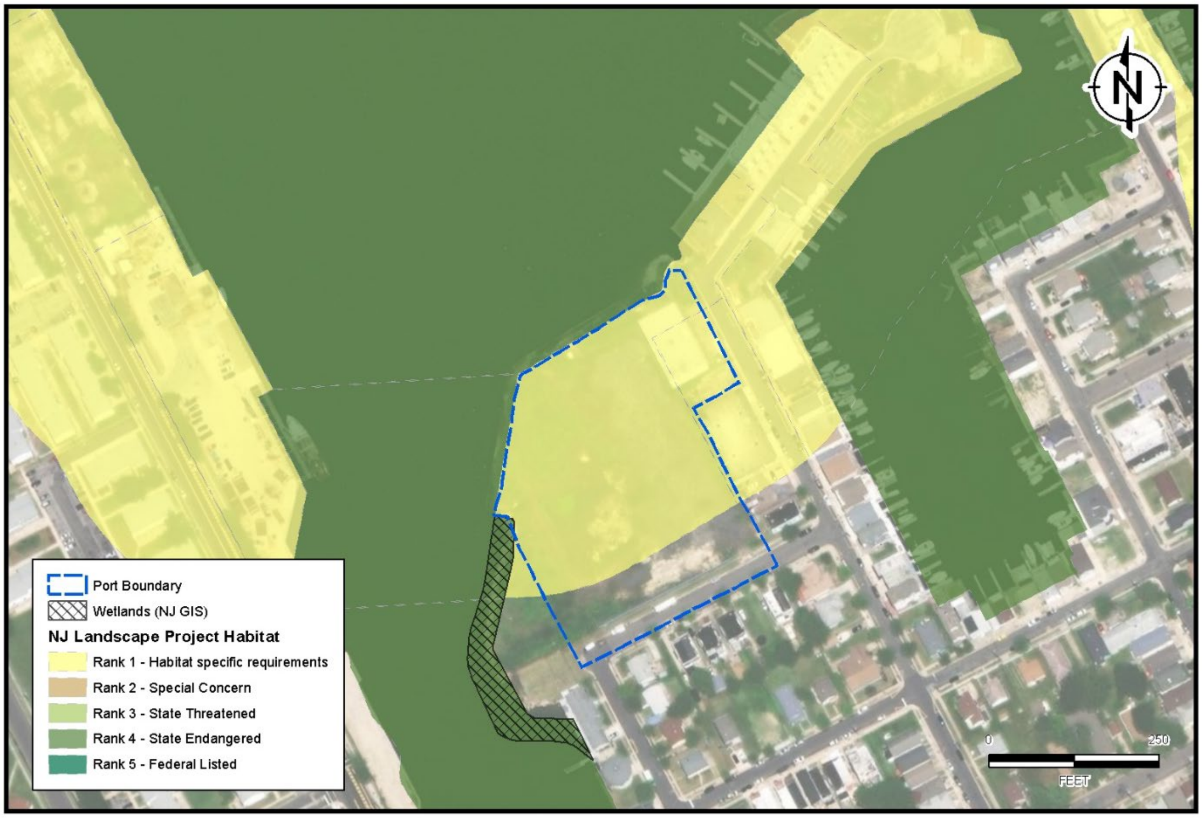


Figure 34: North New Jersey Ave - Wetlands and Habitat Map

Table 27: North New Jersey Ave - Summary of Existing Conditions	
Size	~3.2 acres
Buildings	One ~6,200 sf warehouse
Upland Load Bearing Capacity*	<1,000 psf
Quayside Type	N/A; Retaining wall and riprap
Quayside Length	~460 feet of water frontage
Quayside Load Bearing Capacity*	N/A
Depth at Potential Quayside locations	11-13 feet deep MLLW
Channel Dimensions	400 feet wide by 29-46 feet deep MLLW Inlet: 7-14 feet deep MLLW

Table 27: North New Jersey Ave - Summary of Existing Conditions	
Distance to OSW Lease Areas	OCS-A 0490 – 69 nautical miles OCS-A 0519 – 65 nautical miles OCS-A 0482 (Ørsted/PSEG) - 42 nautical miles OCS-A 0498 (Ørsted) – 9 nautical miles OCS-A 0499 (EDF/Shell) - 10 nautical miles Hudson South Draft WEA – 37 nautical miles OSC-A 0512 (Equinor) – 73 nautical miles Hudson North Draft WEA – 79 nautical miles Fairways South Draft WEA – 94 nautical miles Fairways North Draft WEA – 117 nautical miles
Rail Connection	None identified
Restrictions	No vertical restrictions
Environmental Conditions	NJEMS Site ID 12799; Preferred ID 001043 (Exxon Company USA)
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.	

This location is well-suited to support O&M operations but not for other OSW-related uses. To meet the needs of an O&M facility, certain improvements are necessary. Table 28 below provides a cost summary to construct a pontoon-type quayside, increase upland load bearing capacity, and complete the required dredging. Disposal and quayside development costs are variable, so low and high costs are provided. Costs for existing building demolition are not included.

Table 28: North New Jersey Ave - Summary of Redevelopment Costs

	Low Disposal Cost Scenario	High Disposal Cost Scenario
New quayside (pontoon)	$3,000,000	$4,000,000
Dredge around quayside to 20 feet	$740,741	$2,592,593
Dredge to deep water channel to 20 feet	$7,111,111	$24,888,889
Transportation and disposal costs of upland soils, including excavation	$907,500	$2,420,000
Placement and compaction of 1 foot of CGA	$211,750	$211,750
Placement and compaction of foot of DGA	$302,500	$302,500
Cost to improve upland per acre (excavation, CGA, and DGA)	$568,700/acre	$1,173,700/acre

Table 28: North New Jersey Ave - Summary of Redevelopment Costs

	Low Disposal Cost Scenario	High Disposal Cost Scenario
20% Contingency	$2,454,720	$6,883,146
Total	**$14,728,322**	**$41,298,878**

12.4 Potential Offshore Wind Use

The site's proximity to offshore wind lease areas makes it in an ideal location for an O&M facility. The site is less than 10 miles from OCS-0498 (Ørsted's Ocean Wind) and OCS-0499 (EDF and Shell's joint venture, Atlantic Shores Offshore Wind). Additionally, the site is within 50 nautical miles of Hudson South Draft WEA and OCS-0482 (Ørsted and PSEG's joint venture, Garden State Offshore Energy). There are no vertical restrictions between the site and open ocean. The site does not currently have a suitable quayside, so a new quayside (likely pontoon) will need to be designed and constructed. Additionally, dredging is required to connect the site quayside (to be constructed) to the deep-water channel.

12.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site's acreage makes it unsuitable for fabrication or manufacture of foundation and tubular components.

Nacelles, Blades, Rotors, Generators:

The site's acreage makes it unsuitable for fabrication or manufacture of nacelles, blades, rotors, and generator components.

O&M Service, Cables, Secondary Steel:

The site is ideal for O&M operations from a layout perspective and proximity to OSW lease areas. Due to the relatively small size, the site is not suitable for manufacture of secondary steel components (ladders, platforms, railings, racks) or cables. A new quayside (likely pontoon) will need to be designed and constructed. Additionally, dredging is required to connect the site quayside (to be constructed) to the deep-water channel.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of O&M or fabrication of OSW components, certain site improvements would be required. These would include: improvement of upland load bearing capacity; development of quayside; dredging of berth; and addition of storage buildings.

12.4.2 Reuse Scenario – O&M

The site's layout and proximity to OSW lease areas make it adaptable for O&M. The bulk of the redevelopment costs for O&M are associated with constructing the pontoon quayside, increasing upland load bearing capacity (2.5 acres; including laydown areas), and completing the required dredging. Additional costs may include construction of warehouse/office building (20,000 square feet). This scenario assumes that the current 6,200 square foot warehouse remains in place.

Table 29: North New Jersey Ave - Summary of Reuse Costs –O&M

	Estimated Costs
Construction of warehouse/office building (20,000 square foot)	$524,000
20% Contingency	$104,800
Total	**$628,800**

13. NORTH & MCLESTER – ELIZABETH, NJ

13.1 Existing Conditions

The approximately 78-acre site is owned by Port Authority of NY & NJ and located at 801 McLester Street in Elizabeth, New Jersey (Figure 35). The majority of the property is undeveloped. Approximately 70% of the site is encumbered by wetlands, wetland buffers, and flood zone designations. An access road leads to the southwest corner of the property, which is currently under development. An approximately 357-foot-long finger pier in disrepair extends into the water. The site has approximately 1,700 feet of water frontage.

Figure 35: North & McLester - Site Location Map

Newark Bay bounds the site to the southeast. Global Container Terminal (GCT) is located adjacent north. Warehouses and distribution centers are located south and west of the site. A shopping center is located south of the site. No rail is available on-site; however, rail is accessible within 0.5 miles of the site. The Newark International Airport is located approximately one-mile northwest of the site. Route I-95 is located within one mile west of the site.

Water approaches to the site are via the Port Elizabeth South Reach East and West, both of which are 500 feet wide and at least 45 feet deep (See Figure 36). The deep-water channel continues as the South Reach, Bergen Point West and East Reaches, and Constable Hook Reach. Depth along the pier is approximately 8-10 feet deep.

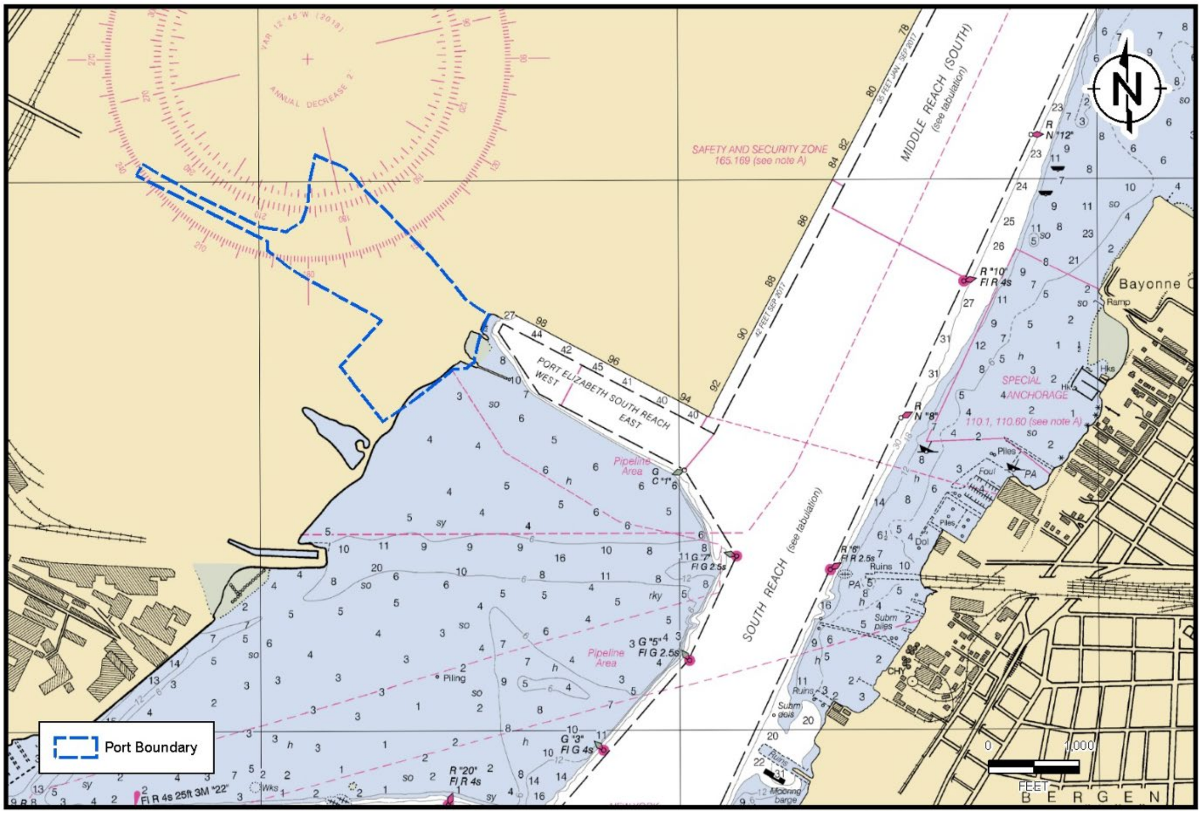


Figure 36: North & McLester - NOAA Depth Chart

13.2 Limitations

Vertical clearance is restricted by the Bayonne Fixed Bridge at 215 feet and the Verrazano-Narrows Bridge at 198 feet (middle 2,000 feet) or 183 feet (piers).

13.3 Environmental Conditions

The site is not listed on NJDEP's database for sites with known contamination. Approximately 70% of site is currently encumbered by freshwater wetlands, wetland buffers, and flood zone designations (Figure 37). There are special habitat requirements for the entire site that will need to be considered during the planning phase of development.

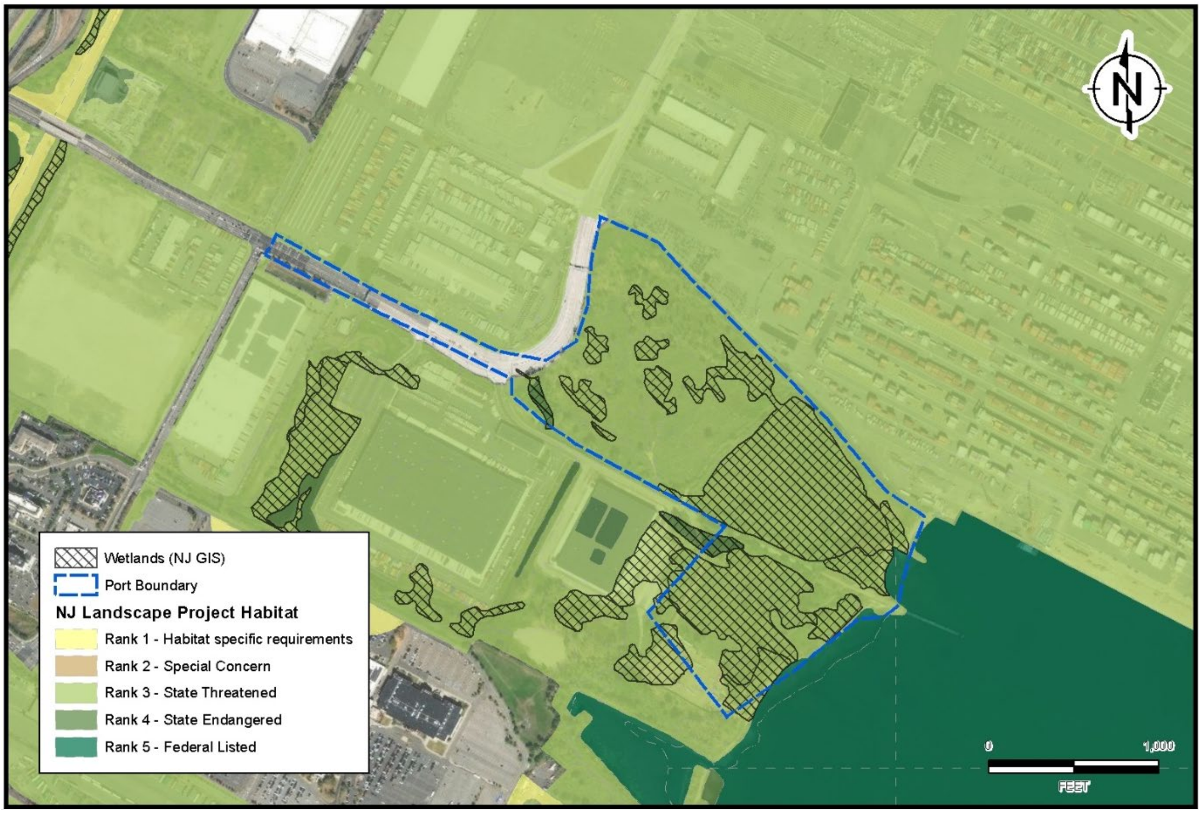


Figure 37: North & McLester - Wetlands and Habitat Map

Table 30: North & McLester - Summary of Existing Conditions	
Size	~78 acres
Buildings	One small building on access road
Upland Load Bearing Capacity*	<1,000 psf
Quayside Type	Pier in disrepair
Quayside Length	Pier is 357 feet long and 15 feet wide; ~1,700 feet of water frontage
Quayside Load Bearing Capacity*	<500 psf
Depth at Potential Quayside locations	8-10 feet deep MLLW
Channel Dimensions	500 feet wide by 45-50 feet deep MLLW

Table 30: North & McLester - Summary of Existing Conditions	
Distance to OSW Lease Areas	OCS-A 0490 – 155 nautical miles OCS-A 0519 – 150 nautical miles OCS-A 0482 (Ørsted/PSEG) - 135 nautical miles OCS-A 0498 (Ørsted) – 100 nautical miles OCS-A 0499 (EDF/Shell) - 71 nautical miles Hudson South Draft WEA – 38 nautical miles OSC-A 0512 (Equinor) – 34 nautical miles Hudson North Draft WEA – 60 nautical miles Fairways South Draft WEA – 63 nautical miles Fairways North Draft WEA – 84 nautical miles
Rail Connection	Rail within 0.5 miles
Restrictions	Verrazano-Narrows Bridge: Vert Cl 198 feet (middle 2,000 feet); Vert Cl 183 ft (piers); Vert Cl 215 feet (center)
Environmental Conditions	Approximately 70% of site is wetlands.
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.	

As discussed below, due to the presence of on-site wetlands, this location is well-suited to support O&M operations but may be challenging to adapt forother OSW-related uses. To meet the needs of offshore wind O&M use, certain improvements are necessary. Table 31 below provides a cost summary to construct the quayside, improve the upland load bearing capacity, and complete the required dredging. Disposal costs are variable, so low and high costs are provided.

