DNV·GL

OCEAN WIND FARM

Navigation Safety Risk Assessment

Ocean Wind, LLC

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Task and objective: Navigation safety risk assessment per U.S. Coast Guard NVIC 01-19. This report presents the results of analysis conducted by DNV GL.

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Abbreviation	Meaning
AIS	Automatic Identification System
ALARP	As low as reasonably practicable
ADLS	Aircraft Detection Light System
AMSA	Australian Maritime Safety Agency
ATB	Articulated Tug Barge
ATON	Aids to Navigation
AWO	American Waterways Operators
BOEM	U.S. Bureau of Ocean Energy Management
CEC	Commission of the European Communities
CFR	Code of Federal Regulations
CIOSS	Cooperative Institute for Oceanographic Satellite Studies, Oregon State University
USCG	U.S. Coast Guard
COGOW	Climatology of Global Ocean Winds
COLREGs	International Regulations for Preventing Collisions at Sea
COP	Construction and Operations Plan
DOE	U.S. Department of Energy
DWT	Dead Weight Tonnage
DSC	Digital Selective Calling
ECA	Emission Control Area
ECDIS	Electronic Chart Display and Information System
FAA	Federal Aviation Administration
FR	Federal Register
FSA	Formal Safety Assessment
GC	Gain Control
GPS	Global Positioning System
HF	High Frequency
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICAO	International Civil Aviation Organisation
IMO	International Maritime Organization
ITB	Integrated Tug Barge
LOA	Length Overall
MARCO	Mid-Atlantic Ocean Data Portal
MARCS	Marine Accident Risk Calculation System
MARI PARS	Areas Offshore of Massachusetts and Rhode Island Port Access Route Study
MARPOL	International Convention for the Prevention of Pollution from Ships
MCA	UK Maritime & Coastguard Agency
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MSL	Mean sea level
NGDC	National Geophysical Data Center
NJDEP	New Jersey Department of Environmental Protection
NMFS	National Marine Fisheries Service
NOAA	U.S. National Oceanic and Atmospheric Administration
NROC	Northeast Regional Ocean Council
NSRA	Navigation Safety Risk Assessment
NVIC	Navigation and Vessel Inspection Circular
O&M	Operations and Maintenance
OREIs	Offshore Renewable Energy Installations
OSS	Offshore substation

Abbreviation	Meaning
PATON	Private Aids to Navigation
PDE	Project Design Envelope
PPU	Portable Pilotage Unit
RI	Rhode Island
RODA	Responsible Offshore Development Alliance
RRO	Risk Reduction Options
SAR	Search and Rescue
SMC	Search and Rescue Mission Coordinator
SOLAS	International Convention for the Safety of Life at Sea
SO_x	Sulfur oxides
STCW	International Convention on Standards of Training, Certification and Watchkeeping
TSS	Traffic Separation Scheme
U.S.	United States
UHF	Ultra-High Frequency
UK	United Kingdom
VHF	Very High Frequency
VMRS	Vessel Movement Reporting System
VMS	Vessel Monitoring System
VTR	Vessel Trip Report
WTG	Wind Turbine Generator

List of units

Unit	Meaning
dB	decibels
ft	Feet
GHz	Gigahertz or 10^9 Hertz
Hz	Hertz
km	kilometers
km^2	square kilometers
kt	Knots
m	Meters
mi	Miles
MJ	megajoules
MW	megawatts
NM	Nautical Miles
m/s	meters per second

EXECUTIVE SUMMARY

This document presents the Navigation Safety Risk Assessment (NSRA) for the Ocean Wind Farm (the Project). The Project will be located approximately 13 nautical miles (NM) (24 km) south of Atlantic City, New Jersey, under a Commercial Lease for Renewable Energy Development on the Outer Continental Shelf (OCS-A 0498).

The NSRA was conducted per the guidance in U.S. Coast Guard (Coast Guard) Navigation and Vessel Inspection Circular No. 01-19 ("NVIC 01-19") (Coast Guard, 2019a). This report is intended to be used by the Coast Guard to assist with evaluating the potential impacts of the Project on the marine transportation system, including navigation safety, traditional uses of the waterways, and Coast Guard missions.

This assessment covers the following elements:

1. Site location and coordinates
2. Traffic survey
3. Offshore above water structures
4. Offshore under water structures
5. Navigation within or close to a structure
6. Effect of tides, tidal streams, and currents
7. Weather
8. Configuration and collision avoidance
9. Visual navigation
10. Communications, radar, and positioning systems
11. Risk of collision, allision, or grounding
12. Emergency response considerations
13. Facility characteristics
14. Design requirements
15. Operational requirements
16. Operational procedures

Key findings for each area are listed in Section 17 of this report. The NSRA did not identify any major areas of concern regarding the Project's impact on marine navigation.

Figure ES-1 shows the boundaries of the Project Area (defined in Section 1).

The study assessed conservative "maximum risk" parameters as relevant to each hazard. For example, a layout with the largest potential footprint (shown in Figure ES-2) was used to assess collision risk from passing vessels. The risk evaluated in this NSRA represents the maximum risk from any design/layout within the maximum risk parameters. The NSRA's maximum risk parameters are within the Project Design Envelope (PDE). If either the finalized project layout or the turbine selection is outside the NSRA maximum risk parameters, the Project may update this NSRA (Orsted, 2021).

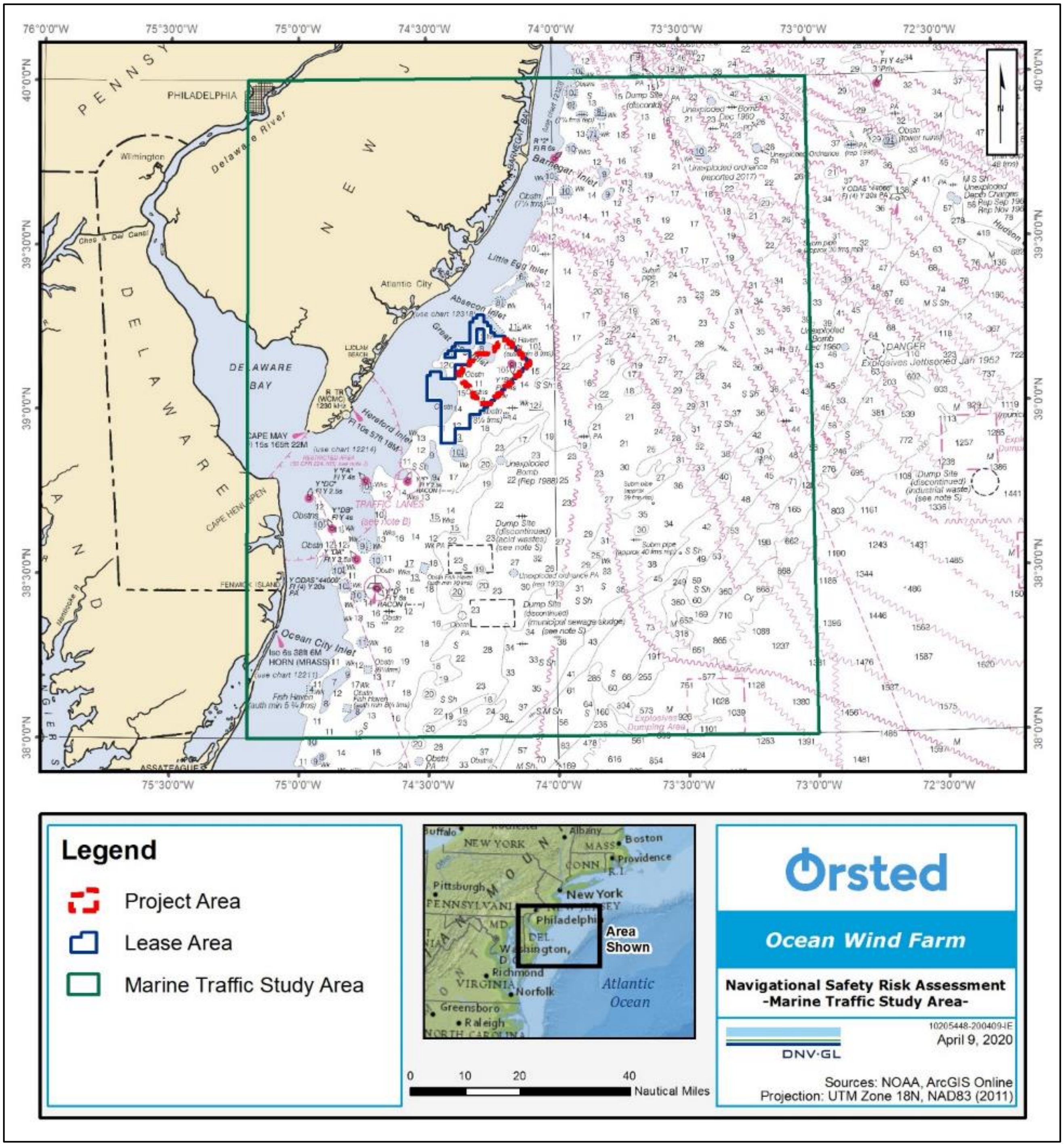


Figure ES-1 Project location and NSRA Marine Traffic Study Area

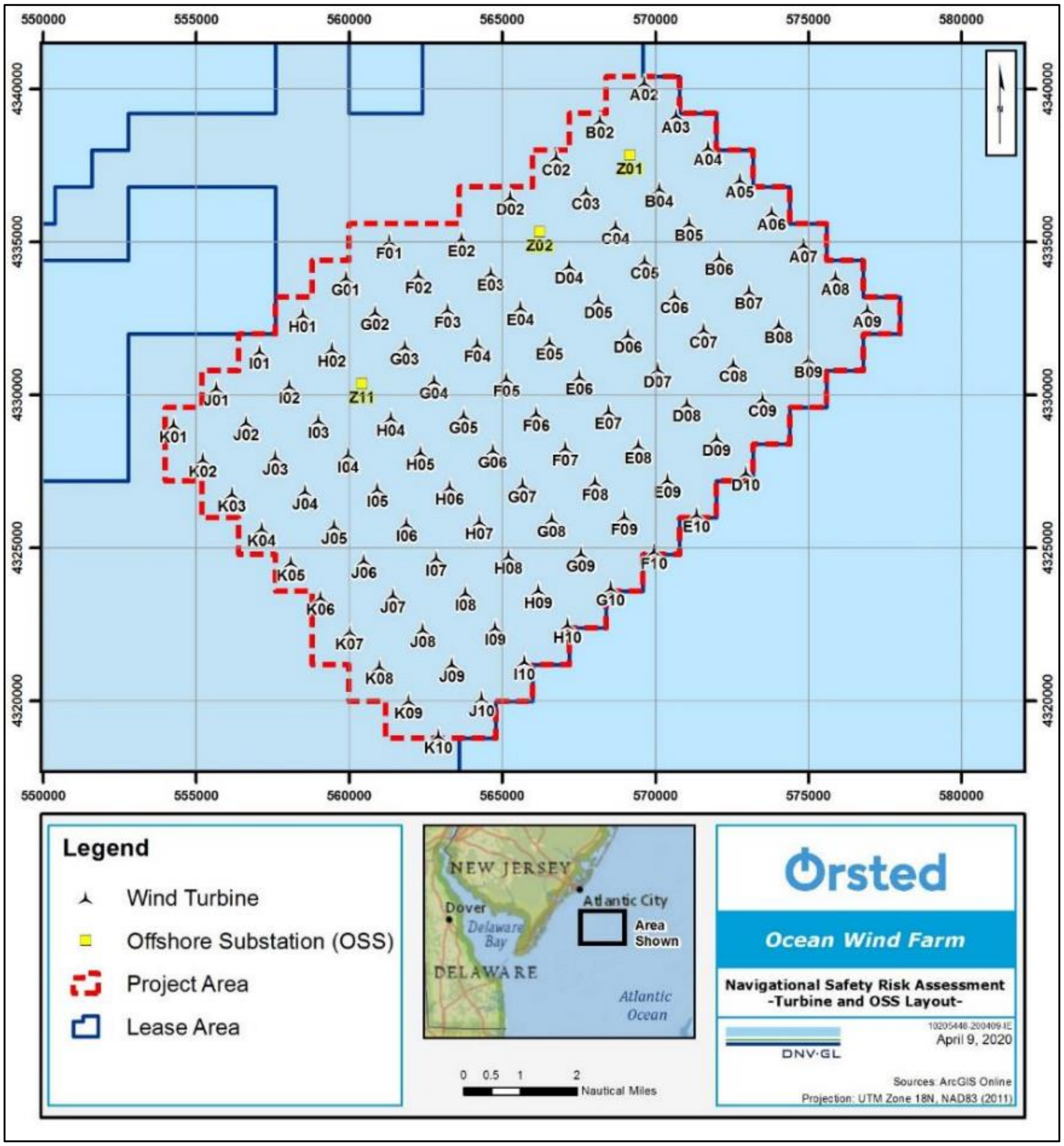


Figure ES-2 Indicative layout used for risk modeling

Marine risk modeling was used to estimate the increase in the number of accidents that could occur as a result of the Project. This study attempts to balance the need to accurately estimate risk with the uncertainty accompanying the data and assumptions and assure that any error is on the side of overestimating the risk.

The marine accidents of primary concern to the quantified risk assessment are:

- Allision of a turbine by a vessel (sometimes called striking or impact)
- Collision between two vessels
- Grounding of a vessel

Generally, most maritime accidents are minor. Similarly, most of the accidents predicted by the modeling are expected to be minor in nature.

One year of AIS data was the primary marine traffic input into the model. Additional vessel transits were added to account for both current and future traffic not represented in AIS (hereafter "non-AIS"). Commercial fishing is one such vessel type that is important in the Study Area. The number of non-AIS commercial fishing transits was estimated by scaling port departures of AIS-carrying commercial fishing vessels per the ratio of registered commercial fishing vessels not required to carry AIS (shorter than 65 ft) to those required to carry AIS (65 ft in length or longer). New pleasure vessel transits to the wind farm were included in the model as well, 1825 trips each way (10 trips per day for six months of the year).

The quantified assessment of the navigation risk for the Project concludes that the risk increase due to the Project lies within the Project Area and between the Project Area and the coast. The increase in risk in the Project Area is due to the potential for a vessel to strike a Project structure (allision risk). The modeled increase in risk along the coast is due to:

1. The assumption that an additional 10 pleasure vessels per day for six months out of the year would transit along the coast for recreational purposes (66 percent of the increase).
2. Re-routing tug and cargo vessels around the Project Area and the adjacent lease area to the north (28 percent and 5 percent of the increase, respectively).

In this assessment, the modeled risk increase is 0.40 accidents per year, 72 percent of which are groundings, primarily of pleasure vessels. This is a best conservative maximum estimate of the additional risk that could result from the presence of the Project, assuming all non-AIS commercial fishing vessel transit to or through the Project Area. The Project poses very little risk in the remainder of the Marine Traffic Study Area. If the number of additional pleasure vessel transits were half of the estimate, the risk would reduce significantly.

The risk model assumes that tugs are not towing. A sensitivity model was run to quantify the effect of this assumption. The sensitivity model shows that if half of the tugs are assumed to be towing[1], the risk from the Project would increase by 5 percent, to 0.42 accidents per year. Thus, the modeled risk in this area is not substantially affected by the configuration of the tows as long as tows intend to route around the Project.

Additional risk mitigation measures whose benefits were not quantified in the model may be employed by the Project, including use of best available Automatic Identification System (AIS) technology within the wind farm. The Project will comply with Coast Guard requirements for lighting, sound signals, and marking of structures, as applicable and as determined in consultation with the Coast Guard (Orsted, 2021).

[1] Tug-with-tows are modeled as ships with length 0.5 NM (3,038 ft) and breadth assumed to be equal to a swept path of 0.25 NM (1,519 ft). The length and swept path are based on information from American Waterways Operators (AWO) (Coast Guard, 2016 and Orsted, 2020).

1 INTRODUCTION AND PROJECT DESCRIPTION

DNV GL Energy USA, Inc. (DNV GL) conducted this independent Navigation Safety Risk Assessment (NSRA) of the proposed Ocean Wind Farm (the Project). The Project's offshore structures will be located within the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf OCS-A 0498 Lease Area (Lease Area).

This NSRA was conducted in line with the guidance provided in U.S. Coast Guard (Coast Guard) *Navigation and Vessel Inspection Circular No. 01-19* (NVIC 01-19) (Coast Guard, 2019a). This report, prepared by DNV GL, presents the results of the risk assessment and is intended to serve as an appendix to the Project's Construction and Operations Plan (COP).

1.1 Objective

The objective of the assessment is to address items in NVIC 01-19 that are pertinent to the Project.

The wind turbine generator (WTG) size and layout have yet to be finalized, and several alternatives are being considered for the Project. To facilitate comprehensive and resilient analyses of the Project, this NSRA is based on a maximum risk design for each analysis herein, such that the accuracy of the analyses will not be affected by potential changes to the layout that are within the envelope described in Section 1.2. The maximum risk parameters are within the Project Design Envelope (PDE). The primary goal of applying a PDE is to allow jurisdictional agencies to make meaningful assessments of the proposed Project elements and activities while also providing the Project reasonable flexibility to make prudent development and design decisions prior to construction.

1.2 Project components

The Project will include up to 98 WTGs and up to three offshore substations (OSS). The WTGs will have monopile foundations. A decision on the final OSS foundation type is pending at the time of this NSRA and thus, the NSRA evaluates both jacket and monopile foundations for the OSS.

Array cables will be laid connecting the WTGs to the OSS. Submarine export cables will convey power from the OSS to shore. There are two scenarios for the export cables:

1. Two cables to Oyster Creek (62 NM, 114 km each) and one cable to BL England (27 NM, 50 km each)
2. Two cables to Oyster Creek (62 NM, 114 km each) and 5 cables to Higbee (27 NM, 50 km each)

Table 1-1 shows the dimensions of the Project's offshore components that define the maximum risk envelope for purposes of the NSRA.

Table 1-1 Project parameters defining the NSRA maximum risk envelope (Orsted, 2021)

<table>
<tr><th>WTG-related Parameters</th><th colspan="2">Values Evaluated in this NSRA</th></tr>
<tr><td>WTG structure locations evaluated in this NSRA</td><td colspan="2">99*</td></tr>
<tr><td>Maximum foundation diameter at sea level</td><td colspan="2">33 ft
10 m</td></tr>
<tr><td>Minimum air gap from Mean Higher High Water (MHHW)</td><td colspan="2">20 m
66 ft</td></tr>
<tr><td>Maximum hub height from Mean Lower Low Water (MLLW)</td><td colspan="2">156 m
512 ft</td></tr>
<tr><td>Maximum blade tip height from MLLW</td><td colspan="2">276 m
906 ft</td></tr>
<tr><th>OSS Components</th><th colspan="2">Values Evaluated in this NSRA</th></tr>
<tr><td>Maximum number of OSS</td><td colspan="2">3</td></tr>
<tr><td>Maximum monopile foundation diameter at sea level</td><td colspan="2">33 ft
10 m</td></tr>
<tr><td>Maximum jacket foundation dimensions (four-legged design)</td><td>Diameter of each leg
15 ft
4.6 m

Distance between legs
(at sea level)
230 ft
70 m</td><td>Total sea-level dimensions

260 ft x 260 ft
79 m x 79 m</td></tr>
<tr><td>Minimum air gap from MHHW</td><td colspan="2">127 ft
39 m</td></tr>
</table>

* This analysis was conducted for up to 99 turbines. The PDE was subsequently reduced to 98 turbines.

The study assessed maximum risk Project characteristics relevant to each evaluated hazard. For example:

- For risk evaluation, the Project was modeled as having 102 offshore structures, consisting of 99 potential WTG positions and 3 OSS positions. However, 98 WTGs and 3 OSS are planned to be constructed. This approach accounts for the largest possible number of structural hazards and the maximum spatial extent of those hazards.
- For Project structure impact analysis, the weakest structure was emphasized in the analysis.
- For visual navigation, the foundation type that provides the largest visual blockage was evaluated.
- For sailing vessel clearance, the foundation type with the smallest air gap was analyzed.

1.3 Site location and installation coordinates

The current Lease Area for Ocean Wind Farm (Lease OCS-A-0498) is shown in Figure 1-1 (blue solid outline). In this NSRA, the Project Area is defined as the largest practical footprint of the Project's offshore structures (red dashed outline).

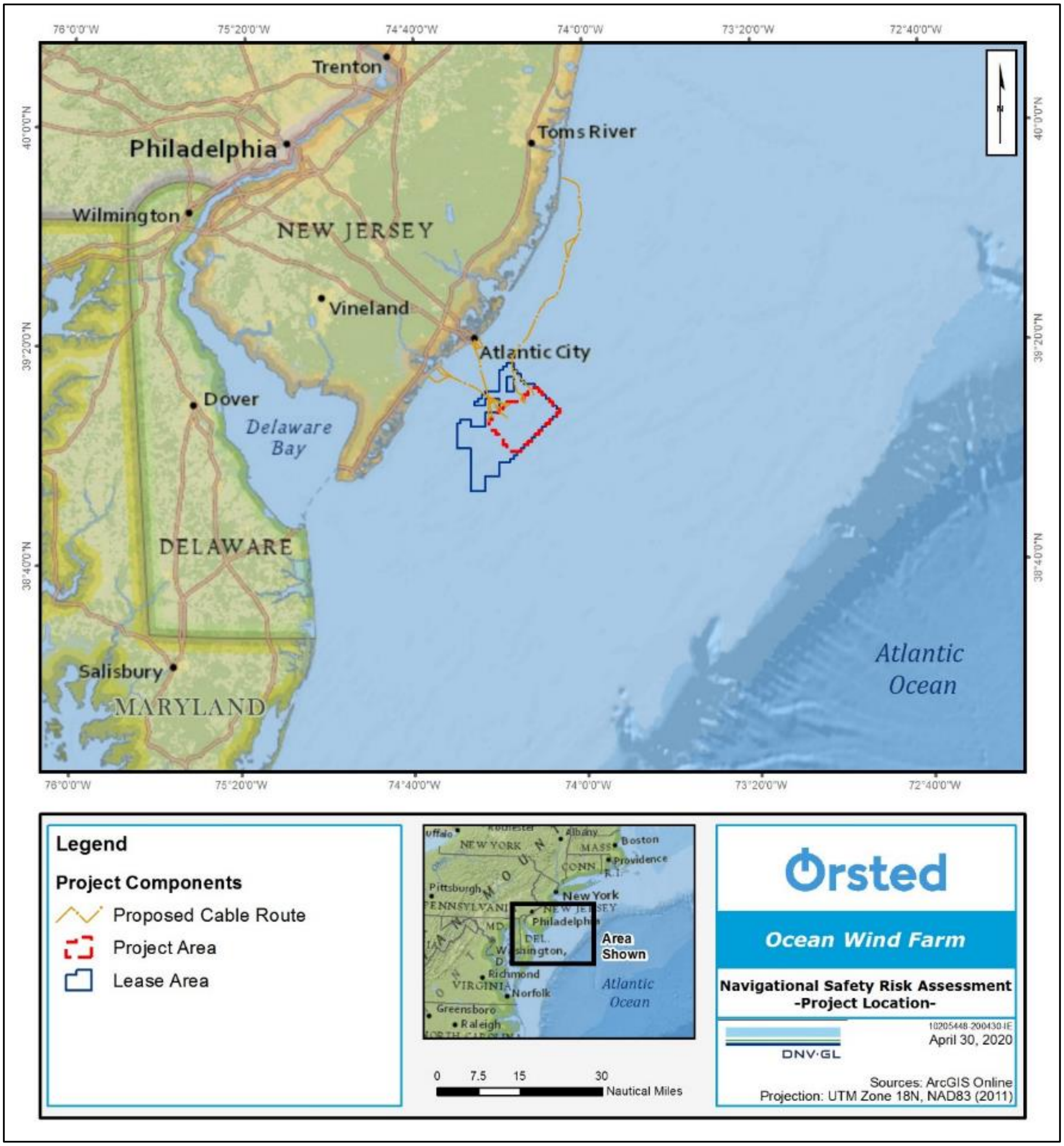


Figure 1-1 Project Location

Figure 1-2 shows the layout of offshore structures evaluated in this NSRA. Appendix G contains the coordinates of the evaluated Project structure locations. The distance between offshore structures evaluated in this assessment is 0.8 NM x 1.0 NM (Orsted, 2021).

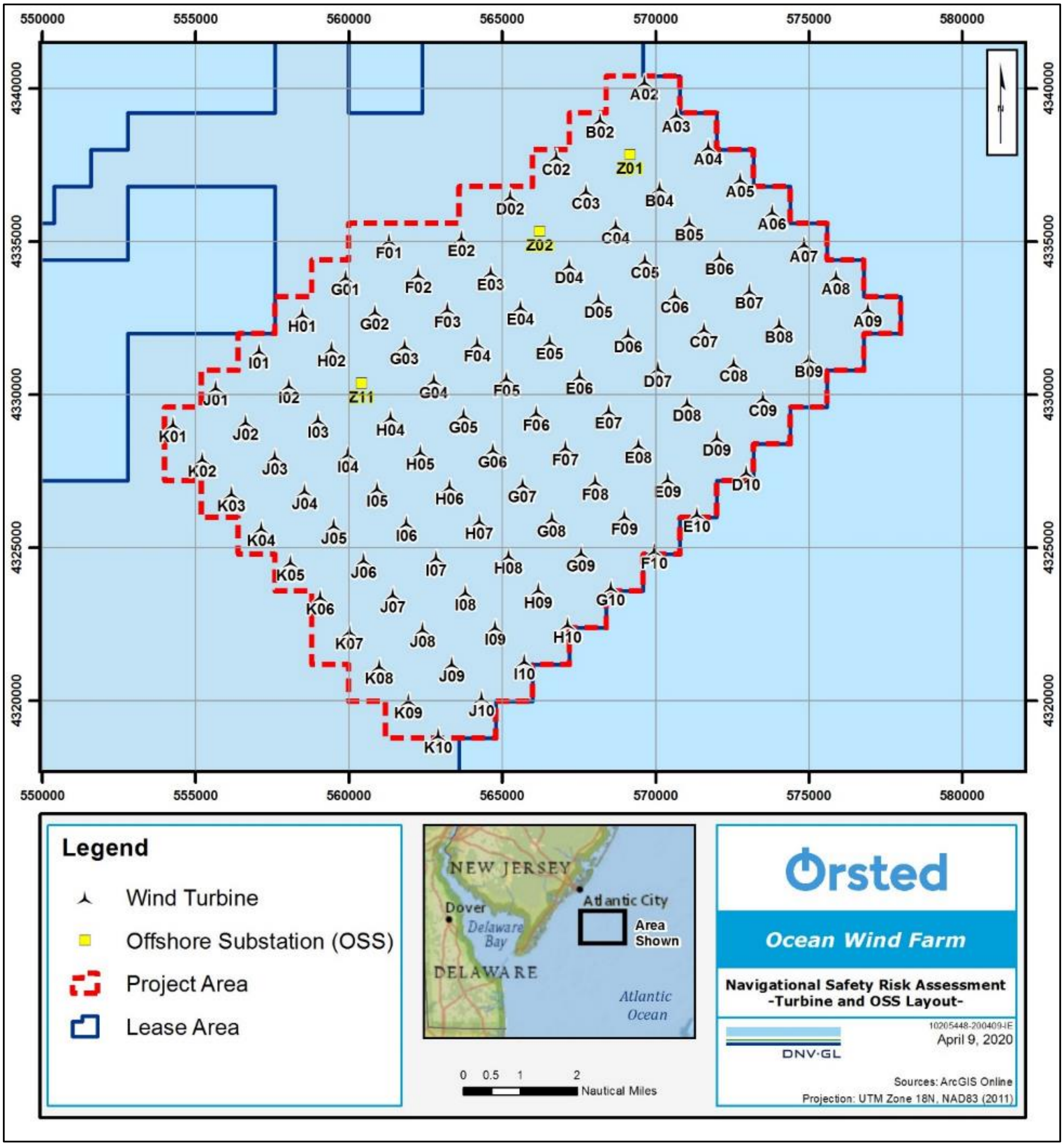


Figure 1-2 Indicative layout used for risk modeling

2 TRAFFIC SURVEY

This section describes marine traffic in the Marine Traffic Study Area. The following main data sources were used to identify traffic patterns:

- Automatic Identification System (AIS) data for one year, 1 March 2019 to 29 February 2020 (MarineTraffic, 2020).
- The Mid-Atlantic Ocean Data Portal, which is used for ocean planning throughout the northeastern United States (U.S.) and provides a source of local information (MARCO, 2020). Specific information used in this analysis from the Data Portal was:
  - Commercial fishing transits inferred from Vessel Monitoring System (VMS) data, which were provided to the portal by National Marine Fisheries Service (NMFS). The most recent data products from NMFS provide processed geospatial statistics through the year 2016.
  - Density maps from Northeast Ocean Data (VMS and recreational survey data).
- The Port Access Route Study report published by the Coast Guard for The Areas off Massachusetts and Rhode Island, referred to as MARI PARS (Coast Guard, 2020).
- Ongoing dialogue with recreational boating, fishing, and towing industry organizations (including the Responsible Offshore Development Alliance [RODA]), pilot organizations, commercial maritime industry, port authorities, and the Coast Guard. See Appendix B and Appendix C for additional details.

The following aspects of local traffic are described in this section:

Section 2.1 Traffic patterns, density, and statistics

Section 2.2 Location of the Project in relation to other uses

Section 2.3 Anticipated changes in traffic from the Project

Section 2.4 Effect of vessel emission requirements on traffic

Section 2.5 Seasonal variations in traffic

Figure 2-1 shows the location of the Project Area and the Marine Traffic Study Area (green solid outline). The Marine Traffic Study Area is inclusive of the Project Area, the remainder of the Lease Area, and offshore waters for more than 40 NM (74 km) in any direction.

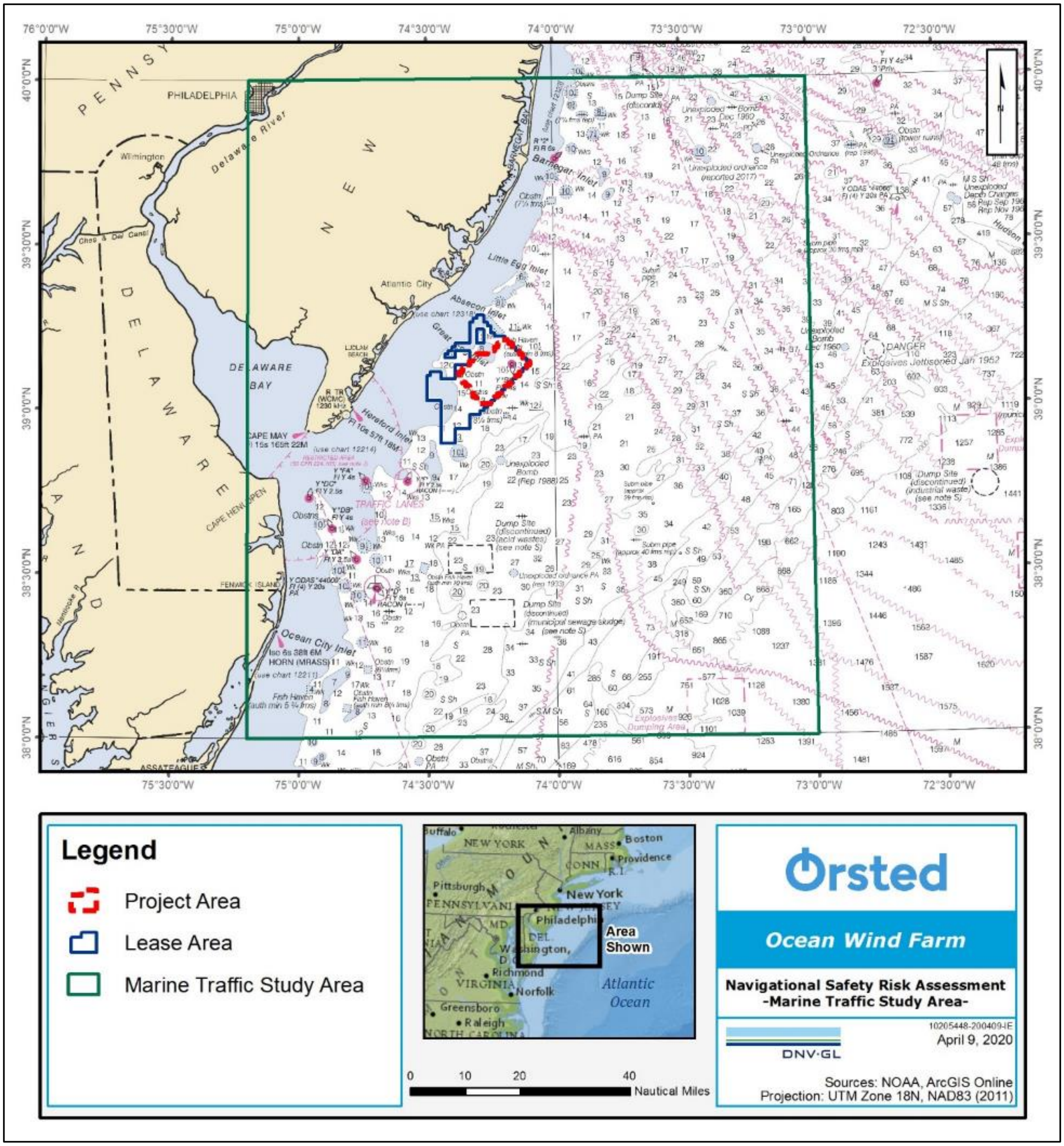


Figure 2-1 Marine Traffic Study Area

Figure 2-2 shows the navigation chart in the vicinity of the Project.

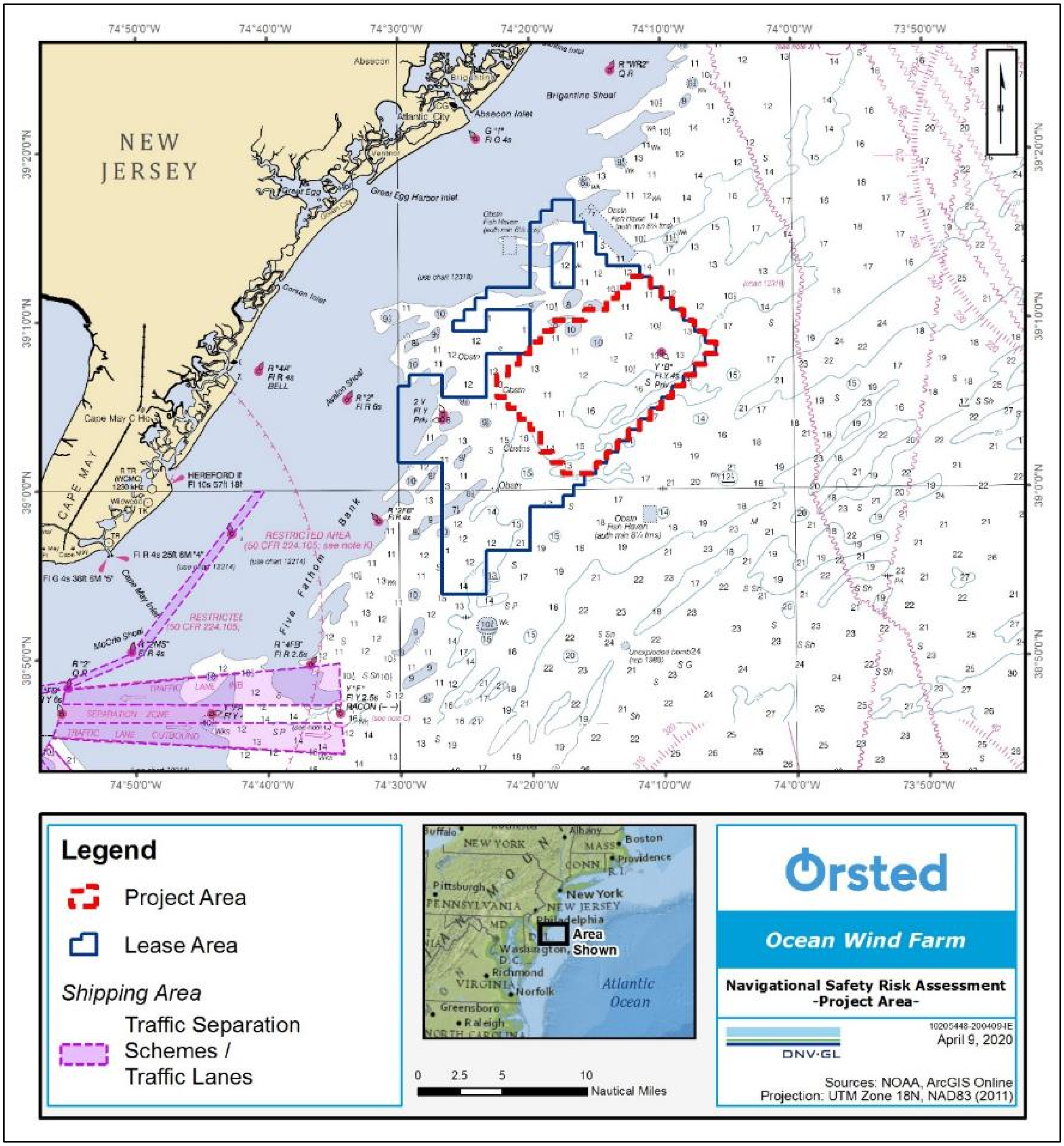


Figure 2-2 Navigation Chart

2.1 Traffic patterns, density, and statistics

Traffic patterns, traffic density, and statistics were developed from one year of AIS data for the period 1 March 2019 through 29 February 2020. The data were spatially analyzed based on timestamp and proximity to create vessel tracks. Each vessel track represents a transit of a single vessel. For each vessel type, AIS tracks, density, and speed are provided in Appendix A.

AIS carriage requirements

Most of this section focuses on traffic as presented in the AIS data. All self-propelled vessels of more than 1,600 gross tons are required to carry AIS, with certain exceptions made for foreign vessels (Coast Guard, 2019b). As a result, the dataset provides a comprehensive view of the vessels and their routes for all of the vessel categories except fishing and pleasure/recreation. Many fishing and pleasure/recreation vessels are exempt from AIS carriage requirements. Fishing and pleasure/recreation vessel density and available statistics are discussed in Section 2.2.

Not all vessels are required to carry AIS. In particular, foreign vessels not destined for or departing from a location under U.S. jurisdiction, and some self-propelled vessels less than 1,600 gross tons are not required to carry AIS under U.S. law. However, international law (IMO, 1974), which applies to all vessels in international trade, requires an AIS Class A device on:

- A vessel of 300 gross tonnage or more, on an international voyage.
- A vessel of 150 gross tonnage or more, when carrying more than 12 passengers on an international voyage.

Under U.S. regulations (33 CFR 164.46), Section (b)(1), “the following vessels must have on board a properly installed, operational Coast Guard type-approved AIS Class A device:

(i) A self-propelled vessel of 65 feet or more in length, engaged in commercial service.

(ii) A towing vessel of 26 feet or more in length and more than 600 horsepower, engaged in commercial service.

(iii) A self-propelled vessel that is certificated to carry more than 150 passengers.

(iv) A self-propelled vessel engaged in dredging operations in or near a commercial channel or shipping fairway in a manner likely to restrict or affect navigation of other vessels.

(v) A self-propelled vessel engaged in the movement of: certain dangerous cargo as defined in subpart C of part 160 of this chapter, or flammable or combustible liquid cargo in bulk that is listed in 46 CFR 30.25-1, Table 30.25-1.

Use of a Coast Guard type-approved AIS Class B device in lieu of an AIS Class A device is *permissible* on the following vessels if they are not subject to pilotage by other than the vessel Master or crew:

(i) Fishing industry vessels;

(ii) Vessels identified in paragraph (b)(1)(i) of this section that are certificated to carry less than 150 passengers and that: do not operate in a Vessel Traffic Service or Vessel Movement Reporting System area defined in Table 161.12(c) of § 161.12 of this chapter; and do not operate at speeds in excess of 14 knots; and

(iii) Vessels identified in paragraph (b)(1)(iv) of this section engaged in dredging operations."

The relevant captain of the port may also determine that the voluntary installation of AIS by a vessel would mitigate a safety concern due to specific circumstances.

In general, the great majority of vessels in the Marine Traffic Study Area except fishing vessels and pleasure vessels (which include recreational craft) carry AIS class A or class B equipment:

- Deep draft vessels (tankers, large passenger vessels, and most commercial ships on international voyages)
- Commercial self-propelled vessels of 65 ft or more in length, regardless of service
- Self-propelled vessels moving certain dangerous cargoes, flammable or combustible liquids in bulk
- Towing vessels of 27 ft or more in length and more than 600 hp
- Passenger vessels certificated to carry 150 or more passengers

Overview of Vessel Tracks

Figure 2-3 presents the Marine Traffic Study Area defined for this study, and the AIS tracks for vessels transmitting AIS signals from 1 March 2019 through 29 February 2020[2]. Although the Marine Traffic Study Area includes some inland waterways, the discussions below primarily focus on offshore vessel traffic.

[2] AIS data for the period 1 March 2019 through 29 February 2020 (MarineTraffic, 2020)

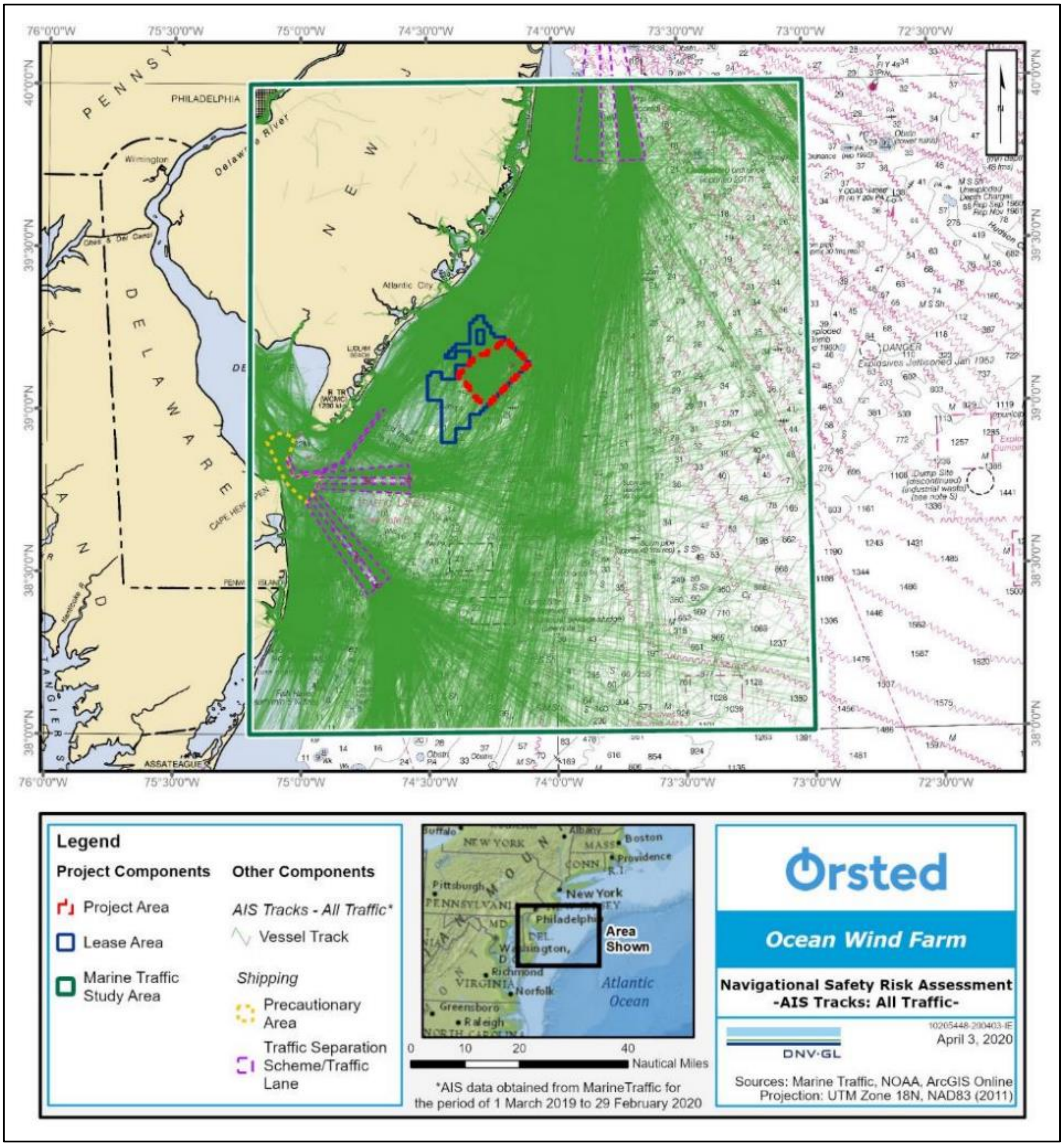


Figure 2-3 AIS tracks in the Marine Traffic Study Area[2]

A closer view in Figure 2-4 shows primary traffic patterns in north-northeast/south-southwest and northwest/southeast directions within the Project Area. The parallel tracks within the Project Area are likely Project-related vessels.

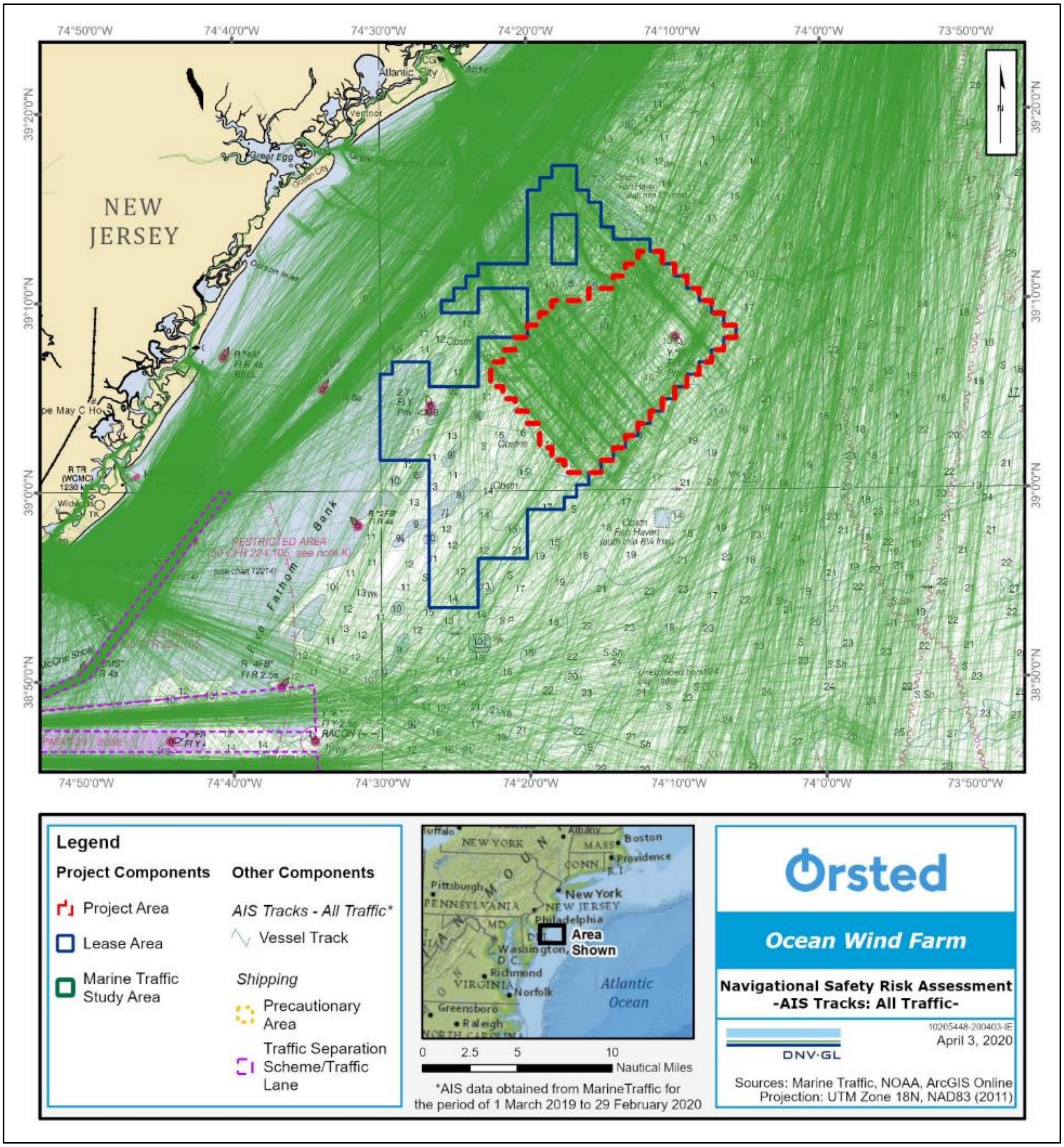


Figure 2-4 AIS tracks in the vicinity of the Project Area[2]

The distribution of AIS-based tracks among the vessel types in the Marine Traffic Study Area is shown in Figure 2-5. Less than 1 percent of the tracks are from tugs self-identified as "Pusher tug."

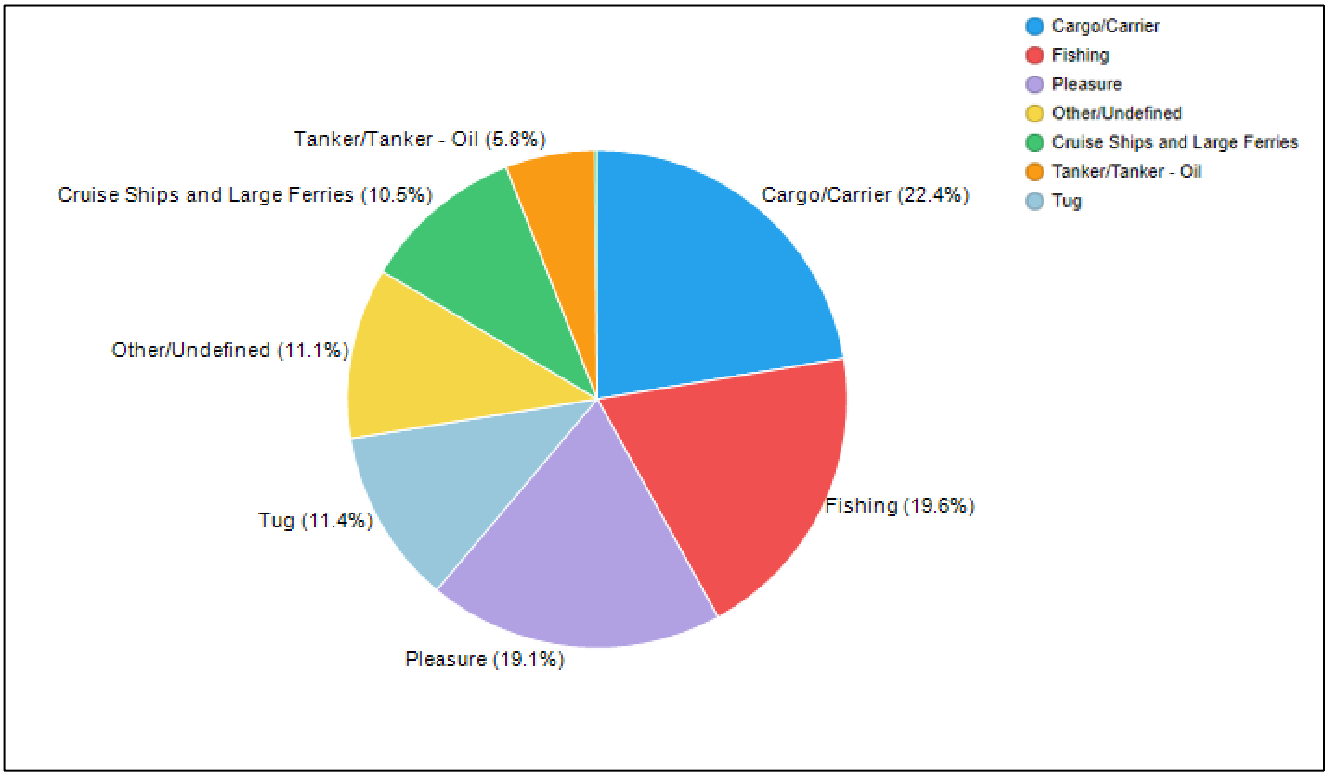


Figure 2-5 Distribution of vessel tracks in the Marine Traffic Study Area[2]

2.1.1 Traffic patterns

The subsections below include discussion of the traffic pattern for each of the six vessel types:

- Deep draft vessels
- Fishing vessels
- Cruise ship and large ferries
- Pleasure and recreational vessels
- Tugs
- Other vessels

2.1.1.1 Cargo/carrier and tanker traffic

Deep draft commercial vessels (cargo/carriers and tankers) transit the main shipping routes following the designated Traffic Separation Schemes (TSS) as expected. Most deep draft vessels in the vicinity of the Project Area pass to the east, but a fraction of them pass through the Project Area while transiting between the Ambrose to Barnegat Traffic Lane and the Five Fathom Bank to Cape Henlopen Traffic Lane.

Figure 2-6 presents the tracks for cargo/carriers and tankers (those that carry hydrocarbon cargo and those that carry other cargoes). On a nautical chart, traffic separation zones are illustrated as purple rectangles. Additional views of the traffic as point density plots are available in Appendix A.

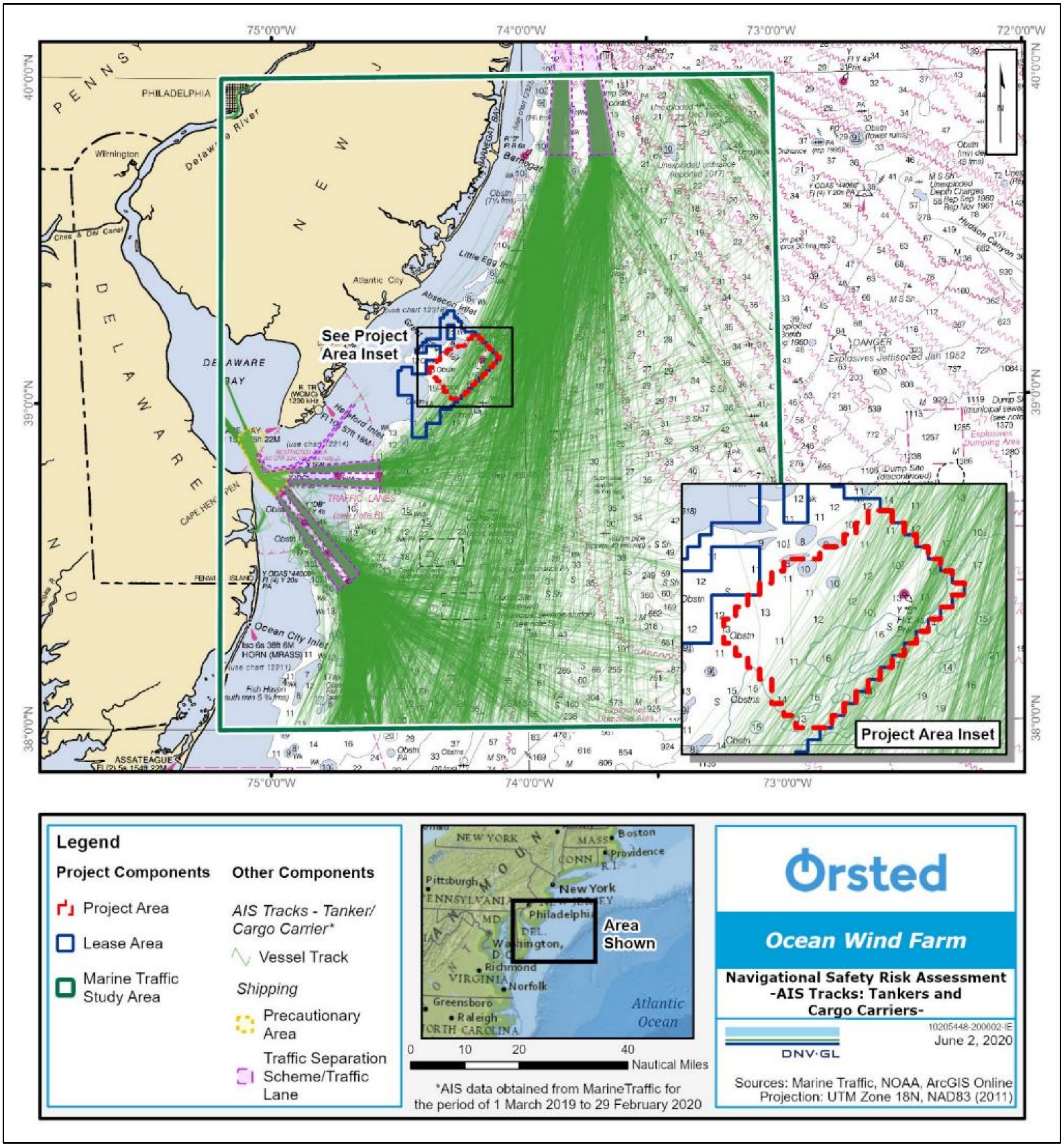


Figure 2-6 AIS tracks for tankers and cargo carriers[2]

2.1.1.2 Commercial fishing vessel traffic

Summary

Figure 2-7 presents the AIS tracks for fishing vessels in the Marine Traffic Study Area and Project Area. The fishing vessel tracks captured in the AIS data show the highest number of tracks adjacent to the coast (north and west of the Project Area). The data also show transits to apparent fishing grounds approximately 22 NM (41 km) southeast of the Project Area.

Commercial fishing vessel tracks in the vicinity of the Project Area show fan-like patterns originating at local ports. For example, tracks passing through the Project Area that originate from Atlantic City are generally oriented northwest-southeast and tracks from Cape May Inlet are generally oriented northeast-southwest.

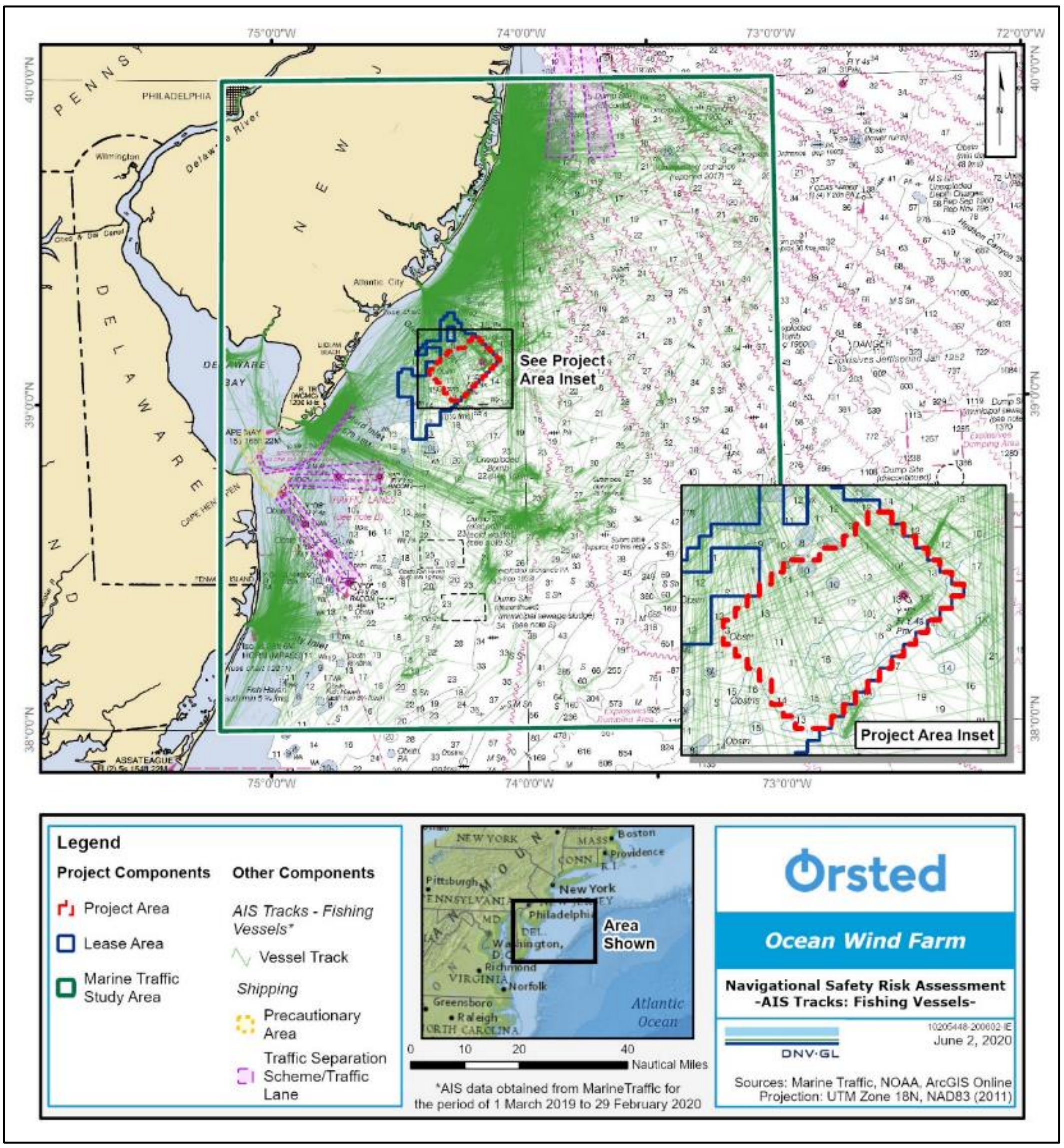


Figure 2-7 AIS tracks for fishing vessels[2]

Commercial fishing vessel activity is generally recognized as not fully captured in AIS data. A significant portion of commercial fishing vessels do not fall under the AIS carriage requirements (see beginning of Section 2.1). A study of AIS-based fishing activity by the Food and Agriculture Organization of the United Nations (Tackonet and Fernandes, 2019) concluded that in the Atlantic waters off the U.S., "…three quarters of the fishing vessels broadcasting AIS use the lower-quality Class B devices, whose reception is poor in most of the area." In line with these findings and similar conclusions in the Coast Guard MARI PARS draft report (2020), this study assumes that fishing vessels are underrepresented in the AIS data obtained for this study. For the purposes of risk modeling, a reasonable maximum number of transits of non-AIS commercial fishing vessels were estimated and added to the base case model, as described below.

Vessel lengths for commercial fishing vessels registered in New Jersey (NOAA, 2020g) showed that 37 percent of the registered commercial fishing vessels have lengths greater than 65 feet and are thus required to use AIS. The potential for vessel traffic in the Project Area from home ports in adjacent states was also evaluated, but these were determined to be insignificant in comparison based on the AIS data at the transects, points along coastal routes, and port entrances as evaluated by DNV GL's risk analysis expert. The total number of transits in AIS is assumed to represent this 37 percent, and the estimated additional non-AIS transits (344) are represented by the remainder required to equal 100 percent.

Key assumptions in the estimate are:

- All of the longer commercial fishing vessels are properly indicated and represented in the AIS dataset on departure from or approach to port, and the shorter vessels are assumed to not be represented in the data at all. Therefore, the New Jersey port entries/exits by vessels indicated as commercial fishing in the AIS dataset and headed toward the Project Area represent all crossings made by 37 percent of the registered commercial fishing vessels. These are the vessels that must carry and turn on AIS and are likely to do so adjacent to the coast.
- The number of transits per year to/through the Project Area taken per fishing vessel longer than 65 feet is, on average, the same as the number of transits per year taken per fishing vessel shorter than 65 feet. Regardless of vessel size, the number of transits per vessel transiting to/through the Project Area is assumed to be the same.
  It is documented that the duration of fishing trips varies and is not always one day, with larger vessels more likely to take multi-day trips than shorter vessels (NJDEP, 2010). However, the fishing vessel traffic of primary concern to this assessment is the traffic near the Project Area. Based on the AIS data shown in Figure 2-7, fishing vessels that transit to fishing grounds further offshore tend to take routes along the coast before heading to deeper waters, bypassing the Project Area rather than transiting through it and were not included in the fishing vessel transit count to/through the Project Area. Surfclams and to a lesser extent, scallops comprise the majority of landings in NJ ports and the majority of landings from the Wind Energy Area that includes the Project (Kirkpatrick, 2017 and NJDEP, 2010), it is reasonable to anticipate that most of the fishing traffic proximate to the Project consists of one-day fishing trips regardless of vessel size.
- This resulted in a reasonable estimate of 344 additional commercial fishing vessel transits from ports to/through the Project Area and 344 return trips.

Commercial fishing vessel density

Fishing vessels generally do not travel within prescribed vessel routes as other commercial vessel types do. The fishing locations chosen by commercial fishing vessels, and hence their routes, are closely guarded. The locations of fish populations change over time, and therefore, the level of fishing activity in a given location varies over time as well. Therefore, fishing activity was qualitatively evaluated in two ways:

- Fishing activity by catch - VMS data were evaluated that indicate which types of fish were caught in the Marine Traffic Study Area
- Fishing activity by year - Combined permit / Vessel Trip Report (VTR) data were evaluated that indicate where specific fishing gear was used in the Marine Traffic Study Area. VMS data are collected by National Oceanic and Atmospheric Administration (NOAA) NMFS via type-approved transmitters that automatically transmit a vessel's position for relay to NMFS. VTR data are collated from vessel reports provided to NOAA's Northeast Fisheries Science Center. VMS data are gathered for a portion of fishery management plan permits, and do not represent all of the transit taken by fishing vessels. In the context of this assessment, the VMS data are used for the purpose of drawing general conclusions concerning the comparative level of fishing in the vicinity of the Project Area.

The Mid-Atlantic Ocean Data Portal (MARCO) was accessed to provide views of commercial fishing activity in the Marine Traffic Study Area for the period 2015 to 2016, the most recent year of available data (MARCO, 2020). The summaries presented below are from VMS data, provided by NMFS. The data are subject to strict confidentiality restrictions, which do not allow for individual vessel tracks or positions to be identified or for the underlying data to be downloaded for uses such as this assessment.

Figure 2-8 to Figure 2-14 show commercial fishing vessel activity available for specific fish species. The scale is based on relative values rather than absolute values. The categories are "Low," "Med-Low," "Med-Hi," "High," and "Very High." Therefore, an area defined as "High" means that the fishing activity in this area is higher than average in the Mid-Atlantic region (approximately Virginia to Maine); the fishing activity is not higher than a specific value.

Fishing activity by catch (VMS data)

This section summarizes fishing activity based on VMS data for:

- Herring
- Monkfish
- Multispecies groundfish
- Pelagics
- Scallops
- Squid
- Surfclam/ocean quahog

The below summaries do not indicate significant commercial fishing occurs in the Project Area, with the possible exception of surfclam.

Figure 2-8 shows herring commercial fishing vessel activity at less than 4 kt. The Project Area had no recorded VMS herring fishing from 2015 to 2016. Very High levels of herring fishing vessel activity occurred around the Cape May Harbor, approximately 18 NM southwest of the Project Area.

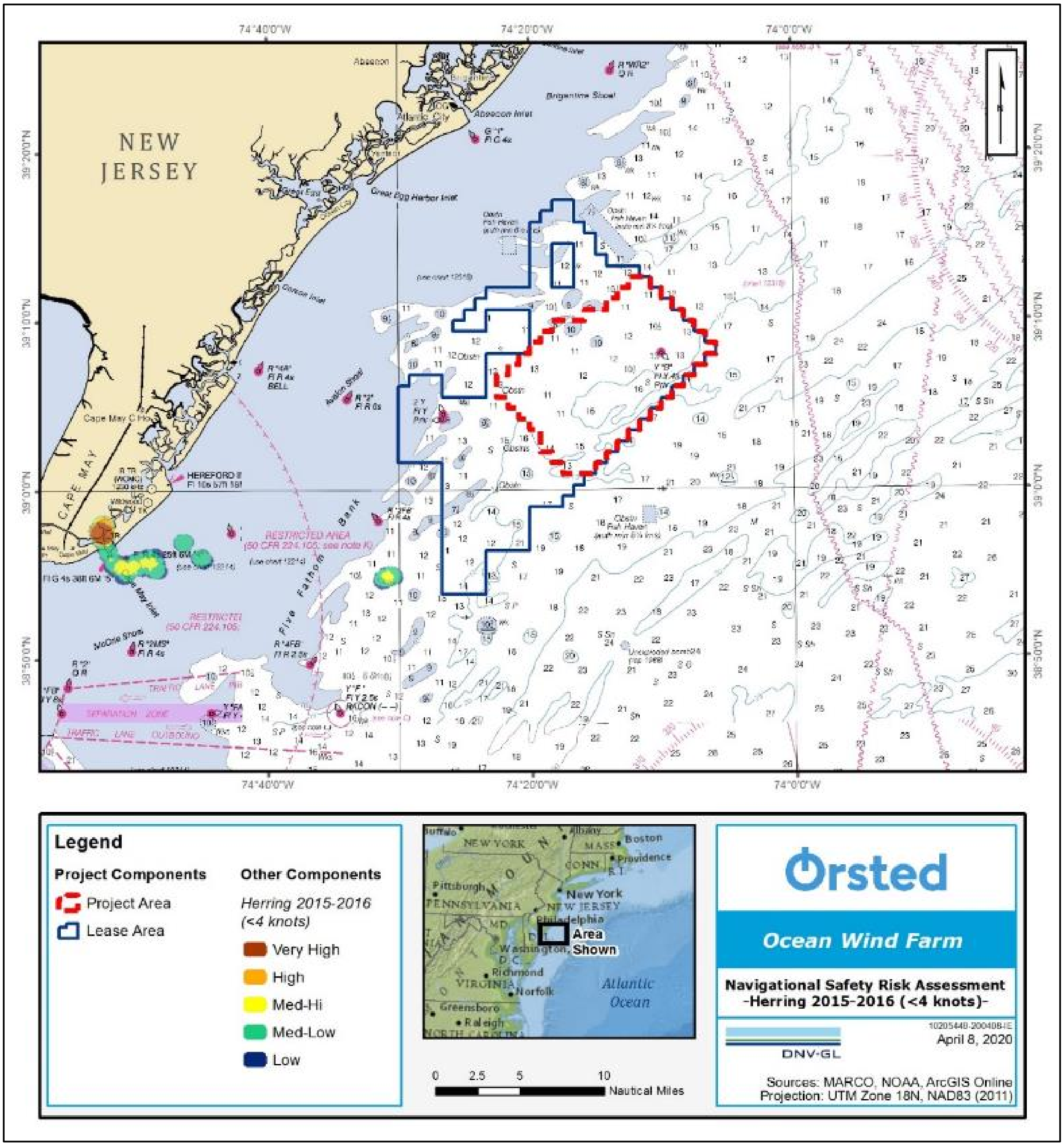


Figure 2-8 Commercial fishing vessel density map herring fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-9 presents monkfish commercial fishing vessel activity at less than 4 kt. The Project Area had no recorded monkfish fishing activity during 2015-2016. Very high levels of monkfish fishing vessel activity occurred in Cape May Harbor, approximately 18 NM southwest of the Project Area.

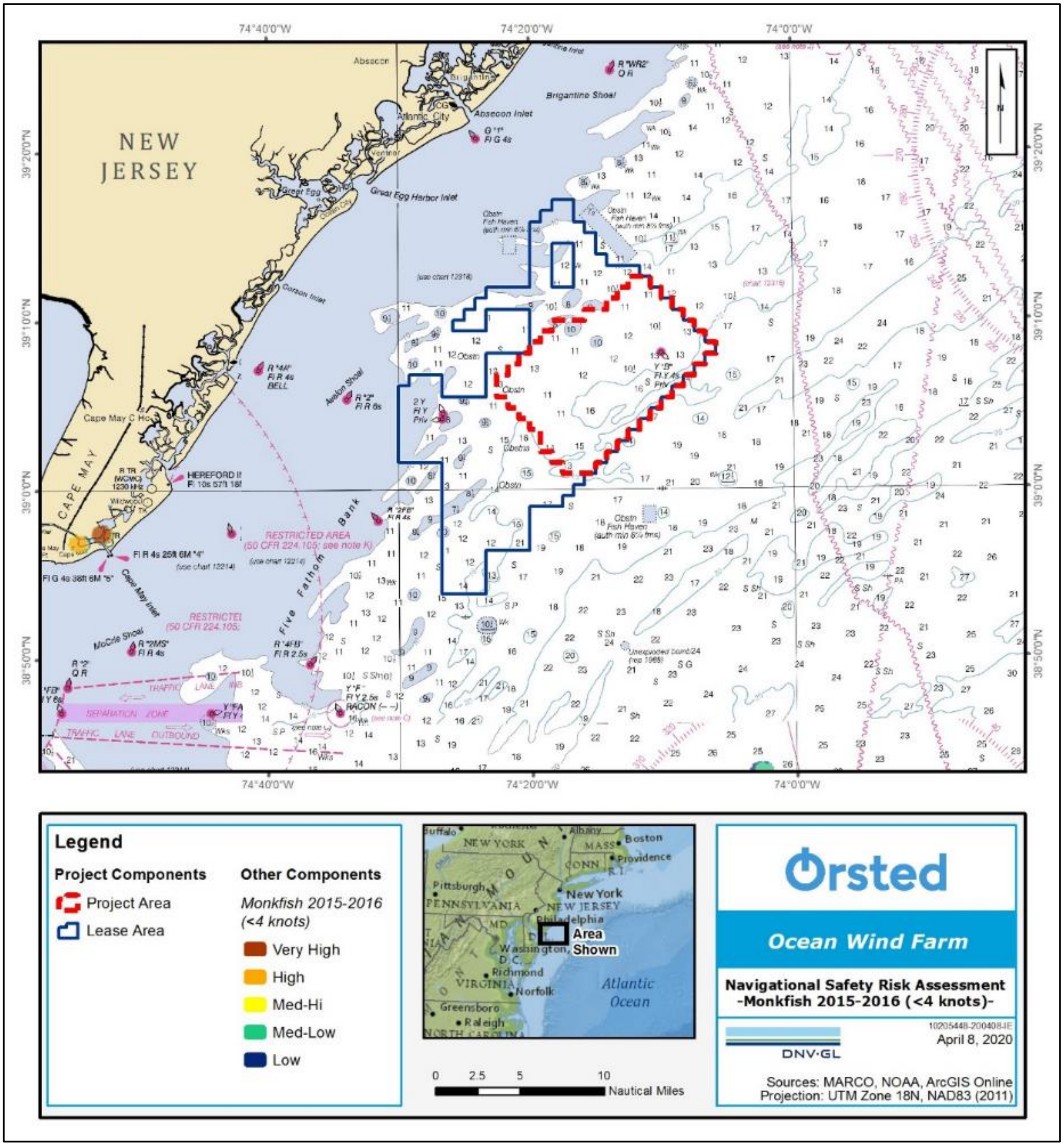


Figure 2-9 Commercial fishing vessel density map monkfish fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-10 shows multispecies (groundfish) commercial fishing vessel activity at less than 4 kt. The Project Area had no recorded VMS groundfish fishing from 2015 to 2016. There was one small zone of “Low” to “Med-Low” fishing activity just outside the southern part of the Lease Area, and some zones in the Cape May Harbor.

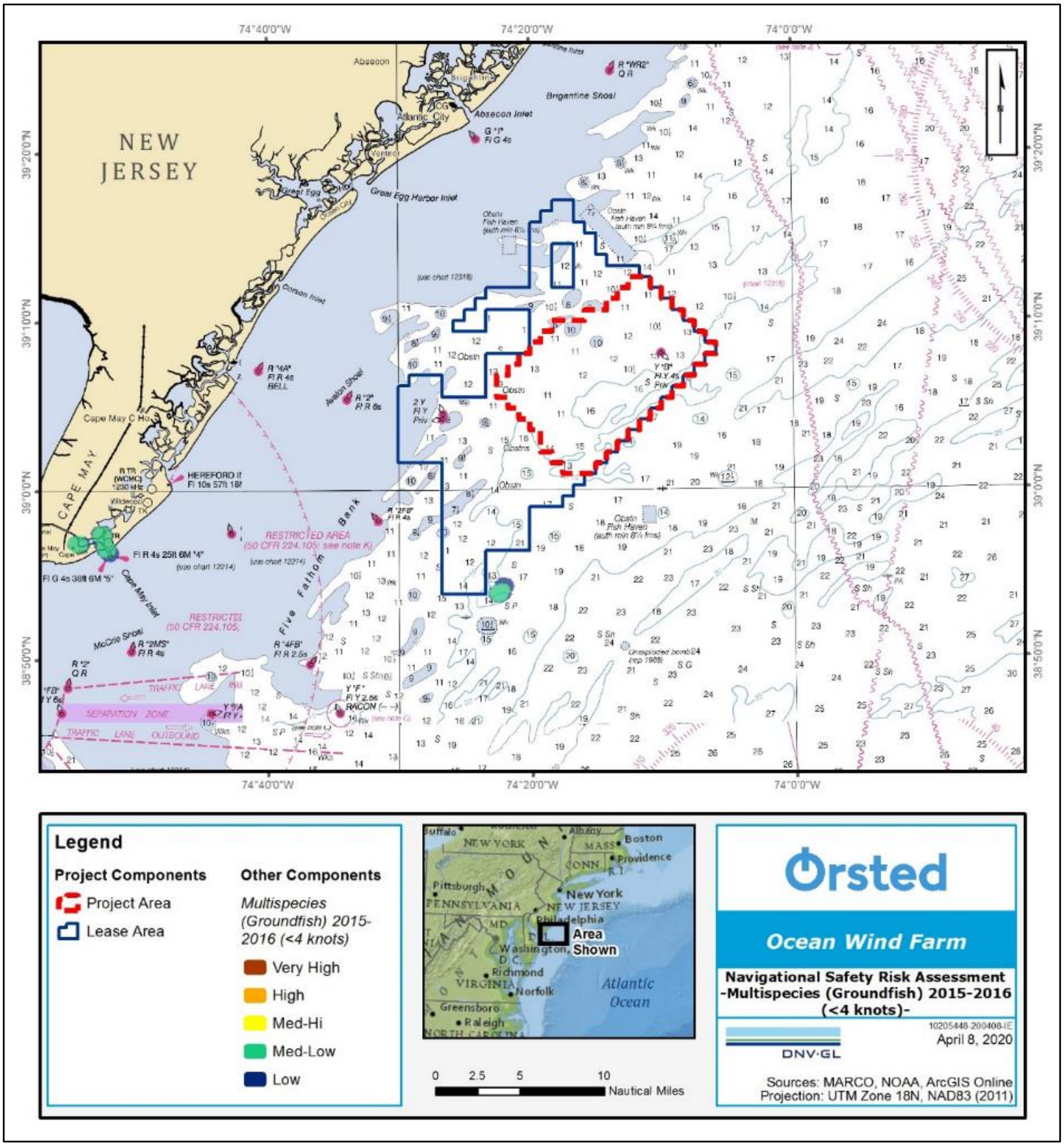


Figure 2-10 Commercial fishing vessel density map multispecies groundfish fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-11 presents pelagics (herring/mackerel/squid) commercial fishing vessel activity at less than 4 kt. The Project Area had no recorded VMS pelagics fishing from 2015 to 2016. The highest level of activity was found in and around Cape May Harbor and Cape May Inlet.