Table 31: North & McLester - Summary of Redevelopment Costs		
	Low Disposal Cost Scenario	**High Disposal Cost Scenario**
New quayside (pontoon)	$3,000,000	$4,000,000
Dredge around quayside to 20 feet	$888,889	$3,111,111
Transportation and disposal costs of upland soils, including excavation	$1,452,000	$3,872,000
Placement and compaction of 1 foot of CGA	$338,800	$338,800
Placement and compaction of 1 foot of DGA	$484,000	$484,000
Cost to improve upland per acre (excavation, CGA, and DGA)	$568,700/acre	$1,173,700
20% Contingency	$1,232,738	$2,361,182

Table 31: North & McLester - Summary of Redevelopment Costs		
	Low Disposal Cost Scenario	**High Disposal Cost Scenario**
Total	**$7,396,427**	**$14,167,093**

13.4 Potential Offshore Wind Use

The site's moderate acreage and potential for sole use make it adaptable for offshore wind manufacturing of a variety of components. However, since the majority of the site is wetlands, permitting will be challenging and potentially prohibitive. The Verrazano-Narrows Bridge with a vertical clearance of 198 feet will present challenges for marshaling without use of feeder barges. The site does not currently have a suitable quayside, so a new quayside will need to be designed and constructed. The upland load bearing capacity will need to be improved. Additionally, dredging at the quayside (to be constructed) will be necessary.

13.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site could be adapted to handle manufacturing/fabrication of monopiles, transition pieces, tower section components and jacket foundations, including lay down. Upland soil load bearing capacities would need to be improved and the quayside will need complete redevelopment to support these operations. Dredging is required at the quaysides as well as the approach channels. Due to the large area of wetlands, permitting is expected to be challenging and possibly prohibitive. Additionally, the site's air draft restriction decreases the probability that it will be fully developed for manufacturing.

Nacelles, Blades, Rotors, Generators:

These components could be manufactured or finished at this site. Upland soil load bearing capacity would need to be improved over portions of the site for the efficiency of this operation to meet serial production standards. Similar to the requirements for other components, the quaysides will require complete redevelopment and dredging at the quaysides and channels would be required. Permitting challenges are expected and the air draft restriction decreases probability of development.

O&M, Service, Cables, Secondary Steel:

The site is well suited for O&M operations from a layout perspective and is within 50 nautical miles of the Hudson South Draft WEA and OCS-A 0512 (Equinor's Empire Wind). Due to the permitting challenges associated with developing wetlands and the large acreage required for these components, manufacture of secondary steel components (ladders, platforms, railings, racks) and cables may present challenges. The permitting challenges associated with wetlands will be more easily managed in the development of an O&M facility due to the small acreage required.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of O&M or fabrication of OSW components, certain site improvements would be required. These would include: improvement of upland load bearing capacity; development of quayside; dredging of berth; and addition of storage buildings.

O&M Service, Cables, Secondary Steel:

Upgrades and Improvements Opportunity for Full Utility:

13.4.2 Reuse Scenario – O&M

The site's layout and proximity to OSW lease areas make it adaptable for O&M. The bulk of the redevelopment costs for O&M are associated with constructing the pontoon quayside, increasing upland load bearing capacity (four acres; including laydown areas), and completing the required dredging. Additional costs may include construction of warehouse/office building (20,000 square feet).

Table 32: North & McLester - Summary of Reuse Costs –O&M

	Estimated Costs
Construction of warehouse/office building (20,000 square feet)	$524,000
20% Contingency	$104,800
Total	**$628,800**

14. CONSTRUCTION & MARINE EQUIPMENT CO (CME) – ELIZABETH, NJ

14.1 Existing Conditions

The approximately 13-acre active marine terminal is owned by Construction & Marine Equipment (CME) and is located at 330 South Front Street in Elizabeth, New Jersey (Figure 38). The site has approximately 90,000 square feet of indoor storage. South Front Street divides the site. The 5.5 acres west of South Front Street are used for outdoor storage. The site has a 730-foot bulkhead with a berthing depth of 26 feet. The site is equipped with over 2,000 feet of rail tracks and spurs.

Figure 38: CME - Site Location Map

An active shipyard and staging area are located northeast of the site. The Arthur Kill bounds the site to the southeast. A fuel terminal is located adjacent southwest of the site. A canal bounds the site to the northwest, beyond which is an industrial area. Rail access is available on-site. The Newark International Airport is located approximately two miles north of the site. Route I-95 is located within one mile west of the site.

Water approaches to the site is via the Elizabethport Reach (See Figure 39). The Elizabethport Reach is 500 feet wide and 50 feet deep. The channel continues as the North of Shooters Island Reach, Bergen Point West and East Reaches, and Constable Hook Reach, all of which are at least 500 feet wide and 50 feet deep. Depth along the quayside is 26 feet deep.

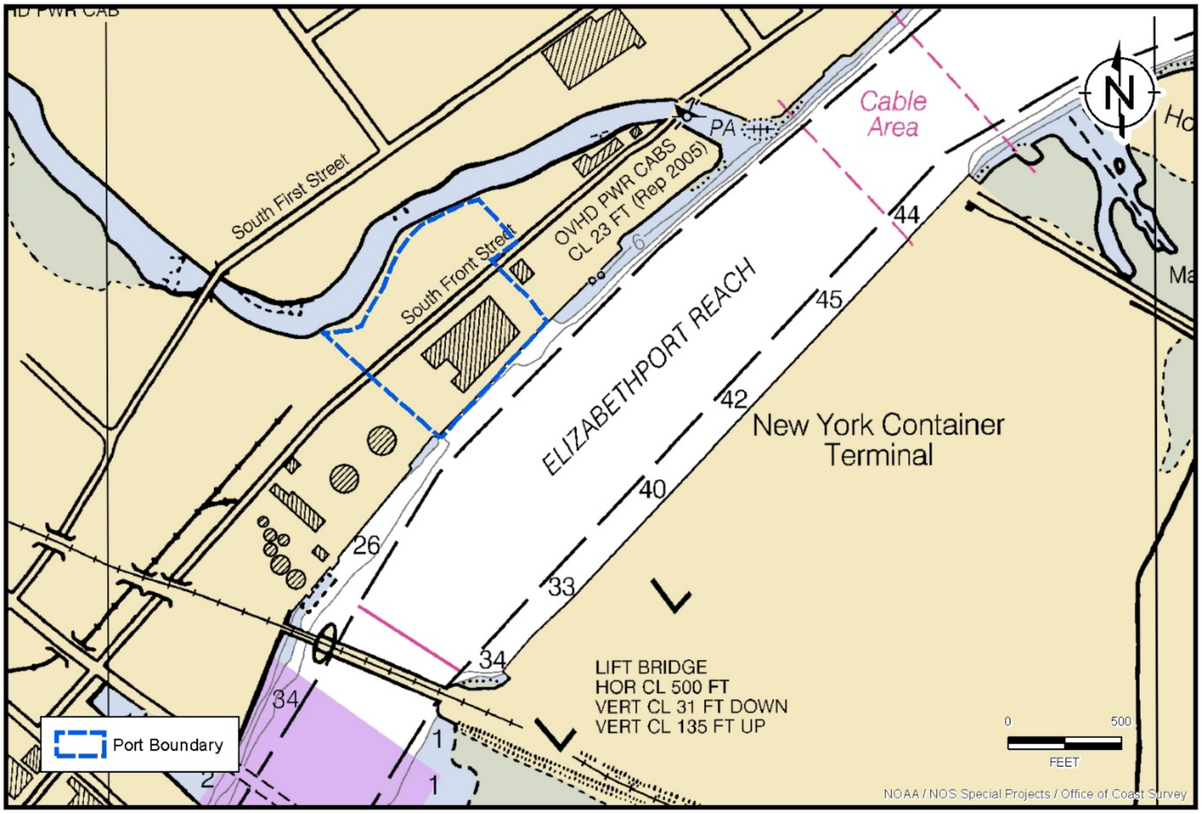


Figure 39: CME - NOAA Depth Chart

14.2 Limitations

Vertical clearance is restricted by the Bayonne Fixed Bridge at 215 feet and the Verrazano-Narrows Bridge at 198 feet (middle 2,000 feet) or 183 feet (piers).

14.3 Environmental Conditions

The site is listed on NJDEP's database for sites with known contamination (NJEMS 37414). The listing is for Chevron Bayway Lube Plant. Remedial activities appear to be ongoing. No wetlands are present on-site (Figure 40). The site has habitat-specific requirements that will need to be considered if redeveloped.

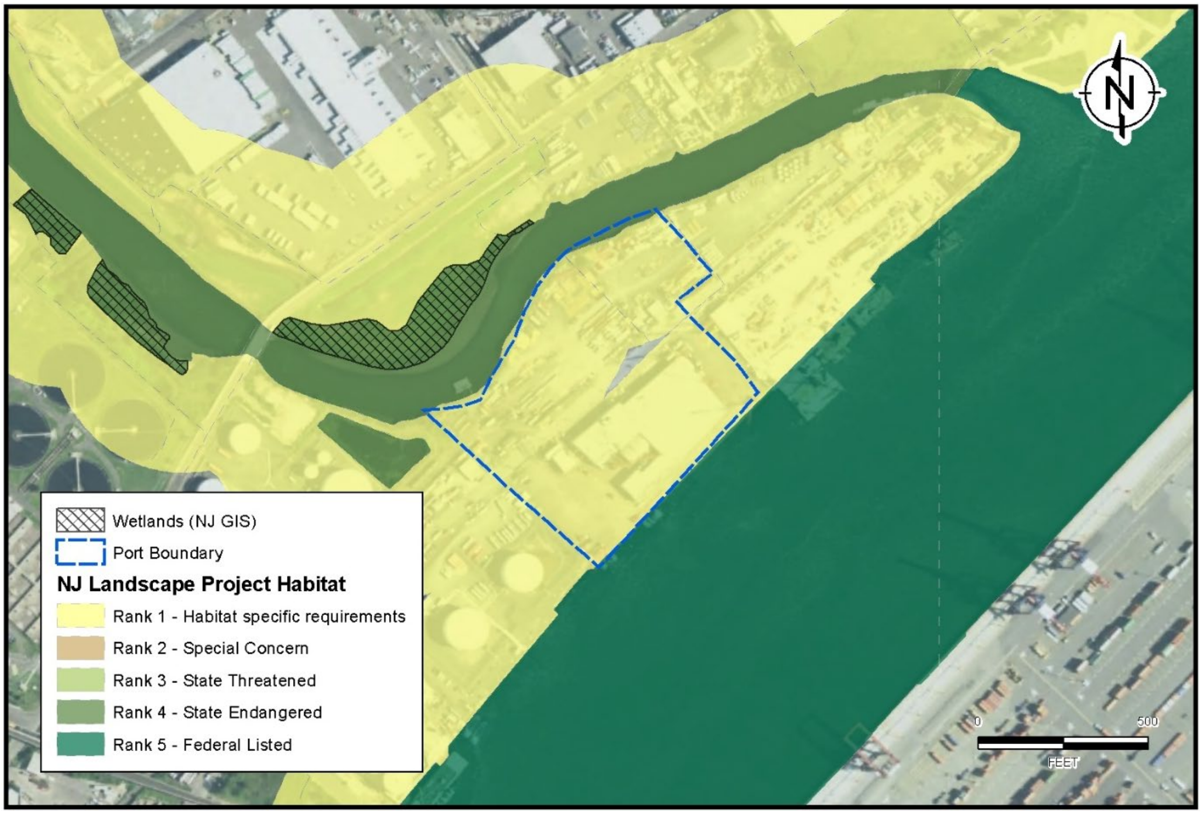


Figure 40: CME - Wetlands and Habitat Map

Table 33: CME - Summary of Existing Conditions	
Size	~13 acres
Buildings	~90,000 square feet of indoor storage
Upland Load Bearing Capacity*	<1,000 psf
Quayside Type	Bulkhead
Quayside Length	~730 feet
Quayside Load Bearing Capacity*	<1,500 psf
Depth at Potential Quayside locations	26 feet deep MLLW
Channel Dimensions	Elizabethport Reach, North of Shooters Island Reach, Bergen Point West Reach, Bergen Point East Reach, and Constable Hook Reach - 500 feet wide by 50 feet deep MLLW

Table 33: CME - Summary of Existing Conditions	
Distance to OSW Lease Areas	OCS-A 0490 – 162 nautical miles OCS-A 0519 – 156 nautical miles OCS-A 0482 (Ørsted/PSEG) - 136 nautical miles OCS-A 0498 (Ørsted) – 101 nautical miles OCS-A 0499 (EDF/Shell) - 71 nautical miles Hudson South Draft WEA – 41 nautical miles OSC-A 0512 (Equinor) – 36 nautical miles Hudson North Draft WEA – 60 nautical miles Fairways South Draft WEA – 62 nautical miles Fairways North Draft WEA – 85 nautical miles
Rail Connection	Over 2,000 feet of rail tracks and spurs
Restrictions	Verrazano-Narrows Bridge: Vert Cl 198 feet (middle 2,000 feet); Vert Cl 183 feet (piers); Vert Cl 215 feet (center)
Environmental Conditions	NJEMS Site ID 37414; Preferred ID G000003268 (Chevron Bayway Lube Plant)
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.	

The quayside and depth at berth currently meet the needs of an O&M facility. To provide supplemental storage, one 20,000 square foot building can be constructed.

14.4 Potential Offshore Wind Use

The site's relatively small size limits its suitability for OSW manufacturing purposes. Its proximity to offshore wind lease areas make it in a suitable location for an O&M facility. The site is less than 50 nautical miles from Hudson South Draft WEA and OCS-0512 (Equinor's Empire Wind). The site's quayside and berthing depth (26 feet) are suitable for O&M use.

14.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site's acreage and current use make it unsuitable for fabrication or manufacture of foundation and tubular components.

Nacelles, Blades, Rotors, Generators:

The site's acreage and current use make it unsuitable for fabrication or manufacture of nacelles, blades, rotors, and generator components.

O&M Service, Cables, Secondary Steel:

The site is suitable for O&M operations due to its proximity to OSW lease areas. If there is availability in the existing 90,000 square foot storage building, then the layout is ideal. An O&M facility could utilize the outdoor storage space for laydown of components. The existing quayside and depth at berth are adequate for O&M use. Due to the relatively small size, manufacture of secondary steel components (ladders, platforms, railings, racks) or cables would be challenging.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of O&M or fabrication of OSW components, certain site improvements may be required. These would include: addition of one storage building.

14.4.2 Reuse Scenario – O&M

The site's layout and proximity to OSW lease areas make it adaptable for O&M. The site's quayside and berthing depths are currently suitable for O&M. Additional reuse costs may include construction of warehouse/office building (20,000 square feet). This scenario assumes that the current 90,000 square feet building remains in place.

Table 34: CME - Summary of Reuse Costs –O&M

	Estimated Costs
Construction of warehouse/office building (20,000 square feet)	$524,000
20% Contingency	$104,800
Total	**$628,800**

15. NAVAL WEAPONS STATION (NWS) EARLE – MIDDLETOWN TOWNSHIP, NJ

15.1 Existing Conditions

The approximately 800-acre site is currently owned by the US Navy and located at State Highway 36 in Middletown Township (Figure 41). The site is improved with several buildings in the Waterfront Area including operations, a fitness center, and security building. The majority of the southern parcel is woodlands. The site has three finger piers that connect to the mainland by a three-mile-long pier. Active military operations include munitions loading and unloading.

Figure 41: Naval Weapons Station Earle - Site Location Map

The piers extend into Sandy Hook Bay. The site is surrounded by residential properties and wetlands. Rail is available on-site. The Newark International Airport is located approximately 16 miles northwest and the JFK International Airport is located approximately 18 miles northeast of the site. State Highway 36 divides the site running east west.

Water approaches to the site is via the Sandy Hook Channel Bayside and the Terminal Channel (See Figure 42). The Terminal Channel is approximately 45 feet deep and 400 feet wide. The Sandy Hook Channel Bayside is 35 feet deep and 800 feet wide. Depth at the finger piers ranges from 34 feet deep to 43 feet deep. Depth along the three-mile pier is approximately 1 foot deep to 16 feet deep. The Sandy Hook Channel Bayside leads to open water.