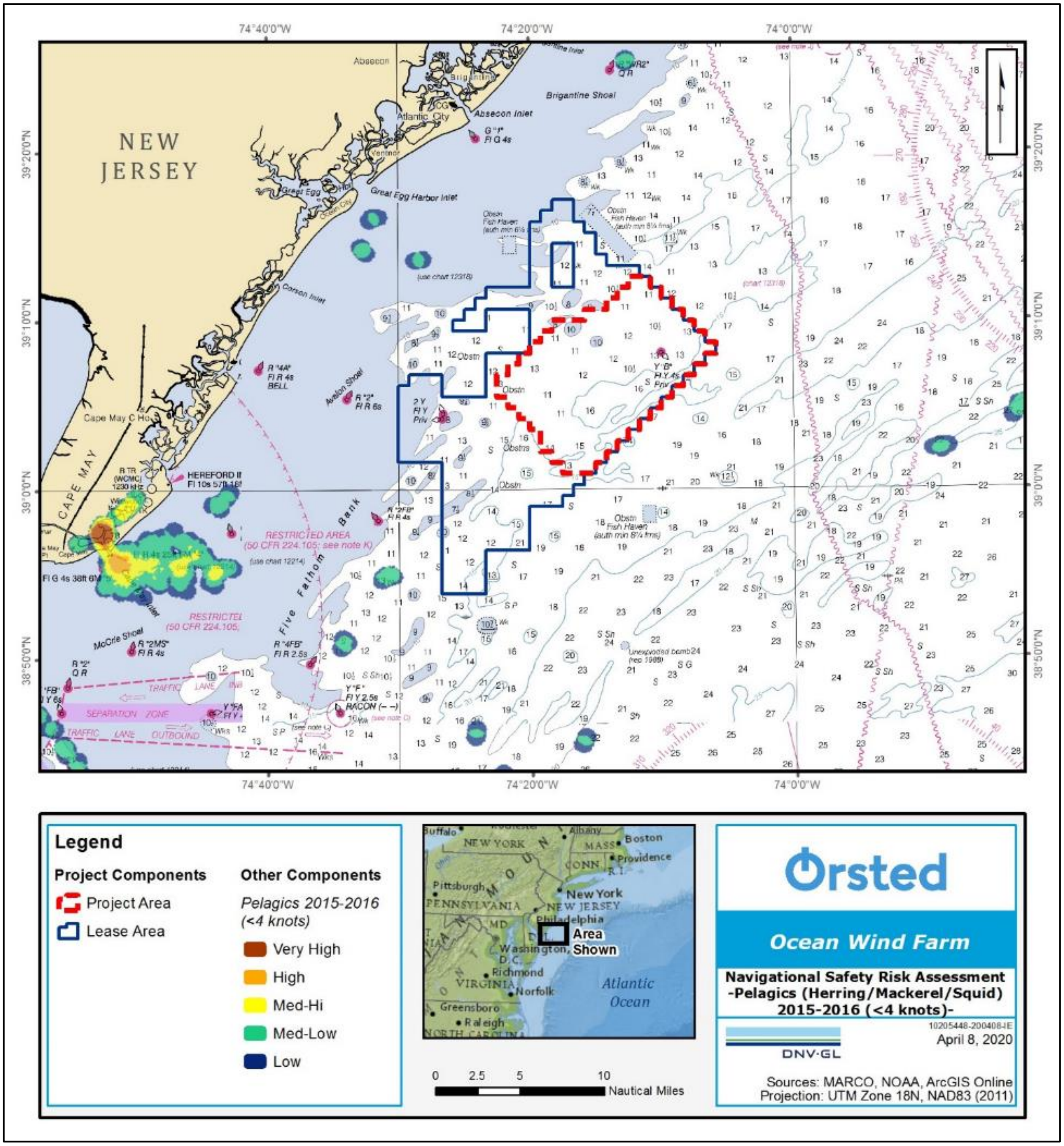


Figure 2-11 Commercial fishing vessel density map pelagics (herring/mackerel/squid) fishing, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-12 shows scallop commercial fishing vessel activity at less than 5 kt. Most of the Project Area had no recorded VMS scallop fishing from 2015 to 2016; however, there was one location that showed a cluster of “Low” to “Med-Low” scallop fishing activity within the Project Area.

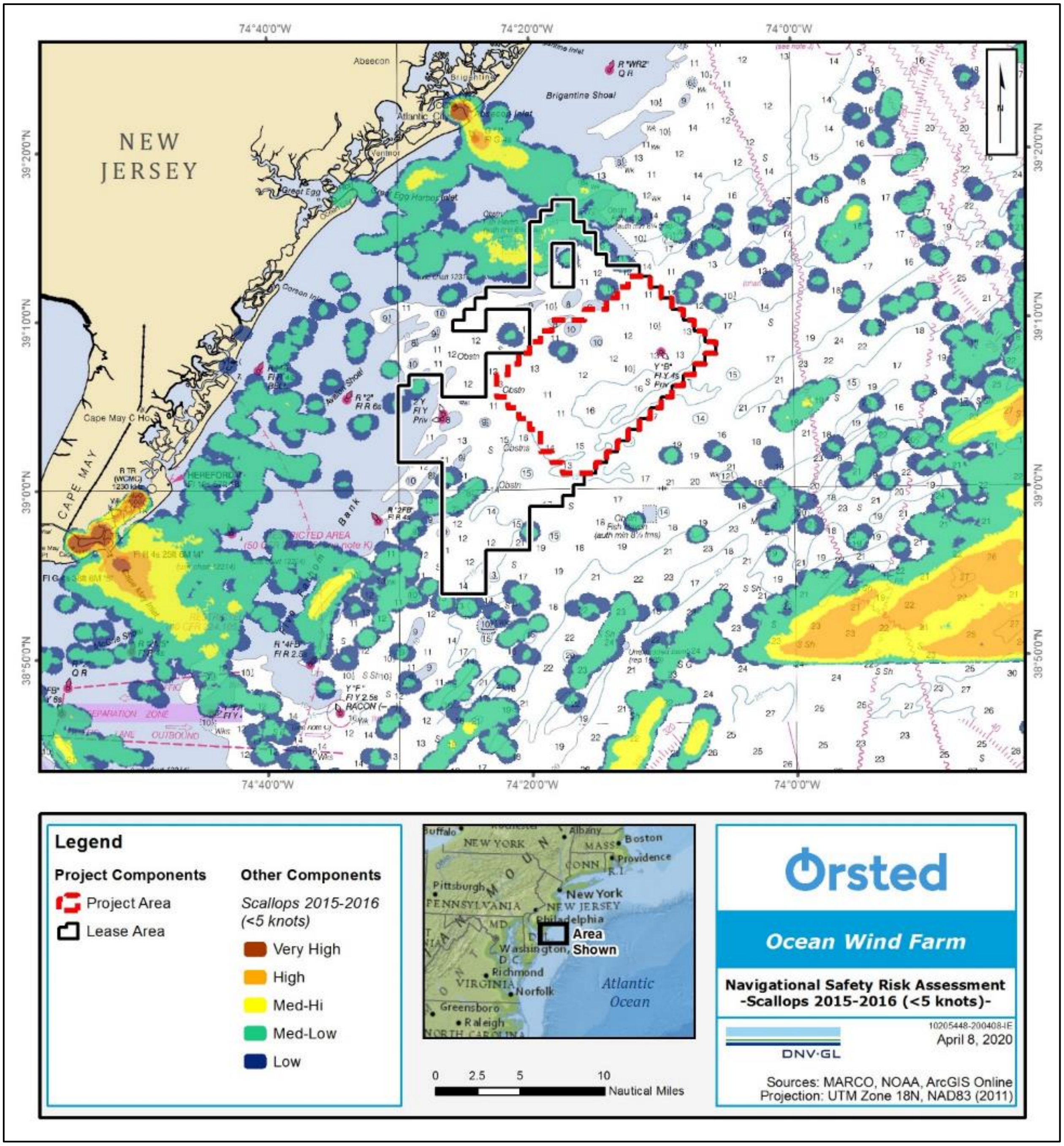


Figure 2-12 Commercial fishing vessel density map scallop fishing at less than 5 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-13 presents squid commercial fishing vessel activity at less than 4 kt. The Project Area had no recorded VMS squid fishing from 2015 to 2016. Similar to pelagics, squid activity was mostly found in and around Cape May Harbor and Cape May Inlet.

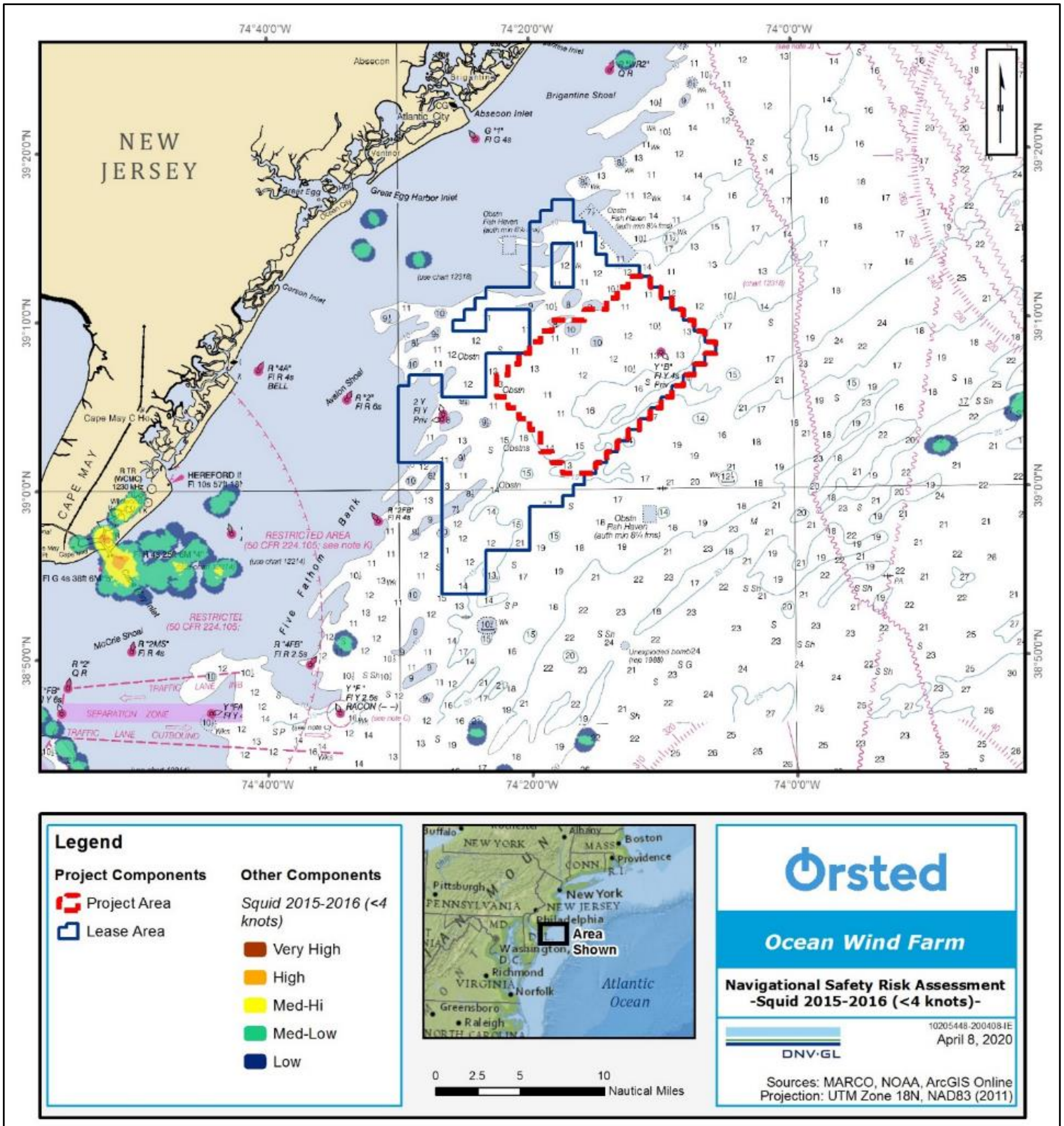


Figure 2-13 Commercial fishing vessel density map squid fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-14 shows surfclam/ocean quahog commercial fishing vessel activity at less than 4 kt. The majority of the Project Area did not have any recorded surfclam/ocean quahog activity from 2015 to 2016, though there was one large pocket along the southeastern edge of the Lease Area with "Low" to "High" activity.

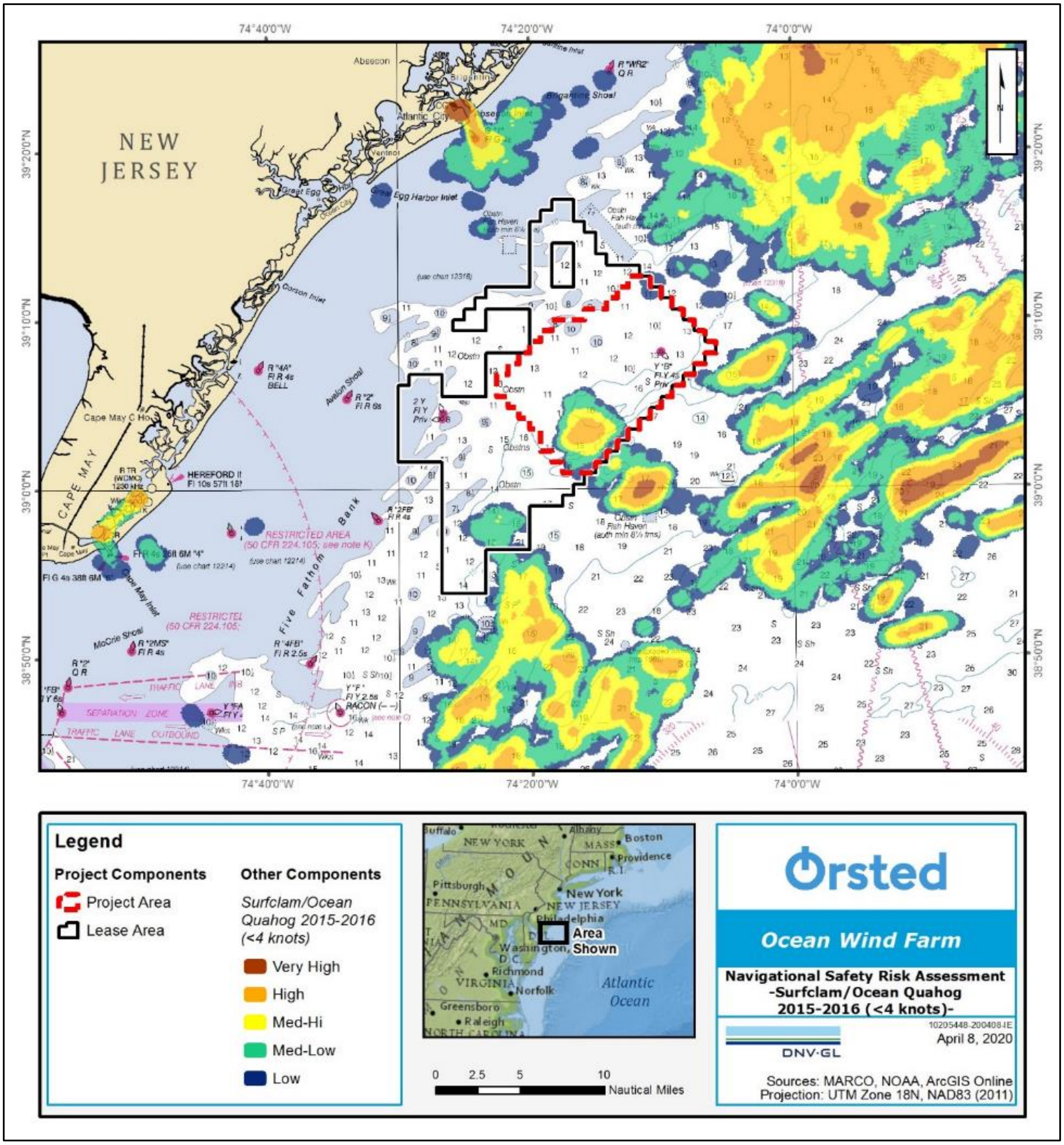


Figure 2-14 Commercial fishing vessel density map surfclam/ocean quahog fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Fishing activity by gear (VTR data)

The major commercial fishing ports closest to the Project Area are located at Cape May, Wildwood, Sea Isle City, and Atlantic City.

The most recent available data were obtained for fishing gear use in the Marine Traffic Study Area. The data represent the period 2011-2015 and are provided by Communities at Sea (MARCO, 2020). Figure 2-15 to Figure 2-20 show activity level by fishing gear type, in order of relative use in the Project Area. These data show some pots and traps and dredge activity in the Project Area, and negligible levels of gillnet, bottom trawling, and longline activity.

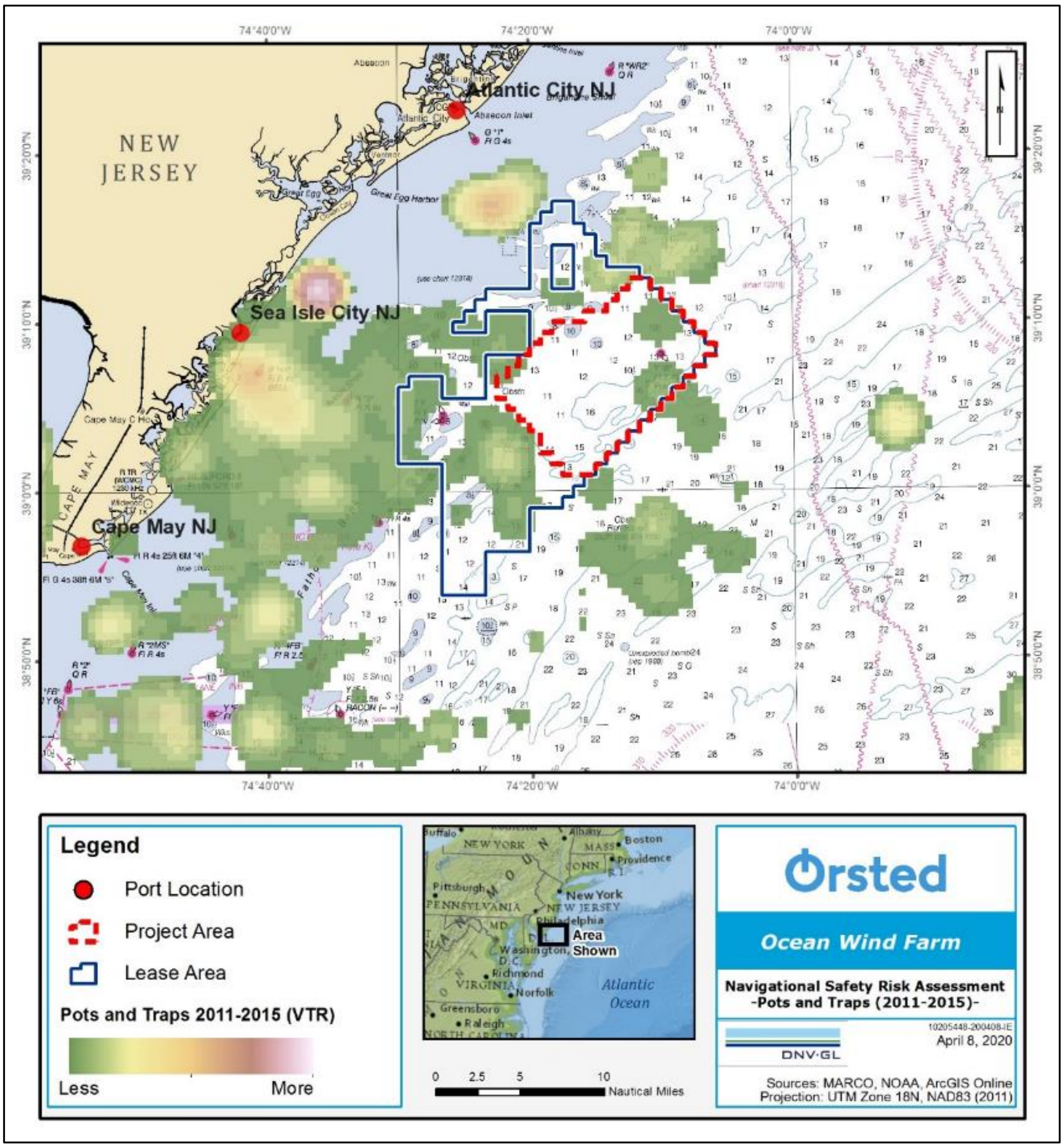


Figure 2-15 Total pots and traps activity for 2011-2015 (MARCO, 2020)

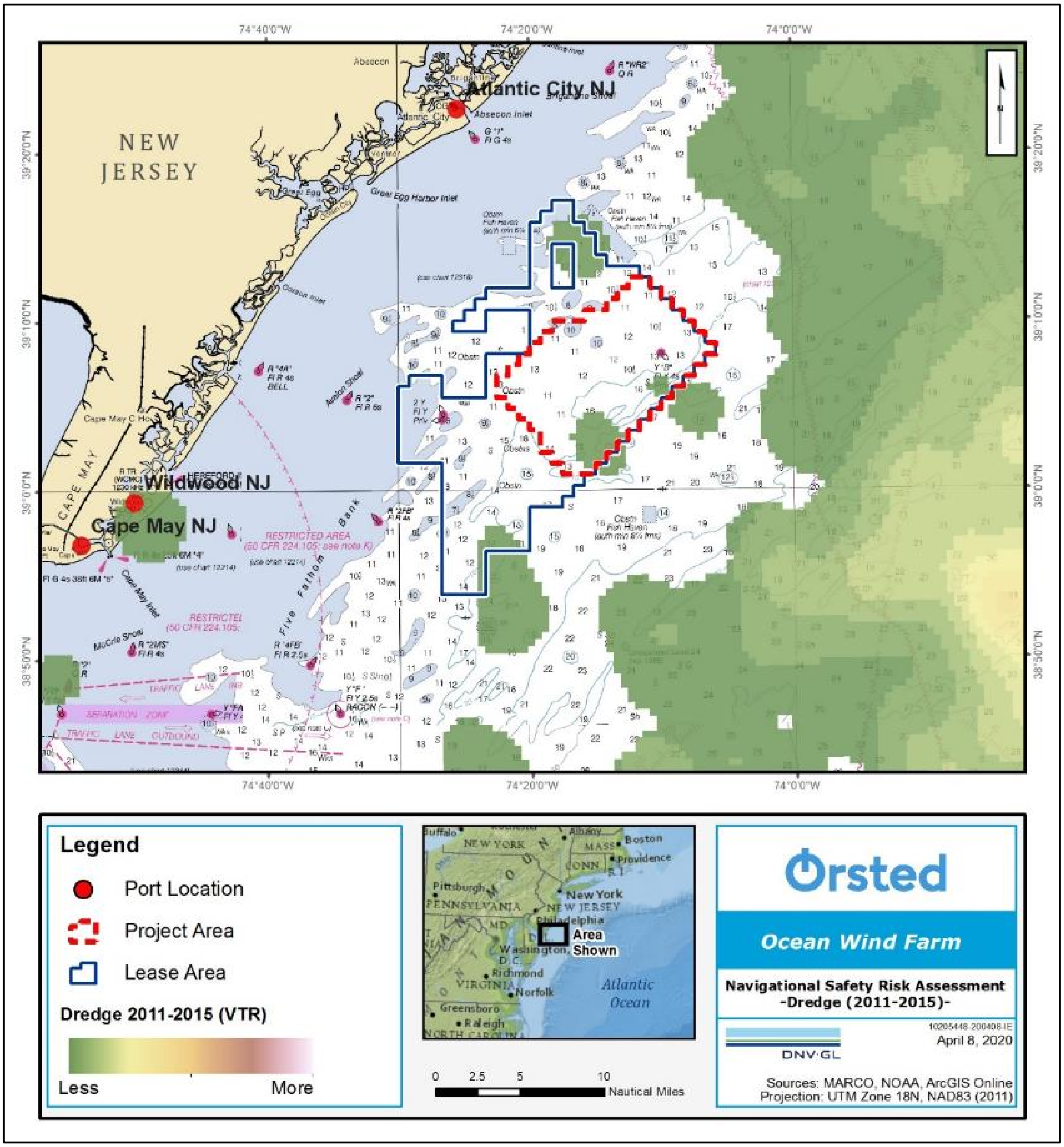


Figure 2-16 Total dredge activity for 2011-2015 (MARCO, 2020)

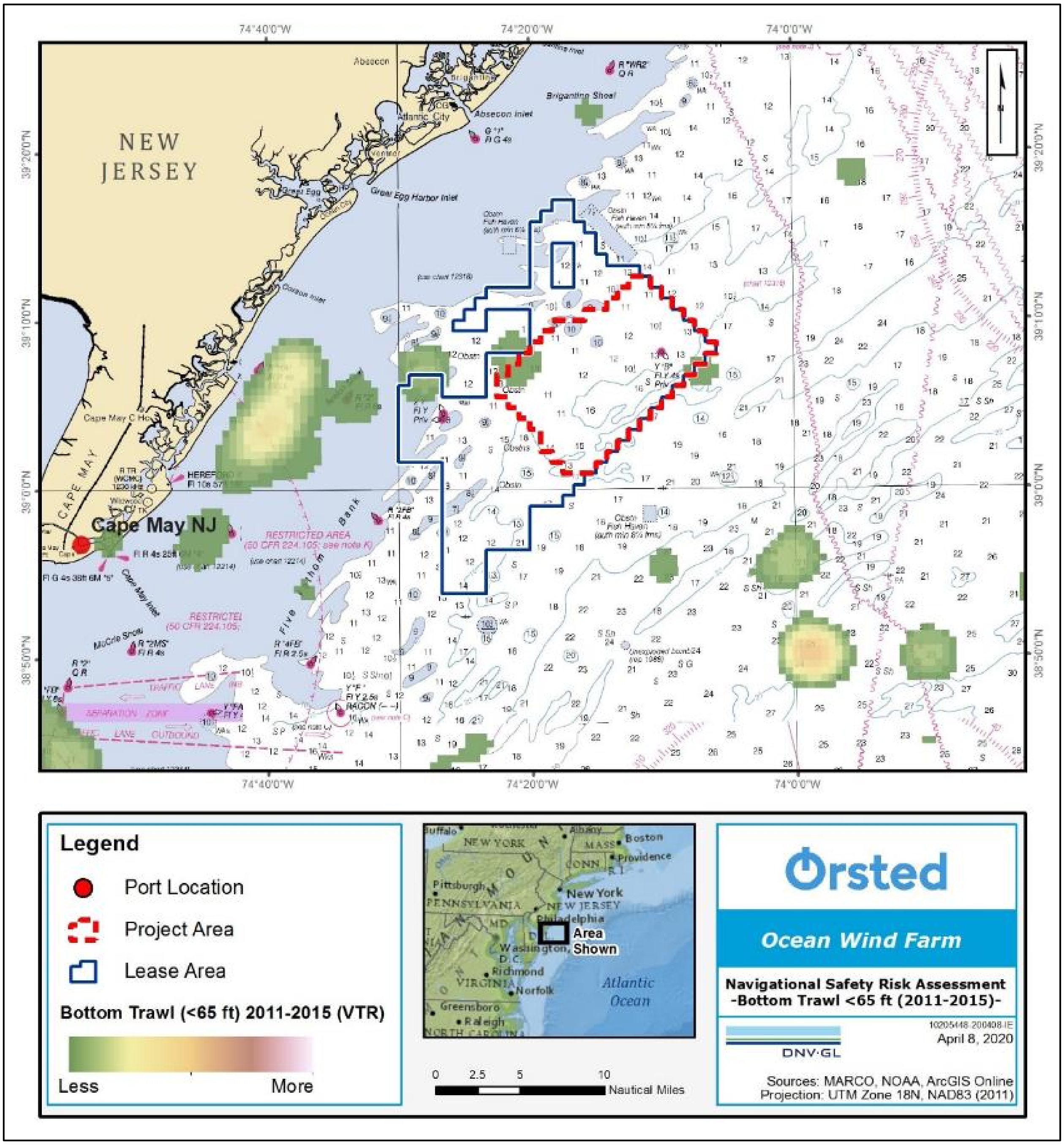


Figure 2-17 Total bottom trawl (<65 ft) activity for 2011-2015 (MARCO, 2020)

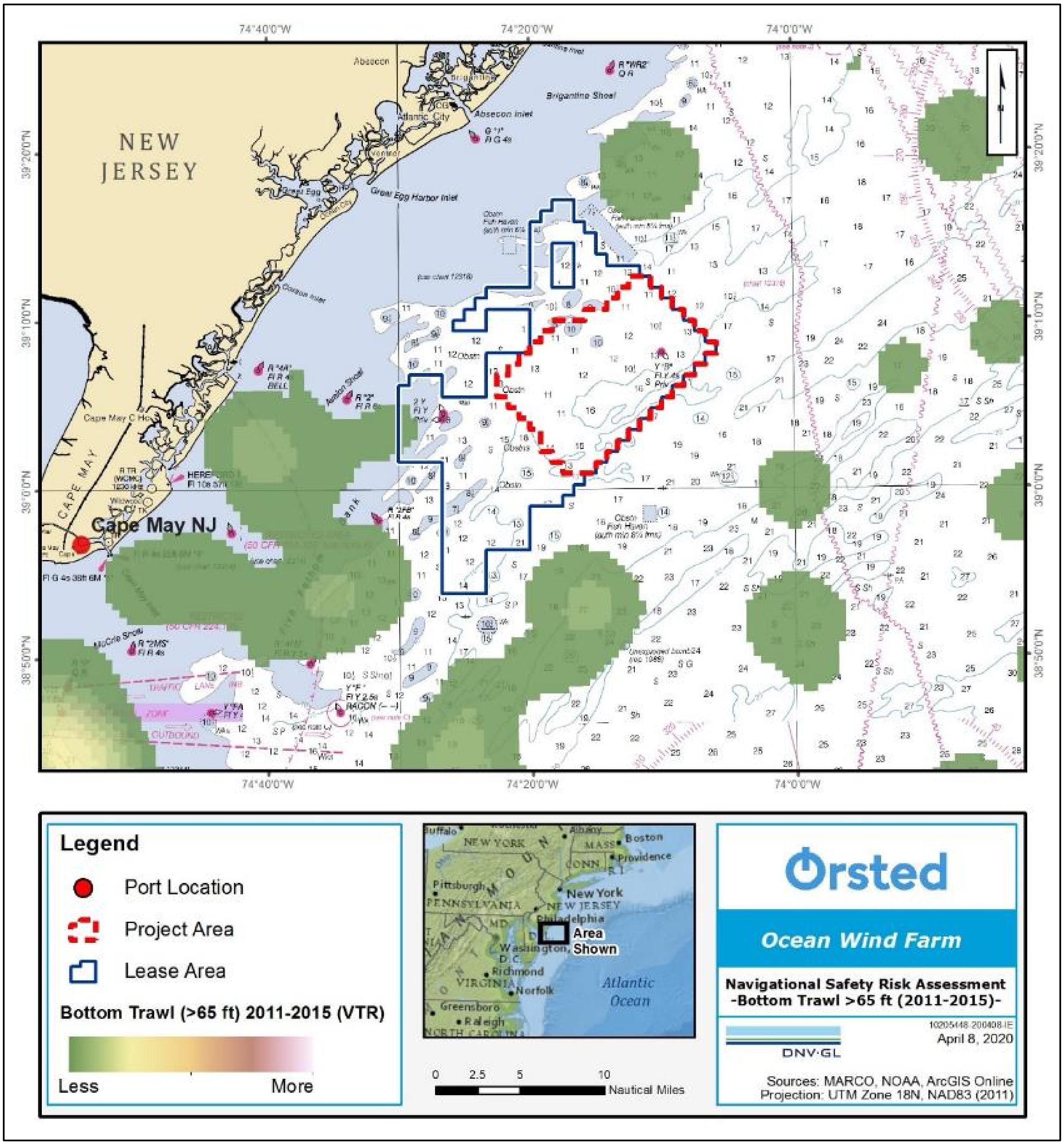


Figure 2-18 Bottom trawl (>65 ft) activity for 2011-2015 (MARCO, 2020)

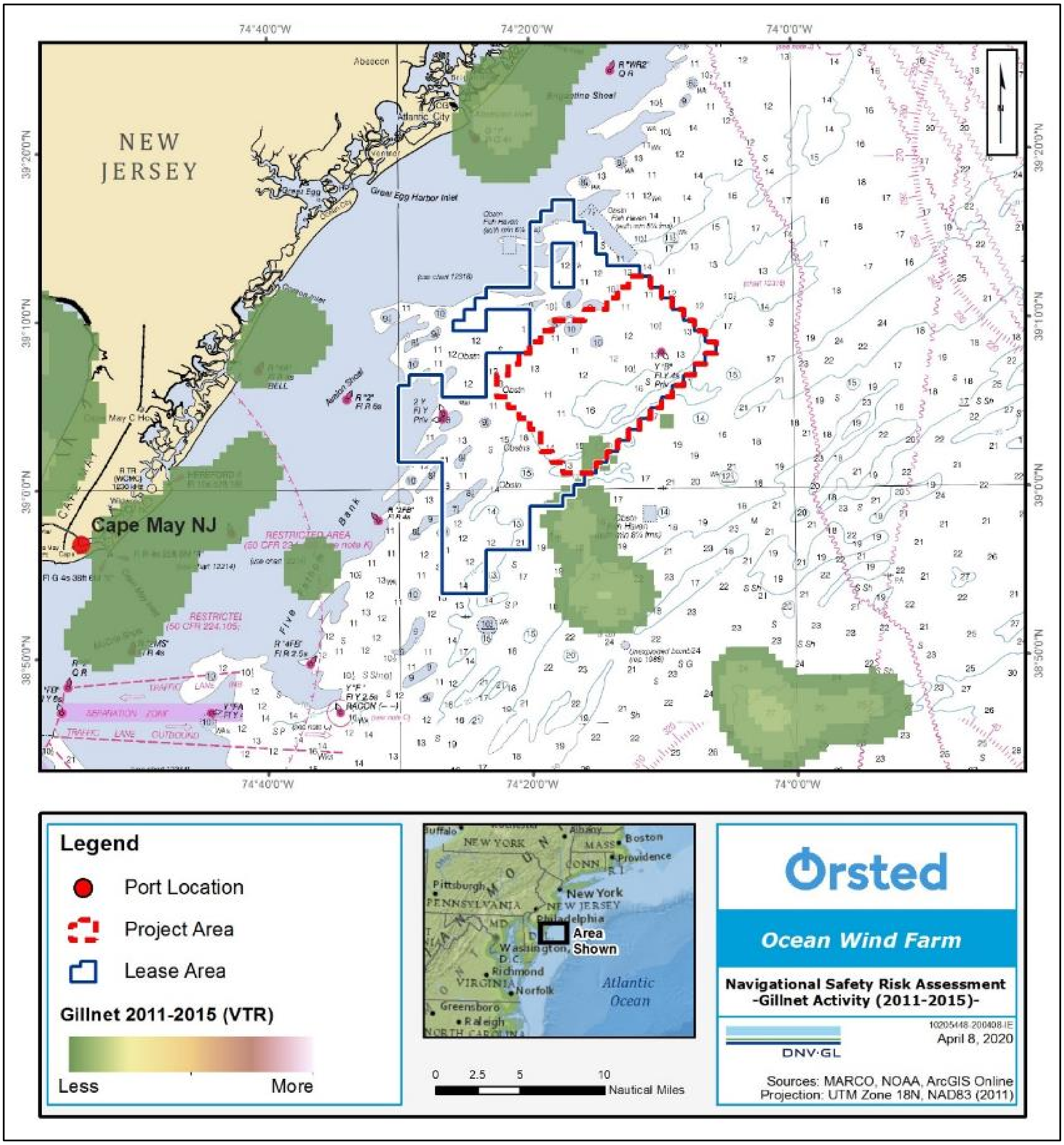


Figure 2-19 Total gillnet activity for 2011-2015 (MARCO, 2020)

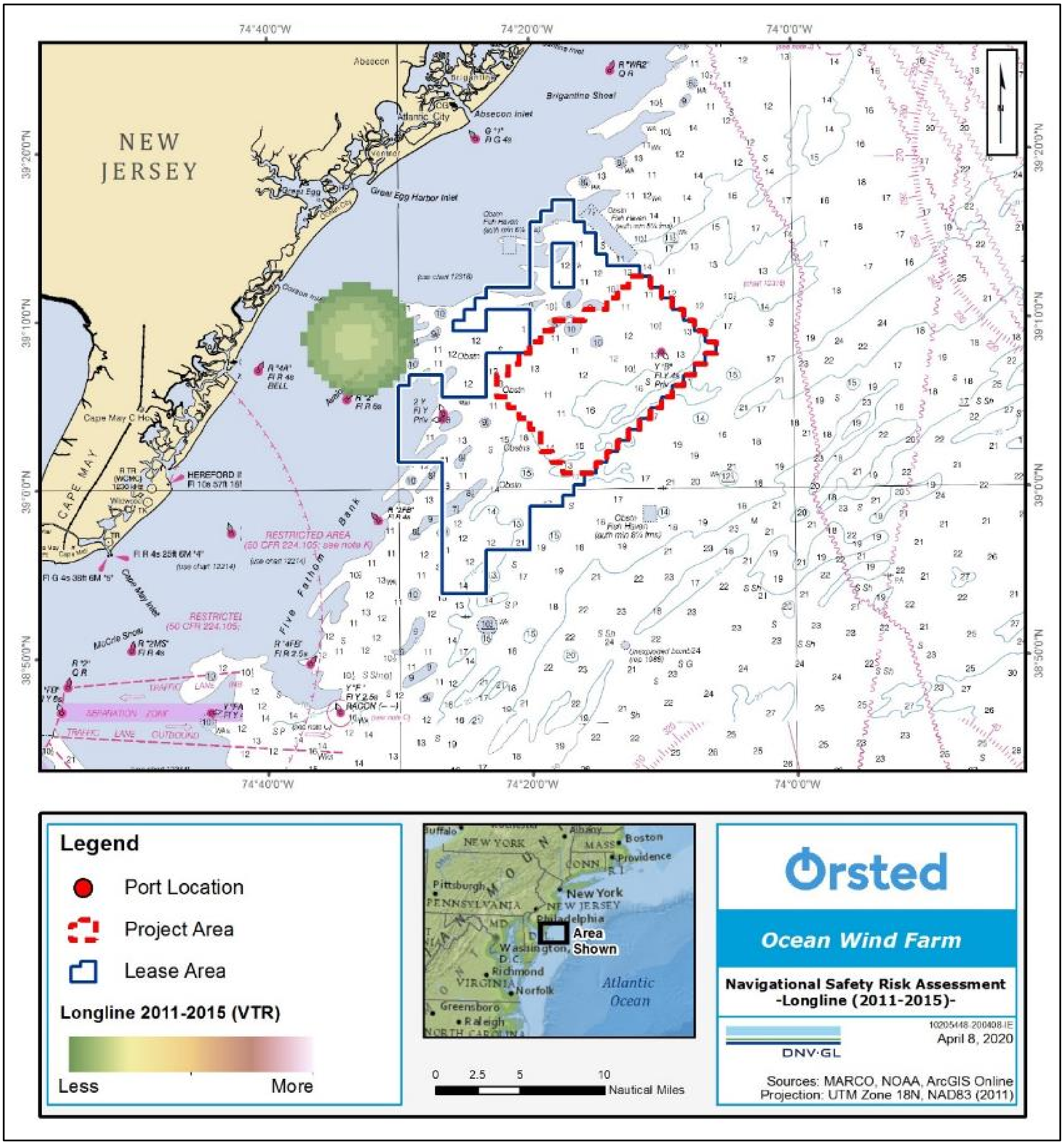


Figure 2-20 Total longline activity for 2011-2015 (MARCO, 2020)

2.1.1.3 Cruise ship and large ferry traffic

For this NSRA, vessels were designated as the type “cruise ships and large ferries” if they were indicated as “Passenger” type vessels in the AIS data and had reported lengths greater than 75 m. Figure 2-21 shows that cruise ships and large ferries followed established routes, primarily in Delaware Bay between Cape May, New Jersey and Lewes, Delaware. Relative to the Project Area, cruise ships and large ferries passed to the east en route to/from the Ambrose/Barnegat Traffic lanes to the north.