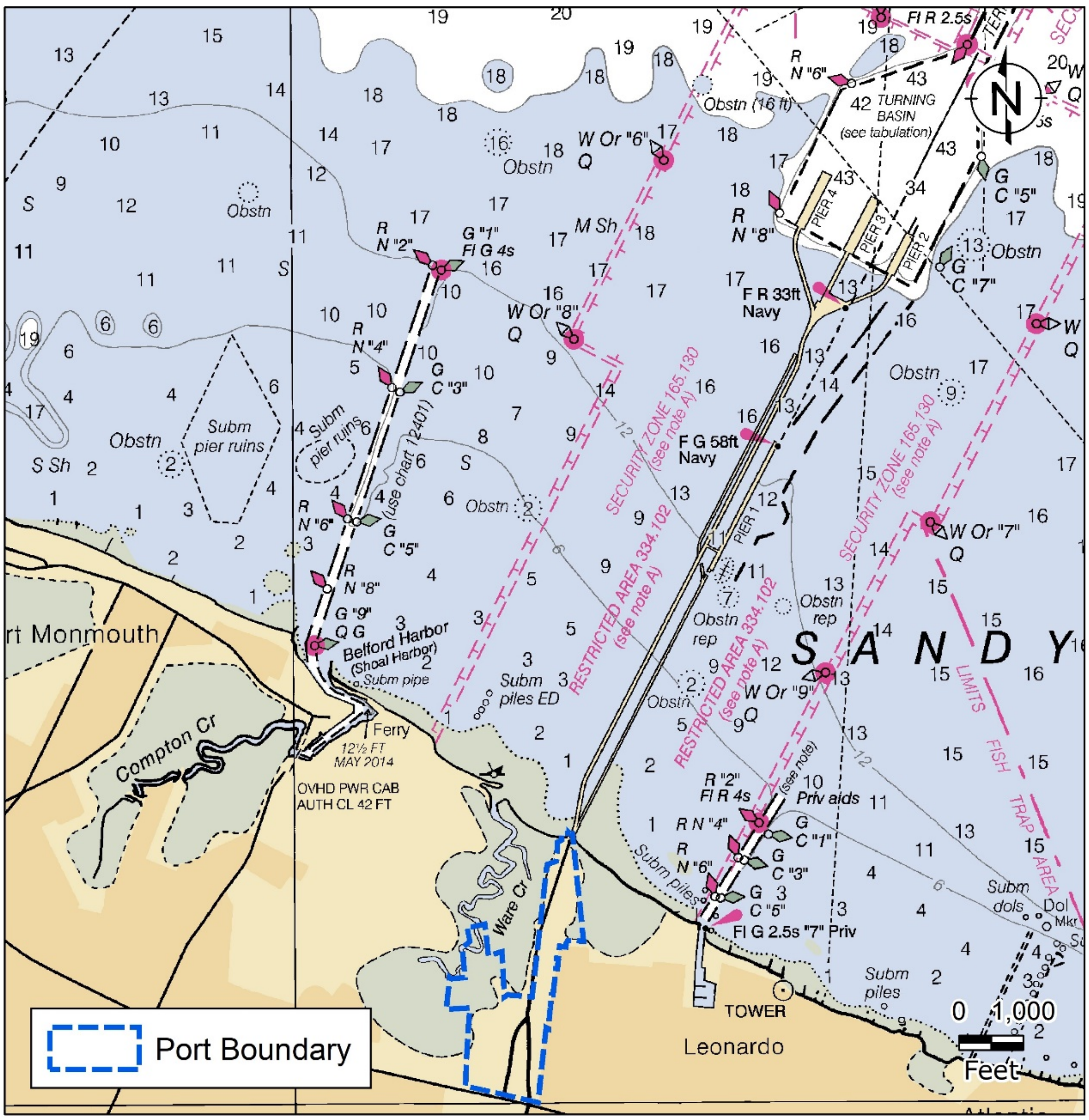


Figure 42: Naval Weapons Station Earle - NOAA Depth Chart

15.2 Limitations

There are no overhead restrictions between the site and open water. The port is likely non-operational several times a year due to military operations.

15.3 Environmental Conditions

Wetlands cover a significant portion of the site (Figure 43). The site has habitat-specific requirements that will need to be considered if redeveloped. Naval Weapons Station Earle is listed as a Superfund site. The majority of the contamination is located on the mainland portion of Naval Weapons Station Earle located in Colts Neck, NJ and is not included in this evaluation. The portion of the Naval Weapons Station Earle included in this evaluation is known as the Waterfront Area and includes Operating Unit 9 (Site IDs 6, 15, and 17). Site ID 6 is associated with industrial waste impacting groundwater. Site ID 15 is associated with bilge sludge impacting soil. Site ID 17 is associated with construction waste impacting soil and groundwater. A remedy is in place for each site.

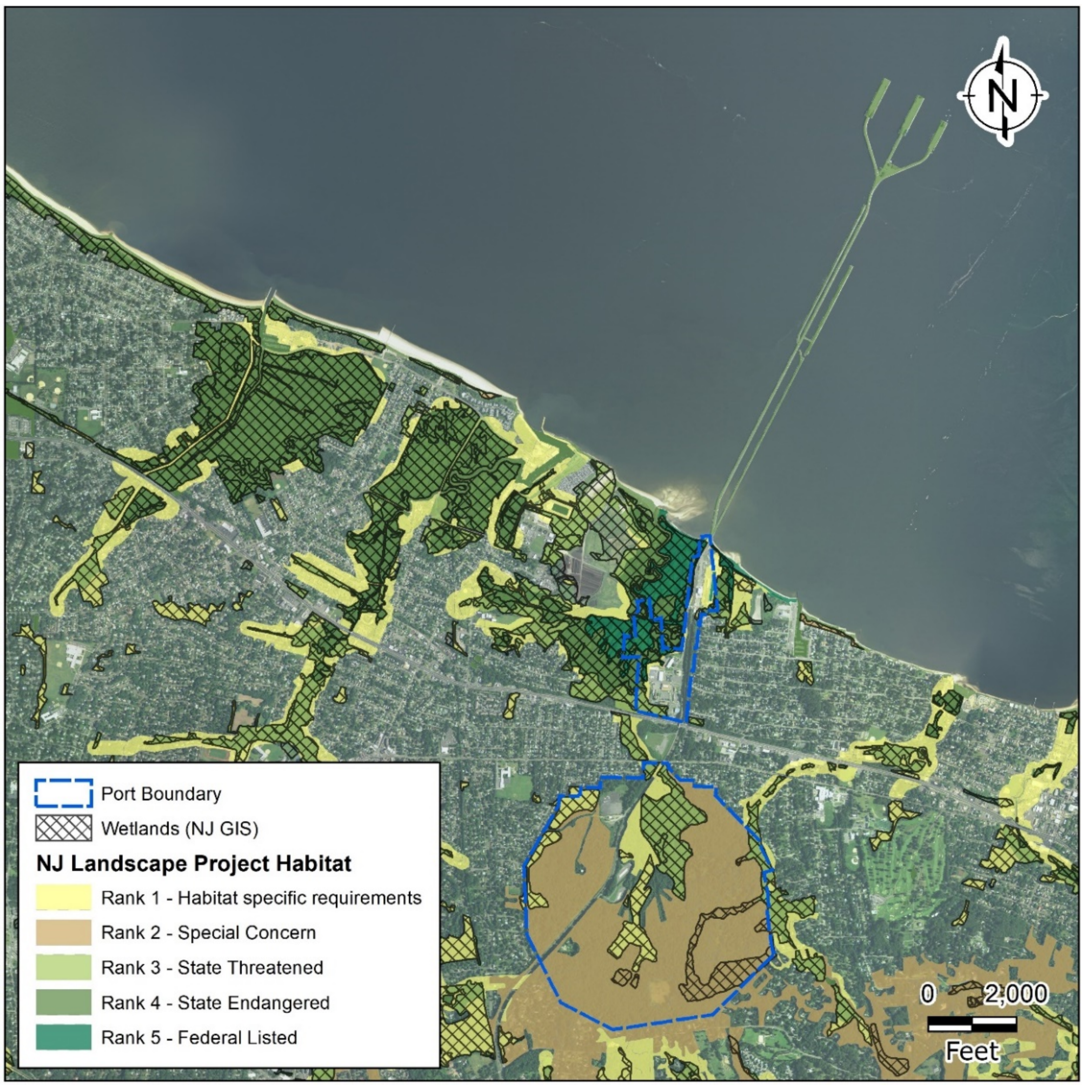


Figure 43: Naval Weapons Station Earle - Wetlands and Habitat Map

Table 35: Naval Weapons Station Earle - Summary of Existing Conditions		
Size	~800 acres, majority woodlands	
Buildings	Waterfront Area: Several buildings including operations, fitness center, and security	
Upland Load Bearing Capacity*	<1,000 psf	
Quayside Type	Three finger piers: Pier 2, Pier 3A, and Pier 4	This evaluation focuses on Pier 2
Quayside Length	Pier 2: 680 feet Pier 3A: 800 feet Pier 4: 800 feet	
Quayside Load Bearing Capacity*	<1,000 psf	Based on information provided in an US Army Engineer Research and Development Center (ERDC), Pier 2 is deteriorated.
Depth at Potential Quayside locations	Pier 2: 19-30 feet deep MLLW Pier 3A: 32-40 feet deep MLLW Pier 4: 35-45 feet deep MLLW	
Channel Dimensions	Sandy Hook Channel: 800 feet wide by 35 feet deep MLLW Terminal Channel: 400 feet wide by 45 feet deep MLLW	
Distance to OSW Lease Areas	OCS-A 0490 – 141 nautical miles OCS-A 0519 – 134 nautical miles OCS-A 0482 (Ørsted/PSEG) - 127 nautical miles OCS-A 0498 (Ørsted) – 84 nautical miles OCS-A 0499 (EDF/Shell) - 57 nautical miles Hudson South Draft WEA – 38 nautical miles OSC-A 0512 (Equinor) – 27 nautical miles Hudson North Draft WEA – 43 nautical miles Fairways South Draft WEA – 49 nautical miles Fairways North Draft WEA – 71 nautical miles	
Rail Connection	Rail on-site	
Restrictions	No vertical restrictions	
Environmental Conditions	Superfund Site – land use controls in place	

Table 35: Naval Weapons Station Earle - Summary of Existing Conditions
Notes: * No direct investigations conducted – estimates based on desktop analysis. All capacities are approximate.

This location is well-suited to support O&M operations, and potentially manufacturing of OSW components. The current munitions loading and unloading operations and associated "blackout" periods would make marshaling challenging. To meet the needs of an O&M facility, certain improvements are necessary. The pier is long and narrow making the transport of large equipment difficult. Table 36 below provides a cost summary to redevelop the quayside, specifically Pier 2. Costs for existing building demolition are not included.

Table 36: Naval Weapons Station Earle - Summary of Redevelopment Costs

	Estimated Cost Scenario
Demolition of existing pier	$1,000,000
Pier redevelopment (200 feet x 800 feet)	$13,450,000
20% Contingency	$2,690,000
Total	**$16,140,000**

15.4 Potential Offshore Wind Use

The site's proximity to offshore wind lease areas makes it in a good location for an O&M facility. The site is less than 50 nautical miles from OCS-0512 (Equinor) and Hudson South Draft WEA. However, current Navy operations would make frequent use of crew transfer vessels (CTVs) too challenging.[6] The site may be better suited for use of support operations vessels (SOVs), that do not require daily access to the quayside. There are no vertical restrictions between the site and open ocean. The site does not currently have a suitable quayside, so a new quayside will need to be designed and constructed.

15.4.1 Suitability Discussion by Use

Foundation and Tubular Components:

The site's acreage and lack of vertical restrictions make it appealing for foundations and tower component manufacturing; however, the three-mile pier will make transportation of components challenging. If a new quayside was constructed at the shore, a significant amount of dredging would be required.

[6] The US Navy has indicated that there would be six-to-eight-day blackout periods eight-months a year during which facility operations would preclude other active site operations,

Nacelles, Blades, Rotors, Generators:

The site's acreage and lack of vertical restrictions make it appealing for component manufacturing; however, the three-mile pier will make transportation of components challenging. If a new quayside was constructed at the shore, a significant amount of dredging would be required.

O&M Service, Cables, Secondary Steel:

The site is ideal for O&M operations due to its proximity to OSW lease areas; however, due to Navy operations, daily docking of CTVs would be challenging. The site may be more appropriate for O&M use with SOVs. The site's large acreage makes it suitable for manufacture of secondary steel components (ladders, platforms, railings, racks) or cables; however, the three-mile pier will make handling of components challenging. A new quayside will need to be designed and constructed.

Upgrades and Improvements Opportunity for Full Utility:

To meet the needs of O&M or fabrication of OSW components, certain site improvements would be required. These would include improvement of quayside (Pier 2) and addition of a storage building.

15.4.2 Reuse Scenario – O&M

The site's proximity to OSW lease areas makes it adaptable for O&M. The bulk of the redevelopment costs for O&M are associated with redeveloping Pier 2. Additional costs may include construction of warehouse/office building (10,000 square feet) on the pier.

Table 37: Naval Weapons Station Earle - Summary of Reuse Costs –O&M

	Estimated Costs
Construction of warehouse/office building (10,000 square foot)	$262,000
20% Contingency	$52,400
Total	**$314,400**