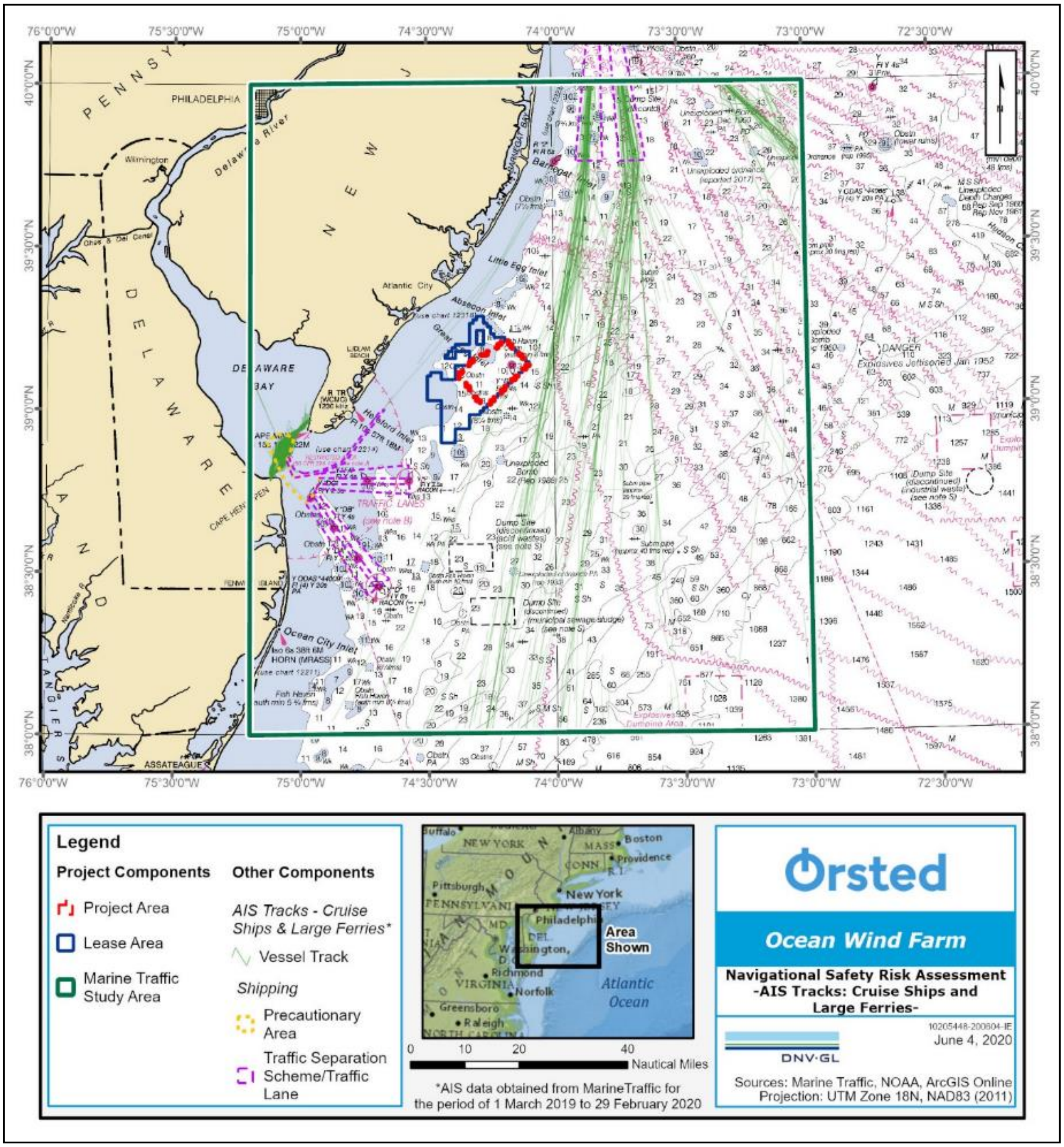


Figure 2-21 AIS tracks for cruise ships and large ferries[2]

2.1.1.4 Pleasure vessel traffic

For this NSRA, vessels were designated as the type “pleasure” if they were indicated as “Pleasure Craft,” “Sailing Vessel,” “Yacht,” and “Passenger” vessels with reported lengths less than 75 m. The data show pleasure vessel traffic primarily transits adjacent to the coast (Figure 2-22), with comparatively few tracks in the Project Area. The AIS tracks that go through the Project Area have generally northwest-southeast or southwest-northeast directionality.

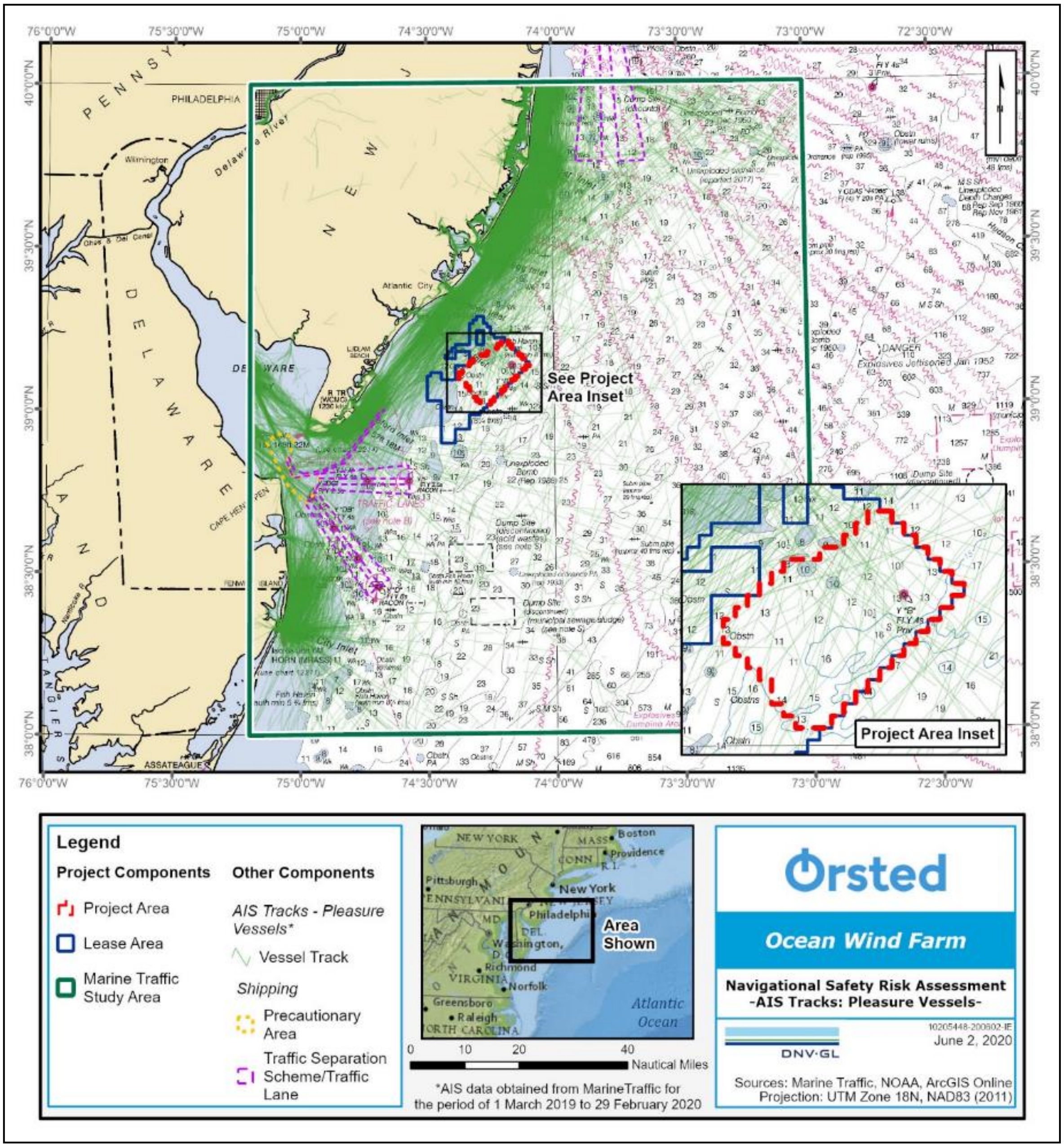


Figure 2-22 AIS tracks for pleasure / recreation vessels[2]

To provide additional information on recreational boating, boater density was mapped using two different layers from the Mid-Atlantic Ocean Data Portal and the Northeast Ocean Data Portal.

- The first layer was based on the Mid-Atlantic Boater Survey (Urban Coast Institute at Monmouth University et al., 2014), an online survey of registered boaters in the Mid-Atlantic region(i.e., New Jersey, Delaware, Maryland, and Virginia) conducted from June to December 2013 (Figure 2-23).
- The second density layer, available on the Northeast Ocean Data Portal, shows boater density based on the 2012 Northeast Recreational Boater Survey (Figure 2-24), which was a randomly selected survey of registered boaters conducted by SeaPlan, the Northeast Regional Ocean Council (NROC), states' coastal agencies, and marine trade associations (Starbuck and SeaPlan, 2012).

Both sources indicate that recreational traffic passes through the Project Area.

In addition to boating density, another data product from the Mid-Atlantic Boater survey (Urban Coast Institute at Monmouth University et al., 2014) was a point layer showing locations of activities such as fishing, swimming, and scenic enjoyment. The activity locations data contain no activities in the Project Area. The AIS data for pleasure vessels shows 92 transits of pleasure vessels into the Project Area, which is more than indicated in the two surveys. Therefore, no adjustments were made to the AIS traffic for pleasure vessels in the Base Case risk model. However, significant adjustments were made to the Future Case model, as described in Section 2.3.

The AIS data for pleasure vessels shows 133 transits of pleasure vessels into the Project Area, which is more than indicated in the 2012 survey of registered boaters. Therefore, no adjustments were made to the AIS traffic for pleasure vessels in the Base Case risk model. However, significant adjustments were made to pleasure traffic in the Future Case model, as described in Section 2.3.

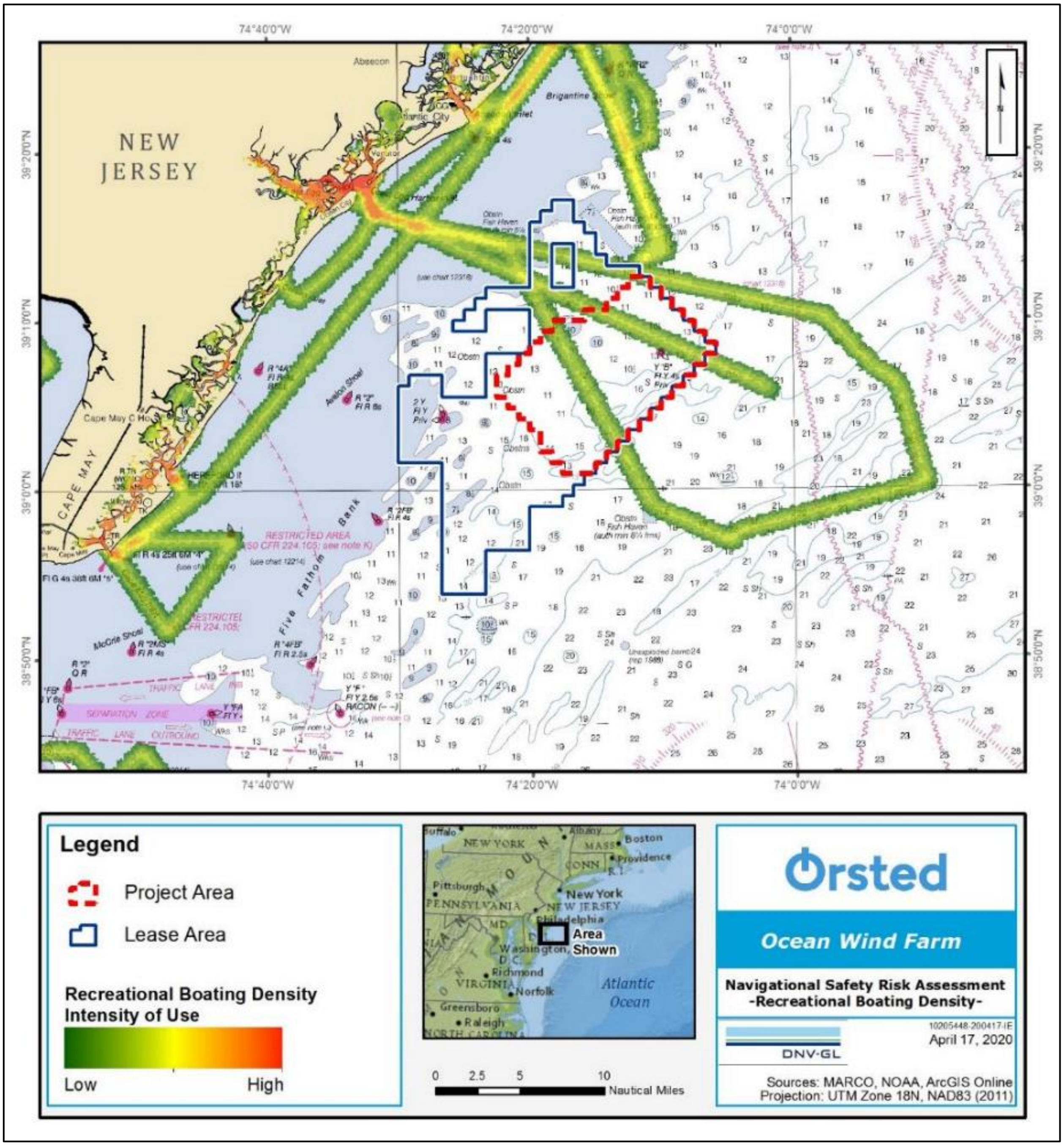


Figure 2-23 Recreational boating density based on data collected for the Mid-Atlantic region from registered boaters June to December 2014 (MARCO, 2020)

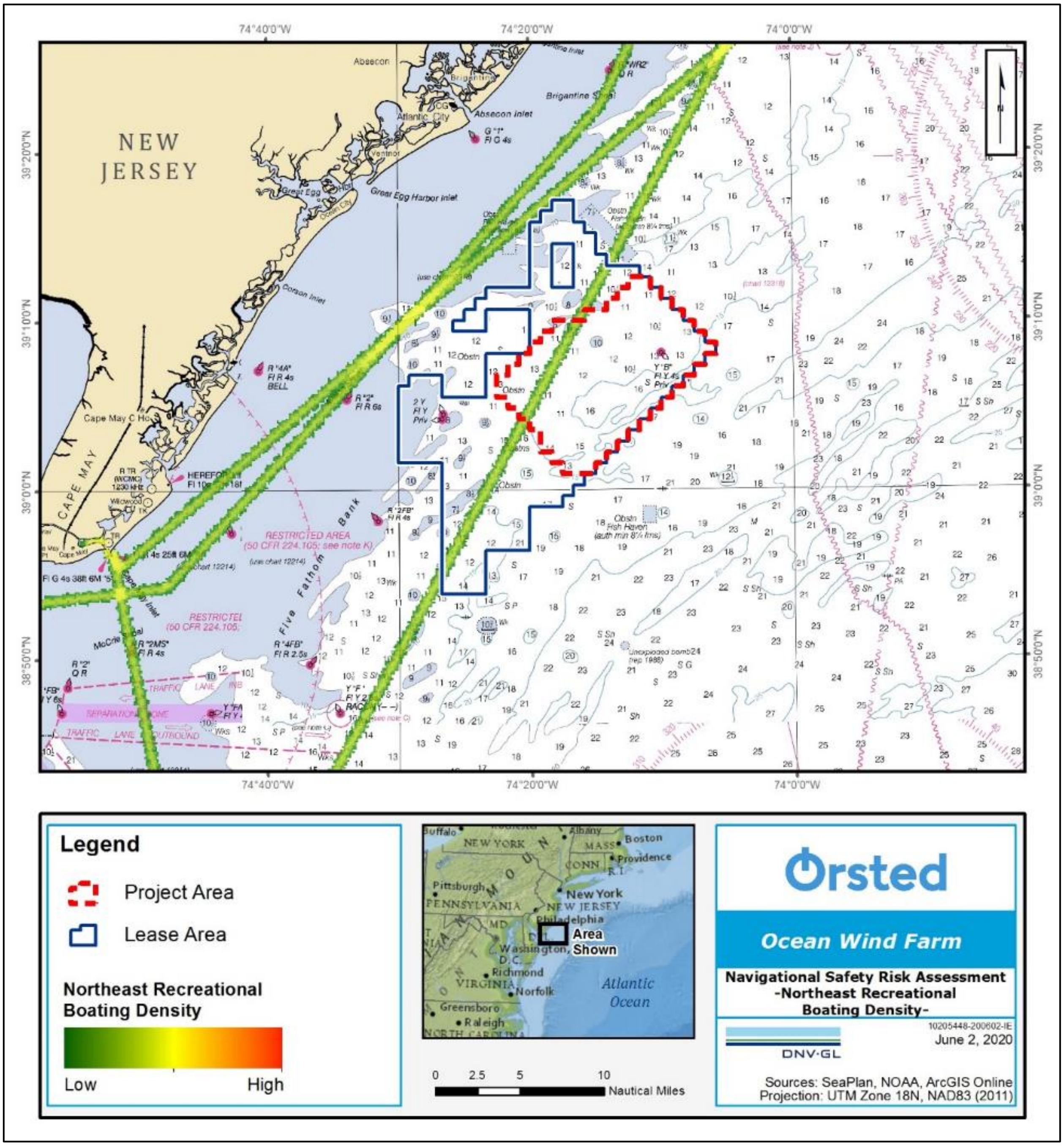


Figure 2-24 Recreational boating density as depicted in the data collected during the 2012 Northeast Recreational Boater Survey (Starbuck and Lipsky, 2012)

2.1.1.5 Tug traffic

The AIS tracks for tug vessels (including tug-with-tow) show distinct patterns, as seen in Figure 2-25. Most of the tug traffic in the vicinity of the Project transits between the Project Area and the coast.

The AIS data indicate that only two percent of the unique tug vessels self-identify as tug-with-tow; however, based on consultations with the American Waterways Operators (AWO) (Orsted, 2021), it is more likely that 5 percent of the coastal traffic are tugs without barges and that, of the remaining 95 percent:

- About half are configured as tug-with-tow, which comprise a tug connected by a wire to the barge which is towed astern.
- About half are Articulated Tug Barge (ATB) or Integrated Tug/Barge (ITB). These push the barge rather than pull it. They maneuver more like larger ships than tug-with-tows because of the direct connection between the tug and barge (Orsted, 2021).

In June 2020, the Coast Guard published an Advance Notice of Proposed Rulemaking (85 FR 37034) seeking comments regarding the possible establishment of shipping safety fairways along the east coast. As currently proposed, the Cape Charles to Montauk Point Fairway overlaps a portion of the Lease Area; however, it does not overlap the Project Area. Orsted’s and other interested parties’ comments on the proposed rulemaking are available at www.regulations.gov.

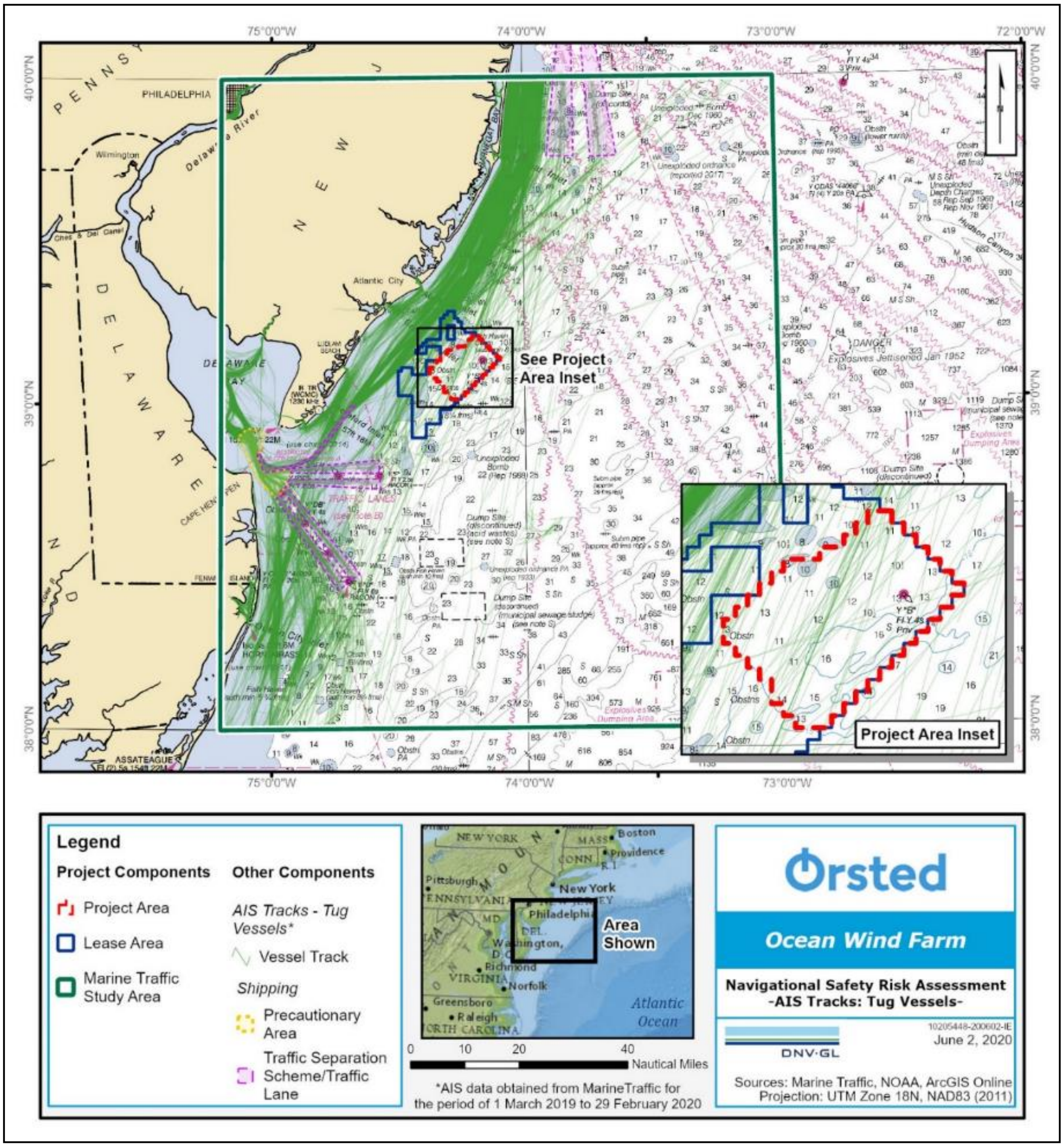


Figure 2-25 AIS tracks for tugs[2]

2.1.1.6 Other vessel traffic

AIS tracks for “Other” vessel types are presented in Figure 2-26. Other vessels are within AIS vessel sub-categories that do not clearly fit into the vessel type categories previously discussed, and include research, military, law enforcement, and unspecified vessels. Most of these tracks are visible adjacent to the coast and in the Project Area.

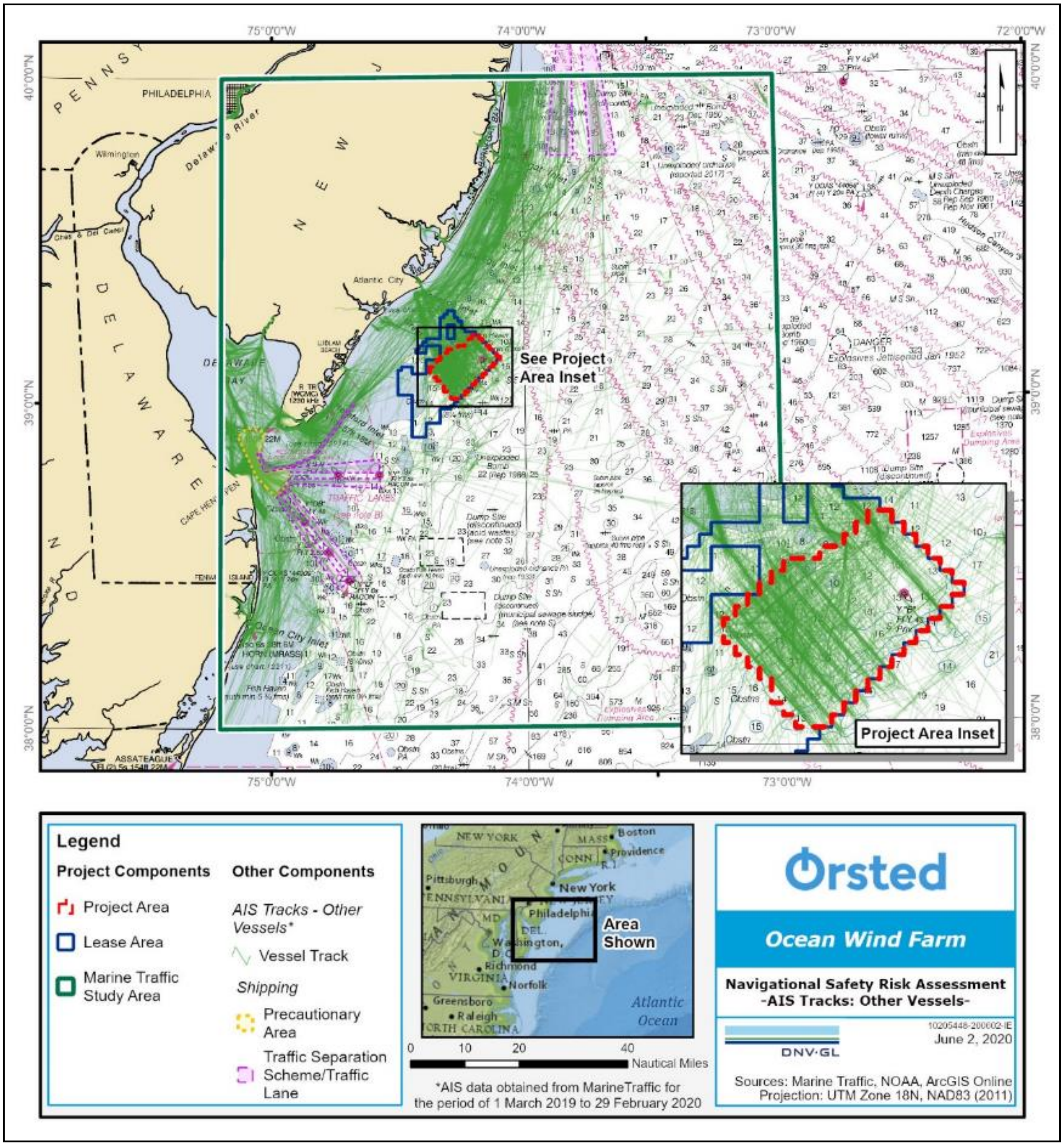


Figure 2-26 AIS tracks for other vessels[2]

Approximately 9 percent of transits for vessel type “other” in the Study Area occurred within the Project Area, and the vast majority of these (88 percent) were indicated in the data as “research/survey” vessels. Figure 2-27 shows the tracks of research/survey vessels based on the AIS data. The straight-line tracks oriented along the proposed structure locations indicate that some of the research vessels were used to collect data for offshore wind projects. Note that some research vessels are also used to collect data on fisheries and other ocean uses. As with all the other tracks indicated in the AIS data set, these tracks were included in the modeling of collision, allision, and grounding risk described in Section 11.

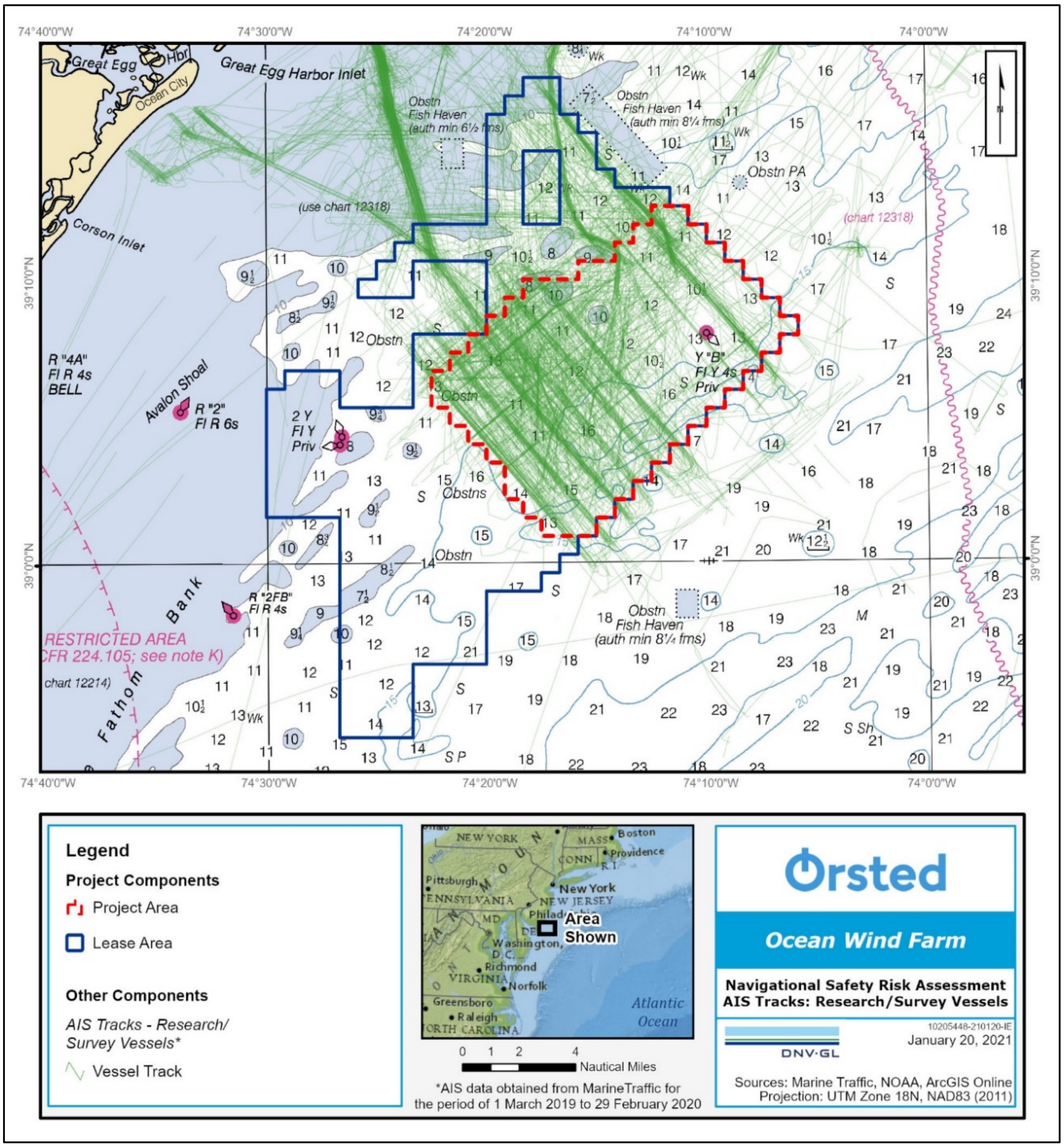


Figure 2-27 AIS Tracks for Research/Survey Vessels[2]

2.1.2 Traffic density

Figure 2-28 presents a density heat map for all AIS points in the Marine Traffic Study Area. It shows that vessels are closer together in space/time adjacent to the coast and in the TSS. The density represented within the Project Area includes research vessels that have been studying the Project Area to support the Project's development. Density maps for each ship type are provided in Appendix A.

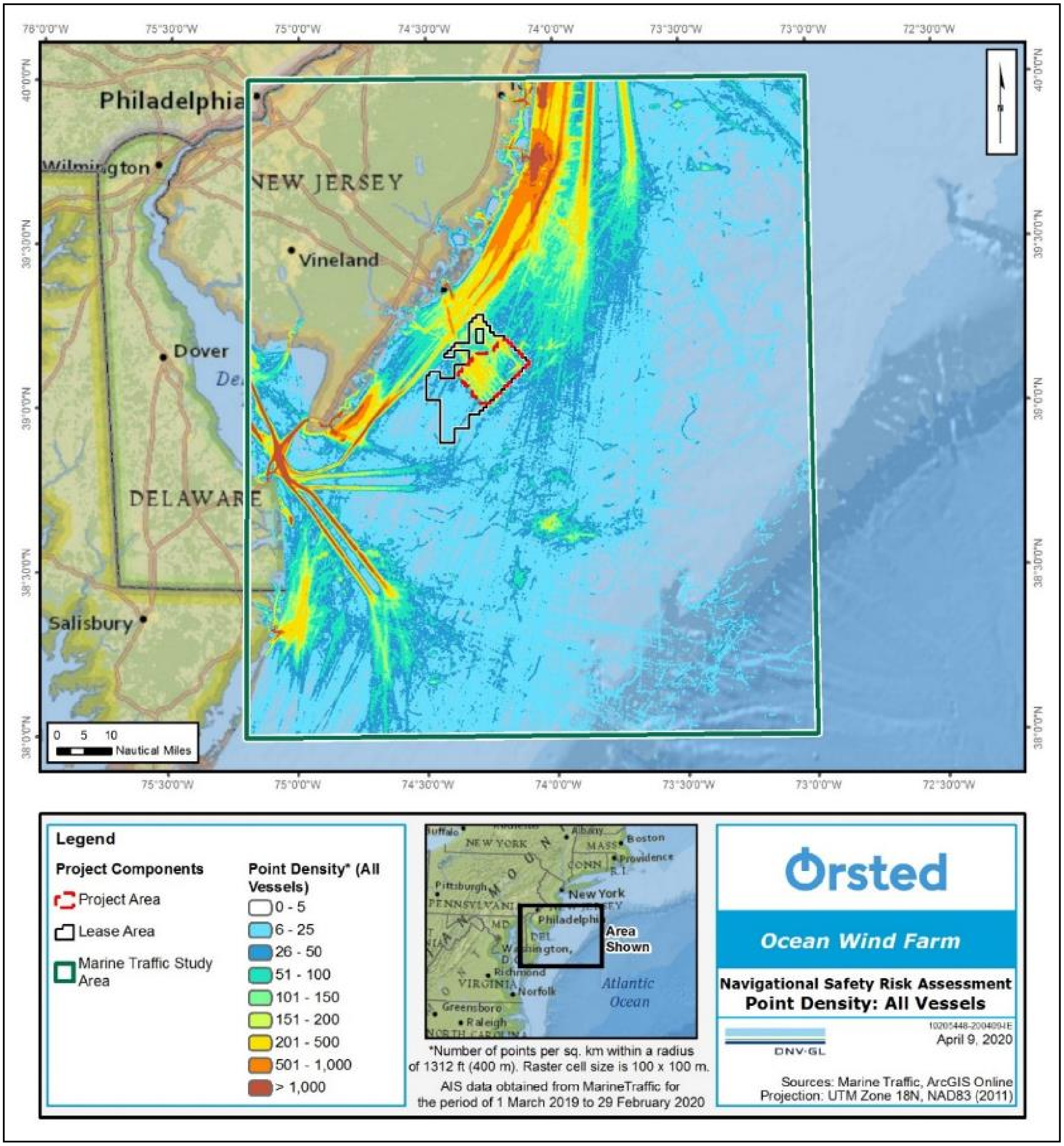


Figure 2-28 AIS point density[2]

2.1.3 Traffic statistics

This section presents the traffic statistics of the Marine Traffic Study Area. The statistics provide insight into how many vessels and which types transit in specific locations

2.1.3.1 Transit counts

Transit counts per transect

Figure 2-29 shows the transects defined for this NSRA. The transect locations were selected to evaluate the major routes in the Marine Traffic Study Area. The resulting number of vessels crossing each transect provides a view of the amount and types of marine traffic in the year of AIS data, 1 March 2019 through 29 February 2020.

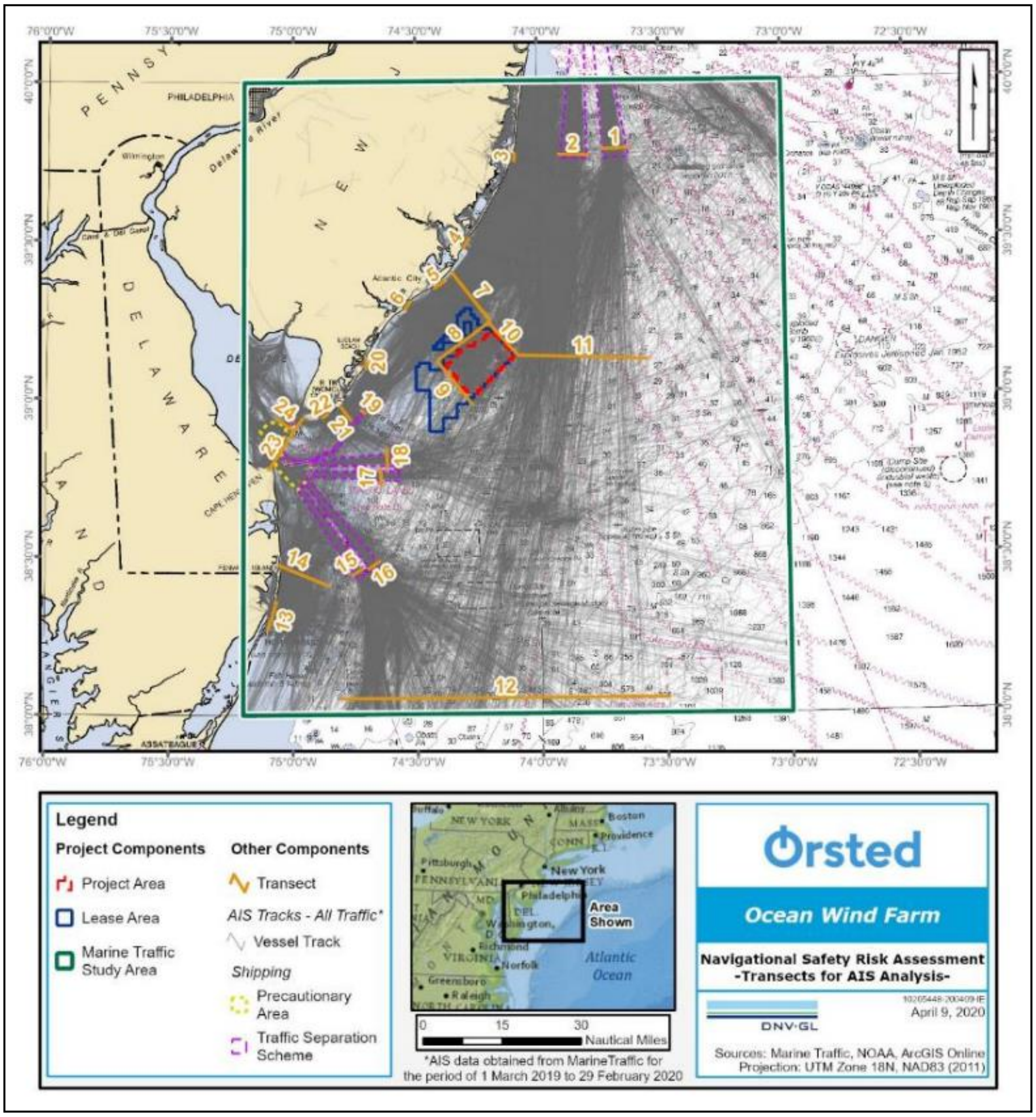


Figure 2-29 Transects used for statistical analysis of traffic[2]

Figure 2-30 presents the total number of transits per transect in the year of AIS data, March 2019 through February 2020 (MarineTraffic, 2020).