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APPENDIX A
PRELIMINARY NEW JERSEY PORT MATRIX

New Jersey

Preliminary Offshore Wind Ports Assessment

Site	Potential Usage	Region	Address	Owner/Operator	Size	Number of Existing Structures	Type of Quayside	Quayside Length	Channel Dimensions	Depth of Berth at Quayside	Distance to Nearest Airport	Distance to OSW Lease Areas (nautical miles)	Rail Connection	Restrictions	Equipment Present	Current Operations and Notable Features	Sources
Military Ocean Terminal at Bayonne (MOTBY)	Manufacturing (cables, foundations, tower sections, blades, nacelles, and substations); O&M	New York Harbor - Upper Bay	630 Avenue C, Bayonne, NJ 100 Military Ocean Term St, Bayonne, NJ Parcel: 0901-404-1	Port Authority of NY & NJ	Parcel: ~427 acres ~150 contiguous acres; 20,650 ft of water frontage; 720,000 sf parking area	Warehouse Area: ~1,200,000 sf (10 - 200 ft x 600 ft)	Pier	Berth A: 225 ft Berths B and C: 348 ft total L-shaped Pier: 120 ft + 100 ft +110 ft + 90 ft Drydock: 1,092 ft by 148 ft	Ambrose Channel Reach D: 2,000 ft wide by 53 ft deep MLLW Anchorage Channel - 51 ft to 54 ft deep MLLW 500 ft of channel dredged to 45 ft MLLW	Berth - 48 ft	Newark International Airport - ~3.5 miles	OCS-A 0490 – 155 nautical miles OCS-A 0519 – 135 nautical miles OCS-A 0482 (Orsted/PSEG) - 132 nautical miles OCS-A 0498 (Orsted) – 97 nautical miles OCS-A 0499 (EDF/Shell) - 68 nautical miles Hudson South Draft WEA – 36 nautical miles OSC-A 0512 (Equinor) – 30 nautical miles Hudson North Draft WEA – 56 nautical miles Fairways South Draft WEA – 59 nautical miles Fairways North Draft WEA – 80 nautical miles	No rail on-site; < 0.5 miles	Verrazano-Narrows Bridge: Vert Cl 198 ft (middle 2,000 ft); Vert Cl 183 ft (piers); Vert Cl 215 ft (center)	100+ Ton Lifts and 0-25 Ton Lifts currently on-site.	Most of the commercial and residential development appears to be in the western portion of the site, along Route 440. Lincoln Equities Group acquired 152.9-acres of the site (northern portion) for redevelopment into 1.6 million square feet of industrial warehouse space. Current tenants of the eastern (water side) of the property include GMD Shipyard and Cape Liberty Cruise Port. There is still a significant portion of the site (up to 150 contiguous acres) that is potentially available for redevelopment. Portions of the 150 acres are occupied by GMD Shipyard and Cape Liberty Cruise Port, so it is unclear if any berthing areas are currently available.	https://njbmagazine.com/njb-news-now/lincoln-equities-group-announces-acquisition-of-90-acre-waterfront-site-in-bayonne/ http://www.roi-nj.com/2018/03/08/real_estate/bayonne-closes-another-sale-military-ocean-terminal/ https://jerseydigs.com/demolition-video-shows-implosion-military-ocean-terminal-bayonne/ http://www.charts.noaa.gov/PDFs/12334.pdf http://bayonnedrydock.com/ https://www.epa.gov/hwcorrectiveactionsites/hazardous-waste-cleanup-military-ocean-terminal-bayonne-new-jersey
Paulsboro Marine Terminal	Marshalling; Manufacturing (cables, foundations, tower sections, blades, nacelles, and substations)	Delaware River	50A Universal Rd, Paulsboro, NJ Parcels: 0814-1-1; 0814-1-2; 0814-1-4; 0814-1-5; 0814-1-19; 0814-1-20; 0814-1-21; 0814-1-22; 0814-1-23	South Jersey Port Corporation Operated by Holt Logistics, LLC	200 acres total; 160 acres laydown	Solar panels on southeastern parcel. Apparent waste water settling basins on the western portion of the property. One structure on the southern boundary. Former oil storage and fueling structures have been demolished.	Quay/marginal wharf proposed (1,500 ft of 1,500 psf uniform live load with reinforced landing pads for mobile harbor crane outriggers)	850 ft (fully utilized); additional 1,500 ft being constructed	Billingsport Range - 800 ft wide by 40 ft deep MLLW Tinicum Range - 800 ft wide by 40 ft deep MLLW Eddystone Range - 800 ft wide by 40 ft deep MLLW Chester Range - 800 ft wide by 40 ft deep MLLW Marcus Hook Range - 800 ft wide by 40 ft deep MLLW Bellevue Range - 800 ft wide by 40 ft deep MLLW Cherry Island Range - 800 ft wide by 40 ft deep MLLW Deepwater Point Range - 800 ft wide by 40 ft deep MLLW Bulkhead Bar Range - 1,600 ft wide by 40 ft deep MLLW New Castle Range - 800 ft wide by 40 ft deep MLLW Reedy Island Range - 800 ft wide by 40 ft deep MLLW Baker Range - 800 ft wide by 40 ft deep MLLW Liston Range - 800-1,000 ft wide by 40 ft deep MLLW	40 ft MLLW	Philadelphia International Airport - directly across the Delaware River	OCS-A 0490 – 103 nautical miles OCS-A 0519 – 98 nautical miles OCS-A 0482 (Orsted/PSEG) - 90 nautical miles OCS-A 0498 (Orsted) – 111 nautical miles OCS-A 0499 (EDF/Shell) - 130 nautical miles Hudson South Draft WEA – 150 nautical miles OSC-A 0512 (Equinor) – 201 nautical miles Hudson North Draft WEA – 202 nautical miles Fairways South Draft WEA – 218 nautical miles Fairways North Draft WEA – 240 nautical miles	Rail connections CSX, NS, and CP Rail Systems with Integrated On-Dock Rail Infrastructure	Commodore Barry Bridge: Vert Cl 190 ft (middle 822 ft); Vert Cl 181 ft, Hor Cl 1,600 ft Overhead Cables Vert Cl 210 ft Delaware Memorial Bridge: Vert Cl 188 ft (middle 800 ft); Vert Cl 175 ft (middle 1,500 ft); Vert Cl 166 ft (Main Towers); Hor Cl 2,000 ft Overhead Cables Vert Cl 223 ft	Not identified	The Port of Paulsboro is currently being upgraded to potentially accommodate additional offshore wind manufacturing. An additional 1,500 ft quayside is under construction and will have a bearing capacity of 1,500 PSF and roll-off capabilities. With the addition of roll-off capabilities, Paulsboro now has the potential to serve as a manufacturing facility for certain foundations, tower sections, blades, nacelles and cables.	http://www.charts.noaa.gov/PDFs/12311.pdf http://www.charts.noaa.gov/PDFs/12313.pdf http://www.charts.noaa.gov/PDFs/12312.pdf http://southjerseyport.com/facilities/paulsboro-marine-terminal/
Werner Power Station	Marshalling; Manufacturing (cables, foundations, tower sections, blades, nacelles, and substations); O&M	Raritan Bay	106 Pupek Rd, South Amboy, NJ Parcels: 1220-161.01-26; 1220-161.02-25.03; 1220-161.02-90; 1220-161.02-25; 1220-161.02-25.04; 1220-161.02-25.05	South Amboy Redevelopment Agency	~97 acres total; 6,130 ft of water frontage	Several buildings remain from power generating operations. Plant is being demolished.	Pier in disrepair	Pier length: ~920 ft Pier face: ~350 ft	South Amboy Reach* - 300 ft wide by 25 ft deep MLLW Great Beds Reach* - 300 ft wide by 25 ft deep MLLW Ward Point Secondary Channel* - 400 ft wide by 30 ft deep MLLW Ward Point Bend East - 600-800 ft wide by 35 ft deep MLLW Red Bank Reach - 600 ft wide by 35 ft deep MLLW Seguine Point Reach - 600-1,000 ft wide by 35 ft deep MLLW Raritan Bay West Reach - 600 ft wide by 35 ft deep MLLW Raritan Bay East Reach - 600-800 ft wide by 35 ft deep MLLW *recent surveys show that these reaches may be shallower than project depth (15-20 ft)	No existing berth; water depth is 15 feet	Newark International Airport: 13.5 miles Old Bridge Airport: 11.4 miles	OCS-A 0490 – 155 nautical miles OCS-A 0519 – 148 nautical miles OCS-A 0482 (Orsted/PSEG) - 132 nautical miles OCS-A 0498 (Orsted) – 91 nautical miles OCS-A 0499 (EDF/Shell) - 64 nautical miles Hudson South Draft WEA – 42 nautical miles OSC-A 0512 (Equinor) – 35 nautical miles Hudson North Draft WEA – 57 nautical miles Fairways South Draft WEA – 59 nautical miles Fairways North Draft WEA – 81 nautical miles	Adjacent; Rail runs along the northwestern site boundary	No overhead restrictions	N/A	Decommissioned Reliant Power Plant. According to the South Amboy Redevelopment Plan, the site planned to sell to Manhattan Beach Club to redevelop for residential use. There are also potential plans to develop a ferry terminal at this site.	http://old.southamboynj.alphadogtest.com/_Content/pdf/Proposed-Beach-Club-District-Redevelopment-Plan.pdf http://www.charts.noaa.gov/PDFs/12332.pdf
Gardner's Basin, Atlantic City	O&M	Atlantic City	Carson Ave, Atlantic City, NJ Parcels: 0102-103-8; 0102-102-1 0102-102-3; 0102-102-4; 0102-102-5; 0102-102-6	1301 Bacharach Blvd; The Landings at Caspian Pointe, LLC; City of Atlantic City	~10 acres total; ~1,400 ft of water frontage	N/A	N/A; riprap	N/A; ~1,400 ft of water frontage	400 ft wide by 29-46 ft deep MLLW	9-15 ft deep MLLW	Atlantic City International Airport: ~9 mi	OCS-A 0490 – 69 nautical miles OCS-A 0519 – 65 nautical miles OCS-A 0482 (Orsted/PSEG) - 42 nautical miles OCS-A 0498 (Orsted) – 9 nautical miles OCS-A 0499 (EDF/Shell) - 10 nautical miles Hudson South Draft WEA – 37 nautical miles OSC-A 0512 (Equinor) – 76 nautical miles Hudson North Draft WEA – 79 nautical miles Fairways South Draft WEA – 94 nautical miles Fairways North Draft WEA – 117 nautical miles	None identified	No overhead restrictions; needs dredging	N/A	Vacant; The city recently (Nov 2018) terminated its relationship with Scarborough Properties, the developer contracted to revitalize the Gardner's Basin area.	http://www.charts.noaa.gov/PDFs/12318.pdf https://www.pressofatlanticcity.com/news/press/atlantic_city/atlantic-city-terminates-agreement-with-gardner-s-basin-developer/article_808047db-e535-5134-a314-fa62506bf3e0.html
Former DuPont Site (Repauno)	Manufacturing (cables, foundations, towers, blades, and nacelles)	Delaware River	200 North Repauno Ave, Greenwich Township, NJ Parcel: 0807-8-4 (developable); other parcels not developable	Delaware River Partners, LLC	~1,600 acres (356 acres for redevelopment)	Several buildings associated with former Dupont operations. Site is currently being redeveloped.	N/A; under construction	N/A; under construction	Tinicum Range - 800 ft wide by 40 ft deep MLLW Eddystone Range - 800 ft wide by 40 ft deep MLLW Chester Range - 800 ft wide by 40 ft deep MLLW Marcus Hook Range - 800 ft wide by 40 ft deep MLLW Bellevue Range - 800 ft wide by 40 ft deep MLLW Cherry Island Range - 800 ft wide by 40 ft deep MLLW Deepwater Point Range - 800 ft wide by 40 ft deep MLLW Bulkhead Bar Range - 1,600 ft wide by 40 ft deep MLLW New Castle Range - 800 ft wide by 40 ft deep MLLW Reedy Island Range - 800 ft wide by 40 ft deep MLLW Baker Range - 800 ft wide by 40 ft deep MLLW Liston Range - 800-1,000 ft wide by 40 ft deep MLLW	40 ft MLLW, dredging completed	Philadelphia International Airport - across the Delaware River	OCS-A 0490 – 100 nautical miles OCS-A 0519 – 95 nautical miles OCS-A 0482 (Orsted/PSEG) - 86 nautical miles OCS-A 0498 (Orsted) – 107 nautical miles OCS-A 0499 (EDF/Shell) - 126 nautical miles Hudson South Draft WEA – 146 nautical miles OSC-A 0512 (Equinor) – 197 nautical miles Hudson North Draft WEA – 199 nautical miles Fairways South Draft WEA – 215 nautical miles Fairways North Draft WEA – 237 nautical miles	Rail on-site	Commodore Barry Bridge: Vert Cl 190 ft (middle 822 ft); Vert Cl 181 ft, Hor Cl 1,600 ft Overhead Cables Vert Cl 210 ft Delaware Memorial Bridge: Vert Cl 188 ft (middle 800 ft); Vert Cl 175 ft (middle 1,500 ft); Vert Cl 166 ft (Main Towers); Hor Cl 2,000 ft Overhead Cables Vert Cl 223 ft	N/A	This former DuPont site is currently being redeveloped for a roll-on/roll-off (RO-RO) facility. It is uncertain if the property will be available for OSW use.	http://www.charts.noaa.gov/PDFs/12311.pdf http://www.charts.noaa.gov/PDFs/12313.pdf http://www.charts.noaa.gov/PDFs/12312.pdf https://www.greenwichtwp.com/2202/Proposed-Port-Development https://www.epa.gov/hwcorrectiveactionsites/hazardous-waste-cleanup-chemours-repauno-gibbstown-new-jersey
Weeks Marine	O&M	New York Harbor - Upper Bay	Foot of Colony Rd, Jersey City, NJ Parcels: 0906-30501-1	Port Authority of NY & NJ	Parcel: ~68 acres total ~43 acres (southeastern portion); 4,460 ft of water frontage	~240,000 sf building associated with car port (northwestern portion of site); several smaller structures adjacent to the pier	Pier	Pier: 1,000 ft (two berths)	Greenville Channel: ~500 ft wide by 17-23 ft deep MLLW Ambrose Channel Reach D: 2,000 ft wide by 53 ft deep MLLW Anchorage Channel - 51 ft to 54 ft deep MLLW	10-22 ft deep MLLW	Newark International Airport: ~4.5 mi	OCS-A 0482 (Orsted/PSEG) - 135 nmi OCS-A 0498 (Orsted) – 92 nmi OCS-A 0499 (EDF/Shell) - 65 nmi Hudson South Draft WEA – 42 nmi OSC-A 0512 (Equinor) – 32 nmi	Rail on-site	Verrazano-Narrows Bridge: Vert Cl 198 ft (middle 2,000 ft); Vert Cl 183 ft (piers); Vert Cl 215 ft (center)	N/A	Staging yard operated by Weeks Marine; NYSERDA notes that it is unlikely that Weeks Marine will re-purpose facility on a long-term basis, but may be available on a project -specific basis.	http://www.charts.noaa.gov/PDFs/12334.pdf
Veckridge Chemical	Manufacturing (cables and nacelles); O&M	New York Harbor - Upper Newark Bay	60 Central Ave, Kearney, NJ Parcels: 0907-288-1; 0907-288-2; 0907-288-3	Town of Kearney	~22.8 acres total; 1,890 ft of water frontage	Buildings associated with former chemical manufacturing have been demolished.	N/A; riprap	N/A; ~1,950 ft of water frontage	Kearney Point Reach - 300 ft wide by 30 ft deep MLLW North Reach - 500-1,030 ft wide by 35 ft deep MLLW Middle Reach North - 565-800 ft wide by 40 ft deep MLLW Middle Reach South - 810-1,655 ft wide by 50 ft deep MLLW South Reach - 1,000-2,360 ft wide by 50 ft deep MLLW Bergen Point West Reach - 800-1,710 ft wide by 50 ft deep MLLW Bergen Point East Reach - 800-895 ft wide by 50 ft deep MLLW Constable Hook Reach - 800-2,000 ft wide by 50 ft deep MLLW	Appears to be very shallow (0.5 ft to 5 ft)	Newark International Airport: ~3.5 mi	OCS-A 0482 (Orsted/PSEG) - 144 nmi OCS-A 0498 (Orsted) – 100 nmi OCS-A 0499 (EDF/Shell) - 73 nmi Hudson South Draft WEA – 50 nmi OSC-A 0512 (Equinor) – 39 nmi	Rail on adjacent property	Lift Bridge: Vert Cl 135 ft (up); Vert Cl 35 ft (down); Hor Cl 300 ft I-78 Newark Bay Bridge: Vert Cl 135 ft; Hor Cl 550 ft Bayonne Fixed Bridge: Vert Cl 215 ft Verrazano-Narrows Bridge: Vert Cl 198 ft (middle 2,000 ft); Vert Cl 183 ft (piers); Vert Cl 215 ft (center)	N/A	Underutilized property adjacent to wastewater treatment plant.	http://www.charts.noaa.gov/PDFs/12333.pdf http://www.charts.noaa.gov/PDFs/12337.pdf
Chemours Company Site Linden	Manufacturing (blades, nacelles, and cables); O&M	Arthur Kill	South Wood Ave, Linden, NJ Parcels: 2009-586-8; 2009-586-9	Chemours Company FC LLC	~98 acres total; 3,176 ft of water frontage	Buildings associated with former chemical manufacturing have been demolished.	Three dolphins; riprap	N/A; 3,176 ft of water frontage	Route North: Pralls Island Reach - 500 ft wide by 35 ft deep MLLW Gulfport Reach - 500-600 ft wide by 35 ft deep MLLW Elizabethport Reach - 500-705 ft wide by 50 ft deep MLLW North of Shookers Island Reach - 515-1,105 ft wide by 50 ft deep MLLW Bergen Point West Reach - 800-1,710 ft wide by 50 ft deep MLLW Bergen Point East Reach - 800-895 ft wide by 50 ft deep MLLW Constable Hook Reach - 800-2,000 ft wide by 50 ft deep MLLW Route South: Pralls Island Reach - 500 ft wide by 35 ft deep MLLW Tremley Point Reach - 500 ft wide by 35 ft deep MLLW Fresh Kills Reach - 500 ft wide by 35 ft deep MLLW Port Reading Reach - 500-850 ft wide by 35 ft deep MLLW Port Socony Reach - 600-800 ft wide by 35 ft deep MLLW Outerbridge Reach - 600-840 ft wide by 35 ft deep MLLW Ward Point Bend West - 600-800 ft wide by 35 ft deep MLLW Ward Point Bend East - 600-800 ft wide by 35 ft deep MLLW Red Bank Reach - 600 ft wide by 35 ft deep MLLW Seguine Point Reach - 600-1,000 ft wide by 35 ft deep MLLW Raritan Bay West Reach - 600 ft wide by 35 ft deep MLLW Raritan Bay East Reach - 600-800 ft wide by 35 ft deep MLLW	1-19 feet MLLW	Newark International Airport: ~4.5 mi	OCS-A 0490 – 159 nautical miles OCS-A 0519 – 153 nautical miles OCS-A 0482 (Orsted/PSEG) - 138 nautical miles OCS-A 0498 (Orsted) – 98 nautical miles OCS-A 0499 (EDF/Shell) - 70 nautical miles Hudson South Draft WEA – 50 nautical miles OSC-A 0512 (Equinor) – 42 nautical miles Hudson North Draft WEA – 62 nautical miles Fairways South Draft WEA – 63 nautical miles Fairways North Draft WEA – 85 nautical miles	Rail at western site boundary	Route North: Overhead Power Cables: Vert Cl 165 ft Goethals Bridge: Under construction; Vert Cl 138 ft Arthur Kill Railroad Bridge: Vert Cl 135 ft (up); Vert Cl 31 ft (down); Hor Cl 500 ft Bayonne Fixed Bridge: Vert Cl 215 ft Verrazano-Narrows Bridge: Vert Cl 198 ft (middle 2,000 ft); Vert Cl 183 ft (piers); Vert Cl 215 ft (center) Route South: Outerbridge Crossing (Cantilever Bridge) Vert Cl 143 ft; Hor Cl 675 ft	N/A	Grasselli Chemical Co manufactured industrial acids from 1885 to 1928. DuPont manufactured pesticides from 1928 to 1990. According to NJ planning documents, the site is fully remediated and ready for redevelopment. Rail on adjacent parcel	http://www.charts.noaa.gov/PDFs/12333.pdf http://www.charts.noaa.gov/PDFs/12331.pdf https://www.nj.com/news/local/index.ssf/2010/09/plan_underway_to_clean_up_lind.html https://www.nj.gov/state/planning/docs/rtm-21-linden-dupont.pdf http://www.caruscorporation.com/resources/content/4/5/1/documents/grasselli-chem-company-site-summary.pdf https://www.nj.gov/dep/passaicdocs/docs/3rd-PartyComplaintNexusPackages/3rd-PartyComplaintBNexus/DuPontGrasselliSite.pdf
Balzano Marine Terminal (Formerly Beckett Street Terminal) - Port of Camden	Manufacturing (blades, nacelles, and cables)	Delaware River	101 Joseph A. Balzano Blvd, Camden, NJ Parcels: 0408-141-1; 0408-215-59; 0408-214-1; 0408-213-29 (GP Gypsum); 0408-213-13 (GP Gypsum)	South Jersey Port Corporation	122 acres (SJPC) total; ~86 acres (upland)	Warehouse area: 21 buildings totaling 1,168,441 sf	Pier	Berths 1-4: 2,655 ft	Reach M to Benjamin Franklin Bridge - 400 ft wide by 40 ft deep MLLW Reach M - 400-500 ft wide by 40 ft deep MLLW East Horseshoe Range - 400-500 ft wide by 40 ft deep MLLW Horseshoe Bend - 500-800 ft wide by 40 ft deep MLLW Eagle Point Range - 800 ft wide by 40 ft deep MLLW Mifflin Range - 800 ft wide by 40 ft deep MLLW Billingsport Range - 800 ft wide by 40 ft deep MLLW Tinicum Range - 800 ft wide by 40 ft deep MLLW Eddystone Range - 800 ft wide by 40 ft deep MLLW Chester Range - 800 ft wide by 40 ft deep MLLW Marcus Hook Range - 800 ft wide by 40 ft deep MLLW Bellevue Range - 800 ft wide by 40 ft deep MLLW Cherry Island Range - 800 ft wide by 40 ft deep MLLW Deepwater Point Range - 800 ft wide by 40 ft deep MLLW Bulkhead Bar Range - 1,600 ft wide by 40 ft deep MLLW New Castle Range - 800 ft wide by 40 ft deep MLLW Reedy Island Range - 800 ft wide by 40 ft deep MLLW Baker Range - 800 ft wide by 40 ft deep MLLW Liston Range - 800-1,000 ft wide by 40 ft deep MLLW	Berths 1 & 2: 30 ft Berth 3: 35 ft Berth 4: 40 ft	Philadelphia International Airport: ~6 miles	OCS-A 0482 (Orsted/PSEG) - 102 nmi OCS-A 0498 (Orsted) – 123 nmi OCS-A 0499 (EDF/Shell) - 142 nmi Hudson South Draft WEA – 175 nnmi OSC-A 0512 (Equinor) – 205 nmi	Rail connections CP Rail System, CSX, and Norfolk Southern	Walt Whitman Bridge: Vert Cl 150 ft (center); Vert Cl 139 ft; Hor Cl 1,930 ft Commodore Barry Bridge: Vert Cl 190 ft (middle 822 ft); Vert Cl 181 ft, Hor Cl 1,600 ft Overhead Cables Vert Cl 210 ft Delaware Memorial Bridge: Vert Cl 188 ft (middle 800 ft); Vert Cl 175 ft (middle 1,500 ft); Vert Cl 166 ft (Main Towers); Hor Cl 2,000 ft Overhead Cables Vert Cl 223 ft	One multi-purpose Kocks bulk/container crane (95 ton); one general purpose Paseco cargo/container crane (35 ton)	The Delaware River port operates as a busy break bulk and cargo terminal. It currently handles steel, project cargo, wood products, cocoa beans, and other bulk cargos.	http://www.charts.noaa.gov/PDFs/12312.pdf http://southjerseyport.com/facilities/balzano-marine-terminal/

New Jersey

Preliminary Offshore Wind Ports Assessment

Site	Potential Usage	Region	Address	Owner/Operator	Size	Number of Existing Structures	Type of Quayside	Quayside Length	Channel Dimensions	Depth of Berth at Quayside	Distance to Nearest Airport	Distance to OSW Lease Areas (nautical miles)	Rail Connection	Restrictions	Equipment Present	Current Operations and Notable Features	Sources
Broadway Terminal - Port of Camden	Manufacturing (cables and nacelles)	Delaware River	2500 Broadway, Camden, NJ Parcels: 0408-455-1; 0408-457-10; 0408-457-16; 0408-515-1	South Jersey Port Corporation Pier 5 is leased by Camden Waterfront Development LLC and operated by Southport Distribution	~92 acres total; 30 acres laydown Pier 5: 28 acres	Pier 1 and 1A Storage capacity: 1,128,000 sf Pier 5: 4 warehouses: 60,000 sf; 75,000 sf; 53,400sf; and 25,000 sf	Pier	Pier 1: 900 ft Pier 1A: 850 ft Pier 5: 1,135 ft	Reach M to Benjamin Franklin Bridge - 400 ft wide by 40 ft deep MLLW Reach M - 400-500 ft wide by 40 ft deep MLLW East Horseshoe Range - 400-500 ft wide by 40 ft deep MLLW Horseshoe Bend - 500-800 ft wide by 40 ft deep MLLW Eagle Point Range - 800 ft wide by 40 ft deep MLLW Mifflin Range - 800 ft wide by 40 ft deep MLLW Billingsport Range - 800 ft wide by 40 ft deep MLLW Tinicum Range - 800 ft wide by 40 ft deep MLLW Eddystone Range - 800 ft wide by 40 ft deep MLLW Chester Range - 800 ft wide by 40 ft deep MLLW Marcus Hook Range - 800 ft wide by 40 ft deep MLLW Bellevue Range - 800 ft wide by 40 ft deep MLLW Cherry Island Range - 800 ft wide by 40 ft deep MLLW Deepwater Point Range - 800 ft wide by 40 ft deep MLLW Bulkhead Bar Range - 1,600 ft wide by 40 ft deep MLLW New Castle Range - 800 ft wide by 40 ft deep MLLW Reedy Island Range - 800 ft wide by 40 ft deep MLLW Baker Range - 800 ft wide by 40 ft deep MLLW Liston Range - 800-1,000 ft wide by 40 ft deep MLLW	Pier 1: 35 ft Pier 1A: 40 ft Pier 5: 35 ft	Philadelphia International Airport: ~5.5 miles	OCS-A 0482 (Orsted/PSEG) - 94 nmi OCS-A 0498 (Orsted) – 115 nmi OCS-A 0499 (EDF/Shell) - 134 nmi Hudson South Draft WEA – 165 nnmi OSC-A 0512 (Equinor) – 211 nmi	Rail connections CP Rail System, CSX, Norfolk Southern	Walt Whitman Bridge: Vert Cl 150 ft (center); Vert Cl 139 ft; Hor Cl 1,930 ft Commodore Barry Bridge: Vert Cl 190 ft (middle 822 ft); Vert Cl 181 ft, Hor Cl 1,600 ft Overhead Cables Vert Cl 210 ft Delaware Memorial Bridge: Vert Cl 188 ft (middle 800 ft); Vert Cl 175 ft (middle 1,500 ft); Vert Cl 166 ft (Main Towers); Hor Cl 2,000 ft Overhead Cables Vert Cl 223 ft	Crane: Multi-purpose Kocks container style electric (95 T)	The site is a busy break bulk and cargo terminal. Additionally, the majority of the site is occupied by an industrial park and large warehouses.	http://www.charts.noaa.gov/PDFs/12312.pdf http://southjerseyport.com/facilities/broadway-terminal/ http://southjerseyport.com/facilities/broadway-terminal-pier-5/
Chemours Chamber Works	Marshalling; Manufacturing (cables, foundations, tower sections, blades, nacelles, and substations)	Delaware River	67 Canal Road, Pennsville Township, NJ Deepwater, NJ Parcel: 1709-301-1	The Chemours Company FC LLC	~412 acres total; up to 230 acres available, of which 101 acres are along the water.	Several structures associated with former manufacturing. Majority of site is paved or improved with buildings.	N/A; retaining wall and riprap	N/A; ~5,300 ft of water frontage	Cherry Island Range - 800 ft wide by 40 ft deep MLLW Deepwater Point Range - 800 ft wide by 40 ft deep MLLW Bulkhead Bar Range - 1,600 ft wide by 40 ft deep MLLW New Castle Range - 800 ft wide by 40 ft deep MLLW Reedy Island Range - 800 ft wide by 40 ft deep MLLW Baker Range - 800 ft wide by 40 ft deep MLLW Liston Range - 800-1,000 ft wide by 40 ft deep MLLW	1-3 ft deep MLLW	New Castle Airport: ~4.5 mi	OCS-A 0490 – 85 nautical miles OCS-A 0519 – 80 nautical miles OCS-A 0482 (Orsted/PSEG) - 74 nautical miles OCS-A 0498 (Orsted) – 95 nautical miles OCS-A 0499 (EDF/Shell) - 112 nautical miles Hudson South Draft WEA – 145 nautical miles OSC-A 0512 (Equinor) – 187 nautical miles Hudson North Draft WEA – 184 nautical miles Fairways South Draft WEA – 200 nautical miles Fairways North Draft WEA – 222 nautical miles	Rail on-site	Delaware Memorial Bridge: Vert Cl 188 ft (middle 800 ft); Vert Cl 175 ft (middle 1,500 ft); Vert Cl 166 ft (Main Towers); Hor Cl 2,000 ft Overhead Cables Vert Cl 223 ft	N/A	Former chemical terminal slated for demolition.	http://www.charts.noaa.gov/PDFs/12311.pdf
Chemours Carney's Point Site	Marshalling; Manufacturing (cables, foundations, tower sections, blades, nacelles, and substations)	Delaware River	600 Shell Road, Carneys Point, NJ (adjacent north to Chamber Works) Parcel: 1702-185-1	The Chemours Company FC LLC	~1,133.55 acres total; 175 acres usable (remaining wetlands)	Waste water treatment plant is located on southern portion of parcel. Majority of the site is undeveloped.	N/A; retaining wall and riprap	N/A; ~11,000 ft of water frontage	Cherry Island Range - 800 ft wide by 40 ft deep MLLW Deepwater Point Range - 800 ft wide by 40 ft deep MLLW Bulkhead Bar Range - 1,600 ft wide by 40 ft deep MLLW New Castle Range - 800 ft wide by 40 ft deep MLLW Reedy Island Range - 800 ft wide by 40 ft deep MLLW Baker Range - 800 ft wide by 40 ft deep MLLW Liston Range - 800-1,000 ft wide by 40 ft deep MLLW	1-3 ft deep MLLW	New Castle Airport: ~4.5 mi		Rail on-site	Delaware Memorial Bridge: Vert Cl 188 ft (middle 800 ft); Vert Cl 175 ft (middle 1,500 ft); Vert Cl 166 ft (Main Towers); Hor Cl 2,000 ft Overhead Cables Vert Cl 223 ft	N/A	Undeveloped; Majority of site is wetlands.	http://www.charts.noaa.gov/PDFs/12311.pdf
Cape May-Lewes Ferry, Cape May, NJ	O&M	Delaware Bay	1200 Lincoln Blvd; 536 Ferry Rd; 576 Ferry Rd; 3920 Bayshore Rd, Lower Township, NJ Parcels: 0505-740-1.05; 0505-740-1.04; 0505-740-1.03, 0505-740-1.02; 0505-740-2	Delaware River and Bay Authority	~250 acres; 160 acres potentially available for redevelopment	5 buildings associated with ferry terminal located in the southwestern portion of the property; 1 building located in the southeastern corner of the property; the majority of the site is undeveloped.	Pier; five berthing areas	Five berthing areas totaling ~1,300 feet	Cape May Canal (Spicer Creek Canal to Inner End of Ferry Basin) - 100 ft wide by 12 ft deep MLLW Cape May Canal (Ferry Basin to Delaware Bay) - 100-150 ft wide by 12 ft deep MLLW	2-14 ft MLLW	Cape May Airport: ~3.5 mi	OCS-A 0490 – 35 nautical miles OCS-A 0519 – 28 nautical miles OCS-A 0482 (Orsted/PSEG) - 22 nautical miles OCS-A 0498 (Orsted) – 37 nautical miles OCS-A 0499 (EDF/Shell) - 56 nautical miles Hudson South Draft WEA – 78 nautical miles OSC-A 0512 (Equinor) – 129 nautical miles Hudson North Draft WEA – 135 nautical miles Fairways South Draft WEA – 152 nautical miles Fairways North Draft WEA – 172 nautical miles	None identified	No overhead restrictions; needs dredging	N/A	Ferry terminal	http://www.charts.noaa.gov/PDFs/12316.pdf
Atlantic City Marina District	O&M	Atlantic City	Atlantic-Brigantine Blvd & Huran Ave, Atlantic City, NJ	AC Holding Corp (MGM Resorts International)	14.7 acres; undeveloped; more than 800 feet of waterfront	N/A; undeveloped	N/A; beach	N/A; 935 ft of water frontage	400 ft wide by 29-46 ft deep MLLW	2-3 ft deep MLLW	Atlantic City International Airport: ~8.5 mi	OCS-A 0482 (Orsted/PSEG) - 22 nmi OCS-A 0498 (Orsted) – 37 nmi OCS-A 0499 (EDF/Shell) - 56 nmi Hudson South Draft WEA – 78 nmi OSC-A 0512 (Equinor) – 129 nmi	None identified	Significant permitting and land disturbance. No overhead restrictions; needs dredging	N/A	Undeveloped	http://www.charts.noaa.gov/PDFs/12318.pdf
Atlantic City - North New Jersey Ave	O&M	Atlantic City	614 North New Jersey Avenue, Atlantic City, NJ Parcels: 0102-564-1; 0102-563-1; 0102-564-2	OCD, Inc.	~3.2 acres upland	~6,200 sf warehouse	N/A; retaining wall and riprap	~460 ft of water frontage	400 ft wide by 29-46 ft deep MLLW Inlet: 7-14 ft deep MLLW	11-13 ft deep MLLW	Atlantic City International Airport: ~8.5 mi	OCS-A 0490 – 69 nautical miles OCS-A 0519 – 65 nautical miles OCS-A 0482 (Orsted/PSEG) - 42 nautical miles OCS-A 0498 (Orsted) – 9 nautical miles OCS-A 0499 (EDF/Shell) - 10 nautical miles Hudson South Draft WEA – 37 nautical miles OSC-A 0512 (Equinor) – 73 nautical miles Hudson North Draft WEA – 79 nautical miles Fairways South Draft WEA – 94 nautical miles Fairways North Draft WEA – 117 nautical miles	None identified	No overhead restrictions; needs dredging	N/A	Unused; for sale	http://www.charts.noaa.gov/PDFs/12318.pdf
North & McLester Property, Elizabeth, NJ	O&M	Newark Bay	801 McLester Street, Elizabeth, NJ Parcels: 2004-0-0; 2004-1-1314; 2004-1-1315; 2004-1-1205.A	Port Authority of NY & NJ	78 acres (upland)	N/A; undeveloped	Pier in disrepair	Pier: ~357 ft long by 15 ft wide ~1,700 ft of water frontage	Port Elizabeth South Reach East - 500 ft wide by 50 ft deep MLLW Port Elizabeth South Reach West - 100-500 ft wide by 45 ft deep MLLW South Reach - 1,000-2,360 ft wide by 50 ft deep MLLW Bergen Point West Reach - 800-1,710 ft wide by 50 ft deep MLLW Bergen Point East Reach - 800-895 ft wide by 50 ft deep MLLW Constable Hook Reach - 800-2,000 ft wide by 50 ft deep MLLW	8-10 ft deep MLLW	Newark International Airport: ~1 mi	OCS-A 0490 – 155 nautical miles OCS-A 0519 – 150 nautical miles OCS-A 0482 (Orsted/PSEG) - 135 nautical miles OCS-A 0498 (Orsted) – 100 nautical miles OCS-A 0499 (EDF/Shell) - 71 nautical miles Hudson South Draft WEA – 38 nautical miles OSC-A 0512 (Equinor) – 34 nautical miles Hudson North Draft WEA – 60 nautical miles Fairways South Draft WEA – 63 nautical miles Fairways North Draft WEA – 84 nautical miles	No rail on-site; < 0.5 miles from rail lines	Bayonne Fixed Bridge: Vert Cl 215 ft Verrazano-Narrows Bridge: Vert Cl 198 ft (middle 2,000 ft); Vert Cl 183 ft (piers); Vert Cl 215 ft (center) Approximately 70% of site is currently encumbered by freshwater wetlands, wetland buffers, and flood zone designations.	N/A	Undeveloped	http://www.charts.noaa.gov/PDFs/12333.pdf http://www.charts.noaa.gov/PDFs/12337.pdf
Construction & Marine Equipment Co (CME), Elizabeth, NJ	O&M	Newark Bay	330 South Front St, Elizabeth, NJ Parcels: 2004-4-1462; 2004-4-1463; 2004-4-1441; 2004-4-1442; 200-4-1438.A	CME; Dengel Enterprises, LLC	~13 acres	90,000 sf of indoor storage	Bulkhead	730 ft	Elizabethport Reach - 500-705 ft wide by 50 ft deep MLLW North of Shooters Island Reach - 515-1,105 ft wide by 50 ft deep MLLW Bergen Point West Reach - 800-1,710 ft wide by 50 ft deep MLLW Bergen Point East Reach - 800-895 ft wide by 50 ft deep MLLW Constable Hook Reach - 800-2,000 ft wide by 50 ft deep MLLW	26 ft deep MLLW	Newark International Airport: ~2 mi	OCS-A 0490 – 162 nautical miles OCS-A 0519 – 156 nautical miles OCS-A 0482 (Orsted/PSEG) - 136 nautical miles OCS-A 0498 (Orsted) – 101 nautical miles OCS-A 0499 (EDF/Shell) - 71 nautical miles Hudson South Draft WEA – 41 nautical miles OSC-A 0512 (Equinor) – 36 nautical miles Hudson North Draft WEA – 60 nautical miles Fairways South Draft WEA – 62 nautical miles Fairways North Draft WEA – 85 nautical miles	Over 2,000 ft of rail tracks and spurs	Bayonne Fixed Bridge: Vert Cl 215 ft Verrazano-Narrows Bridge: Vert Cl 198 ft (middle 2,000 ft); Vert Cl 183 ft (piers); Vert Cl 215 ft (center)	Crane capacities of 50 to 440 tons.	The approximately 13-acre site is an active marine terminal. The owners have expressed an interest in the site supporting the OSW industry. The site has approximately 90,000 square feet of indoor storage. The rear 5.5 acres of the property could be used for outdoor storage of various OSW components.	http://www.charts.noaa.gov/PDFs/12333.pdf http://www.charts.noaa.gov/PDFs/12337.pdf
Naval Weapons Station Earle	Manufacturing (cables, foundations, tower sections, blades, nacelles, and substations); O&M	Raritan Bay	Highway 36, Middletown Township, NJ Parcel: 1332-306-45; 1332-658-76	US Navy	~800 acres (upland); majority of site is woodlands	Waterfront Area: Several buildings including operations, fitness center, and security	Three finger piers (3 miles from shore)	Pier 2: ~680 ft Pier 3A: ~800 ft Pier 4: ~800 ft	Sandy Hook Channel: 800 feet wide by 35 feet deep MLLW Terminal Channel: 400 feet wide by 45 feet deep MLLW	Pier 2: 19-30 ft MLLW Pier 3A: 32-40 ft MLLW Pier 4: 35-45 ft MLLW	Newark International Airport: ~16.6 mi	OCS-A 0490 – 141 nautical miles OCS-A 0519 – 134 nautical miles OCS-A 0482 (Orsted/PSEG) - 127 nautical miles OCS-A 0498 (Orsted) – 84 nautical miles OCS-A 0499 (EDF/Shell) - 57 nautical miles Hudson South Draft WEA – 38 nautical miles OSC-A 0512 (Equinor) – 27 nautical miles Hudson North Draft WEA – 43 nautical miles Fairways South Draft WEA – 49 nautical miles Fairways North Draft WEA – 71 nautical miles	Rail connections on-site	No overhead restrictions	N/A	Active military operations including munitions loading and unloading. The ERDC report indicates that according to recent engineering inspections, Pier 1 and Pier 2 are seriously deteriorated and limited or no vehicular loadings are recommended. Both Piers 1 and 2 show deteriorating pilings and bracing. The ERDC report recommends that a comprehensive engineering assessment be conducted. The report notes that "Recovering the original train load-capacity is likely not economically feasible, but regaining the ability to support transport trucks, crane/forklift loadings, and ship mooring may well be feasilble."	NAVFAC - Bathymetric Condition Survey (April 2018) US Army Engineer Research and Development Center (ERDC). Assessment of Trestle 2 and Pier 2. Naval Weapons Station Earle, Colts Neck, New Jersey. December 2018
Dorchester Shipyard	O&M	Delaware Bay	13 Front St, Dorchester, NJ Parcels: 0609-274-1; 0609-274-4; 0609-252-21	Nicole-Kristie LLC; Dorchester Shipyard is operated by Aries Marine	14 acres; 1,200 ft riverfront	Several buildings associated with shipyard	Approximately four piers; two piers appear to be wooden; two piers appear to be concrete New drydock (100 ft by 71 ft) with 500 ton bearing capacity	Berthing areas total approximatley 330 ft ~1,200 ft of water frontage	Maurice River - 400 ft wide by 7-17 ft deep MLLW Maurice River Cove - 3-8 ft deep MLLW	9-16 ft deep MLLW	Cape May Airport: ~18 mi Atlantic City International Airport: ~25 mi	OCS-A 0482 (Orsted/PSEG) - 46 nmi OCS-A 0498 (Orsted) – 67 nmi OCS-A 0499 (EDF/Shell) - 86 nmi Hudson South Draft WEA – 129 nmi OSC-A 0512 (Equinor) – 165 nmi	None identified	No overhead restrictions	Not identified	Historic shipyard; owner has expressed interest in supporting offshore wind.	http://www.charts.noaa.gov/PDFs/12304.pdf https://www.dorchestershipyard.com/
Lower Alloways Creek	Marshalling; Manufacturing (cables, foundations, tower sections, blades, nacelles, and substations)	Delaware River	Alloways Creek Neck Road, Lower Alloway Creek Township, NJ Parcels: 1705-26-2	PSEG	~320 acres; majority of site is wetlands	N/A; undeveloped	N/A; undeveloped	N/A; 8,000 ft of water frontage	Baker Range - 800 ft wide by 40 ft deep MLLW Liston Range - 800-1,000 ft wide by 40 ft deep MLLW	10-12 ft MLLW	New Castle Airport: ~12.5 mi	OCS-A 0490 – 71 nautical miles OCS-A 0519 – 66 nautical miles OCS-A 0482 (Orsted/PSEG) - 57 nautical miles OCS-A 0498 (Orsted) – 76 nautical miles OCS-A 0499 (EDF/Shell) - 95 nautical miles Hudson South Draft WEA – 121 nautical miles OSC-A 0512 (Equinor) – 169 nautical miles Hudson North Draft WEA – 170 nautical miles Fairways South Draft WEA – 186 nautical miles Fairways North Draft WEA – 208 nautical miles	None identified	No overhead restrictions; the site is approximately 4,600 ft from the deep water channel	N/A	The property is located adjacent north of the Hope Creek Generating Station. NJ EDA has recently announced that the New Jersey Wind Port (Lower Alloways Creek site) will be developed by New Jersey and others as a manufacturing and marshaling site. Construction is planned in two phases, beginning in 2021. Phase 1 will develop a 30-acre site to accommodate marshaling activities and a 25-acre component manufacturing site. Phase 2 adds another 150+ acres to accommodate expanded marshaling activities and extensive manufacturing facilities for turbine components like blades and nacelles.	http://www.charts.noaa.gov/PDFs/12311.pdf https://www.nap.usace.army.mil/Portals/39/docs/Civil/Public%20Notice/PSEG%20EA%207-1-2014%20Draft.pdf?ver=2014-07-15-130609-563 https://www.nj.com/salem/index.ssf/2014/08/new_salem_county_nuclear_reactor_would_have_small_impact_on_environment_be_boost_to_economy_nrc_stud.html https://www.nap.usace.army.mil/Portals/39/docs/Civil/Reports/NJ-DMU/MainReport_Volume1.pdf?ver=2017-10-17-102517-133