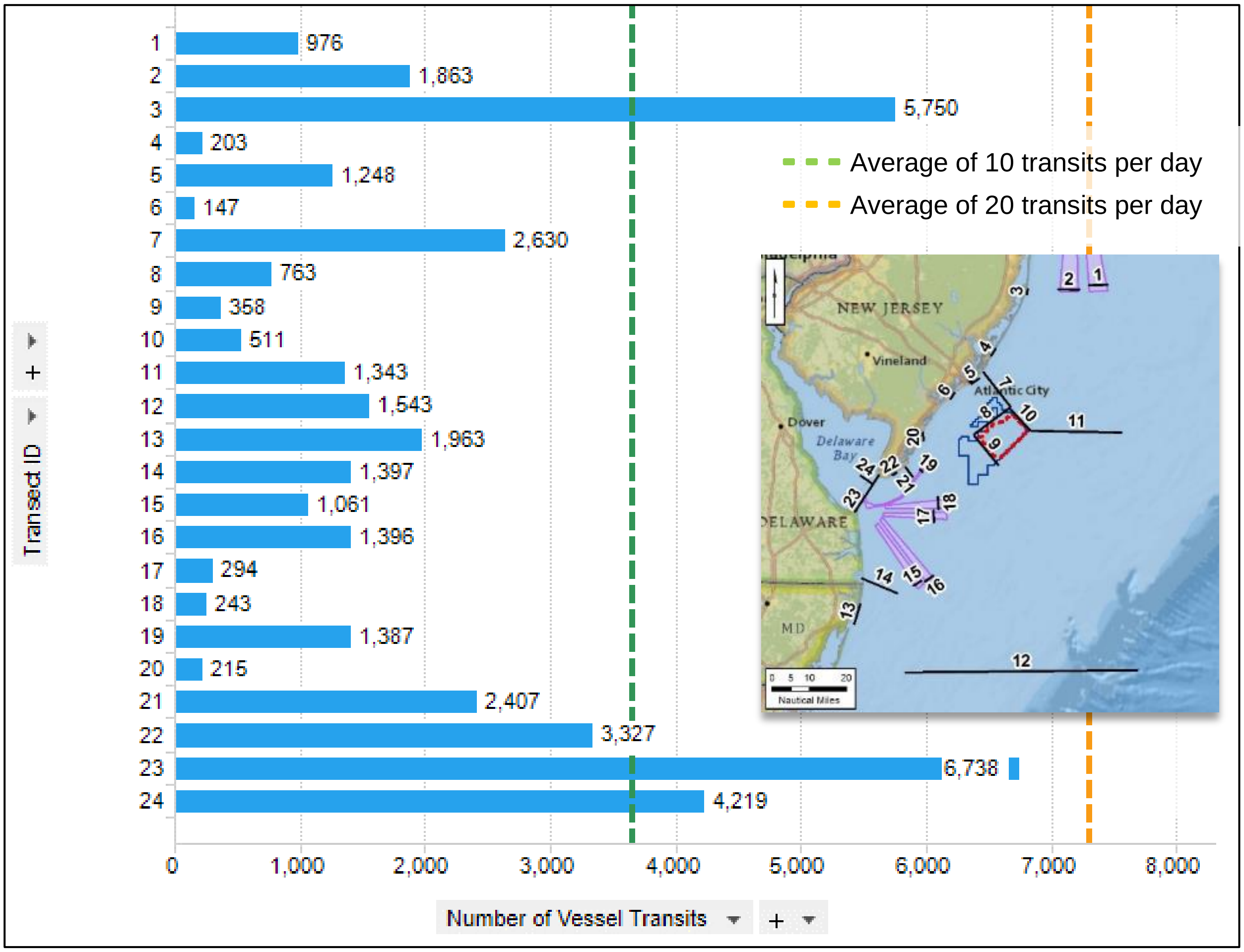


Figure 2-30 Annual number of transits per transect[2]

Only three transects have more than 10 transits per day (3,650 transits per year):

- The entrance to Delaware Bay (transect 23) with an average of about 18 transits per day
- Barnegat Inlet (transect 3) with an average of 16 transits per day
- The east end of Delaware Bay (transect 24) with an average of 11 transits per day

The coastal traffic west of the Project Area (transect 7) is predominantly tug transits, while the majority of the coastal traffic further south (transect 21) is predominantly pleasure and fishing vessels.

The aggregated transects bordering the Project Area (8, 9, and 10) show an average of 5 transits per day entering the Project Area, 1632 per year in total, including some minor double-counting. The vessel composition in these transects varies substantially:

- The northwestern boundary (transect 8) includes tracks from vessels headed to/from the coast, consisting primarily of:
    - 57 percent other/undefined vessels
    - 36 percent fishing and pleasure vessels
- Considerably fewer transits cross the northern boundary of the Project Area (transect 10). This traffic is:
    - 47 percent cargo/carrier vessels
    - 25 percent fishing and pleasure vessels
    - 14 percent other/undefined vessels
    - 10 percent tugs
- Even fewer transits cross the southern boundary (transect 9). Four vessel types each comprise about 20 percent of the transits: cargo/carrier, fishing, tug, and other/undefined.

Figure 2-31 to Figure 2-33 present the distribution of vessel types for each transect.

Most of the traffic to/from ocean-access ports are transits of fishing and pleasure vessels:

- Barnegat Inlet (Transect 3)
- Little Egg Inlet (Transect 4)
- Abescon Inlet (Transect 5)
- Great Egg Inlet (Transect 6)
- Indian River Inlet (Transect 13)
- Hereford Inlet (Transect 22)

Two other inlets show a significant proportion of tug transits with the fishing and pleasure transits: Townsends Inlet (transect 20) Great Egg Inlet (transect 6).

The cost of AIS technology has significantly decreased in the past 10 years and voluntary use of AIS in recreational vessels has increased over time; however, the adoption rates are relatively low. It is reasonable to assume that recreational fishing vessels (“pleasure” vessel type) continue to be underrepresented in the AIS data.

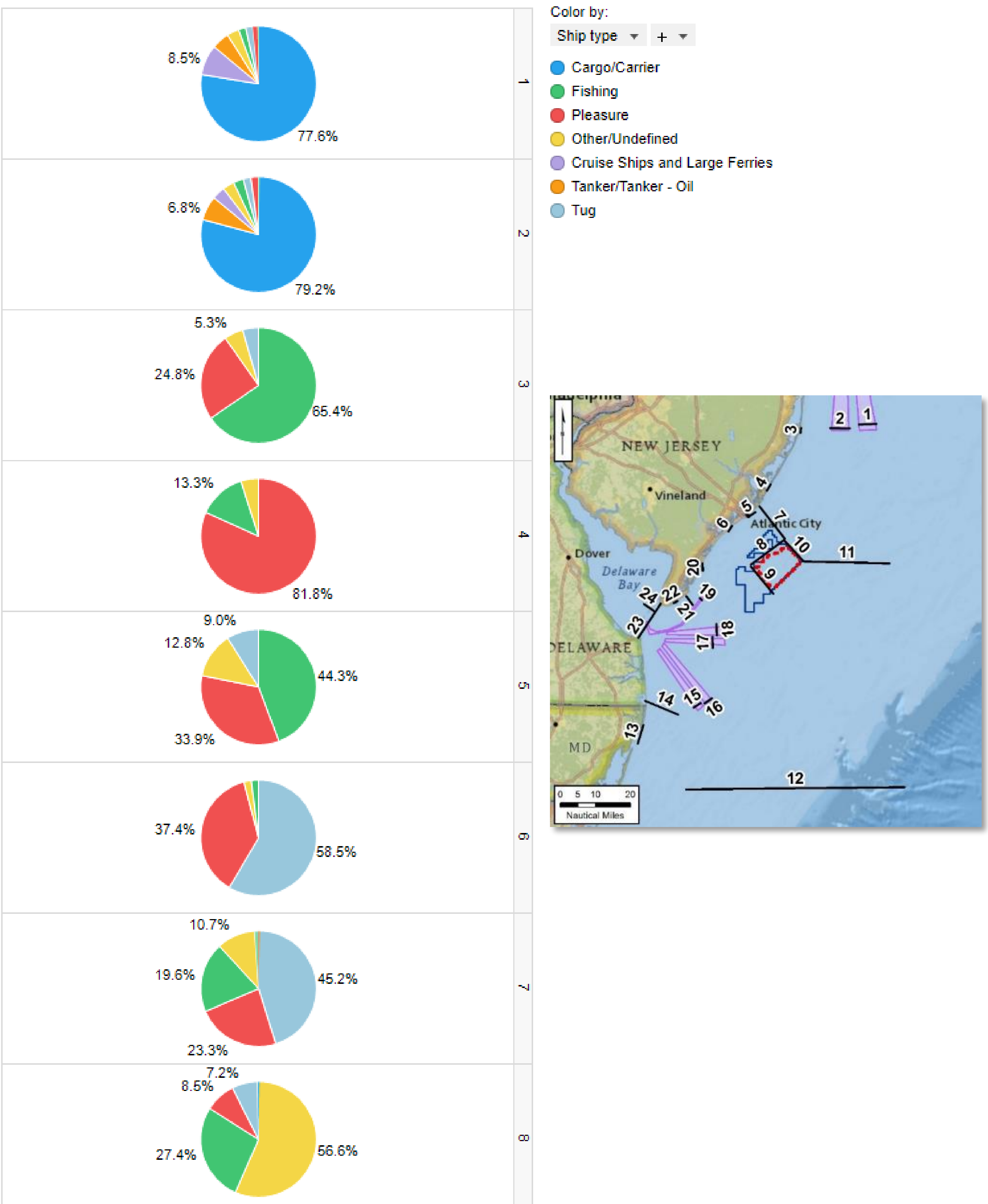


Figure 2-31 Traffic distributions for Transects 1 to 7[2]

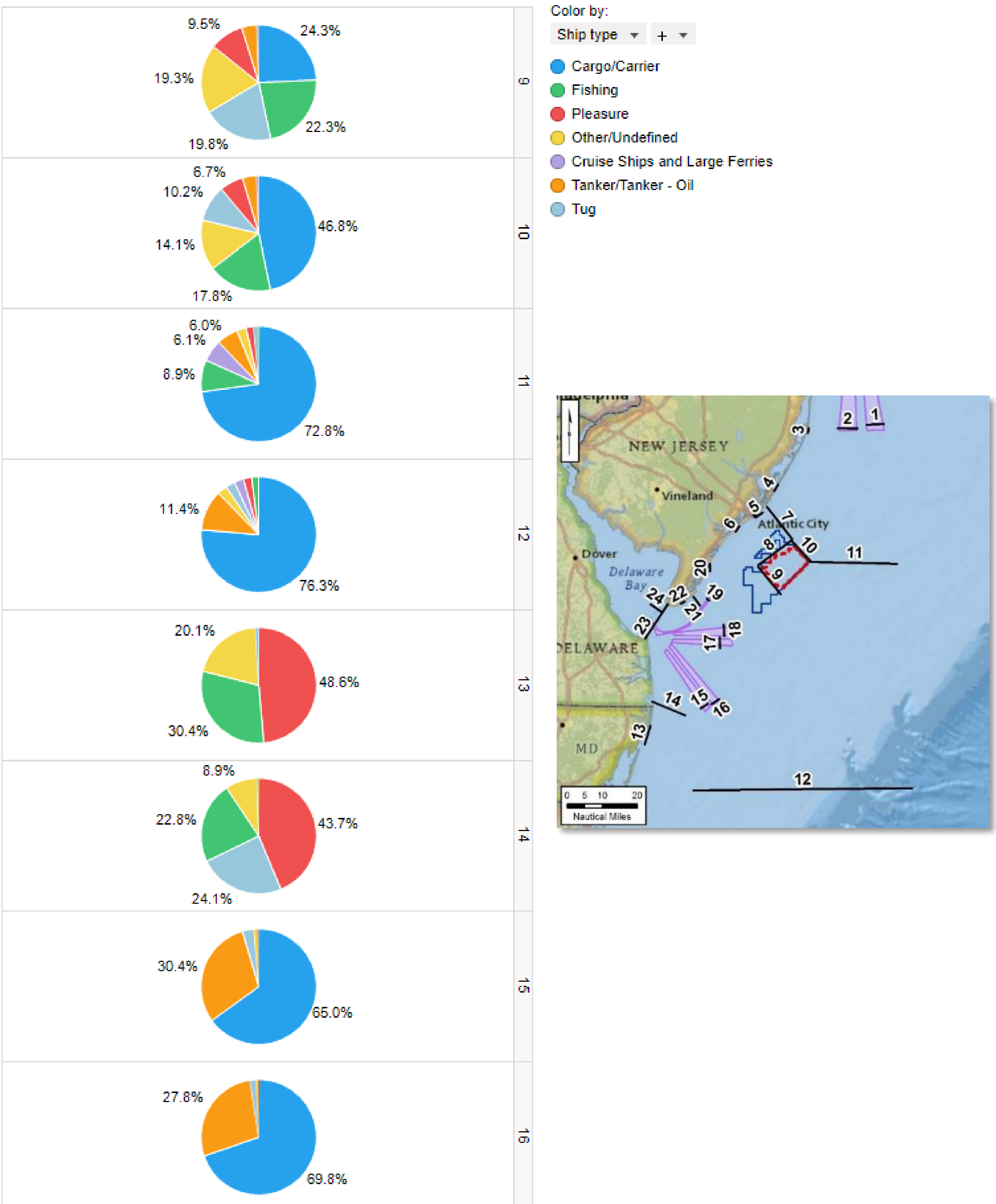


Figure 2-32 Traffic distributions for Transects 8 to 14[2]

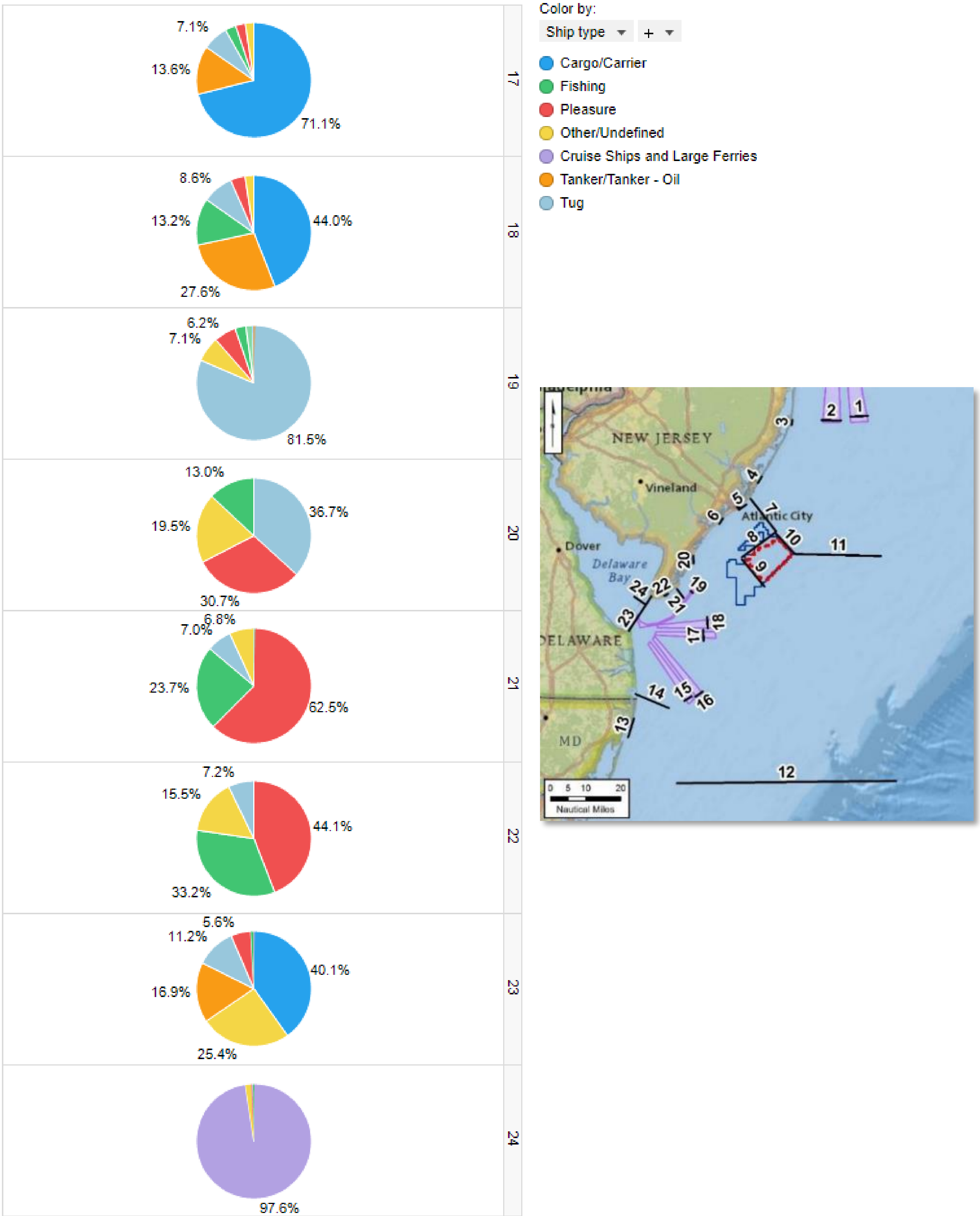


Figure 2-33 Traffic distributions for Transects 15 to 21[2]

2.1.3.2 Vessel size

Vessel sizes were evaluated within the Marine Traffic Study Area and also around the Project Area so that differences between the two could be identified. A 5-statute-mile area (4.34 NM, 8 km) was defined around the Project Area for this evaluation based on precedent. Any size area between 3 and 6 NM around the Project would be suitable to assess vessel sizes based on modeling results and analysis of vessel sizes.

Vessel size statistics presented in this section are based on user input into each vessel's AIS system. The data show that on a percentage basis, the AIS input is less complete and contains more obvious errors (e.g., 0, 1, or not credible entries) for vessels without mandatory AIS carriage. For example, fishing vessels less than 65 ft in length are generally not required to use AIS, and 90 percent of these vessels do not enter a dead weight tonnage (DWT). Therefore, the AIS statistics for DWT are expected to be weighted toward larger vessels, with the result that the average of the DWT data is larger than the true average. Similar trends were noted for Length Overall (LOA) and breadth.

There are three primary uses of the ship size data and statistics:

- A general sense of the range of vessel sizes in the vicinity of the Project
- The ship's breadth and length are used in the powered and drift allision models, respectively.
- A value for average DWT used in the analysis described in Section 11 to estimate allision energies. Any over-estimation of vessel size adds a margin of conservatism, over-estimates the potential allision energy, and, therefore, over-estimates the consequences.

Size distributions for LOA, beam, and DWT for vessels in the Marine Traffic Study Area are provided in **Figure** 2**-**34, Figure 2-35, and Figure 2-36.

The data indicate that the great majority of vessels are small: less than 40 m LOA and 10 m beam. In the AIS dataset, more than 95 percent of the transits included credible data in the LOA and beam fields. However, only 33 percent of the data entries included a DWT value.

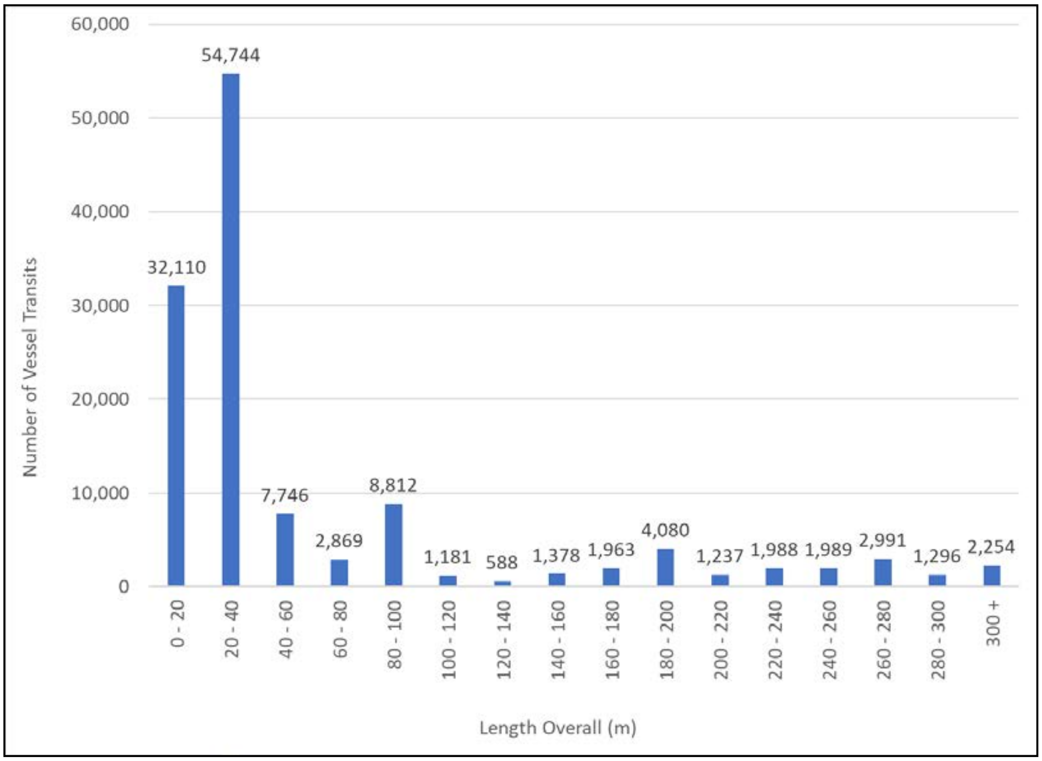


Figure 2-34 LOA distribution in Marine Traffic Study Area[2]

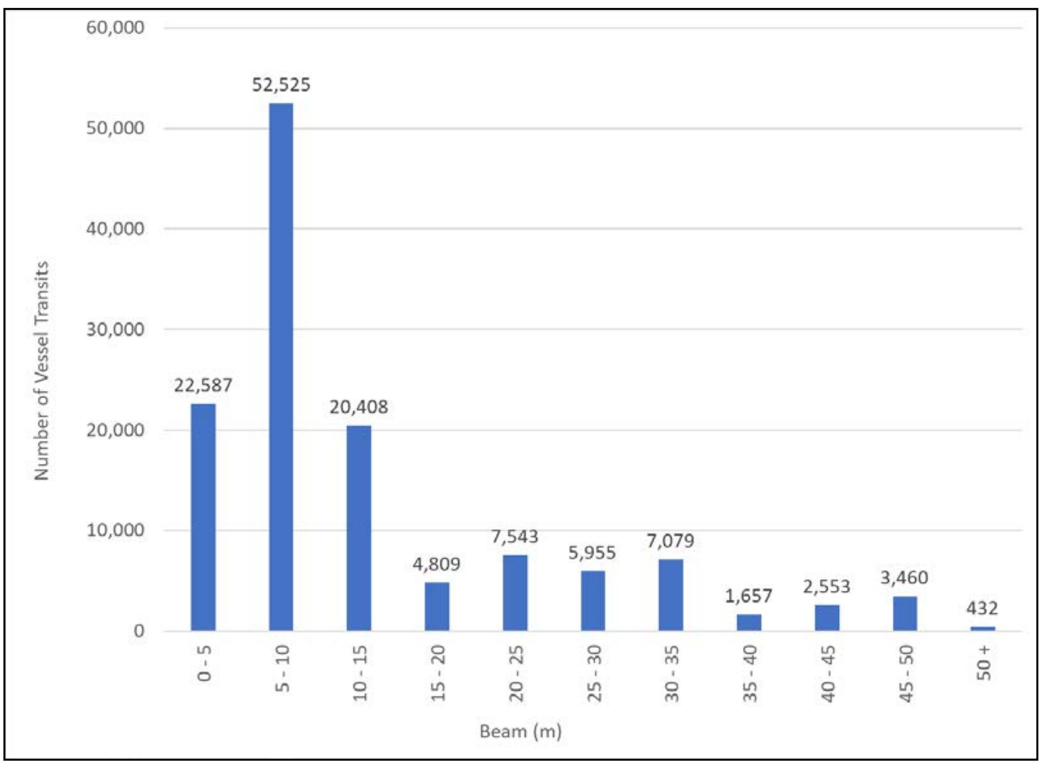


Figure 2-35 Beam distribution in Marine Traffic Study Area[2]

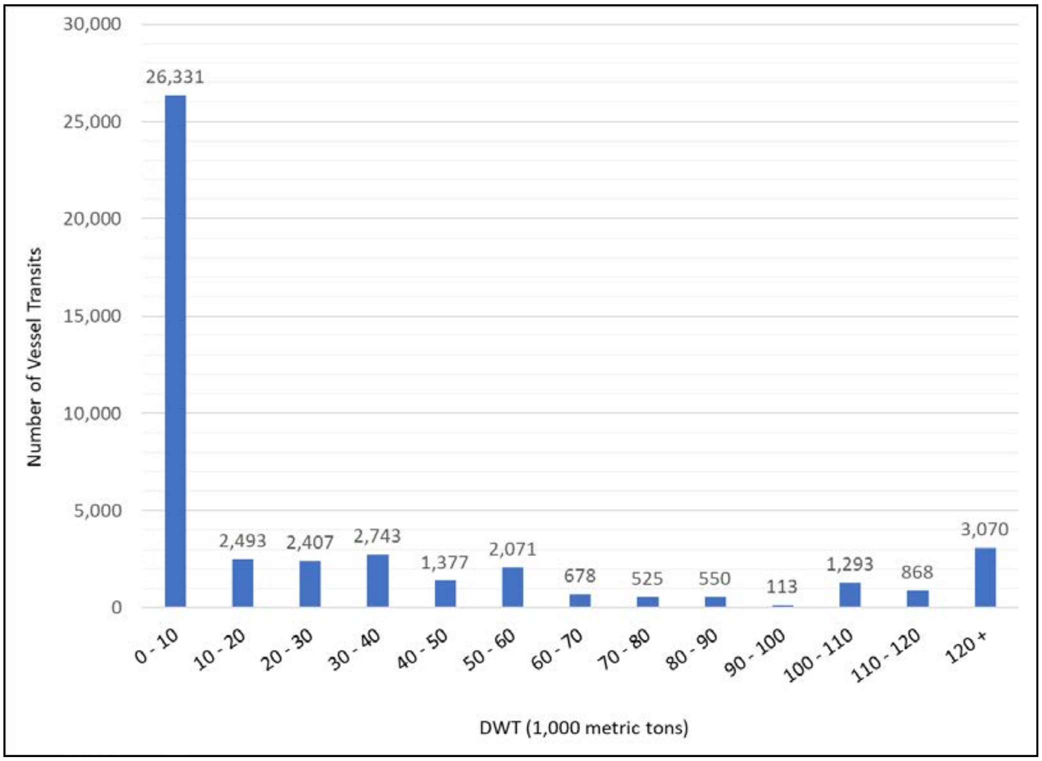


Figure 2-36 DWT distribution in Marine Traffic Study Area[2]

The average and maximum DWT of vessels in the Marine Traffic Study Area are shown in Figure 2-37.

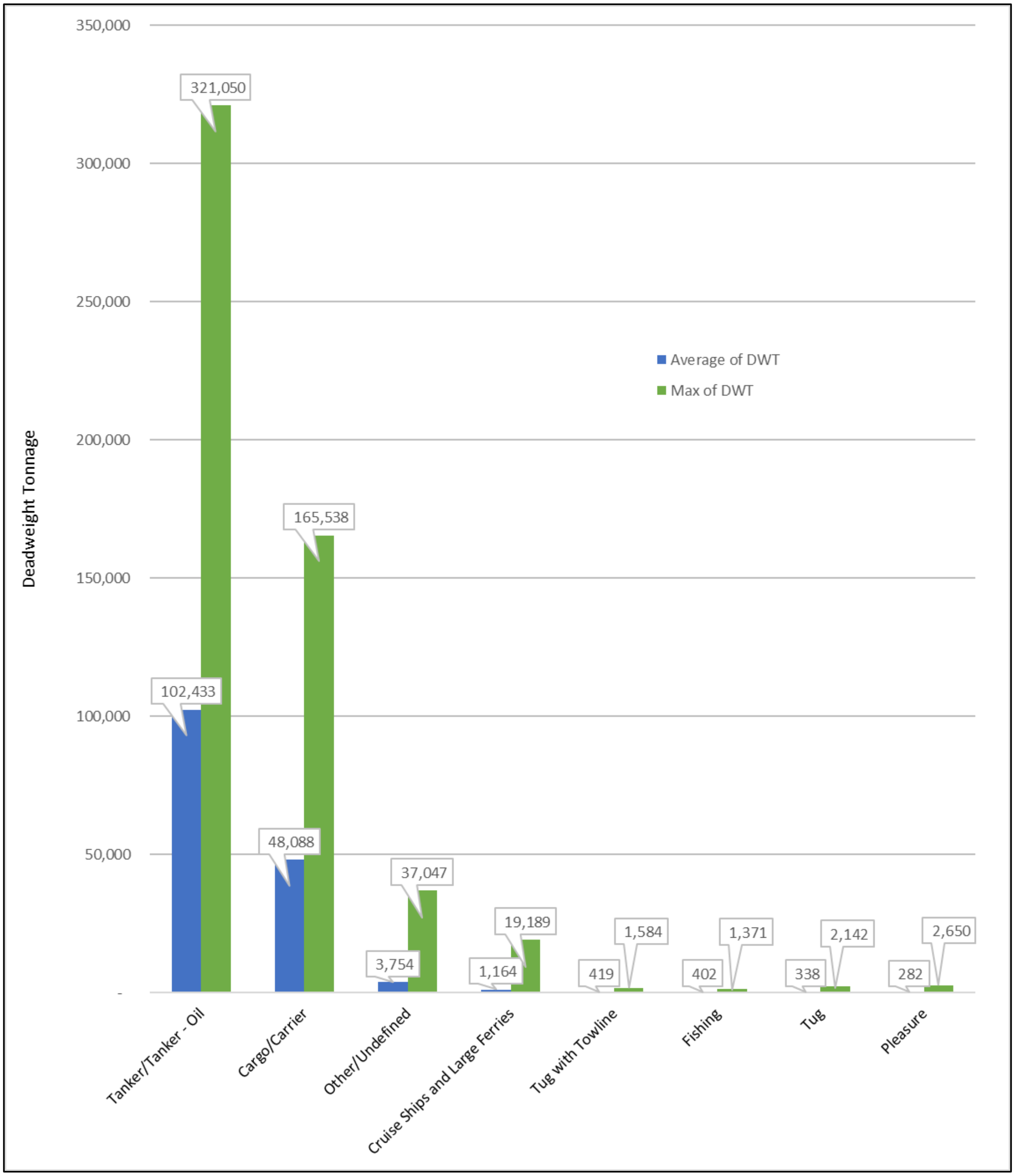


Figure 2-37 Average and maximum DWT of vessels in Marine Traffic Study Area[2]

Figure 2-38 through Figure 2-40 present similar statistics for vessel size in the vicinity of the Project Area.

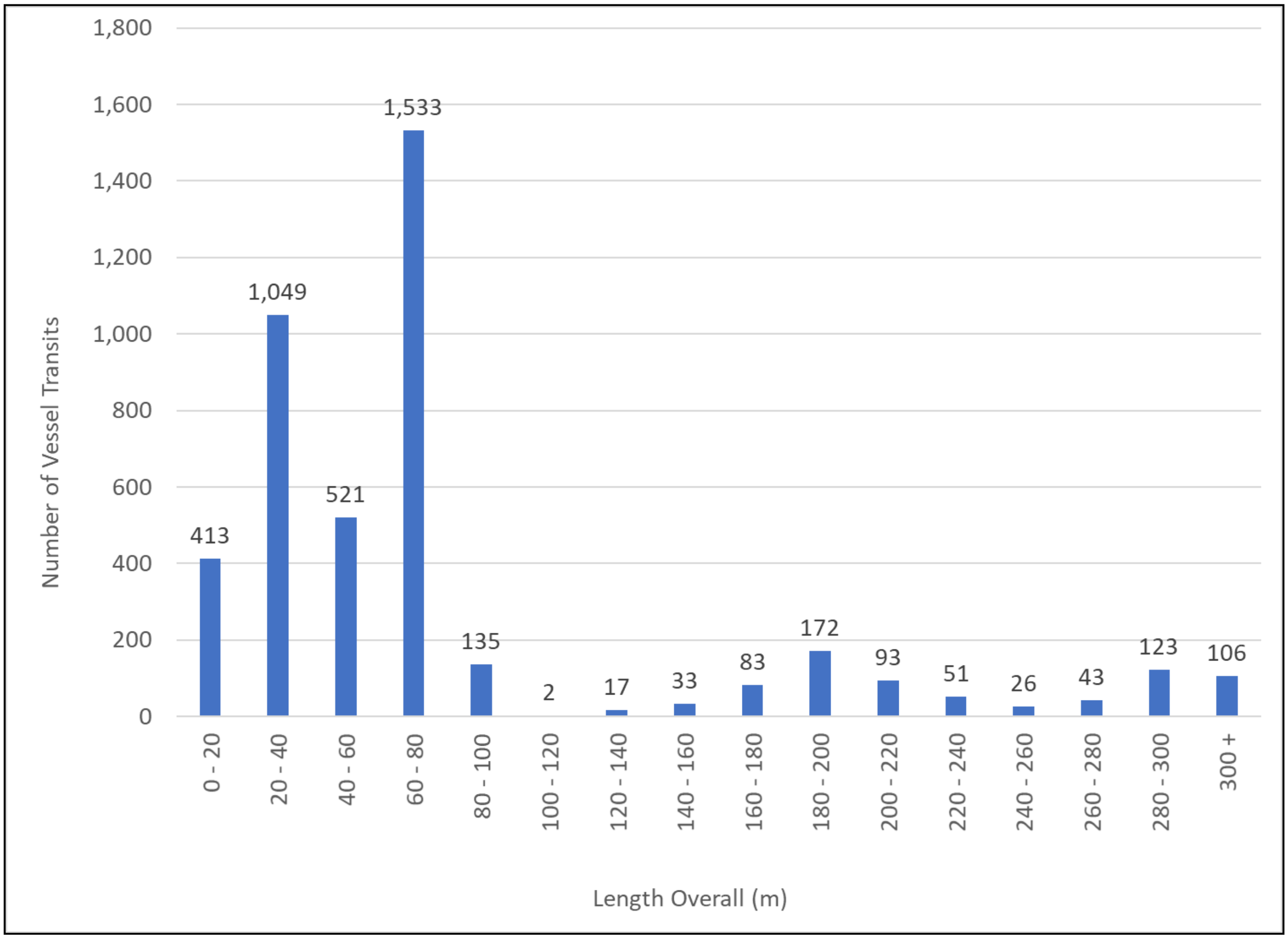


Figure 2-38 LOA distribution within 4.34 NM (8 km) of Project Area[2]

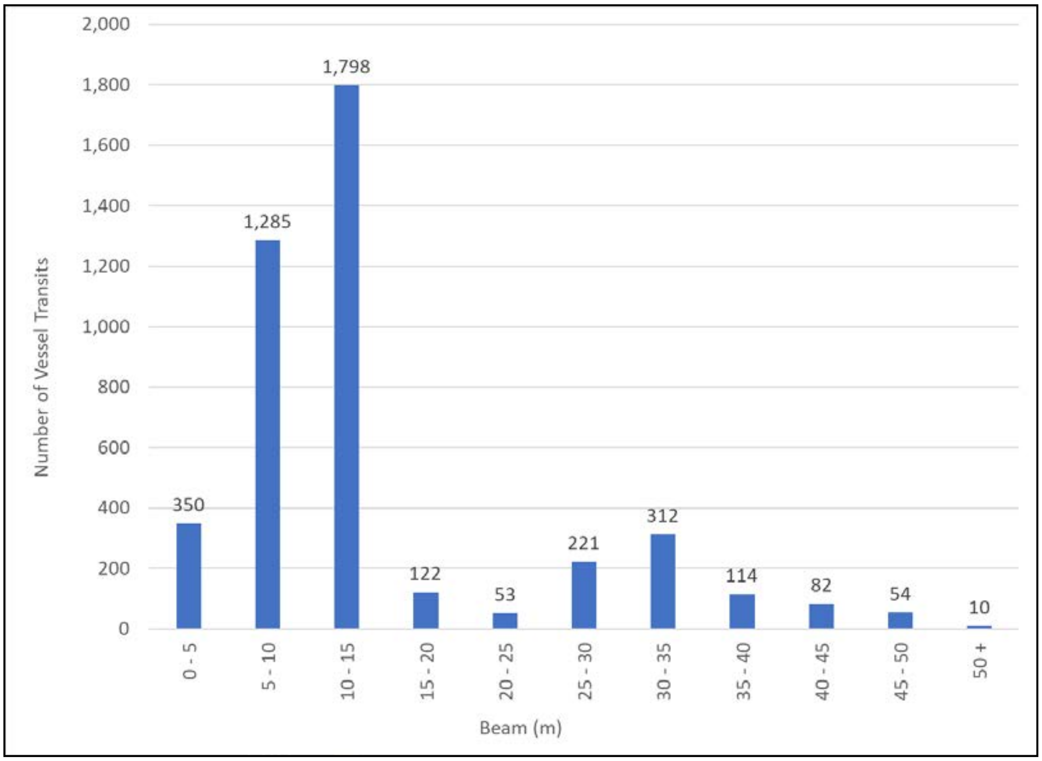


Figure 2-39 Beam distribution within 4.34 NM (8 km) of Project Area[2]

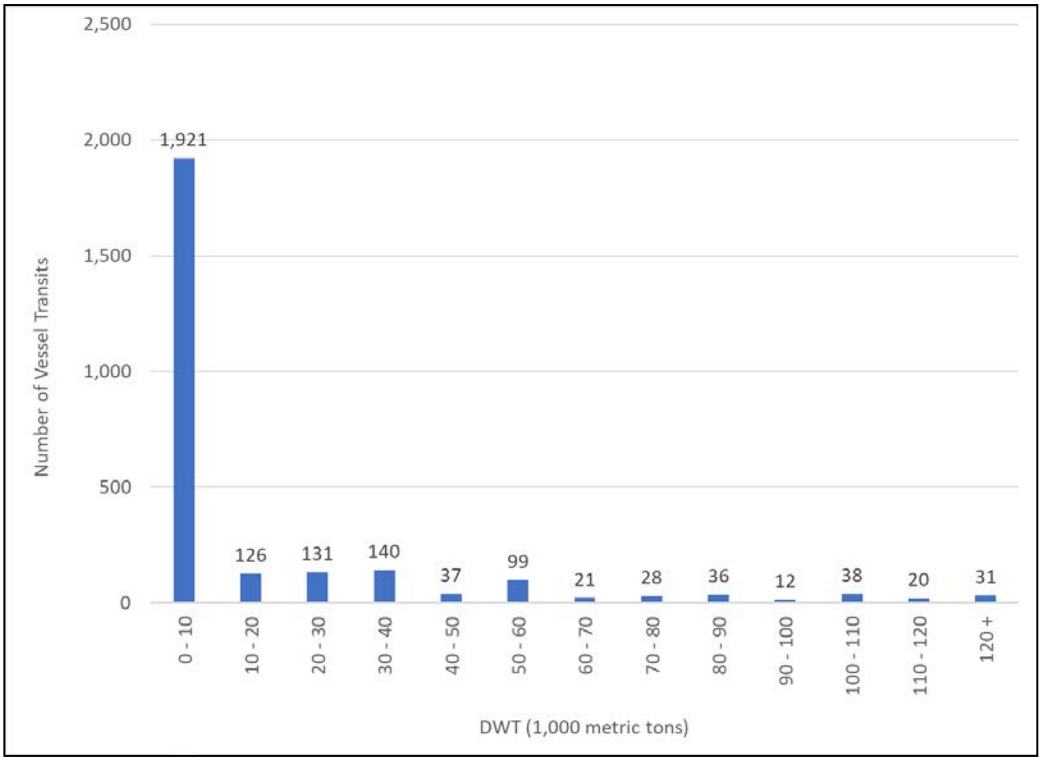


Figure 2-40 DWT distribution within 4.34 NM (8 km) of Project Area[2]

Table 2-1 presents the average LOA, beam, and DWT for vessel types in the Marine Traffic Study Area taken from one year of AIS data (MarineTraffic, 2020). The average is based on the number of tracks rather than the number of vessels. Tankers and cargo/carriers are the largest vessels in the Marine Traffic Study Area.

Table 2-1 Summary of vessel size and track count per vessel type in the Marine Traffic Study Area[2]

Vessel type	Count of AIS tracks	Average LOA	Average beam	Average DWT
Tanker/Tanker - Oil	6,481	751 ft (229 m)	129 ft (39 m)	102,433 metric tons
Cargo/Carrier	12,111	745 ft (227 m)	107 ft (33 m)	48,088 metric tons
Cruise Ships and Large Ferries	5,126	355 ft (108 m)	73 ft (22 m)	1,164 metric tons
Other/Undefined	23,533	181 ft (55 m)	42 ft (13 m)	3,754 metric tons
Tug with Towline	697	106 ft (32 m)	38 ft (12 m)	419 metric tons
Tug	35,341	105 ft (32 m)	35 ft (11 m)	338 metric tons
Fishing	23,580	80 ft (25 m)	24 ft (7 m)	402 metric tons
Pleasure	26,541	64 ft (20 m)	21 ft (6 m)	282 metric tons

Table 2-2 shows the average sizes of vessels within a zone that includes the Project Area plus a buffer of 4.34 NM (8.0 km) around it (Figure 2-41). The vessels are listed in order of decreasing LOA. In this subset of vessels, cruise ships are the largest, as many of the larger cargo and tanker vessels transit further offshore.

Table 2-2 Average LOA, beam, and DWT per vessel type within 4.34 NM (8 km) of Project Area[2]

Vessel type	Count of AIS tracks	Average LOA	Average beam	Average DWT
Cruise Ships and Large Ferries	33	968 ft (295 m)	132 ft (40 m)	9,141 metric tons
Cargo/Carrier	639	789 ft (241 m)	113 ft (34 m)	51,138 metric tons
Tanker/Tanker - Oil	65	573 ft (175 m)	94 ft (29 m)	38,589 metric tons
Other/Undefined	2169	205 ft (63 m)	43 ft (13 m)	1,033 metric tons
Tug	324	123 ft (38 m)	37 ft (11 m)	495 metric tons
Tug with Towline	8	121 ft (37 m)	37 ft (11 m)	538 metric tons
Fishing	901	102 ft (31 m)	29 ft (9 m)	Insufficient data
Pleasure	262	69 ft (21 m)	18 ft (6 m)	154 metric tons

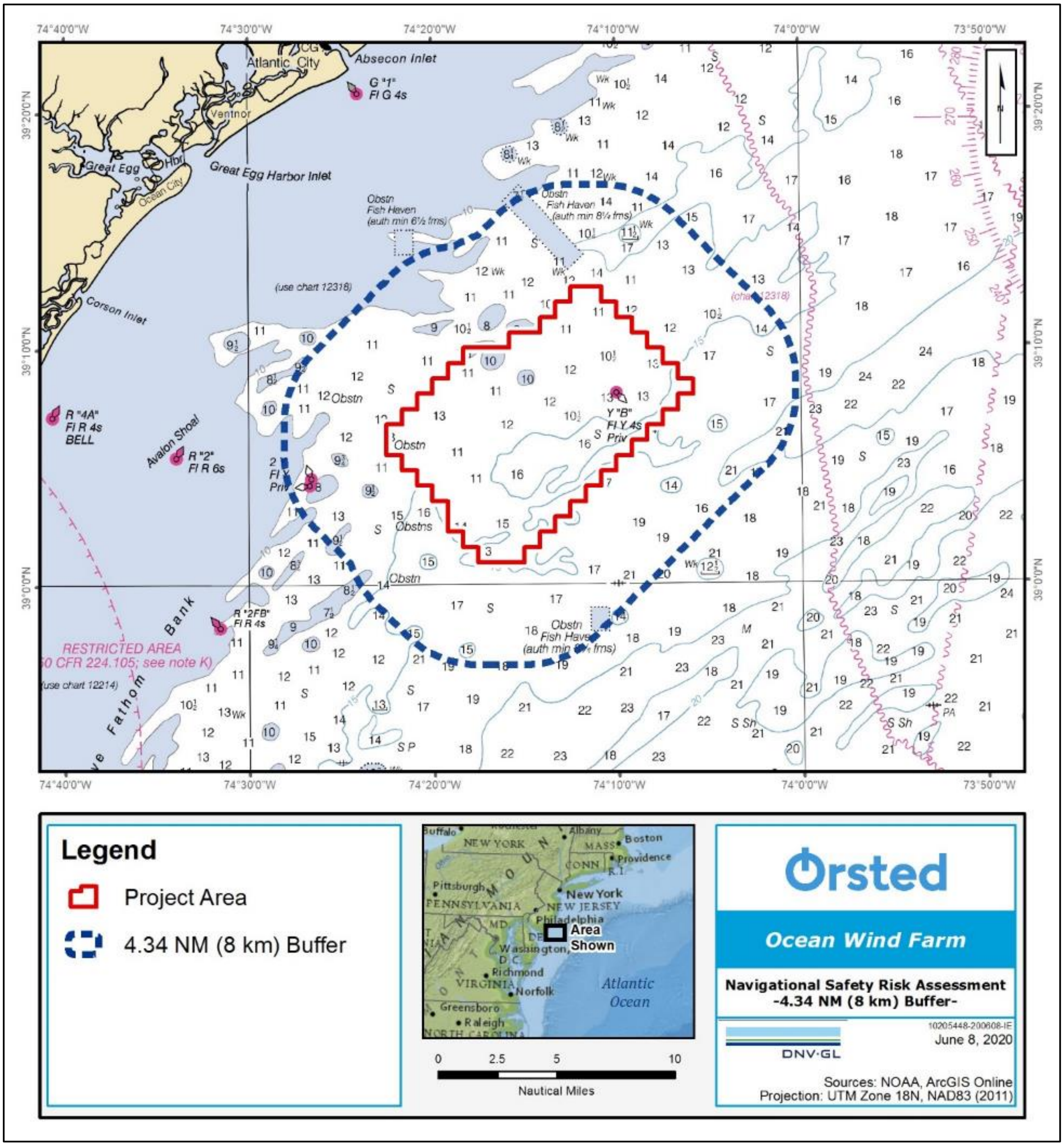


Figure 2-41 Zone defined by 4.34 NM (8 km) around the Project Area[2]

2.1.3.3 Vessel speed

This section characterizes vessel speeds in the Study Area. Figure 2-42 presents speed as calculated from points in the AIS data. The average speeds within the Project Area are notably slower than in other areas, likely due to research vessels supporting the Project.

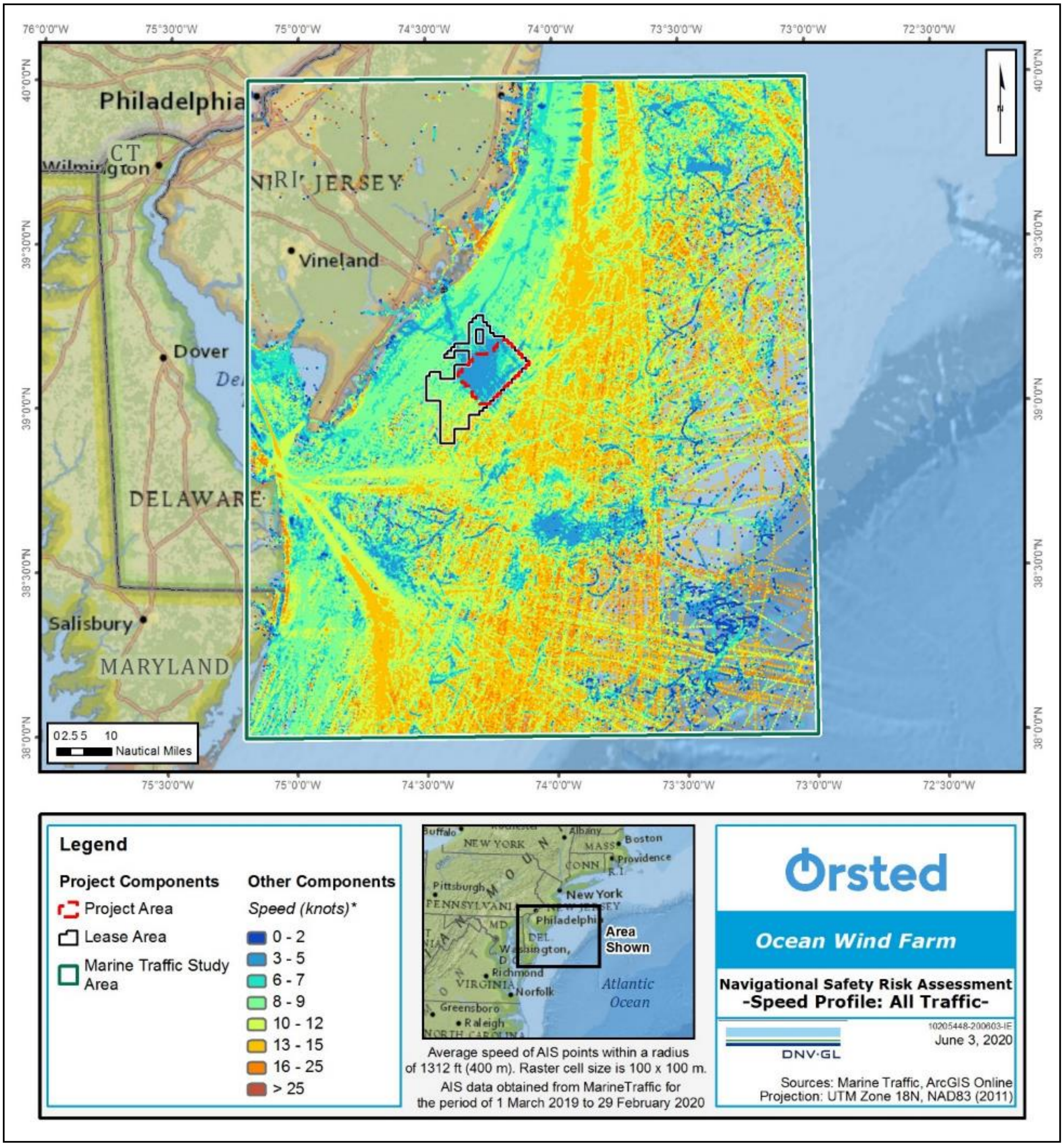


Figure 2-42 Speed profile of all vessels in the AIS data[2]

The average speed of vessels transiting[3] in the Marine Traffic Study Area is 9.3 kt (4.8 m/s) with a standard deviation of 4.7 knots (2.4 m/s). Figure 2-43 shows the traffic speed distribution for each vessel type, limited to speeds between 2 and 45 knots.

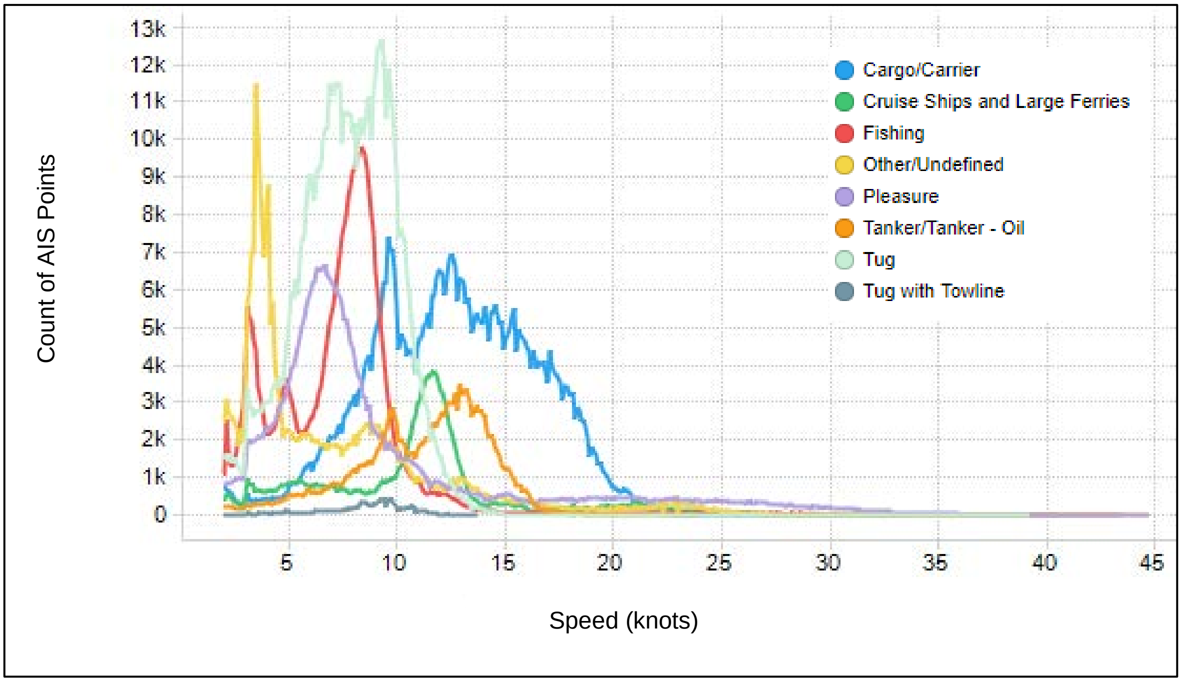


Figure 2-43 Speed profile for each vessel type in the AIS data[2]

2.1.4 Types of cargo

The cargoes arriving and departing at ports in the region include:

- Containerized cargo
- Cars
- Break bulk and bulk commodities (i.e., equipment, steel, wood pulp, petroleum products)
- Refrigerated cargo
- Livestock

[3] Defined for this study as greater than or equal to 2 knots

2.2 Location of the Project in relation to other activities

This section describes the proximity of the Project to navigation-related aspects. Figure 2-44 shows the navigation chart in the vicinity of the Project.

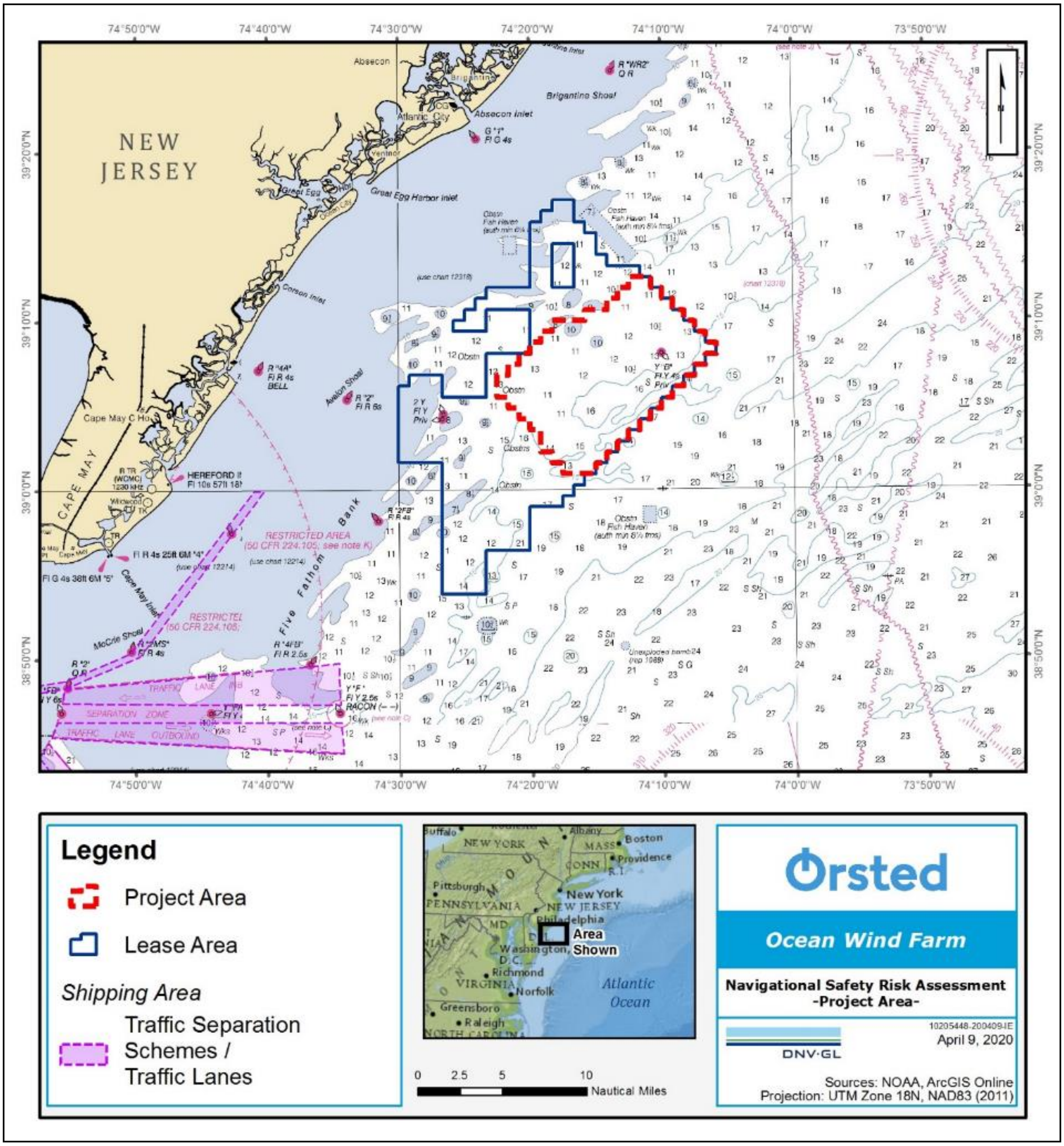


Figure 2-44 Navigation chart in the vicinity of the Project

2.2.1 Proximity to non-transit waterway uses

Table 2-3 provides an overview of the Project's proximity to non-transit uses of the waterway.

Table 2-3 Proximity of the Ocean Wind Farm to non-transit waterway uses

Section in this report	Type of waterway use	Closest proximity to the proposed maximum footprint of the Project (measured from the nearest WTG)
2.2.1.1	Fishing (recreational and commercial)	Occurs within the footprint
2.2.1.2	Day cruising of leisure craft, other recreation, and wildlife viewing	Occurs within the footprint
2.2.1.3	Racing	Identified race courses are approximately 10 NM from the Project Area
2.2.1.4	Aggregate mining	One sand and gravel lease area 10 NM from the Project Area (Great Egg Harbor/Townsends)

2.2.1.1 Fishing

The Project is co-located with commercial and recreational fishing. Figure 2-45 illustrates prime fishing grounds identified by the New Jersey Department of Environmental Protection (NJDEP) in consultation with boat captains hailing from New Jersey ports (NJDEP, 2019). Apart from one small patch in the northeast section, the Project Area has no prime fishing grounds. Prime fishing grounds occur within the western parts of the Lease Area that are outside the Project Area.

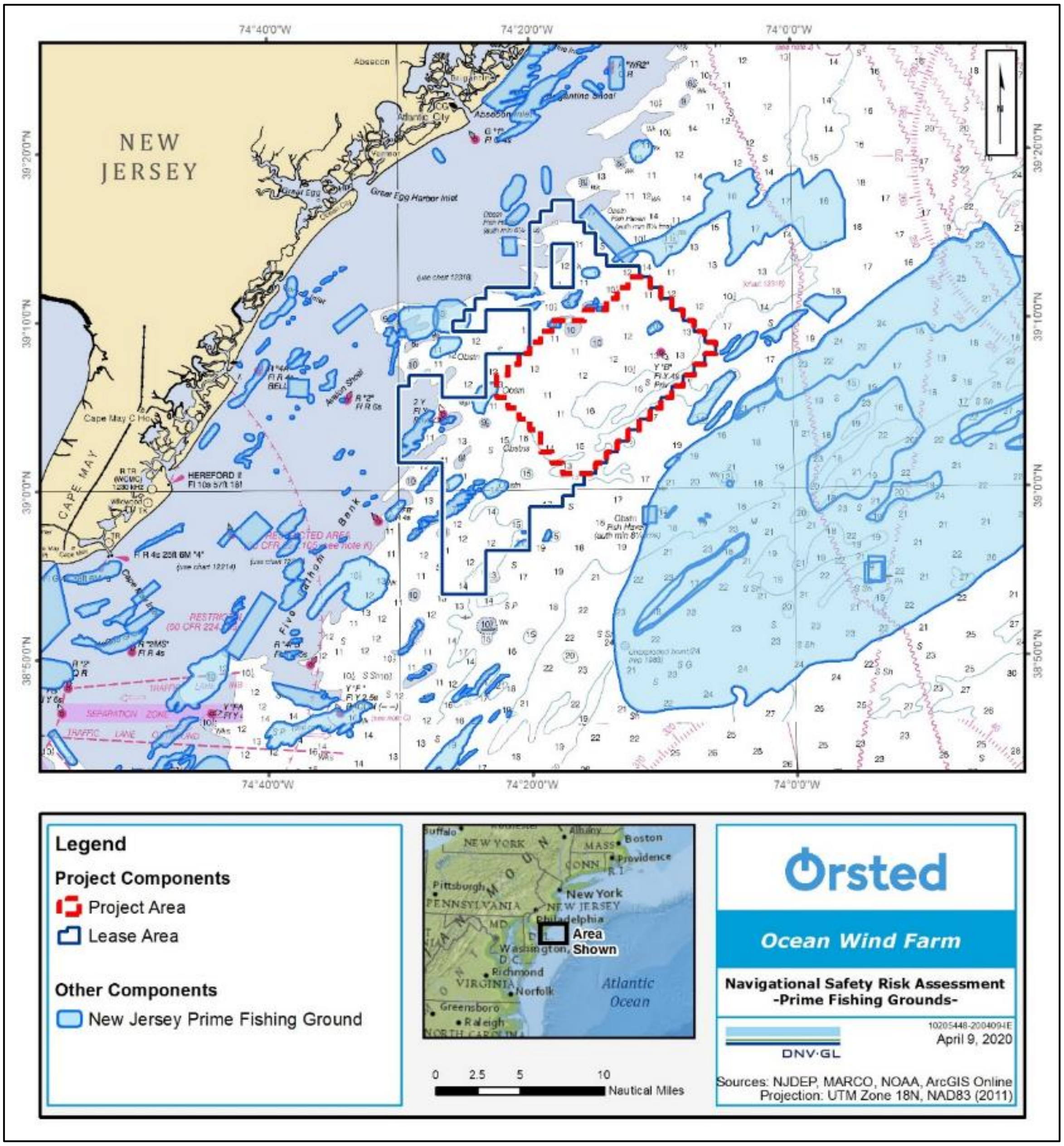


Figure 2-45 New Jersey prime fishing grounds (NJDEP, 2019)

The New Jersey Recreational Use Survey (summary layer obtained from MARCO, 2020) also investigated recreational fishing. The survey collected data through participatory GIS workshops, which mapped 20 different types of recreational uses including fishing, diving/snorkeling, sailing, sport, and wildlife/scenic viewing. The workshops distinguished between "general use" areas (i.e., where a use occurs at least some of the time) and "dominant use" areas (i.e., areas that were regularly used by most participants for a particular activity).

Figure 2-46 shows the areas that were identified as having dominant fishing activities not near shore: "fishing (diving)," "charter fishing (large vessel)," "charter fishing (small vessel)," and "recreational fishing (motor vessel)." No dominant fishing activity was identified in the Project Area; however, some activity was identified to the southeast. It is reasonable to assume that fishing vessels transit through the Project Area to fish.

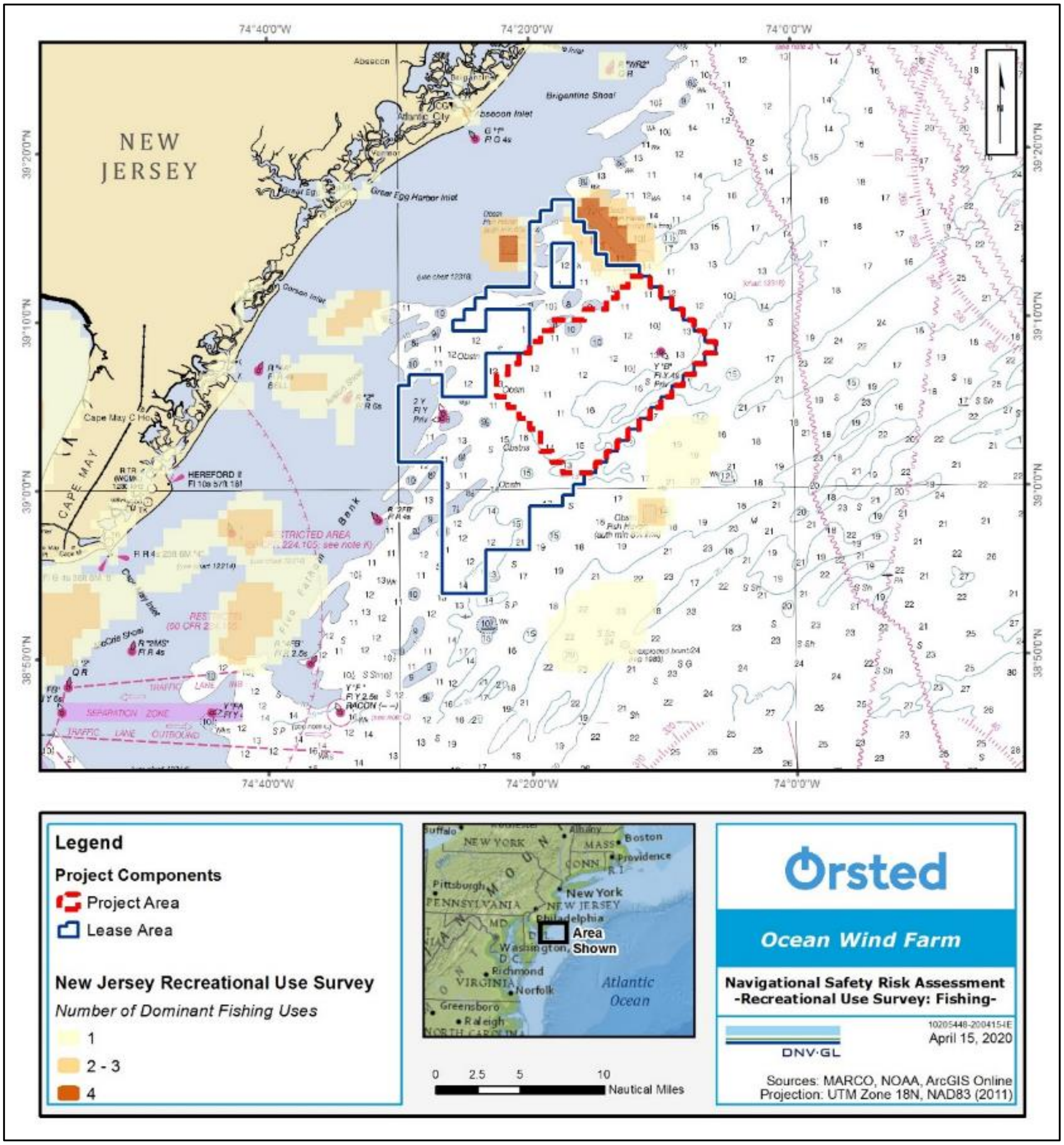


Figure 2-46 Dominant fishing use mapped in the New Jersey Recreational Use Survey (MARCO 2020)

2.2.1.2 Day cruising of leisure craft and other recreational activities

Pleasure and recreational activities in the vicinity of the Project Area are described in the New Jersey Recreational Use Survey (MARCO, 2020). Non-fishing recreational uses are shown in Figure 2-47. Pleasure and recreational craft transits are described in Section 2.1.1.4.

Within the Project Area, only the northeastern edge shows dominant non-fishing recreational use.

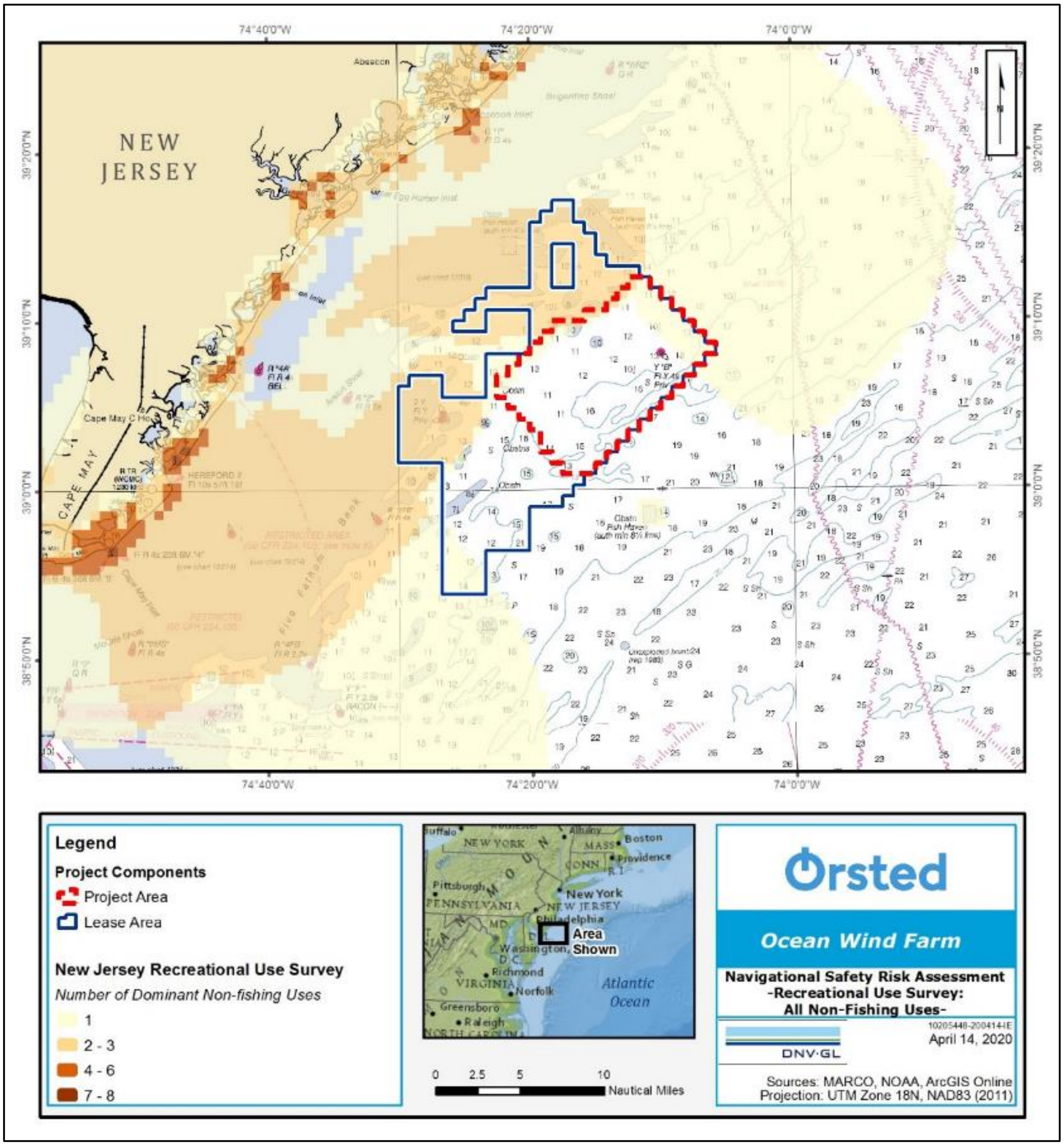


Figure 2-47 Dominant non-fishing use mapped in the New Jersey Recreational Use Survey (MARCO 2020)

Other types of dominant recreational use are shown in Figure 2-48. Diving/snorkeling, which includes the “charter diving/snorkeling” and “scuba diving/snorkeling” categories, occurred in the north and west parts of the Lease Area.

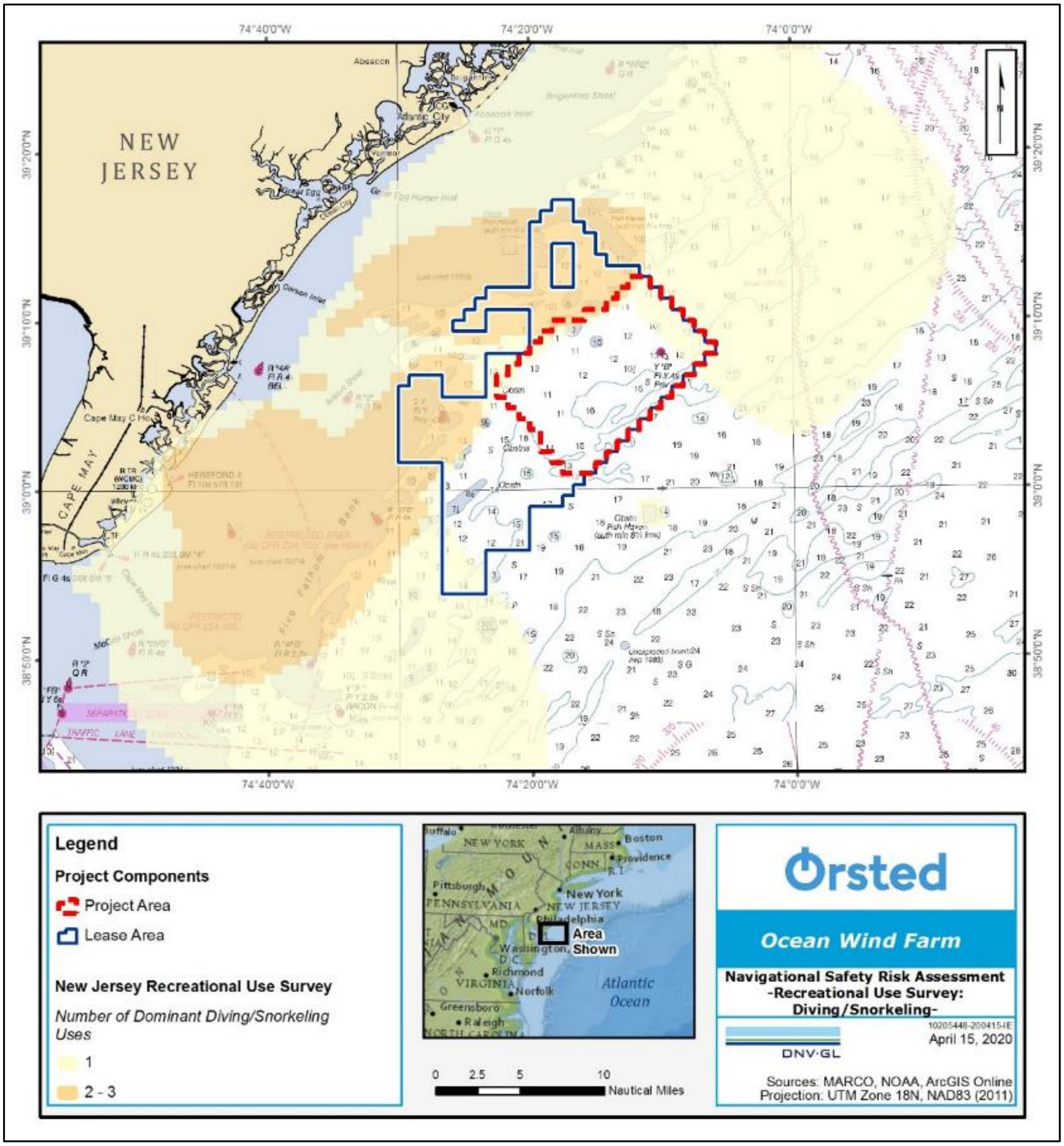


Figure 2-48 Dominant diving/snorkeling use mapped in the New Jersey Recreational Use Survey (MARCO 2020)

The New Jersey survey shows that other dominant uses were not reported in the vicinity of the Project Area, including:

- Wildlife and scenic viewing
- Sailing
- Sport (“kayak/non-motor vessel fishing,” “paddling,” “swimming,” and “surface water sports”)
- Other (“charter/party cruises,” “charter transportation,” and “motorized boating”)

2.2.1.3 Sailing and racing courses

Figure 2-49 illustrates the typical routes of distance sailing races identified in the Northeast Ocean Data Portal (NROC, 2013; RI, 2019). The routes identified in the data portal do not pass through the Project Area.

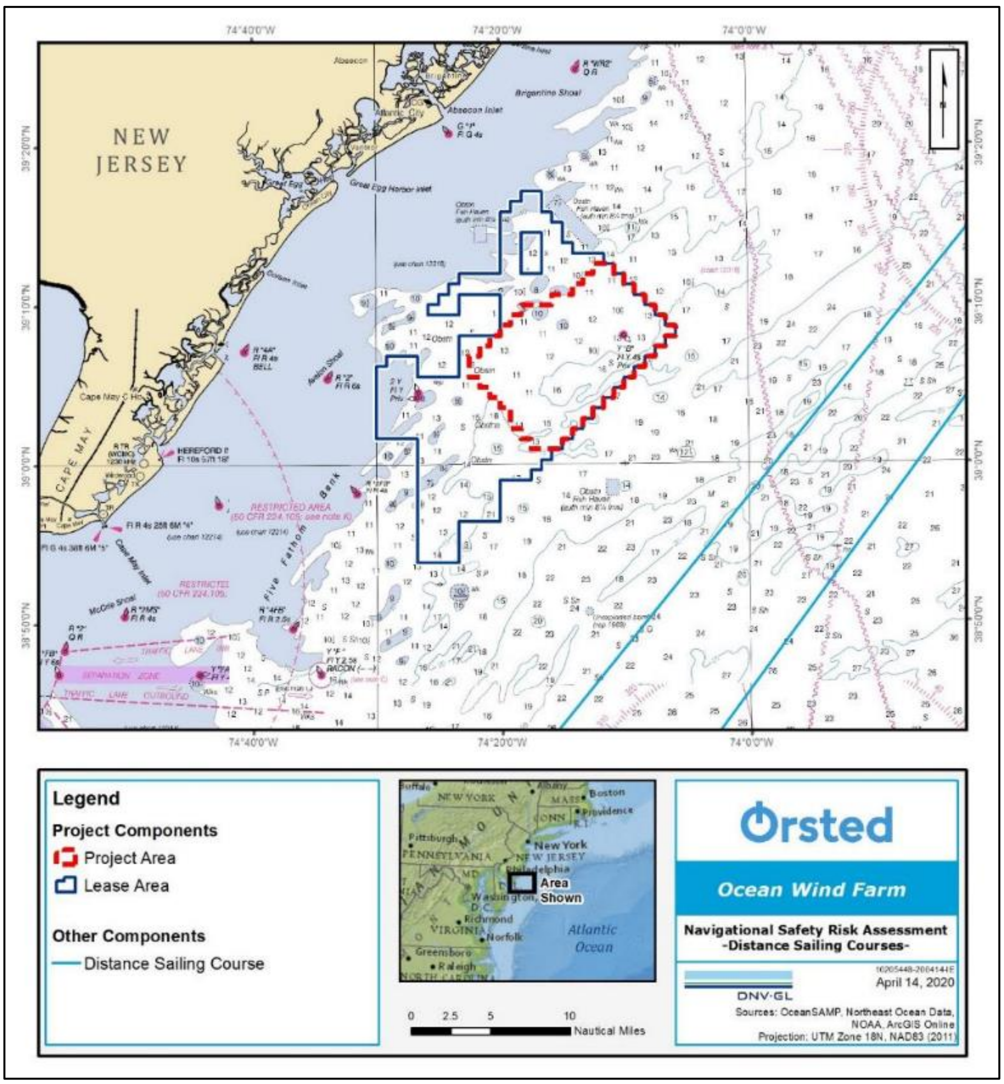


Figure 2-49 Distance sailing race courses (NROC, 2013; RI, 2019)

In addition to the routes in Figure 2-49, the following races were identified that might have routes in the vicinity of the Project (Avalon Yacht Club, 2020):

- Avalon Cup
- Avalon Yacht Club Pursuit Race
- Leukemia Cup
- Cape-to-Cape Challenge

Individual yacht clubs serve as hosts to race events. The following is a non-exhaustive list of the yacht clubs identified along the New Jersey coast in the Marine Traffic Study Area.