APPENDIX E

LCOE and Energy Production of Offshore Wind Farms in New Jersey for 7,500 MW by End of 2035

Commercial in confidence

LCOE and Energy Production of Offshore Wind Farms in New Jersey for 7,500 MW by End of 2035

An Analysis for the New Jersey Board of Public Utilities

June 2020

Document History

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1. Introduction

This report covers the modelling of the levelized cost of energy (LCOE) and energy production of offshore wind farms in New Jersey (NJ).

This report is part of the NJ Offshore Wind Strategic Plan (OWSP) and part of a task to evaluate LCOE. We first evaluated 3.5GW by end 2030 in 2019, and now have revised the analysis to 7.5GW by end 2035. To evaluate LCOE, we worked with the supply chain infrastructure and workforce development team to develop scenarios for offshore wind development in New Jersey and the adjacent states, and then costed these scenarios. We also worked with the environmental analysis team to describe the wind resource off New Jersey coast to enabled us to model the associated energy production. Combining the cost and energy production provides us with a LCOE.

LCOE is the lifetime average cost of the energy generated by the wind farm per unit (usually megawatts per hour [MWh]) and is comprised of the development, capital, operational and decommissioning expenditures. The LCOE includes the time-value of money (the effects of compound interest) so that the costs of different energy sources can be compared fairly. The cost of financing and the timing of expenditure are therefore also included in LCOE.

One way to consider LCOE is to imagine an average year in the life of the system. For that year:

$$LCOE = \frac{(levelized\ annual\ capital\ cost + average\ annual\ operating\ cost)}{average\ annual\ energy\ production}$$

“Average annual operating costs” and “average annual energy production” are simple to picture. The “levelized annual capital cost” is the share of total capital cost that gets assigned to each year in the life of the system. It depends on the total capital, when in time it is spent, the planned lifetime of the asset and the finance costs. It is analogous to the annual cost of a repayment mortgage at a fixed interest rate.

For this project, BVGA modelled the energy production and cost of currently proposed wind farms in New Jersey. The methodology is described in Section 2. The energy production is described in Section 3. The LCOE is described in Section 4. We also show the sensitivity of this LCOE to various changes in site and approach in Section 5. We provide conclusions and offer recommendations in Section 6.

2. Methodology

2.1. Scenario Definitions and Project Locations

The scenario definitions for this task apply across the project as a whole (covering LCOE and supply chain) and are provided in Appendix A for reference. The scenarios were selected based on BVGA previous experience and in discussion with the wider project Team and the New Jersey Board of Public Utilities (NJBPU). The scenarios represent:

- the realistic “balanced” approach - balancing jobs and value-added against cost – Scenario A, and
- the realistic “lowest LCOE” approach – cost (LCOE) reduction is maximised at the expense of local content – Scenario B.

The scenarios include the impact of developments in technology, turbine sizes and supply chains over the timescales of the installation of the NJBPU-projected 7.5 gigawatts (GW) of new offshore wind in New Jersey by 2035. The scenarios are relevant to this task, because costs and energy production are influenced by the following:

- build-out plan timings,

- project sizes, and
- supply chain assumptions, in particular the degree of localization.

For each project in each of the scenarios, we agreed upon representative site locations with Ramboll and NJBPU. For each location we determined the following set of parameters required for our LCOE modelling:

- wind speed at a 120-meter (m) hub height,
- water depth,
- distance from construction port,
- distance from operations ports, and
- distance to onshore grid connection point.

The detailed data for all of the modelled project sites are provided in Appendix A and B.

This analysis is based upon the NJBPU OSW energy solicitation schedule as provided below:

NJ Offshore Wind Solicitation Schedule:

- 1,100 MW in 2018
- 1,200 MW in 2020[1]
- 1,200 MW in 2022[1]
- 1,200 MW in 2024[1]
- 1,400 MW in 2026[1]
- 1,400 MW in 2028[1]

Total: 7,500 MWs by 2035

Overview of Sites

More details are provided on the generalized-modelled sites in Appendix A, but essentially, we build out sites that are near shore first. We assume that the solicitations are in pairs: the first and second solicitations use “Site A,” which is near to shore and shallow. The next two solicitations use “Site B,” which is a little further from shore and a little deeper. Solicitations 5 and 6 use “Site C,” which is also further from shore and a little deeper, but it is also a little windier. Site A is indicative of Ocean Wind (BOEM lease area OCS-A 0498) and the BOEM near shore leases off the New Jersey coast (OCS-A 0498, OCS-A 0499, OCS-A 0482). Site B is indicative of the BOEM leases off the New Jersey coast (OCS-A 0512, OCS-A 0519, or OCS-A 0490). Site C is indicative of the future lease in Hudson South WEA.

[1] Actual quantities to be solicited and awarded will be determined by the NJBPU at the time of solicitation and award.

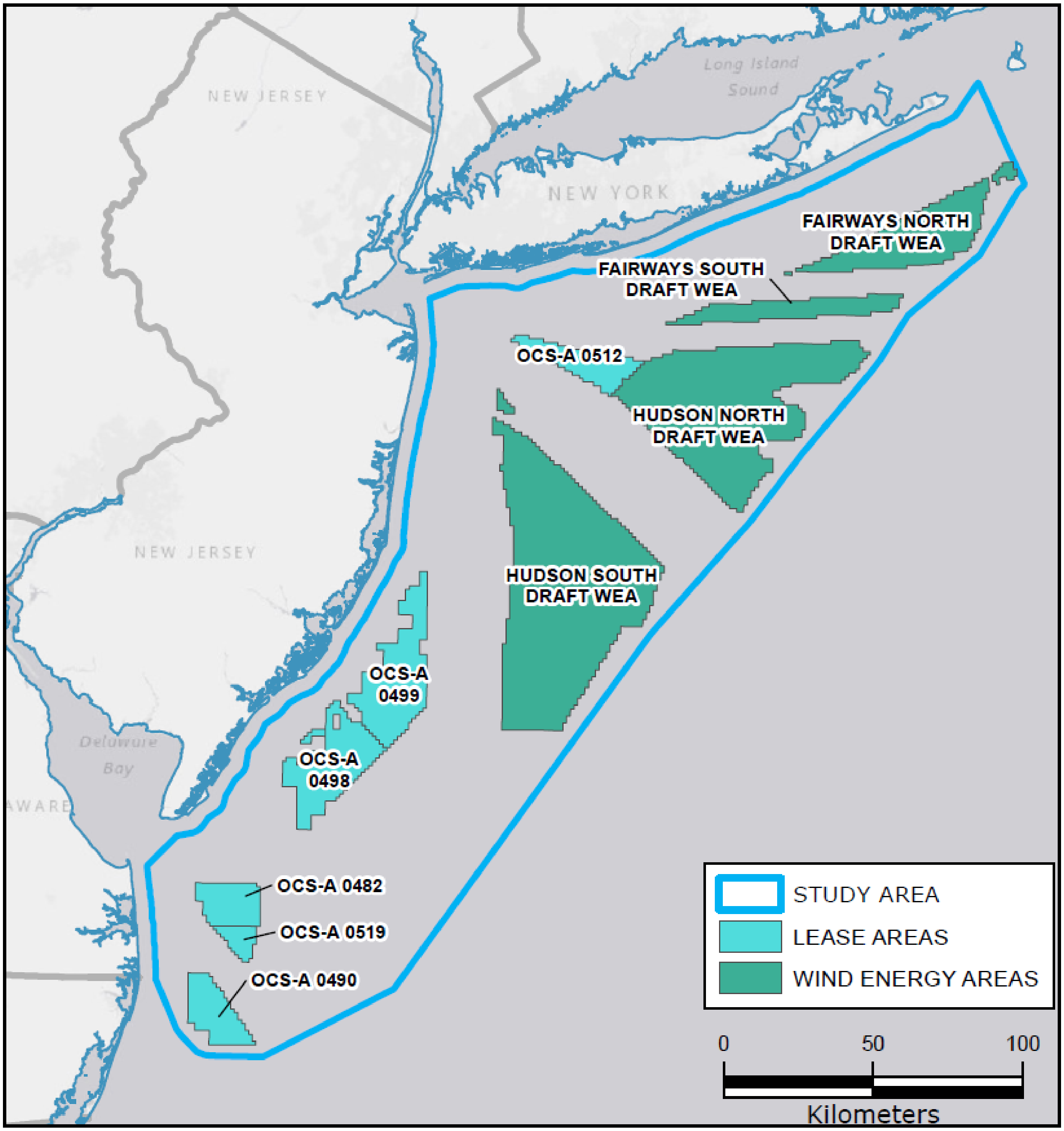

Figure 1: Leases and WEAs in the Study Area.

LCOE Modelling

BVGA's modelling approach is founded on extensive industry engagement, our subject matter expertise and application of proven techniques. Our industry engagement focuses on players with track record in the industry to gain relevant, "real-world" and up-to-date information. From this insight, we apply a top-down overview analysis to moderate and validate the industry's estimation of innovation. The results are then peer reviewed with BVGA and at least two reviewers with expertise in the area under review inputting into each section.

We update our innovation and LCOE modelling regularly. In addition, on an ongoing basis, we also incorporate information from published reports. The data is also cross-checked with press releases and direct academic or industrial enquiry.

Our LCOE model includes spatial variation by taking into account site characteristics such as wind speed, water depth, distance to port(s) and distance to grid. It uses rules for changes with spatial characteristics validated by direct academic and industrial enquiry. Top-down and bottom-up modelling approaches are meshed together and the results are pinned to the specific sites described in the BVGA innovation model. Bottom-up modelling is important for dependencies on materials and vessels, while top-down modelling is important for including ancillary items, warranty, contingency and similar issues.

We used the BVGA offshore wind model to develop detailed cost breakdowns and power curves for the projects as though the sites in New Jersey have the same supply chain as equivalent sites in Europe. We then modified the sites for the specific New Jersey supply chain scenarios described in Appendix A. These modifications were based on changes to material, labor and process costs as well as on import and new market differences.

Although the results are presented at the LCOE-level, the BVGA offshore wind model calculates expenditure on the wind farms for approximately 15 items. This detailed modelling is then used to provide total expenditure and, combined with energy production, LCOE.

The modelling shows how each of six successive solicitations of offshore wind in New Jersey may achieve cost reductions. The build-out of offshore wind assumed in states neighboring New Jersey is shown in Appendix A.

2.2. Energy Information

As well as assessing the costs, we assessed the energy production for the different sites in the scenarios by producing power curves for the turbines and combining this with calculated losses and downtime across the year. This gave a value for the total energy generated by the farms in the year.

3. Energy Production

Based upon BVGA's understanding and knowledge of the developing OSW market, for each of NJBPU-planned solicitations, we assumed that the following turbine is used: 2024, 12 MW; 2027, 15 MW; 2029, 16 MW; 2031, 18MW; 2033, 20MW; and, 2035, 20MW. The potential effects of other turbine ratings are discussed in the sensitivity analyses provided below. To calculate the gross energy production for the wind farms, we used a power curve for each turbine rating in conjunction with the mean wind speed. The power curves used are shown in Figure 2.

To estimate the net power production, we estimated the typical losses and assumed a fixed percentage of instantaneous power output for most losses.

We assume that the PJM grid can consume all of the electrical output from the offshore wind farms.

The annual energy production by project for each scenario is given in Appendix B Table 6.

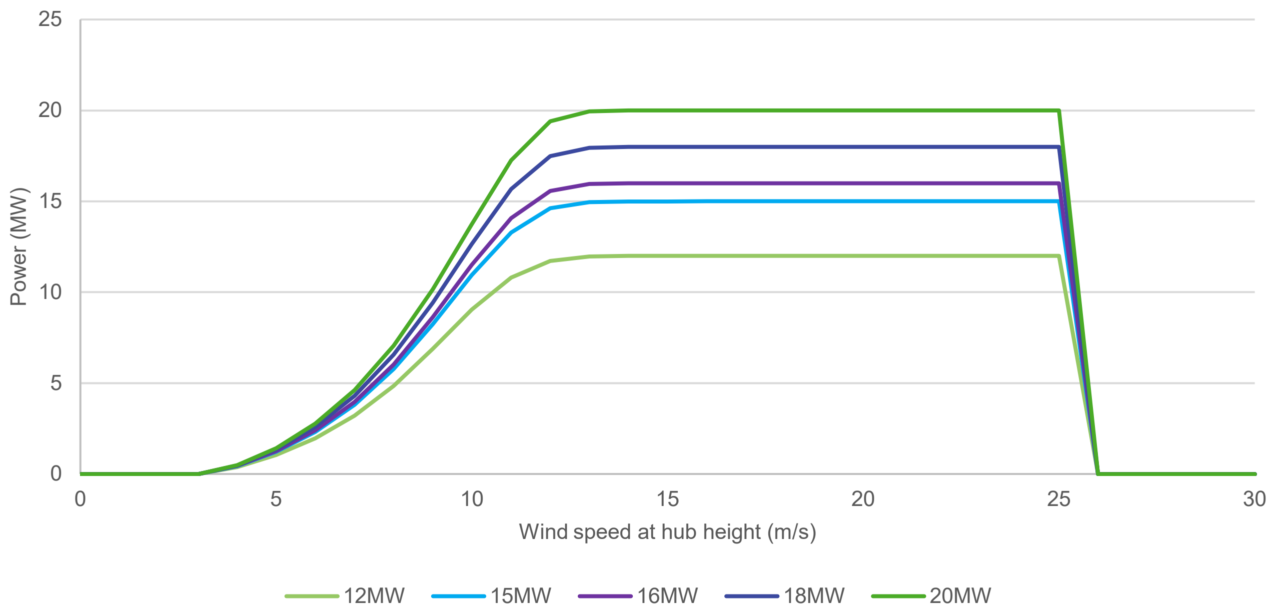

Figure 2: Power curves used to derive energy production.