- Corinthian Yacht Club of Cape May
- Ocean City Yacht Club
- Avalon Yacht Club
- Greater Wildwood Yacht Club
- Yacht Club of Sea Isle City
- Yacht Club of Stone Harbor
- Yacht Club of Pleasantville
- Brigantine Yacht Club
- Brant Beach Yacht Club
- Surf City Yacht Club
- Little Egg Harbor Yacht Club
- Mallard Island Yacht Club
- Beach Haven Yacht Club
- Barnegat Light Yacht Club
- Laurel Harbor Yacht Club
- High Bar Harbor Yacht Club
- Long Key Yacht Club

Regattas and other marine events in the vicinity of the wind farm may choose to avoid the Project Area. Though safety is a factor, feedback from event organizers indicated that the primary reason for avoiding the Project Area is to promote a leisurely recreational event in open water (Orsted, 2021).

2.2.1.4 Aggregate mining

One sand and gravel lease area, Great Egg Harbor/Townsends, was found 10 NM from the Project Area (Bureau of Ocean Energy Management [BOEM], 2020). The lease, which occupies two discrete areas approximately 1.8 NM off the coast, was proposed in 1998 and is not active.

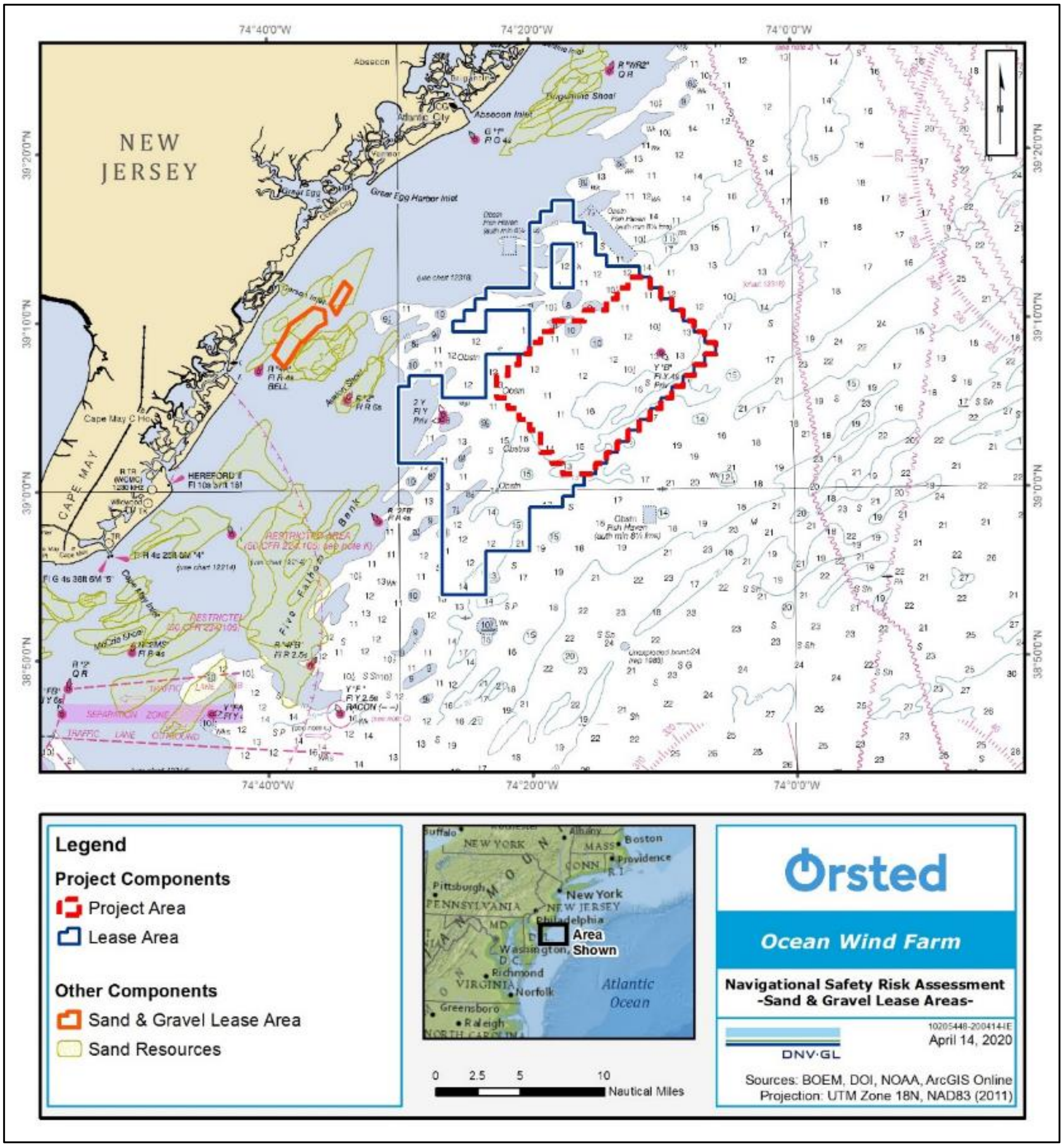


Figure 2-50 Sand and gravel lease areas (BOEM, 2020)

2.2.2 Proximity to transit-related waterway uses

Table 2-4 summarizes the Project's proximity to transit-related uses of the waterway.

Table 2-4 Proximity of the Ocean Wind Farm to transit-related waterway uses

Type of waterway use	Closest proximity to the proposed maximum footprint of the Project (measured from the closest WTG)
Transit routes used by coastal or deep-draft vessels, ferry routes	Deep draft traffic occurs within the footprint. No ferry routes are identified within the footprint. The closest ferry route is 29 NM (54 km) (Cape May – Lewes) from the Project.
Transit routes used by fishing vessels	Occurs within the footprint.
Shipping routes	No international shipping routes are identified within the footprint. The closest route to the Project is the Inbound Five Fathom Bank to Cape Henlopen Traffic Lane, 18 NM (33 km).
Routing measures or precautionary areas	None identified within the footprint. The routing measures that are closest to the Project are the speed restricted area (14 NM, 26 km) and the two-way traffic lane used primarily by tug and barge vessels (15 NM, 28 km). The closest precautionary area is 32 NM (59 km) southwest of the Project.
TSS	None identified within the footprint. The closest TSS is 15 NM (28 km) from the Project, the two-way traffic lane used primarily by tug and barge vessels.
Anchorage grounds or safe havens	None identified within the footprint. The closest designated anchorage is 38 NM (70 km) from the Project, Big Stone Beach Anchorage.
Port approaches	No approaches to major ports identified within the footprint. The closest port is Atlantic City, 14 NM (26 km) west of the Project.
Pilot boarding or landing areas	None identified within the footprint. The closest pilot boarding area is 35 NM (65 km) from the Project.

2.2.2.1 Coastal, deep-draft, and ferry routes

The only identified ferry route within the Marine Traffic Study Area is the Cape May-Lewes Ferry. The route transits roughly parallel to the mouth of Delaware Bay, 29 NM (54 km) from the Project.

Routes used by coastal vessels, deep draft vessels, and ferries are described in Section 2.1.1. Some deep draft traffic passes through the eastern part of the Project Area in a NE-SW direction. However, the AIS data show that most deep draft traffic transits east of the Project Area.

2.2.2.2 Transit routes used by fishing vessels

Transit routes used by fishing vessels may traverse the Project Area and are discussed in Section 2.1.1.2.

2.2.2.3 Shipping routes

International shipping traffic uses the established TSS:

- Five Fathom Bank to Cape Henlopen – The inbound lane is 18 NM (33 km) and the outbound lane is 20 NM (37 km) from the nearest Project structure.
- Delaware to Cape Henlopen – The inbound lane is more than 34 NM (63 km) and the outbound lane is 36 NM (67 km) from the nearest Project structure.

Coastwise shipping primarily transits west of the Project Area, while north-south deep draft traffic primarily transits east of the Project Area. Further discussion is in Section 2.1.1.

2.2.2.4 Routing measures, precautionary areas, and separation zones

Distances from routing measures, precautionary areas, and TSS are listed in previous Table 2-4. All are much farther than the planning guideline distances of 2 NM and 5 NM.

NVIC 01-19 lists site-specific considerations for potential contributions to risk. These were reviewed, and they are accounted for in the risk modeling presented in Section 11. They are:

- High-density traffic areas
- Obstructions/hazards on the opposite side of a route
- Severe weather/sea state conditions
- Severe currents
- Mixing vessel types
- Complex vessel interactions
- Large distances along a route
- Undersized routing measures

Based on the quantified risk assessment in Section 11, the Project does not measurably affect navigation accident risk in any of the TSS in the Marine Traffic Study Area.

NVIC 01-19 also provides a list of potential risk mitigation measures, which either currently exist or are proposed in association with the Project:

> "(a) Mitigating factors include aids to navigation, pilotage, vessel traffic services, precautionary areas, areas to be avoided, anchorages, limited access areas, and other routing measures. Mitigating factors can be used to lower risk in many ways, such as increasing predictability of vessel traffic, increasing local knowledge and expertise, increasing situational awareness, or improving navigation. Proper marking and lighting of the structures of a wind farm can be used for navigation purposes improving the ability to fix a vessel's position;
>
> (b) Low traffic density. Low traffic density will decrease vessel interactions and allow for more space for transiting vessels to maneuver;

(c) Predominantly smaller vessels. If only smaller vessels call on a port or if large vessel transits are very infrequent, smaller planning distances may be appropriate; especially if other mitigations are in place for the large vessel transits, such as tug escorts or moving safety zones;

(d) Distance from ports, shoals, and other obstructions. If there are large distances to other hazards vessels will be able to adjust their route to ensure safe transits; and

(e) Aids to Navigation. Enhanced Aids to Navigation may assist vessels in more accurately determining their position as well as identifying potential hazards."

2.2.2.5 Anchorages, safe havens, approaches, or pilot areas

Figure 2-51 shows the designated anchorages in the area. The closest anchorage is Big Stone Beach Anchorage Ground, located 38 NM (70 km) from the Project. The AIS data does not indicate any significant anchorage activity in the Project Area.

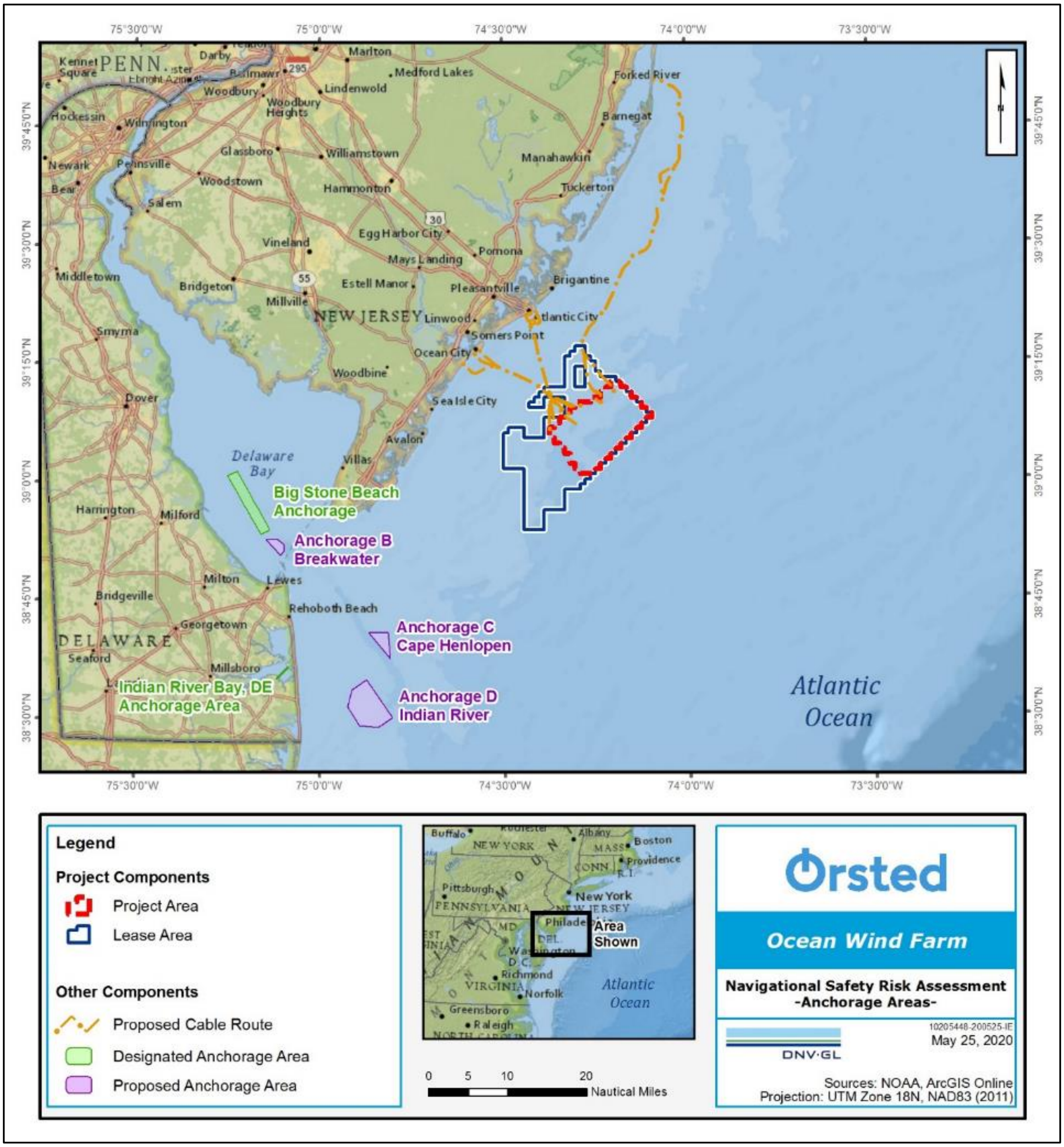


Figure 2-51 Current and Proposed Anchorage areas

Figure 2-52 shows pilot boarding areas in the vicinity of the Project Area. The Project is at least 35 NM (65 km) from the nearest pilot boarding area.

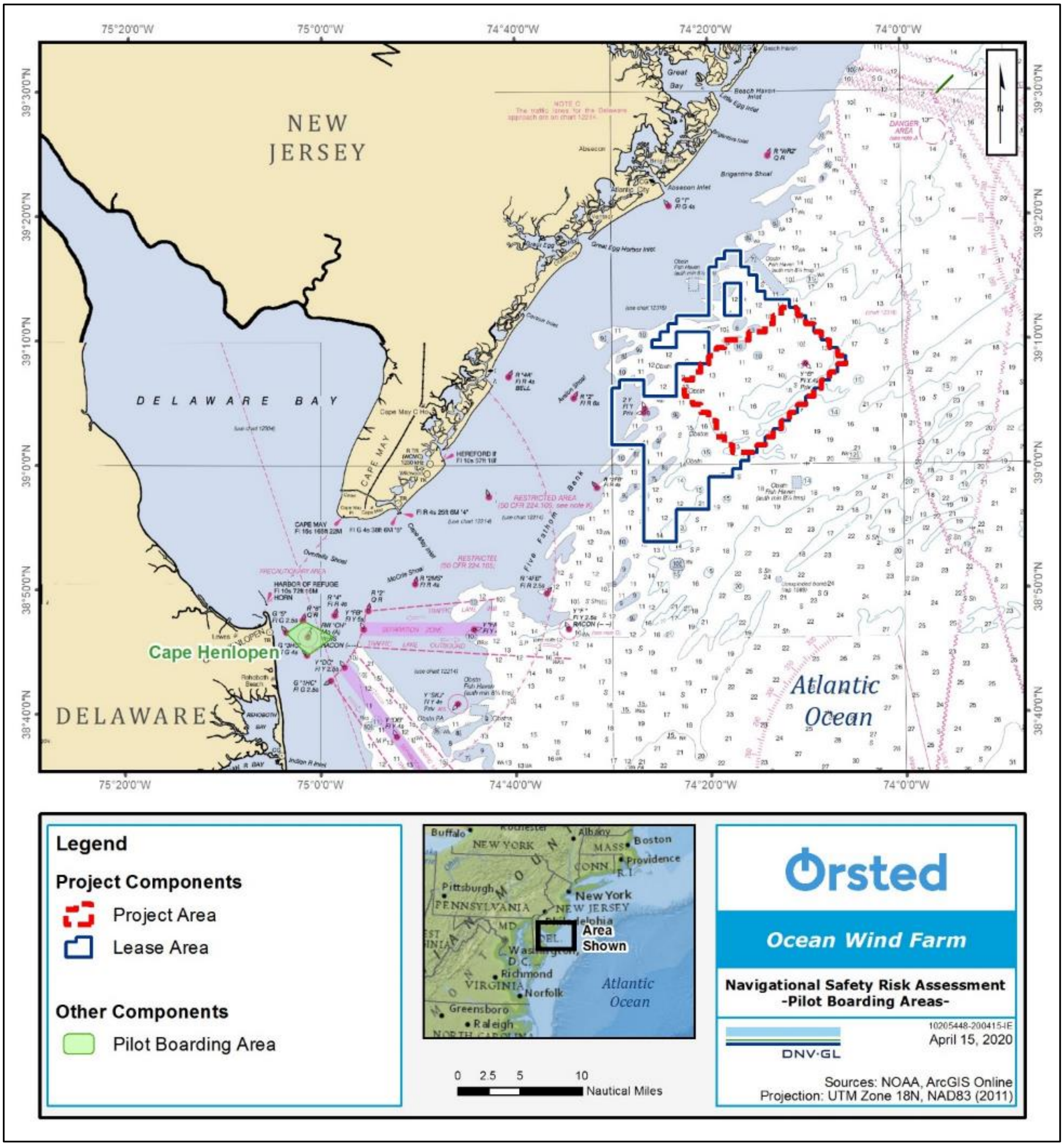


Figure 2-52 Pilot boarding areas

2.2.3 Proximity to other uses of interest

Table 2-5 describes the proximity of the Project to other uses of interest.

Table 2-5 Proximity of the Ocean Wind Farm to other uses of interest

Type of waterway use	Closest proximity to the proposed maximum footprint of the Project (measured from the nearest WTG)
Fishing grounds or routes used by fishing vessels to fishing grounds	Occurs within the footprint. Routes that fishing vessels in AIS take through the wind farm to, for example, prime fishing areas, are discussed in Section 2.1.1.2.
Within the jurisdiction of a port or navigation authority	None identified within the footprint.
Offshore firing/bombing ranges or areas used for military purposes	The Project is within the Atlantic City Operations Area. It is also within military regulated airspaces W-107A and W-107C, which are used for surface-to-air gunnery exercises. The Project is more than 100 NM (185 km) from identified submarine transit lanes.
Existing or proposed offshore renewable energy facility, gas platform, or marine aggregate mining	None identified within the footprint. Figure 2-53 shows energy-related facilities. Four leased areas for offshore energy are in the Marine Traffic Study area. The closest of these is BOEM Lease Block OCS-A 0499, which is adjacent to the Project's northeast edge. The three other BOEM leases within the Marine Traffic Study Area are southwest of the Project: OCS-A-0482 located 23 NM (43 km) away; OCS-A-0499 located 29 NM (54 km) away; and OCS-A-0519 located 41 NM (76 km) away. One sand and gravel lease area 10 NM is from the Project Area (Great Egg Harbor/Townsends); however, the project is not currently active. No oil or gas lease areas were identified within the Marine Traffic Study Area.
Existing or proposed structure developments or existing designated offshore disposal areas	No other existing or proposed non-energy structures were identified within the Marine Traffic Study Area. No disposal areas were identified within the footprint. The closest designated disposal area is 1.2 NM (2.2 km) from the Project Area.
Aids to navigation (ATON) and/or Vessel Traffic Services	The closest Federal ATON is Avalon Shoal Lighted Buoy 2, which is 9.1 NM (17 km) from the Project. There is one private buoy located within the Lease Area and another located 3.8 NM from the Project. No negative effects from the Project are anticipated on existing ATON. Section 9 provides further discussion concerning ATON. The closest Vessel Traffic Service is the Vessel Movement Reporting System (VMRS) New York.

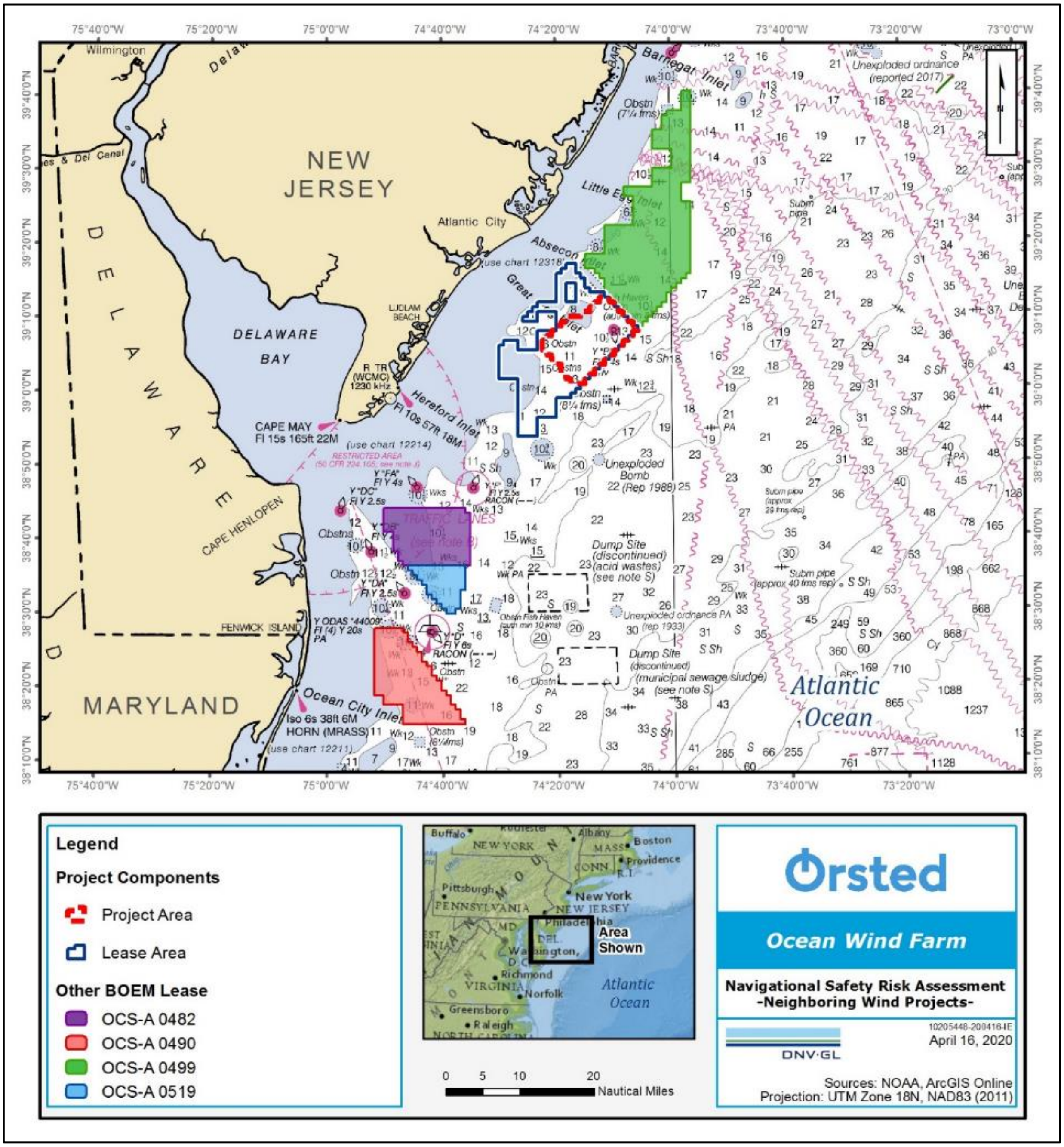


Figure 2-53 Existing BOEM leases for offshore wind projects in the Marine Traffic Study Area

2.3 Anticipated changes in traffic from the Project

Reasonably foreseeable changes to marine traffic resulting from the Project include:

1. Additional non-Project traffic that might be generated by the presence of the wind farm.
2. The modification of traffic routes for some ship types due to the presence of wind farm structures.
3. Project-related vessel traffic related to operations and maintenance activities. Project traffic is not explicitly included in the risk model; however, it appears to be more than offset in the AIS data by Project-related vessel traffic performing site surveys and other site characterization studies. The majority of Project-related traffic will originate and terminate at the port of Norfolk, Virginia, though other ports such as Baltimore, Maryland or the proposed New Jersey Wind Port in Paulsboro, may also support the project. Project vessel routes are described in the COP Section 6.1.

Each is described below.

2.3.1 Additional traffic added to the Future Case

The traffic patterns and statistics described in Sections 2.1 and 2.2 are based on AIS data and qualitative descriptions of non-AIS traffic. For the purposes of quantitative modeling, the below traffic adjustments are made to the Future Case MARCS model, with the Project.

It is anticipated that there will be public interest in the Project that could potentially lead to pleasure vessel trips to the Project Area and a potentially similar increase in recreational traffic (including recreational fishing). It is difficult to estimate a precise number of vessels per year that will be added to local traffic patterns. The following was assumed:

- Additional pleasure vessel trips for recreation. The potential exists for the Project to attract recreational boaters for fishing or other recreational uses. Since data is not available on which to base an estimate of future recreational trips, a reasonable upper bound was based on simple assumptions: (1) ten trips per day for (2) half of the year because of the strong seasonality associated with pleasure vessel transits (see Section 2.5). The resulting estimate is an additional 1825 round trips; 3650 total transits per year.
- Additional pleasure vessel trips for sight-seeing. One hundred trips per year; two hundred transits per year.

These are conservatively high estimates for the first operational year of the Project. As time passes, there could be less traffic due to wind farm tours and the increase in vessels may diminish. This study aims to present a conservative case with the most possible traffic, as opposed to an average traffic scheme over a longer period.

2.3.2 Modification of traffic routes in the Future Case

Currently, some shipping routes traverse the area where the wind farm is to be constructed. Many ships will choose not to navigate through the wind farm. At this time, the extent to which they will adjust their course is a matter of speculation. DNV GL developed alternative routes for vessels to avoid the wind farm footprint and to minimize additional navigation while taking into account the existing TSS.

Deep draft ships (e.g., cargo/carrier, tankers, cruise ships) and tug/service vessels whose routes in the AIS data intersected the Project Area were re-allocated to modified routes around the Project for the Future Case. Tugs were routed to the west of the Project Area (coastal routes) and deep draft vessels were routed to the east of the Project Area (ocean routes).

The remaining traffic types (fishing, other, and pleasure) continue to navigate through the wind farm in the Future Case, and were assumed to use the same routes in the Future Case as in the Base Case.

The USCG published an advance notice of proposed rulemaking requesting comments on the possible establishment of shipping safety fairways along the Atlantic Coast of the U.S. (85 FR 37034). NVIC 01-19 does not require an NSRA to evaluate the potential effects on navigation safety from possible changes to existing regulations.

This assessment does not assume that any of the traffic in the Base Case or Future Case is rerouted on the possible safety fairways. Several factors influenced this decision:

- It is unclear how the possible safety fairways would be implemented (e.g., they are unlikely to be mandatory).
- It is uncertain whether the currently proposed safety fairways would be implemented as they are currently proposed, if they would be modified based on comments, or modified based on USCG's deeper analysis of the fairways' effects on the safety of shipping in the region.
- It is unclear, if implemented as currently proposed, the proportion of each vessel type that would take each fairway.

2.4 Effect of vessel emission requirements on traffic

The International Maritime Organization (IMO) implemented limits on sulfur (SO_x) emissions in defined Emission Control Areas (ECA) in North America and other locations (IMO, 1997). Since 1 January 2015, vessels in international trade must use fuel with a maximum of 0.10 percent sulfur content when within 200 miles of the U.S. coast (or comply by controlling emissions) (Figure 2-54). Typically, vessels switch to the more expensive low-sulfur fuel prior to entry into the ECA, which is expected to have no effect on traffic patterns in the vicinity of the Project.

Additional fuel restrictions came into effect on 1 January 2020. The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI (IMO, 1997) contains a global requirement regarding fuels used in ships in international trade. Ships using fuel oil must have a maximum of 0.50 percent (mass basis) sulfur content in their fuel or be fitted with an approved equivalent means of compliance, such as a scrubber. Switchover to lower sulfur fuel for inbound traffic will continue to take place outside the ECA boundary. Not many inbound deep draft vessels transit near the Project Area. The risk of loss of propulsion near the Project due to switchover is below a level that is reasonably quantified in a risk model.

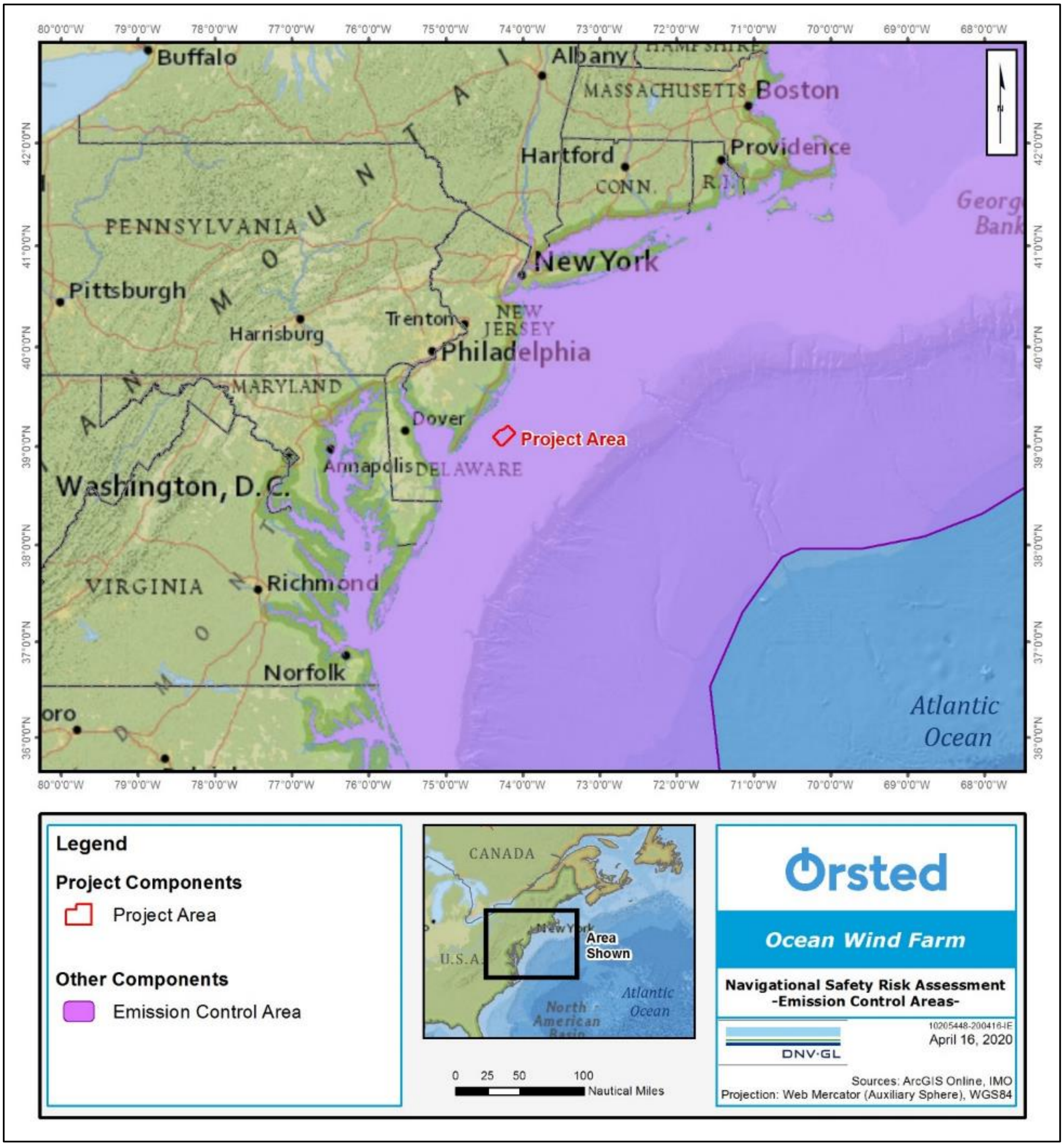


Figure 2-54 Project Area and boundary of the North American Emission Control Area

2.5 Seasonal variations in traffic

The AIS dataset used in this assessment covers a time span of one year. Seasonal variations in traffic were analyzed by comparing the annual average number of tracks to the value for each season and for each vessel type.

Figure 2-55 and Figure 2-56 show the number of transits per season per vessel type for each of the route transects.

In general, traffic is significantly higher in the summer and lowest in the winter. In the year of data, summer increases were the greatest for pleasure and other/undefined vessel types. Traffic for fishing vessels was also notably higher in both the summer and fall relative to the winter and spring.

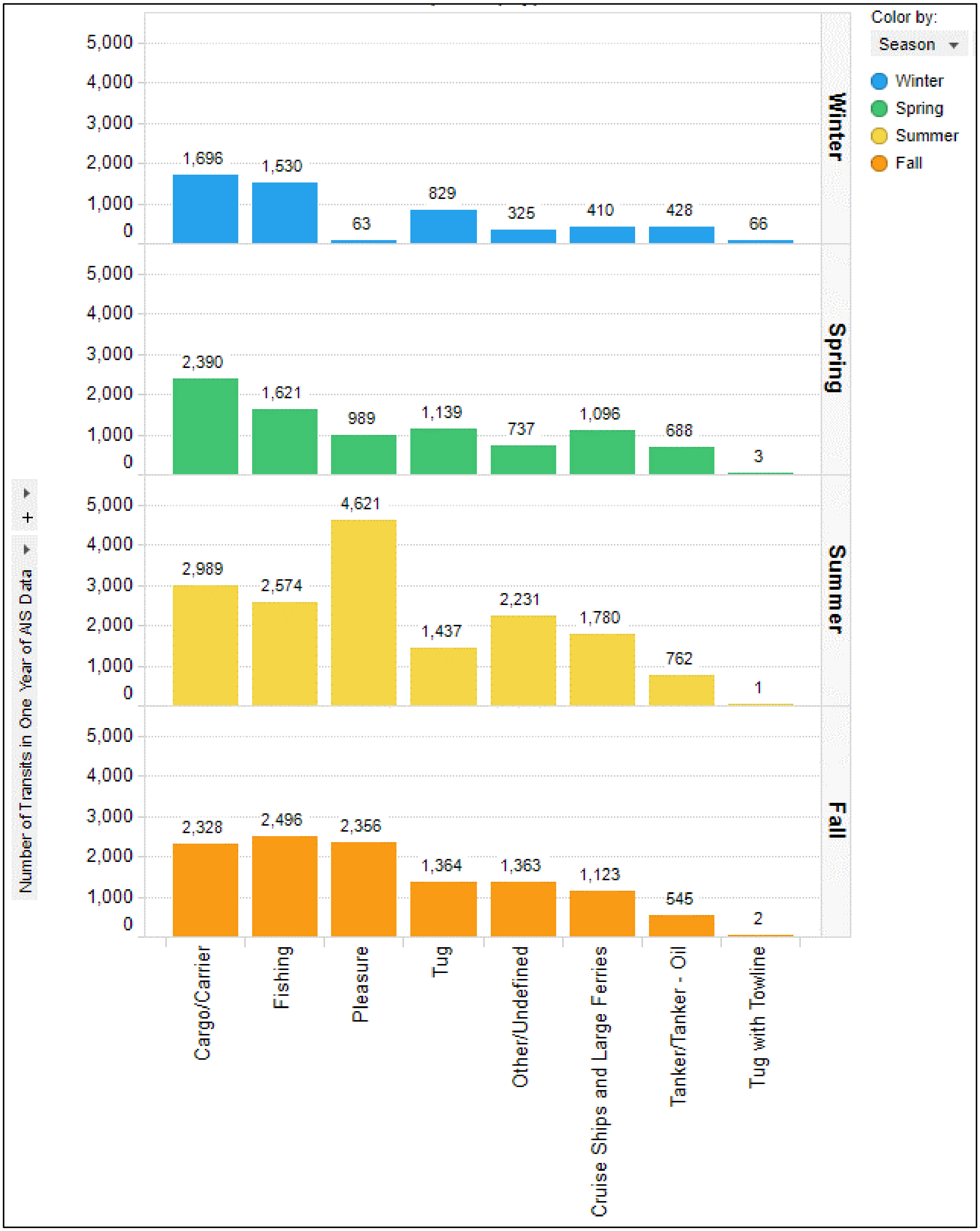


Figure 2-55 Seasonality of vessel transits per vessel type[2]

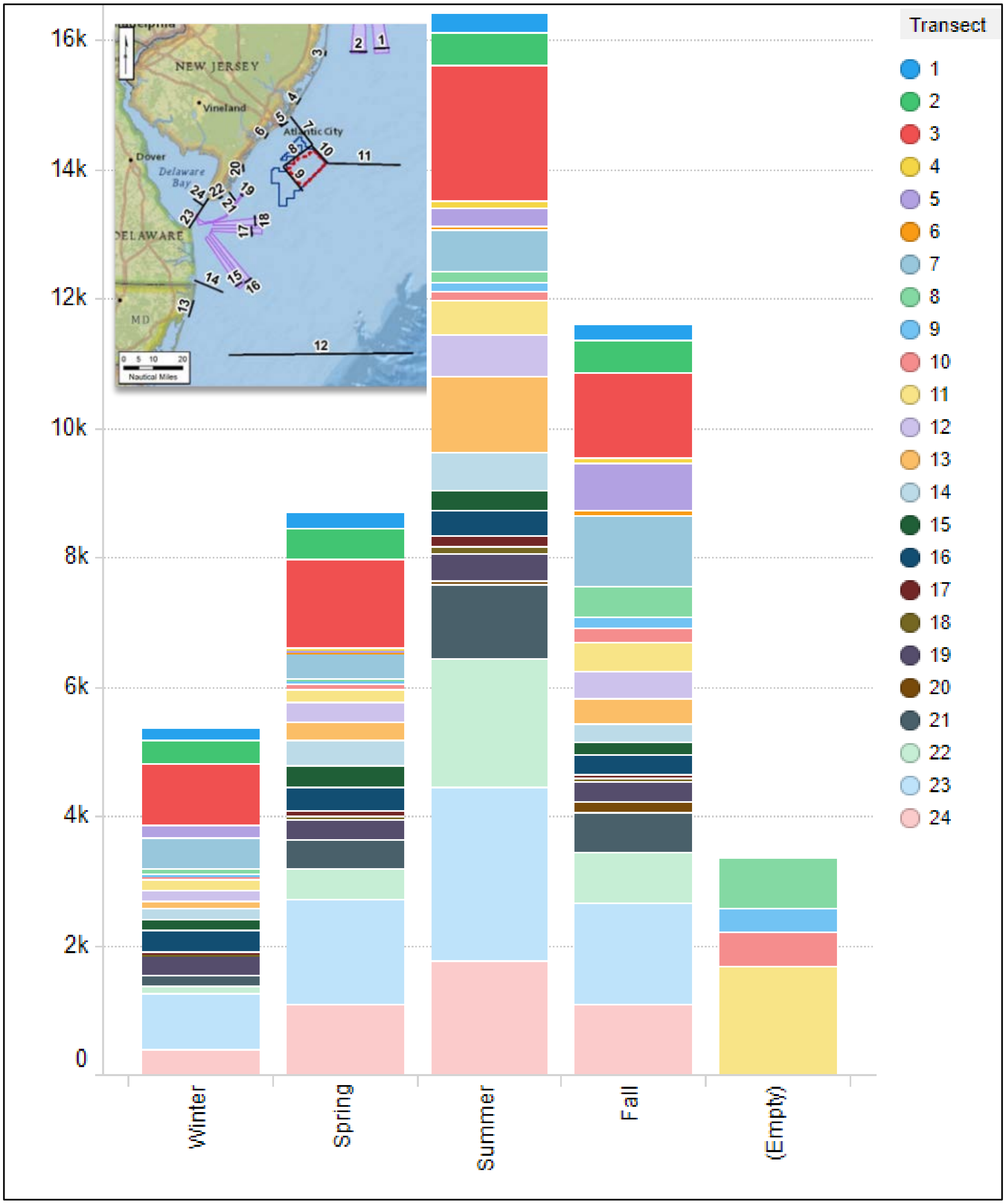


Figure 2-56 Seasonality of vessel tracks crossing all route transects[2]

Key conclusions concerning seasonality of traffic are:

1. Several vessel types show significant increases in the summer and/or fall with spring transits higher than winter transits:
    - Pleasure vessel transits had the strongest seasonal increase of any of the traffic types. Transits across the entrance of Cape May Harbor (transect 22) showed the greatest increase.
    - Fishing vessel transits were significantly higher in the summer and fall, though a few transects deviated from the overall trend. For example, the number of transits through the mouth of Barnegat Bay (transect 3) was flat across all seasons.
    - Cruise ships and large ferries. The vast majority (93 percent) of annual cruise ship and large ferry vessel traffic passed between Cape May, NJ and Lewes, DE (transect 24).
    - Other and undefined vessels
2. Cargo/carrier, tugs, and all types of tanker traffic were slightly lower in the winter, but otherwise relatively flat.
3. Tugs with towlines were the only vessel type showing more transits in the winter than in other seasons. However, the number of transits was significantly less than other vessel types, so while the percentage increase in the winter was high, the magnitude of the increase was relatively small.