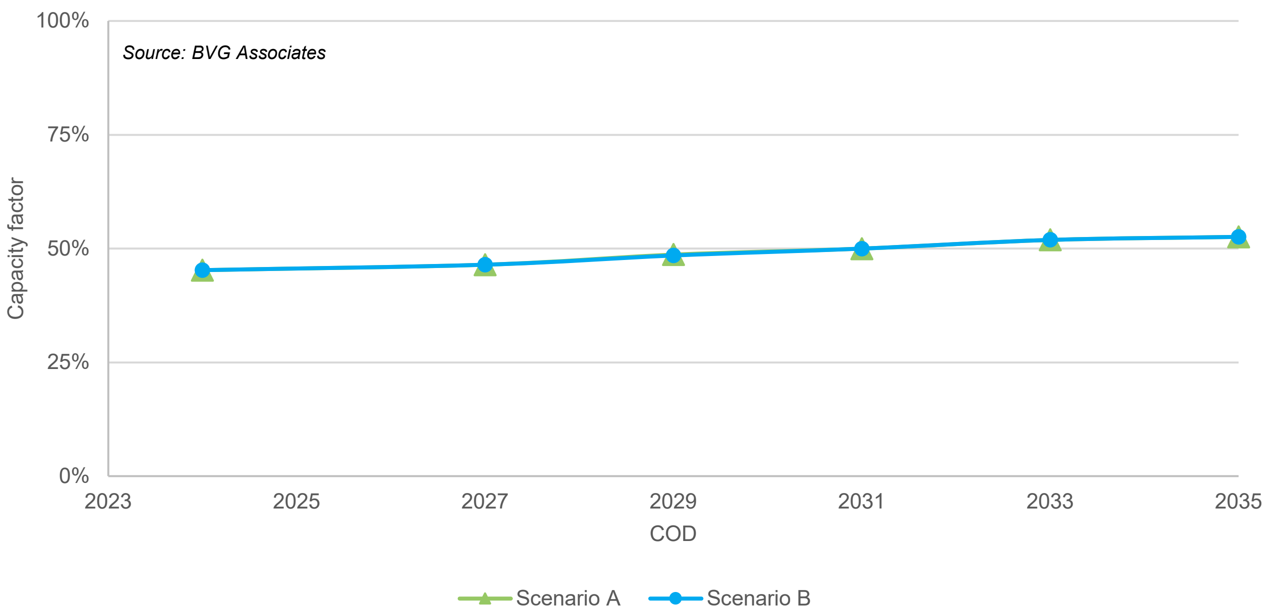

Figure 3: Energy production shown as capacity factor for the solicitations.

Summary of energy production analysis:

- Larger, more advanced turbines produce more energy for the same wind speed; and
- For each solicitation, the energy production in the two scenarios is very similar.

4. LCOE

The LCOEs that we calculated for each project in each scenario are provided in Table 1.

Table 1: LCOEs for Scenarios A and B in $/MWh (pre-tax, real, 2018 prices).

Comercial Operation Date	2024	2027	2029	2031	2033	2035
LCOE Scenario A ($/MWh)	98.6	78.3	66.0	55.6	50.8	47.4
LCOE Scenario B ($/MWh)	96.3	76.8	66.5	55.8	50.8	47.4

These tables are summarized in Figure 4, showing the LCOE for each scenario in each solicitation.

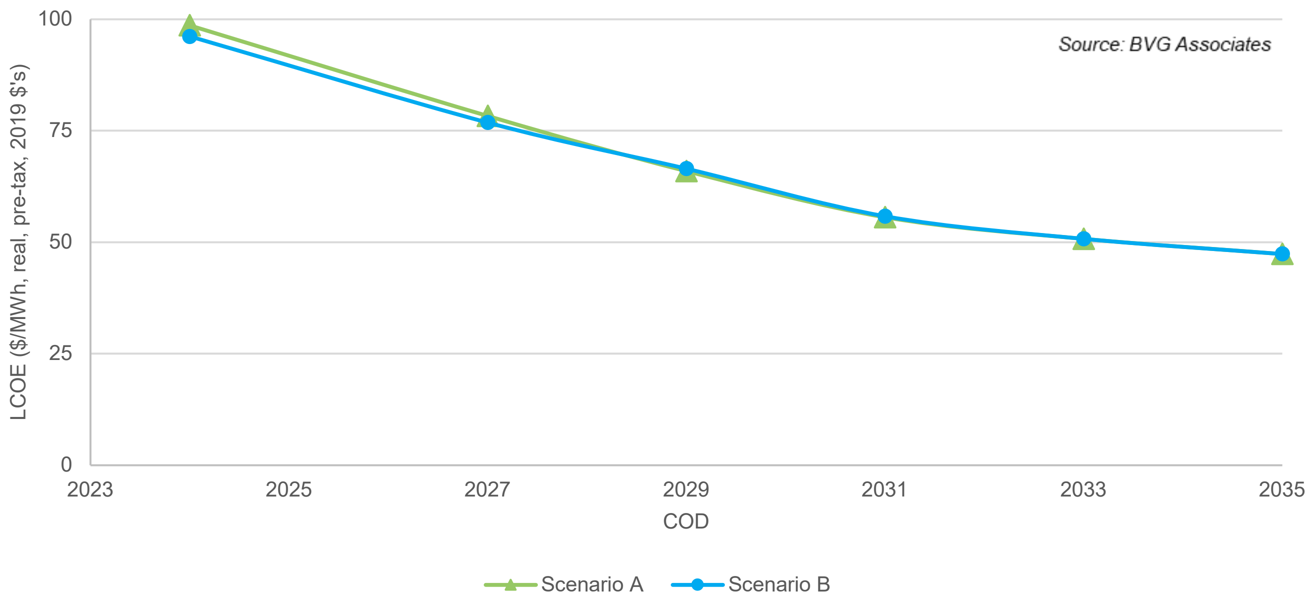

Figure 4: LCOE for each scenario in each solicitation.

The results and ramifications of this LCOE analyses are discussed in detail below.

In comparison to wind farms in other parts of the world, the wind speeds in New Jersey are not high, so the energy output is low, making the LCOE high. The LCOEs start higher than in Europe but drop as experience and the supply chain build-up to European levels (depending on scenario).

Looking closer to New jersey, a straighforward comparison with the offshore wind auction prices in Massachusetts is not advisable – the lack of US OSW track-record means that we cannot assume the relationship between the agreed auction price and LCOE operates in the same way as Europe. The offshore wind auction prices take into account tax credits which reduce the price in comparison to the LCOE shown here. There also may be market forces behind the prices that have an extra effect.

In 2035, the LCOE is as low as wholesale electricity prices are now. The market revenue that the offshore wind farm would receive might not cover this LCOE, however, because in 2035 there will be 7.5GW of offshore wind in New Jersey. Then offshore wind will be a sizeable proportion of the total electricity supply, along with onshore wind and solar. In an energy system with a lot of renewable energy, the prices are low when that energy is being produced and high when it is not, which means that renewables will get less than the average price for its electricity. Private PPAs will be able to stabilize prices for some of this capacity, but not all. Price stabilization of large quantities of renewables is a challenge that the established markets are beginning to work on. The Dutch Ministry for Economic Affairs and Climate Policy recently reported on the business case for offshore wind. In this they report that improving offshore wind returns through matching supply and demand, and maintaining low financing costs can be done, but that additional work will be needed[2]. The UK's Department for Business, Energy and Industrial Strategy consulted on future offshore wind revenue stabilization during H1 2020[3]. There has not yet been consensus so far in Europe on the best approach for future revenue stabilization.

Summary of LCOE analysis

- For the first 1,100 MW solicitation, the "balanced" approach has LCOE of $99/MWh.
- By COD 2029 (the third 1,200 MW, solicitation), the "balanced" approach results in the lowest LCOE.
- This LCOE is $66/MWh, a 33% saving in comparison to the LCOE for the first 1,100 MW solicitation.
- For the first 1,100 MW solicitation, lower LCOE can be obtained by using a "lowest cost" approach that has LCOE 3% lower than the "balanced" approach.
- Over the whole period, LCOE decreases to $47/MWh.

5. Sensitivity Analysis - All Aspects

Using the COD 2027 site (the second 1,100 MW solicitation with 15 MW turbines) from the balanced Scenario A, we modified the site type by moving the distance to construction port by ±25% (37 kilometers [km]), operations port by ±25% (5 km), water depth by ±25% (5 m) and wind speed by ±10% (0.93 meters per second [m/s] at 120 m). For the grid connection, we considered the grid connection distance ±25% from the site (7.5 km). (increased offshore distance to grid). We chose all the aforementioned factors to cover the majority of projects in New Jersey.

We also considered the difference in LCOE with different weighted average cost of capital (WACCs) (±0.5% absolute: 7% and 8%). This shows the sensitivity of the LCOE to perceived risk (e.g., risk of overspend, delay or project failure). We show the effect of farm rating for ±25% (275MW). Finally, we also show the difference if smaller (14 MW) or larger (16 MW) turbines were used. The effect on LCOE of all these changes is shown in Figure 5.

[2] The business case and supporting interventions for Dutch offshore wind, a report to the Ministry of Economic Affairs and Climate Policy https://afry.com/sites/default/files/2020-03/dutch_offshorebusinesscases_onlineversion_final.pdf

[3] Contracts for Difference (CfD): proposed amendments to the scheme 2020, BEIS, https://www.gov.uk/government/consultations/contracts-for-difference-cfd-proposed-amendments-to-the-scheme-2020

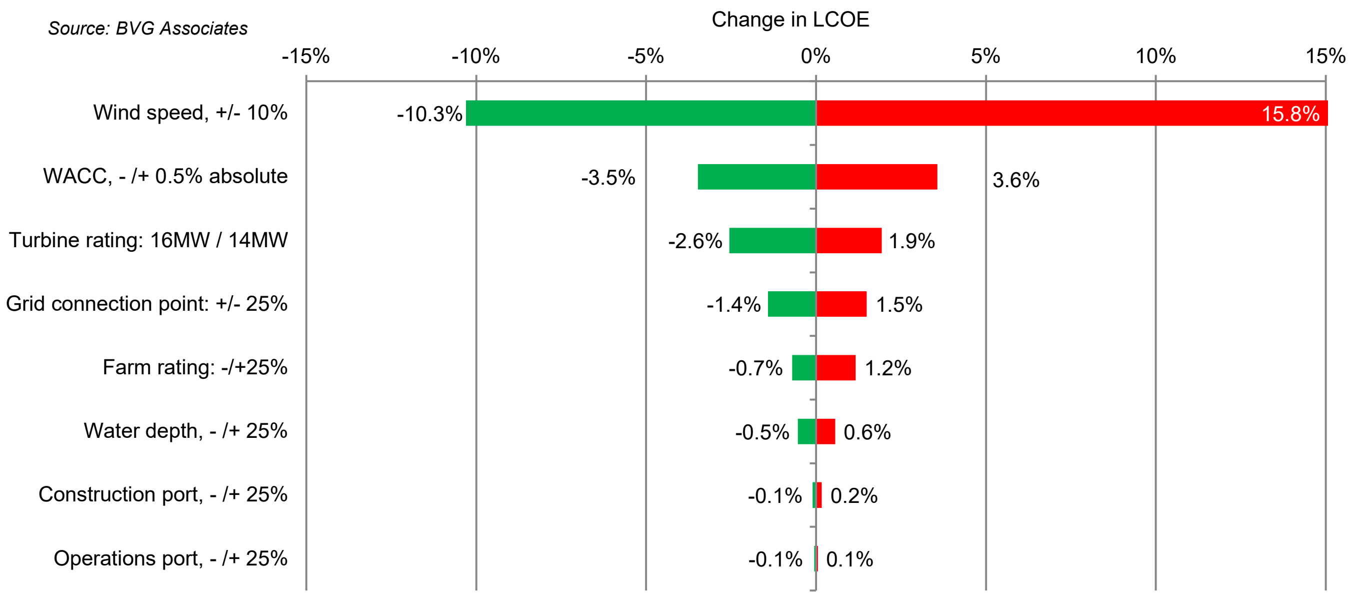

Figure 5: Sensitivity of the 2027 site in Scenario A, using plausible up- and down-sides.

The most important factor of influence on the LCOE is the wind speed: the energy production of the farm has a direct effect on the LCOE.

Next we show the non-geographical factors: WACC, turbine rating and farm rating. A larger WACC increases the amount required to pay back the CAPEX. A smaller farm decreases economies of scale savings, as does a smaller turbine.

Finally, we show the geographical factors. The transmission connection is the most sensitive of the geographical factors. Water depth, construction port and operations port all have some effect, but not as large as that for transmission. If the transmission CAPEX and OPEX is excluded from the LCOE entirely and not paid for by the projects, the LCOE reduces by approximately 15%. Sensitivity of LCOE to construction port and operations port distances is approximately linear.

The values shown in Figure 5 are for Scenario A in the second solicitation. The range of likely values is therefore different if other scenarios were considered. Construction port distance was varied by 37km. For some sites in New Jersey, the difference between using a northern or southern construction port could be as much as 150km. The variation in LCOE would therefore be higher than suggested in the chart. With such an impact on LCOE, a project developer would select the construction port nearest to the site. If using CTVs for operations, then over the lifetime of a project, the distance to operations port will have a stronger effect on LCOE. For the solicitation 2 shown here and those in future solititions, SOVs are expected to be used, so the operations port distance has only a very mdoest effect. Wind speed variation in Figure 5 is based on ±0.93m/s at 120m. In moving from Site B to Site C, the wind speed only increases by 0.3m/s. The LCOE upside will therefore be lower than that shown in Figure 5.

In Figure 5 the WACC is shown changing by +/-0.5% absolute. A difference of 0.5% in WACC is large, but between projects, WACC can change significantly. If the debt portion of the WACC remains the same, but the equity taker takes 0% return, the WACC approximately halves and the LCOE reduces by 25%. If there is currently a lot of competition pressure in the market, this can reduce the WACC in this way, but such WACC reductions are not stable long-term.

The increase in turbine rating from 12MW to 15MW between the first and second solicitations is key to the reducing cost reduction trajectory, accounting for 3.9% of the total reduction. This reduction comes from the savings made in balance of plant and OMS per MW, rather than from large turbines being cheaper per MW. For example, the increase in cost per foundation from 12MW to 15MW is less than the decrease in cost because fewer foundations are needed to make up the 1.2 GW wind farm.

Sensitivity to Foundation Type

Another key difference in LCOE for offshore wind comes from the foundation type used. In the first four solicitations, we assume monopile foundations are used, while for the fifth and sixth solicitations we use jacket foundations. Jacket foundations have structural advantages to monopiles for deeper waters and for larger turbines but are generally more expensive. The fourth solicitation has water depths of 30m and turbines ratings of 18MW and monopiles are most likely to be used. If monopiles, however, cannot be used so jacket foundations must be, we expect the increase in LCOE to be approximately 2.2%. See Figure

6. Note that an increase of 2.2% in LCOE for the entire project represents results from a large increase in foundation costs when using jackets.

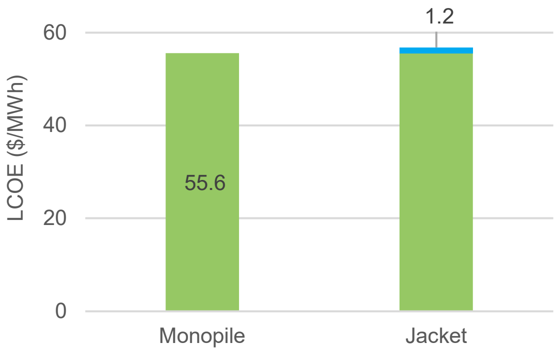

Figure 6: Sensitivity of solicitation 4 (COD 2031), scenario A, to foundation type.

Sensitivity to Turbine Spacing

Spreading the turbines further apart reduces aerodynamic array (wake) losses, but increases array cable losses. Array cables need to be longer so supply and installation costs increase along with operations-phase costs because it takes longer to travel between turbines.

Standard turbine spacing is approximately 5 to 10 rotor diameters, depending on the configuration and whether with the direction of the prevailing wind or not.

In this analysis we have assumed typical wind turbine seperations of 9 diameters (9D) in the prevailing wind direction and 6 diameters (6D) in the perpendicular direction. For the 220m diameter rotor assumed for the 12MW. 15MW and 16MW turbines in solicitations 1 to 3 this is 1.98 km by 1.32 km or 1.07 nautical miles by 0.712 nautical miles.

If a farm of 1,200MW using a 15MW turbines was shaped in a 8 by 10 turbine rectangle with the 8 turbines row seperated by 9Ds, it would occupy about 165 square km or 48.0 square nautical miles. If the 6D spacing was increased to 1 nautical mile or 1.85km then it would occupy about 231 square km or 67.4 square nautical miles that is 40% more space and a significant impact on what wind capacity could be accomodated in any lease area. The costs of the cabling and cabling installation will increase, the electrical losses and maintenance and operations cost especially from transit times to further out turbines and because of that, the cost of time waiting on weather. Electrical losses in the cables will increase while the array losses due to turbines being less in the wake of upwind trubines will reduce. The LCOE of the wind farm itself will increase by about 0.4%. The increase in cost of the wind farm is compounded as it would also force an ealier move to more expensive sites in deeper water and further from shore.

For a larger 18MW turbine with a 220m diameter rotor the impact of making the 6D seperation 1 nautical mile or 1.85km the impact is less for a 6 by 11 recatangle with the 6 turbine rows seperated by 9D but still requires about 23% more space. This remains a significant impact on space. A turbine would need to have a diameter of 309m for the 6D seperation to be 1 nautical mile and so make no difference.

Sensitivity to a Backbone Type Grid Connection

We considered the second solicitation site linking into an offshore “backbone” grid connection. We assumed that this backbone grid was high-voltage direct current (HVDC) and shared by 32 GW of offshore wind farm facilities. We assumed that the wind farm had a connection of 20 km to the backbone (a shorter connection than for returning to shore) and that each farm contributes its share to the backbone cost: the CAPEX for transmission includes the 20km to the backbone plus a share of the backbone cost. We did not consider any change in risk or penalty from project delay from connecting via this “backbone.” We also did not consider the potential benefits to return on investment of supplying into this “backbone.” Such a “backbone” grid connection reduced the LCOE by 2.8%.

Summary of Sensitivity Analysis

- The project-level changes (turbine rating, WACC) have a larger effect on LCOE than most of the site characteristics (e.g., distance to ports, water depth).
- Removing the cost of interconnection from the LCOE of the project reduces the LCOE value by 15%, but does not remove the cost. It might be ratepayers rather than bill-payers who pay, but it will be paid for by someone.

- Using a minimum turbine seperation distance of 1 nautical miles in solicitation 2 will increase the wind farm area by 40% and its LCOE by 0.4%. The overall cost impact will be larger as it would force an ealier move to more expensive sites in deeper water and further from shore.
- Using jacket foundations in solicitation 3 will increase LCOE by 2.2%.
- Using a backbone approach to transmission can reduce the transmission CAPEX and OPEX. It will reduce LCOE if there is no corresponding increase in WACC. A small increase in perceived risk will increase WACC, however, and the downside sensitivity to WACC is greater than the upside from the backbone cost reduction.

6. Summary, Conclusions and Recommendations

Summary and Conclusions:

- Larger, more advanced turbines produce more energy for the same wind speed.
- For each solicitation, the energy production in the two scenarios are very similar.
- For the first 1,100 MW solicitation, the “balanced” approach has LCOE of $99/MWh.
- By COD 2029 (i.e., third, 1,200 MW, solicitation), the “balanced” approach results in the lowest LCOE.
- This LCOE is $66/MWh, a 33% saving in comparison to the LCOE for the first 1,100 MW solicitation.
- For the first 1,100 MW solicitation, lower LCOE can be obtained by using a “lowest cost” approach that has LCOE 3% lower than the “balanced” approach.
- Over the whole period, LCOE decreases to $47/MWh for the sixth solicitation.
- The project-level changes (turbine rating, WACC) have a larger effect on LCOE than most of the site characteristics (e.g., distance to ports, water depth).
- Removing the cost of interconnection from the LCOE of the project reduces the LCOE value by 15%, but does not remove the cost. It might be ratepayers rather than bill-payers who pay, but it will be paid for by someone.
- Using a minimum turbine seperation distance of 1 nautical miles in solicitation 2 will increase the wind farm area by 40% and its LCOE by 0.4%. The overall cost impact will be larger as it would force an ealier move to more expensive sites in deeper water and further from shore.
- Using jacket foundations in solicitation 3 will increase LCOE by 2.2%.
- Using a backbone approach to transmission can reduce the transmission CAPEX and OPEX. It will reduce LCOE if there is no corresponding increase in WACC. A small increase in perceived risk will increase WACC, however, and the downside sensitivity to WACC is greater than the upside from the backbone cost reduction.

Recommendations:

- NJ BPU should seek to achieve the balanced scenario Scenario A: Long-term, the lowest LCOE scenario (Scenario B) and the balanced scenario (Scenario A) converge on the same LCOEs. The gain in local content in the balanced scenario in comparison to the lowest LCOE scenario is small in comparison to the LCOE impact.
- NJ BPU should continue to support sharing of understanding on sites between BOEM and other stakeholders so that the sites with the best wind conditions move forward with development.
- NJ BPU should focus on taking risk out of the projects: supporting smooth planning processes and aligning these with offtake agreements for the power generated reduces the project risk for developers (and thus reduces LCOE) without increasing costs for ratepayers.
- NJ BPU in the longer term should work to ensure that price stabilization of large quantities of renewables is in place for the 2030s.

Appendix A Scenarios

To model the LCOE of offshore wind in NJ, we need to consider two scenarios. Suggestions for these scenarios are described below.

Baseline

Scenario 0: baseline – no offshore wind.

Two Offshore Wind Scenarios

Tables of the assumptions in the two scenarios with offshore wind are given below.

The locations used are BOEM lease areas for sites A and B, and draft NY Bight lease areas for site C.

Table 2: Scenario A 'Balanced' - the trade-off between local content and cost is balanced based on expert judgement.

GW OSW	COD	Wind farm details	Definition of site	Transmission Site	Marshaling (construction) port	Operations and maintenance port	Technology assumptions	Supply chain assumptions
1.1	2024	Site A	20 m water depth (mean lease values); 9.3m/s AMWS at 120m	Not specified, 30 km cable length to landside grid interconnect (mean distance value)	Not specified, 145 km distance to marshaling port (mean distance)	Not specified, 20 km distance to O&M port (mean distance value)	12MW turbine; monopile foundation; 66kV array cables	Imported turbine and US made monopiles, US made substations, cables, global installation vessel(s) with Jones Act feeder vessel(s)
1.2	2027	Site A	20 m water depth (mean lease values); 9.3m/s AMWS	Not specified, 30 km cable length to landside grid interconnect (mean distance value)	Not specified, 145 km distance to marshaling port (mean distance)	Not specified, 20 km distance to O&M port (mean distance value)	15MW 220m diameter turbine; monopile foundation;	Imported turbine, US made substations, cables, monopiles, Jones Act installation vessel(s)
1.2	2029	Site B	30 m water depth (mean lease values); 9.3m/s AMWS	Not specified, 55 km cable length to landside grid interconnect (mean distance value)	Not specified, 190 km distance to marshaling port (mean distance)	Not specified, 80 km distance to O&M port (mean distance value)	16MW 220 m diameter turbine; monopile foundation;	Imported turbine, US made substations, cables, monopiles, Jones Act installation vessel(s)

GW OSW	COD	Wind farm details	Definition of site	Transmission Site	Marshaling (construction) port	Operations and maintenance port	Technology assumptions	Supply chain assumptions
1.2	2031	Site B	30 m water depth (mean lease values); 9.3m/s AMWS	55 km cable length to landside grid interconnect	190 km distance to marshaling port (mean distance)	45 km distance to O&M port (mean distance value)	18MW 250 m diameter turbine; monopile foundation;	US made turbine, substations, cables, monopiles, Jones Act installation vessel(s)
1.4	2033	Site C	40 m water depth (mean lease values); 9.6m/s AMWS	75 km cable length to landside grid interconnect	235 km distance to marshaling port	65 km distance to O&M port	20MW 250 m turbine; jacket foundation;	All local supply
1.4	2035	Site C	40 m water depth (mean lease values); 9.6m/s AMWS	75 km cable length to landside grid interconnect	235 km distance to marshaling port	65 km distance to O&M port	20MW 250 m turbine; jacket foundation;	All local supply

Table 3: Scenario B 'Lowest LCOE' - cost (LCOE) reduction is maximized at the expense of local content.

GW OSW	COD	Wind farm details	Definition of site	Transmission Site	Marshaling (construction) port	Operations and maintenance port	Technology assumptions	Supply chain assumptions
1.1	2024	Site A	20 m water depth (mean lease values) 9.3m/s AMWS at 120m	Not specified, 30 km cable length to landside grid interconnect (mean distance value)	Not specified, 145 km distance to marshaling port (mean distance)	Not specified, 20 km distance to O&M port (mean distance value)	12MW turbine; monopile foundation; 66kV array cables	Mostly imported, global installation vessel(s) with Jones Act feeder vessel(s)

GW OSW	COD	Wind farm details	Definition of site	Transmission Site	Marshaling (construction) port	Operations and maintenance port	Technology assumptions	Supply chain assumptions
1.2	2027	Site A	20 m water depth (mean lease values) 9.3m/s AMWS	Not specified, 30 km cable length to landside grid interconnect (mean distance value)	Not specified, 145 km distance to marshaling port (mean distance)	Not specified, 20 km distance to O&M port (mean distance value)	15MW turbine; monopile foundation;	Mostly imported, Jones Act installation vessel(s)
1.2	2029	Site B	30 m water depth (mean lease values) 9.3m/s AMWS	Not specified, 55 km cable length to landside grid interconnect (mean distance value)	Not specified, 190 km distance to marshaling port (mean distance)	Not specified, 80 km distance to O&M port (mean distance value)	16MW turbine; monopile foundation;	Mostly imported, US made monopiles, Jones Act installation vessel(s), US made array cables
1.2	2031	Site B	30 m water depth (mean lease values) 9.3m/s AMWS	55 km cable length to landside grid interconnect \	190 km distance to marshaling port (mean distance)	45 km distance to O&M port (mean distance value)	18MW 250 m diameter turbine; monopile foundation;	US made turbine, substations, cables, monopiles, Jones Act installation vessel(s)
1.4	2033	Site C	40 m water depth (mean lease values) 9.6m/s AMWS	75 km cable length to landside grid interconnect	235 km distance to marshaling port	65 km distance to O&M port	20MW 250 m turbine; jacket foundation;	All local supply
1.4	2035	Site C	40 m water depth (mean lease values) 9.6m/s AMWS	75 km cable length to landside grid interconnect	235 km distance to marshaling port	65 km distance to O&M port	20MW 250 m turbine; jacket foundation;	All local supply

Build-out Assumptions for Rest of US Market

For the rest of the US East Coast, we assume a market build-out as shown in Table 4.

Table 4: Cumulative market build-out.

Date (COD)	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35
NJ market (GW)	0	0	1.1	0	0	1.2	0	1.2	0	1.2	0	1.4	0	1.4
Rest of US East Coast market (not NJ) (GW)	0.3	1.8	2.6	2.5	2.5	1.9	2.6	2.8	2.9	2.4	1.7	1.8	0.8	1.7
Total US east Coast market (GW)	0.3	1.8	3.7	2.5	2.5	3.1	2.6	4.0	2.9	3.6	1.7	3.2	0.8	3.1
Cumulative NJ market (GW)	0.0	0.0	1.1	1.1	1.1	2.3	2.3	3.5	3.5	4.7	4.7	6.1	6.1	7.5
Cumulative rest of US East Coast market (not NJ) (GW)	0.3	2.1	4.6	7.1	9.6	11.5	14.1	16.9	19.8	22.2	23.8	25.6	26.4	28.1
Cumulative total US east Coast market (GW)	0.3	2.1	5.7	8.2	10.7	13.8	16.4	20.4	23.3	26.9	28.5	31.7	32.5	35.6

Table 5: Cumulative market build-out.

STATES	'22	'23	'24	'25	'26	'27	'28	'29	'30	'31	'32	'33	'34	'35	Total
ME	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.40	0.80
NH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.40	0.80
MA	0.00	0.80	0.00	0.80	0.00	0.80	0.00	0.80	0.00	0.80	0.00	1.00	0.00	0.00	5.00
RI	0.00	0.40	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
CT	0.00	0.30	0.00	0.80	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
NY	0.13	0.00	1.70	0.00	0.80	0.70	0.00	1.20	1.20	0.80	0.80	0.80	0.00	0.87	9.00
NJ	0.00	0.00	1.10	0.00	0.00	1.20	0.00	1.20	0.00	1.20	0.00	1.40	0.00	1.40	7.50
DE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.80
MD	0.13	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	1.20
VA	0.00	0.00	0.88	0.88	0.88	0.00	0.88	0.00	0.88	0.00	0.88	0.00	0.00	0.00	5.28
NC	0.00	0.00	0.00	0.00	0.80	0.00	0.80	0.00	0.80	0.00	0.00	0.00	0.00	0.00	2.40
Total	0.26	1.77	3.68	2.48	2.48	3.10	2.58	4.00	2.88	3.60	1.68	3.20	0.80	3.07	35.6
Running total	0.26	2.03	5.71	8.19	10.7	13.8	16.4	20.4	23.2	26.8	28.5	31.7	32.5	35.6	

Appendix B Energy Production

The annual energy production by project for each scenario is shown in Table 5.

Table 6: Energy production for each scenario as capacity factor.

	2024	2027	2029	2031	2033	2035
Scenario A	45.2%	46.4%	48.7%	50.0%	51.9%	52.6%
Scenario B	45.2%	46.4%	48.5%	50.0%	51.9%	52.6%

Appendix C Definitions and Assumptions

This section details the wider modelling assumptions that underpin the cost trends presented above.

C.1 Definitions

Definitions of the scope of each model element are summarized in Table C.1, below.

Table C.1: Definitions of the scope of each element.

Type	Parameter	Definition	Unit
CAPEX	Development	Includes: • Development, consenting and project management work paid for by the developer up to WCD. • Internal and external activities such as environmental and wildlife surveys, met mast (including installation) and engineering (pre-FEED) and planning studies up to FID • Further site investigations and surveys after FID • Engineering (FEED) studies • Environmental monitoring during construction • Project management (work undertaken or contracted by the developer up to WCD) • Other administrative and professional services such as accountancy and legal advice, and • Any reservation payments to suppliers. Excludes: • Development costs of transmission system • Construction phase insurance, and • Supplier's own project management.	$/MW
	Turbine (including tower)	Includes: • Delivery to nearest port to supplier • Payment to wind turbine manufacturer for the supply of the tower, nacelle and its sub-systems, the blades and hub, and the turbine electrical systems to the point of connection to the array cables. • Warranty, and • Commissioning costs. Excludes: • Turbine OPEX, and • RD&D costs.	$/MW
	Foundations (excluding tower)	Includes: • Payment to suppliers for the supply of the support structure comprising the foundation (including any piles, transition piece and secondary steelwork such as J-tubes and personnel access ladders and platforms). • Delivery to nearest port to supplier, and • Warranty. Excludes: • Tower • Foundation OPEX, and • RD&D costs.	$/MW

Type	Parameter	Definition	Unit
	Array electrical	Includes: • Delivery to nearest port to supplier, and • Warranty. Excludes: • OMS costs, and • RD&D costs.	$/MW
	Transmission	Includes: • Development of transmission system • Payment to manufacturer for the supply of onshore and offshore export cables and substations, and • Installation of onshore and offshore substations and export cables Excludes: • OMS costs, and • RD&D costs.	$/MW
	Installation	Includes: • Transportation of all from each supplier's nearest port • Pre-assembly work completed at a construction port before the components are taken offshore • All installation work for support structures, turbines and array cables • Commissioning work for all but turbine (including snagging post-WCD) • Scour protection (for support structure and cable array) • Subsea cable protection mats etc., as required. • Construction phase insurance cover, from start of construction until operation start, including all construction risks & third party Excludes • Construction contingency • Installation of offshore substation / transmission assets, and • Decommissioning.	$/MW
	Contingency and insurance	Construction contingency for unexpected additional CAPEX items and construction overrun (including weather risk) Construction phase insurance	$/MW
OPEX	Operation, maintenance and service (generating assets)	Includes operation and planned (routine) maintenance, unplanned service (in response to faults; may be either proactive or reactive), operations phase insurance and other OPEX. Starts once first turbine is commissioned. Operation and planned maintenance includes: • Operational costs relating to the day-to-day control of the wind farm • Condition monitoring • Planned preventative maintenance, health and safety inspections Unplanned service includes: • Reactive service in response to unplanned systems failure in the turbine or electrical systems. • Operations phase insurance:	$/MW/year

Type	Parameter	Definition	Unit
		• Takes the form of a new operational "all risks" policy and issues such as substation outages, design faults and collision risk become more significant as damages could result in wind farm outage. Insurance during operation is typically renegotiated on an annual basis. Other OPEX covers fixed cost elements that are unaffected by technology innovations, including: • Site rent • Contributions to community funds. • Monitoring of the local environmental impact of the wind farm	
	Operation, maintenance and service (transmission assets)	Using the timing and other definitions above, includes: • Planned maintenance and unplanned service of transmission assets, • Operational phase insurance for the transmission asset, and • Grid charges.	$/MW/year
DECEX	Decommissioning	Includes: • Planning work and design of any additional equipment required • Removal of the turbine and support structure to meet legal obligations, and • Further environmental work and monitoring	$/MW
Annual energy production (AEP)	Net AEP	AEP averaged over the wind farm life at the offshore metering point at entry to offshore substation. Accounts for improvements in early years and degradation in later years. Lifetime energy loss from cut-in / cut-out hysteresis, power curve degradation, and power performance loss. Includes: • Site air density adjustments from the standard turbine power curve, due to temperature and altitude. • Aerodynamic array losses • Electrical array losses • Losses due to blockage effect • Losses due to unavailability of the wind turbines, structure and array cables, and • Losses from cut-in/cut-out hysteresis, power curve degradation, and power performance loss. Excludes external wake effects from neighboring wind farms	MWh/year/MW

C.2 Assumptions

Baseline costs and the impact of innovations are based on the following assumptions for offshore wind.

Global assumptions:

- Real (2019) prices,
- Commodity prices fixed at the average for 2019, and
- Exchange rates fixed at the average for 2019 (for example, $1 = €0.9)

Wind farm assumptions:

General

- Turbines are spaced at nine rotor diameters (downwind) and six rotor diameters (across-wind) in a rectangle,
- The lowest point of the rotor sweep is at least 22 meters above mean high water spring,
- The development and construction costs are funded entirely by the project developer, and
- A multi-contract approach is used to contracting for construction.

Spend profile:

Table C.3: CAPEX spend profile.

Year	-5	-4	-3	-2	-1	0
CAPEX Spend			6%	10%	34%	50%

Year 1 is defined as year of first full generation.

AEP and OPEX are assumed as 100% for each year within the operational lifetime.

Meteorological Regime:

- A wind shear exponent of 0.12,
- Rayleigh wind speed distribution,
- A mean annual average temperature of 10°C, and
- No storm surge is considered.

Turbine:

- The turbine is certified to Class IA to international offshore wind turbine design standard IEC 61400-3.

Support Structure:

- Ground conditions are suitable for installation of monopiles and jacket foundations and pin-piles, only occasionally with locations with lower bearing pressure, the presence of boulders or significant gradients.

Array Electrical:

- A three core 66kV AC cable in fully flexible strings is used, that is, with provision to isolate an individual turbine.

Installation:

- Installation is carried out sequentially by the foundation, array cable, then the pre-assembled tower and turbine together; and
- Array cables are installed via J-tubes, with separate cable lay and survey and burial.

OMS:

- Nearshore access is by service operation vessels (SOVs) or crew transfer vessels (CTVs). Jack-ups are used for major component replacement in both cases.

DECEX:

- Decommissioning reverses the assembly process to result in construction taking one year. Piles and cables are cut off at a depth below the seabed, which is unlikely to lead to uncovering. Environmental monitoring is conducted at the end. The residual value and cost of scrapping are ignored.