In addition to the data analysis, local mariners were engaged to capture their views concerning the potential impacts of the Project on navigation. A summary of these discussions is included in Appendix C.

3 OFFSHORE ABOVE WATER STRUCTURES

This section describes:

- Hazards posed by Project components to vessels
- Project clearances and vessel types
- Emergency rescue activities in the Project Area
- Noise from the Project
- Potential damage to Project components from allision by a passing vessel

3.1 Hazards to vessels

The hazards posed to vessels from the Project are:

- **Air gap** – WTG blades could pose a hazard to a vessel with a mast or other structural component taller than 20 m (66 ft) above Mean Higher High Water (MHHW). The OSS platform could pose a hazard to a vessel with a component taller than 39 m (127 ft) above MHHW. (Orsted, 2021) Section 3.2 discusses this risk.
- **Keel clearance** – A jacket leg could pose a hazard to a deep draft vessel depending on the hull shape if the vessel was extremely close to the jacket leg. Vessels passing at a safe distance per COLREGS will be well away from the jacket legs. The primary scenario of concern for keel clearance would be allision with the jacket near the waterline. Section 6 discusses water depths.
- **Subsea (buried) cable** – A subsea cable could pose a hazard to a vessel if an anchor penetrated the seabed to the depth of the cable at a cable location or impacted cables that are otherwise protected. See further discussion below.
- **Stationary object at / near the waterline** – The sea level portion of Project foundation with associated J-tubes could pose a hazard to: (1) a vessel on course with the foundation or (2) a vessel adrift and being pushed (primarily by the wind) toward the foundation. Section 11.1 discusses the consequences of an allision with a Project structure and Section 11.1.1 presents an estimate of the frequency of an allision with a Project structure.
- **Radar clutter** – WTGs and the movement of turbine blades can potentially interfere with communication signals from radio and radar transmitters by either blocking or reflecting the signals. See discussion in Section 10.2.
- **Noise** – Sound from Project components will add to background noise levels. See discussion in Section 3.4.
- **Mobile and fixed gear fishing techniques and Project structures** –Fishing gear in the Project Area could snag on a foundation or ancillary components on the outside of a foundation such as J-tubes. This assessment has not been able to identify any documented occurrences of gear snags that have caused a vessel to lose stability, but the possibility cannot be ruled out. Sufficient sea room for a vessel actively fishing should consider WTG spacing and the turning circle of the vessel

with gear. As discussed in Section 2.1.1.2, the data indicate that dredging for the surfclam/ocean quahog and pots and traps are the two most prevalent fishing activities in the Project Area.

A typical hydraulic clam dredge in depths such as the Project Area will have a towline length of approximately three times the water depth (Meyer, et. al., 1981). Although most of these dredges haul back rather than turn with gear (Orsted, 2021), a general rule of thumb is that the turning circle of a deep draft vessel is, at most, five times its LOA (IMO, 2002). Given that vessels typically transit at slower speeds when actively fishing, the assumptions applied should provide a sufficient margin of safety when applied to vessels permitted for fishing in the Project Area.

For purposes of illustration, the effective horizontal length is approximately 310 m (1,020 ft; 0.16 NM) for a medium-sized, 80 m (148 ft) LOA hydraulic dredge vessel (Meyer, et. al., 1981) in waters approximately 80 m (148 ft) in depth. If the vessel and gear were in line and fixed in relationship to each other, like a tanker, the resulting turning radius at cruising speed would be 0.83 NM (1,550 m; 5,085 ft). The actual turning radius of a fishing vessel would be smaller given the flexibility of the towline, proportionally less mass per size than a tanker, and vessel speed less than 4 kt, which are more typical of fishing activity.

On the basis of vessel speed and the above generic evaluation of turning radius, the Project layout with a minimum of 0.8 NM between offshore structures (Orsted, 2021) is estimated to provide sufficient sea room for safe navigation of vessels engaged in fishing within the Project Area; however, depending on the exact gear length and type that is utilized, the distances between structures may limit safe fishing patterns within the Project Area.

- **Mobile gear fishing techniques and subsea cables** – These techniques are employed in the vicinity of the Project. These techniques present an additional potential hazard from mobile fishing gear and operations potentially damaging Project submarine power cables by penetrating the seabed or impacting unburied cables that are otherwise protected. The fishing activities that pose a risk include bottom trawling and shellfish dredging. Both activities are expected in the vicinity of the Project Area and export cable. Risk control options include:
    - Assurance that the cable is buried at sufficient depth for any gear type, and/or
    - Adequately protecting cable that cannot be buried to target burial depth, and/or
    - Using gear that has limited penetration depth in the wind farm.

  To reduce the likelihood of interactions between fishing activities and a subsea cable, the Bureau of Ocean Energy Management recommends a minimum burial depth of 3.28 ft (1 m) and at least a single armor layer (BOEM, 2011).

  A study by Stostek et al. (2017) measured penetration depths of various types of fishing gear (Table 3-1). The Project has committed to a 4- to 6-ft (1.2 to 1.8 m) target cable burial depth when possible (Orsted, 2021). A cable burial risk assessment will be conducted for the Project, and the results of that study will inform the target depth for the cables.

Table 3-1 Penetration depth of trawl boards, beam trawls, and scallop dredges (Szostek et al., 2017)

Substrate	Penetration depth
Fine sand	< 1.3 ft < 0.4 m
Fine clay	< 1.3 ft < 0.4 m
Coarse sand	1.6 ft 0.5 m

3.2 Vessel clearances from project components

The *air draft* required by a vessel is the distance between the waterline and the highest point on the vessel. The *air gap* is the distance of clearance between the water's surface and an obstruction, most frequently a bridge but for Project purposes is defined as the distance of clearance between the water's surface as MHHW and the lowest part of Project structure.

The Project WTG air gap is 20 m (66 ft) (depicted in Figure 3-1) and the minimum OSS air gap within the PDE would be provided by the monopile foundation, 39 m (127 ft) (Orsted, 2021). Per standard marking requirements, all WTG foundations will indicate the as-built air gap on the structure, similar to that depicted in Figure 3-2, a photo of a Block Island Wind Farm WTG. See Section 13 for further discussion on markings on structures.

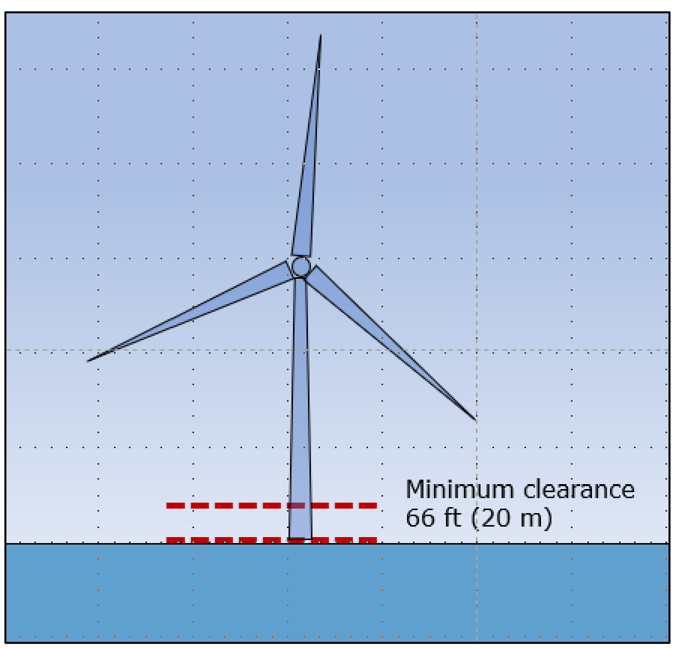


Figure 3-1 Illustration of air gap

Figure 3-2 Photo of air draft marking on a wind turbine

The restricted air clearance between the WTG blade and foundation exists only within a narrow range of distance from the structure as illustrated in Figure 3-3 and the distance depends on the rotation speed. For purposes of illustration, the tips of WTG blades on an 8 MW turbine are about 10 m to 25 m (33 to 82 ft) away from a monopile (Ostachowicz et al., 2016).

Figure 3-3 Illustration of blade tip distance from monopile

Comparing this distance to the types of vessels in the AIS dataset, the following vessel types could have air drafts that exceed the Project envelope, and therefore could be exposed to the hazard from a blade:

- Oil Tanker
- Tanker
- Cargo/carrier
- Sailing vessels with masts taller than the air draft of the selected wind turbines

These vessels are not expected to transit through the wind farm, in line with safe practices (IMO, 1972).

3.3 Emergency rescue activities and project components

The Coast Guard will provide search and rescue services in U.S. waters in and around offshore wind farms, including the Project. It is anticipated that emergency response assets (vessels, aircraft) from federal, state, local, commercial, and private sources may be utilized within the wind farm should an emergency situation arise.

To facilitate search and rescue within the Project footprint (and all potential U.S. offshore wind farms) Orsted conducted both table-top and operational exercises with the U.S. Coast Guard at the Block Island Wind Farm. These exercises demonstrated the Coast Guard's capability to search in the vicinity of WTGs with both vessels and aircraft, and rescue (extract) an injured person from a nacelle. Additionally, Ørsted hosted U.S. Coast Guard officials, including search and rescue specialists, at its Marine Coordination Center in Grimsby, England and the nearby Race Bank offshore wind farm. The site visit included observations and discussion of United Kingdom Maritime and Coastguard Agency (UK MCA) search and rescue best practices, organization, and operational processes. Future field exercises during operations and additional simulation exercises are planned by Orsted (Orsted, 2021).

The MARI PARS (Coast Guard, 2020) examined potential navigation safety and search-and-rescue (SAR) issues associated with anticipated offshore wind farm development off New England. While the study did not include the Project Area, the general principles for evaluating the safety of SAR operations apply to the Project. The MARI PARS study concluded that a wind turbine array "developed along a standard and uniform grid pattern with at least three lines of orientation and standard spacing" (such as proposed for the Project) would maintain the Coast Guard's ability to conduct SAR operations within the project area."

As requested in NVIC 01-19, Table 3-2 lists key component heights relevant to SAR (Orsted, 2021).

Table 3-2 WTG component heights

Component	Height
Upper blade tip height [MLLW]	276 m 906 ft
Hub height [MLLW]	156 m 512 ft
Lower tip height [MHHW]	20 m 66 ft
Maximum rotor diameter	243 m 797 ft

3.4 Noise

Pile driving, if used during construction, would pose the most significant noise level of any Project-related activity. It is anticipated that the Coast Guard will implement a safety zone around construction-related vessels and activities (see Section 5.1 for more detail about safety zones). Noise levels outside the safety zone are not expected to have negative effects on navigation safety or Coast Guard missions.

During operations, no negative effects from wind turbine noise on Coast Guard missions or navigation safety are expected from the Project.

Operational noise from an offshore wind farm is generated primarily by mechanical equipment or by aerodynamic interactions. The mechanical noise from the WTGs and OSS are anticipated to be minimal. The aerodynamic noise is strongly dependent on local conditions such as wind speed and is expected to be within similar ranges of the predicted levels for Horns Rev 3 : 111 dB(A) to 113 dB(A), for 8 MW and 10 MW turbines (Energinet.dk, 2014).

International Regulations for Preventing Collisions at Sea (COLREGs) Annex III (IMO, 1972) describes the required sound signal intensity and range of audibility for vessels by length. Table 3-3 summarizes the requirements. The COLREGS requirements assume an average background noise level at the listening posts of a vessel to be 68 dB (IMO, 1972).

Table 3-3 Intensity requirements of whistle (IMO, 1972)

Length of vessel in meters	1/3-octave band level at 1 m in dB	Audibility range in NM
200+	143	2
75-200	138	1.5
20-75	130	1
<20	120 / 115 / 111*	0.5

*for frequency ranges 180-450 Hz / 450-800 Hz / and 800-2100 Hz, respectively

Operational noise from an offshore wind farm is generated primarily by mechanical equipment or by aerodynamic interactions. The mechanical noise from the WTGs and OSS are anticipated to be minimal. The aerodynamic noise is strongly dependent on local conditions such as wind speed and is expected to be within similar ranges of the predicted levels for Horns Rev 3: 111 dB(A) to 113 dB(A), for 8 MW and 10 MW turbines (Energinet.dk, 2014). The modeled sound level from Horns Rev 3 wind farm was less than 60 dB(A) within the wind farm (a 24-hr average assuming 8 m/s wind and 10 MW turbines operating continuously).

The COLREGS estimated onboard background noise level of 68 dB is greater than the maximum predicted noise level, therefore noise from the Project turbines is not anticipated to have negative effects on navigation in the region.

3.5 Project structure impact analysis

This section describes the potential damage to a WTG from a marine accident and provides a sense of whether or not WTGs may present a hazard to navigation if struck.

The damage from a powered allision is generally more severe than from a drift allision, and therefore presents the most conservative damage case. Therefore, this assessment focuses on the consequences from a powered allision of a WTG by a vessel transiting at cruising speed within the Project. This is a reasonably conservative scenario and provides a high-end estimate of the potential damage.

The level of damage is directly related to impact energy transmitted by the ship to the WTG, which is dependent on the weight and speed of the vessel. Specific consequences of an allision with a WTG are highly dependent on the inherent design strength of the structure. The discussion below relates to generic designs.

A study published in 2017 in the Ocean Engineering Journal discusses ship impact consequences to monopile and to jacket fixed-bottom foundations when struck by a 4,000-ton class vessel (Moulas et al., 2017). Should a vessel hit a monopile foundation, the three main factors that influence the location and extent of the damage to the foundation are the collision energy, the height of the vessel, and the area of impact. Vessels with a lower profile are expected to result in less damage to the monopile due to the stiffness of the design (Moulas et al., 2017).

Due to this, it is unlikely that smaller vessels (including pleasure and recreational fishing) will damage the monopile to the extent that it may collapse. For monopile foundations, studies show that the damage ranges from minimal (possibly not even in need of repair) to severe plastic deformation and permanent indentation (Moulas et al., 2017). At higher allision energies, the monopile foundation is likely to deform below sea level, nearer to the seabed, and will likely not collapse.

Should a vessel strike a jacket foundation, the main factors affecting the resulting damage include the vessel speed and impact area. When a vessel strikes a WTG at a low speed, the damage to the jacket foundation may not be extensive and may not even require repairs. However, for a 4,000-ton vessel traveling at about 7.8 kt, the forces generated are sufficient to cause multiple failures of joints and/or rupture of elements of a jacket foundation. This is equivalent to 32 MJ.

Given the range of vessel sizes (Table 3-4) and speeds (Table 3-5) found in the AIS dataset, a range of impact energies is estimated for each vessel type, shown in Table 3-4.

Table 3-4 Vessel sizes in the AIS dataset[2]

Vessel type	DWT (metric tons)		
	Low	Average	High
Tankers	4,671	69,484	321,050
Cargo/Carrier	1,600	50,872	165,538
Cruise Ships and Large Ferries	420	7,176	19,189
Other	50	7,025	37,047
Fishing	90	648	1,371
Tug-with-tow	143	631	1,584
Tug	1	458	2,142
Pleasure	1	221	2,650

The speeds in Table 3-5 are based on the speed profiles in the AIS dataset within the Project Area, which are greater than or equal to average speeds in the Marine Traffic Study Area. High speed is calculated as 120 percent of the representative (average) speed based on AIS data. The low speed is 50 percent of the representative speed.

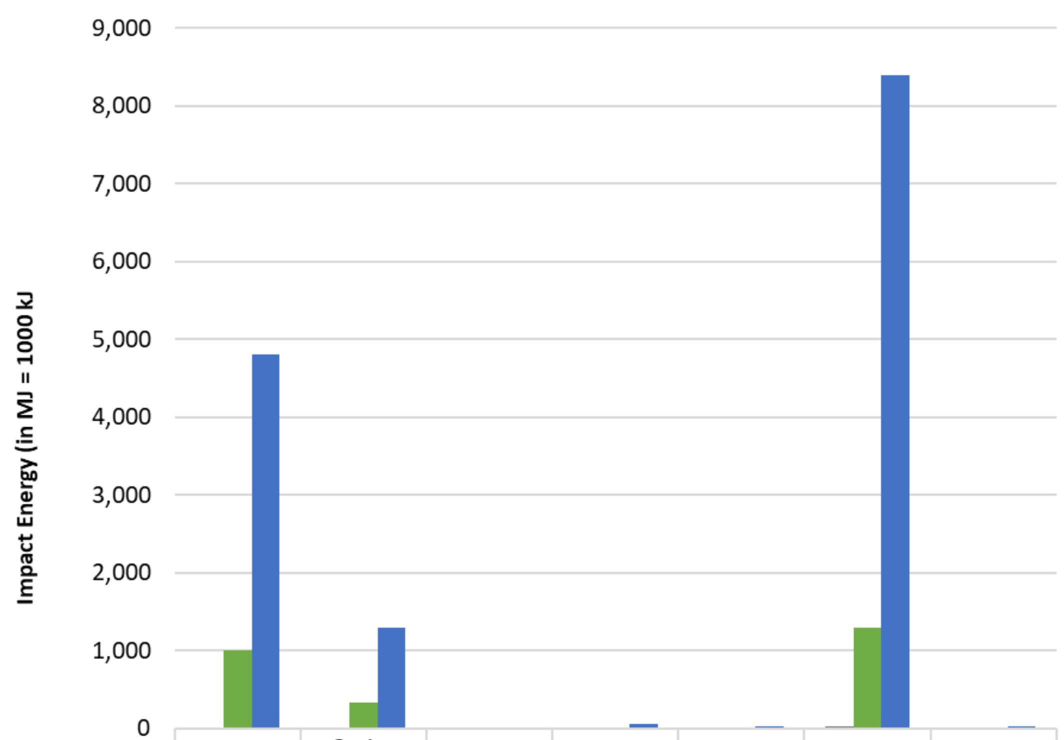
Table 3-5 Assumed vessel speed when allision occurs

Vessel type	Low speed (kt)	Representative speed (kt)	High speed (kt)
Tankers	5.9	11.7	14.1
Cargo/Carrier	6.1	12.3	14.7
Cruise Ships and Large Ferries	9.3	18.5	22.2
Other	1.4	2.7	3.3
Fishing	3.5	7.0	8.4
Tug-with-tow	4.1	8.2	9.9
Tug	3.6	7.2	8.7
Pleasure	3.3	6.5	7.8

A rough estimate of kinetic energy (in joules) is obtained using the following formula, together with inputs of DWT (in kilograms) and speed in (in meters per second):

$$E_k = \frac{1}{2} DWT * Speed^2$$

Figure 3-4 gives the resulting ranges of kinetic energy.



	Cargo	Cruise Ships and Large Ferries	Fishing	Other	Pleasure	Tankers	Tug
Low	8	5	0.1	0.0	0.0	21	0.0
Average	1,000	330	4	6.9	1	1,300	3.2
High	4,800	1,300	13	52	21	8,400	21

Calculated Impact Energy (MJ) per Vessel Type

Figure 3-4 Ranges of kinetic energy per ship type

The estimated energies are considered extreme bounds because the kinetic energy is assumed to be received by the WTG/structure. However, the energy received by the structure will be less than the kinetic energy, as some of the energy will be dispersed during the collision (e.g., vessel hull plastic deformation, vessel movement/rotation).

Due to the range of sizes and speeds of vessels in this study, it can be concluded that pleasure and fishing vessels are unlikely to cause extensive damage to a jacket because of their low tonnage and average speeds. Deep draft vessels such as tankers and carriers have a greater potential to cause damage to the jacket, even at lower speeds.

The highest postulated consequences would be from allision by a non-oil tanker, oil tanker, or cargo/carrier. An impact by a large vessel at average cruising speed is expected to cause severe damage, potentially jacket failure, depending on the impact geometry and the design of the jacket.

As previously stated, it is not anticipated that any deep draft / large vessel types will transit within the Project. Based on MARCS model results, the annual frequency of a powered allision with a WTG involving a tanker, cruise ship, or cargo/carrier is less than 0.0005/year; at most a 1-in-2000-years event.

During construction, the primary risk is from an on-site construction vessel allision with a WTG while transiting through the wind farm. However, construction vessels are anticipated to be travelling at low speeds through the construction zone and are unlikely to cause significant damage in the event of an allision. Based on the low speeds that are expected in a construction zone, a drifting or direct strike from a construction or work vessel is unlikely to cause extensive enough damage to a monopile or jacket based on the WTG strength analysis discussed earlier in this section.

In addition, drift allisions are typically low consequence because the allision location on the ship could be anywhere along the ship's length, but only near the center of mass will the energy transfer be significant. If the allision location is off-center, some of the energy will not go toward deformation of the vessel or Project structure, but instead will rotate the vessel around the turbine.

In terms of damage to a WTG, neither pleasure vessels nor recreational fishing vessels should be able to cause significant damage, regardless of the specific tower design.

4 OFFSHORE UNDERWATER STRUCTURES

The Project does not include underwater devices. All cables will be buried below the seabed or otherwise protected on the seabed and all structures on the seabed will extend above the water line.

Subsea cables are a hazard to anchoring and to fishing with bottom gear; conversely, anchoring and fishing with bottom gear are hazards to Project components. It is anticipated that deep draft vessels and tugs will avoid the wind farm and sail in historical or designated lanes; however, smaller vessels, such as pleasure vessels and commercial fishing vessels, will likely transit the wind farm. Some of these vessels will fish in the Project Area and some will transit through the Project Area and not fish during the transit. See Section 2.3 for a discussion on the current and potential future pleasure vessel traffic.

For commercial fisheries, the primary fishing gear utilized in the vicinity of the Project Area (New Jersey waters) between 2003 and 2007 (Geo-Marine, 2010) were dredges, trawls, purse seines, hook-and-line, gillnets, and pots/traps. Figure 4-1 presents the comparative level of landings per gear. Dredges and trawls were the predominant gears.

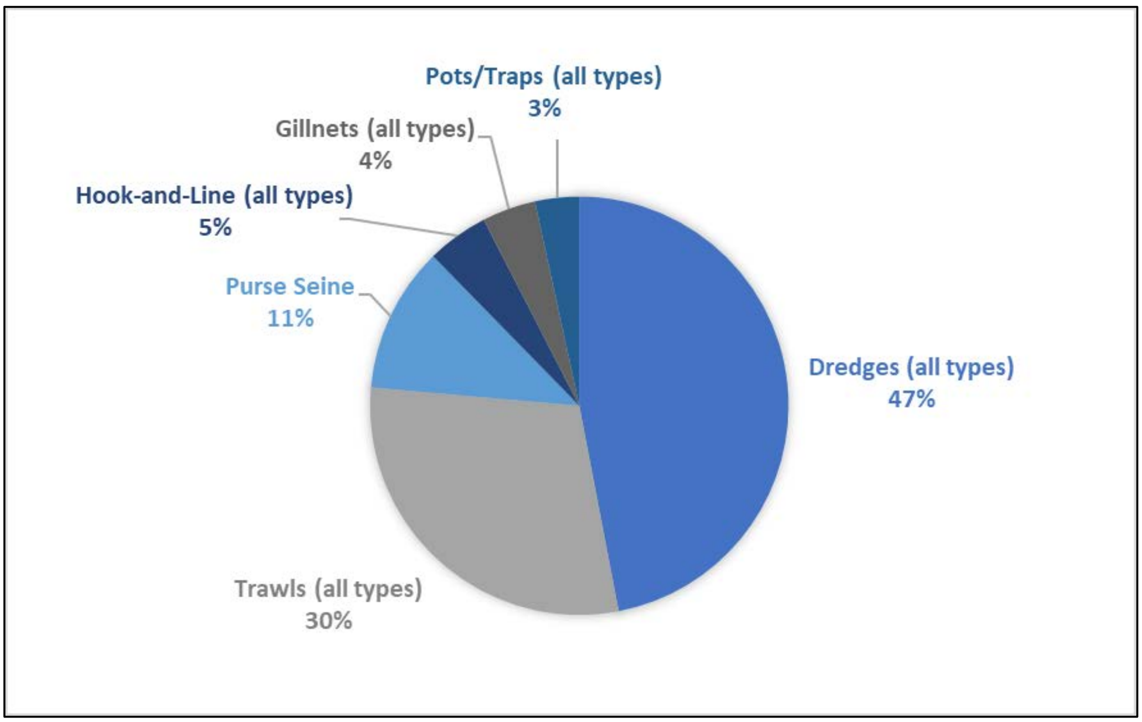


Figure 4-1 Distribution of landings per fishing gear type in New Jersey waters (NJ, 2010)

Anchoring, bottom trawling, and dredging pose the greatest risk of contact. To reduce the risks associated with these hazards, the cable target burial depth is one meter (3.28 ft) and includes at least a single armor layer. Where possible, the cable will be buried to a depth of four to six feet deep. In addition, and to assure the risk is sufficiently mitigated, a separate cable burial risk assessment is being conducted for the Project, and the results of that study will inform the depth of cable burial for the Project and cable protection measures where necessary.

5 NAVIGATION WITHIN OR CLOSE TO A STRUCTURE

This section assesses:

- The safety of navigation in the vicinity of the Project during construction
- The safety of navigation in the vicinity of the Project during operation.
- Potential effects on anchorage areas.

Orsted has an ongoing dialogue with local mariners on the potential effects of the Project, which is summarized in Appendix C.

5.1 Construction and decommissioning phase navigation risks

Project installation is scheduled to take place over a one- to two-year period. The general sequence of events for construction will be:

Offshore construction activities could be a hazard and Project construction vessels could experience hazards from passing vessels. Two primary means of reducing this risk are updates to mariners from the Project and safety zones around construction activity.

The Project has committed to informing fishermen and other mariners about offshore activities related to the Project. Fisheries liaisons and a team of fisheries representatives are based in regional ports, and updates will be provided to mariners online and via twice-daily updates on Very High Frequency (VHF) channels.

To reduce the likelihood of an allision or collision during construction, Project safety vessel(s) will be on scene to advise mariners of construction activity. (Orsted, 2021)

The Elijah E. Cummings Coast Guard Authorization Act of 2020[4], which became law in January 2021 provides the USCG authority to establish and enforce safety zones on the OCS for activity related to wind energy development and operation. It is reasonable to assume that subsequent to Orsted's request, temporary safety zones will be established and enforced to protect mariners during construction and selected maintenance activities.

Orsted will include notice and status of safety zones in its frequent Mariners Information posted to the website https://us.orsted.com/mariners and through weekly Local Notice to Mariners submitted to the Coast Guard. However, in the unlikely event that the Coast Guard cannot or will not establish and enforce safety zones, the Project will coordinate closely with the USCG to develop an alternative plan to facilitate vessel safety(Orsted, 2021).

[4] H.R. 6395, Elijah E. Cummings Coast Guard Authorization Act of 2020, https://www.congress.gov/bill/116th-congress/house-bill/6395/text#H07669B44D8C54EC9887FF078B3A3165F

Such a plan may include:

- Use of private safety vessels to monitor construction sites and alert mariners of construction activities
- Regular presence by Coast Guard and/or Coast Guard Auxiliary vessels and aircraft
- Placement of marker buoys to clearly delineate construction areas
- Active engagement with applicable waterways users and stakeholders to advise of the nature and duration of construction activity (Orsted, 2021)

As with all marine navigation, it is assumed that all vessels, including construction and service vessels, follow COLREGs (IMO, 1972). Vessels must use all available means appropriate to the prevailing circumstances and conditions to determine if the risk of collision exists. If there is any doubt, the vessel operator will assume that there is a risk of collision (IMO, 1972). This applies to vessels that should take special precautions when navigating within the vicinity of the WTGs, particularly in limited visibility. COLREGs also state that every vessel shall proceed at a safe speed so that proper and effective actions could be taken to avoid a collision, and the vessel could be stopped within a distance appropriate for the prevailing circumstances and conditions.

To determine a safe speed as defined in the COLREGs, the elements a vessel will consider include but are not limited to the following (IMO, 1972):

- The state of visibility
- The traffic density (including fishing vessels or other vessels)
- The maneuverability of the vessel with reference to stopping distance and turning ability in prevailing conditions
- The state of wind, sea and current, and the proximity of navigational hazards

In addition to the above hazards, Project construction vessels may experience hazards from weather or sea state and from each other. Risk controls for these hazards include daily / weekly team briefings and a Project construction guideline that defines wind, sea state, and other constraints under which activities will start/continue or will stop/be discontinued. Conditions and forecasts will be monitored to aid proactive planning and early warning of future unsafe conditions.

Generally, decommissioning operations can be thought of as the reverse of installation, in terms of the techniques used and the preparatory measures required, with the exception of cutting activities. The detailed processes, equipment, and procedures used in decommissioning activities cannot be determined until much closer to the end of the project's service life. They will depend on many factors such as equipment and vessel technologies, potential for repurposing the facility, and environmental protection technologies and practices.

The current process for decommissioning broadly follows this sequence:

1. Completion of decommissioning planning, permitting, inspection, surveys, and disposal/recycling plans.

2. Immediately prior to dismantling the turbines, any movable equipment will be removed or secured, fluids or hazardous materials removed or made safe, the turbine rotor oriented and electrically isolated to the extent feasible, and the turbine is prepared to be dismantled (for example, easing bolts or cutting bolts that cannot be loosened).
3. A lift vessel will remove the blades, nacelle, then the tower. A detailed loading plan will specify how and where each of the components is secured on the transport vessel.
4. Immediately prior to removing the foundations, the array cable connections will be severed, the seabed material and/or scour protection around the foundation will be removed to allow access to the foundation, the cutting equipment will be fit, and the lifting equipment will be made fast.
5. A heavy lift vessel will take the load as the foundations are cut below the seabed.
6. If some cables are to be left in place, the cable ends will be buried. For the cables that are to be removed, the method of cable removal will depend on the soil type and is likely to be similar to the method used to bury the cable. Once aboard, the cables will be cut with hydraulic shears to facilitate transportation.
7. A post-decommissioning survey will confirm the status of the seabed, removal of objects on the seabed, and confirm that the decommissioning has been carried out as agreed.
8. Activities per an agreed monitoring plan will be carried out per conditions and requirements established with authorities, typically at intervals of one, five, and ten years after decommissioning.

The risks from decommissioning activities closely resemble risks from construction, described above.

5.2 Operations phase navigation risks

In contrast to Project construction, safety / exclusion zones are not anticipated during Project operation. Therefore, vessels will be free to navigate close to and within the Project.

The Project will lay on charted depths of 16.5 to 36.6 m (54 to 120 ft). Vessels that choose to navigate through the Project will not be draft limited; therefore, grounding risk exists only outside the Project footprint. The potential hazards include collisions between vessels or allisions with Project structures.

It is anticipated that deep draft and commercial vessels (excluding commercial fishing vessels) will not choose to transit through the wind farm. The PDE provides a minimum distance of 0.8 NM (1.5 km) between WTGs. However, the spacing is 1.0 NM for 10 routes that could be transited by fishing and pleasure vessels between local ports like Atlantic City and offshore fishing grounds (Figure 5-1). This design is a navigation risk mitigation measure and provides sufficient room for anticipated vessels to transit through and safely maneuver within the Project. The risk modeling assumes that the space is available, but does not assume that pleasure vessels take the 1.0 NM-wide routes.

Mariners, including those onboard Project service vessels, should strictly adhere to all COLREGs and be aware of the prevailing environment and situation to avoid unsafe situations. The PDE provides sufficient sea room for most vessels to transit between WTGs if the risks have been considered and a vessel is transiting at a safe speed per COLREGs (IMO, 1972).

A potential concern about offshore wind farm layouts is the potential for compression and funneling traffic through relatively narrow lanes. The Project layout provides vessels with sufficient spacing and multiple options to transit safely through the Project. There will be 18 straight-line corridors through the Project:

- Ten 1.0 NM-wide corridors, generally perpendicular to the coast (shown in Figure 5-1)
- Eight 0.8 NM-wide corridors, generally coastwise

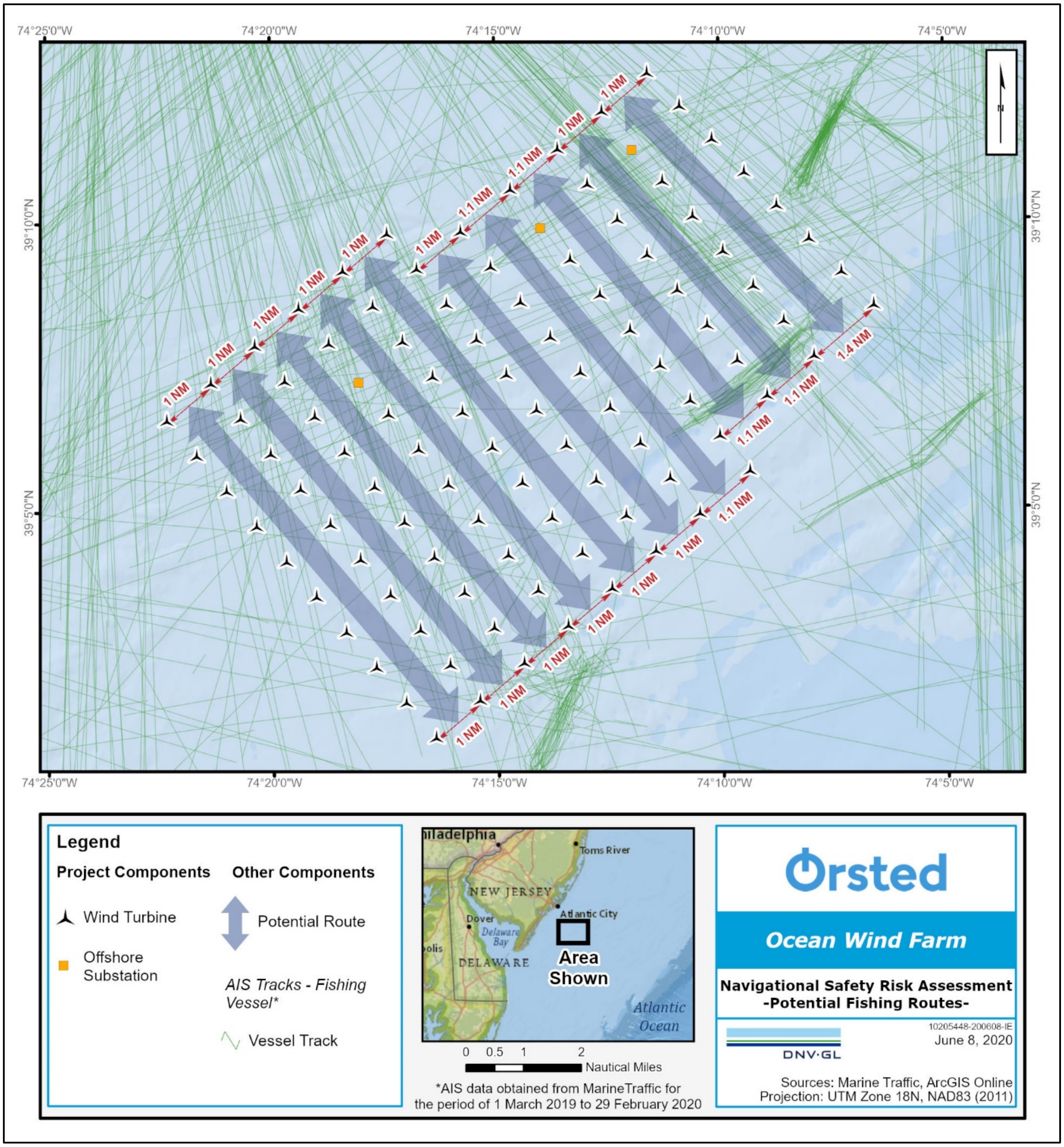


Figure 5-1 AIS tracks for fishing vessels and potential routes through the Project

5.3 Project impact on anchorage areas

NVIC 01-19 guides applicants to consider the effect the Project will have on anchorage areas. Figure 5-2 shows anchorage areas and Project cable routes. The closest anchorage is Big Stone Beach Anchorage Ground, located 38 NM (70 km) from the Project.

Figure 5-3 shows proposed anchorage areas in the Marine Traffic Study Area (84 FR 65727). B and Anchorage C are closer to the Project Area than the proposed anchorage areas.

The Project is not anticipated to affect vessel anchorage operations.

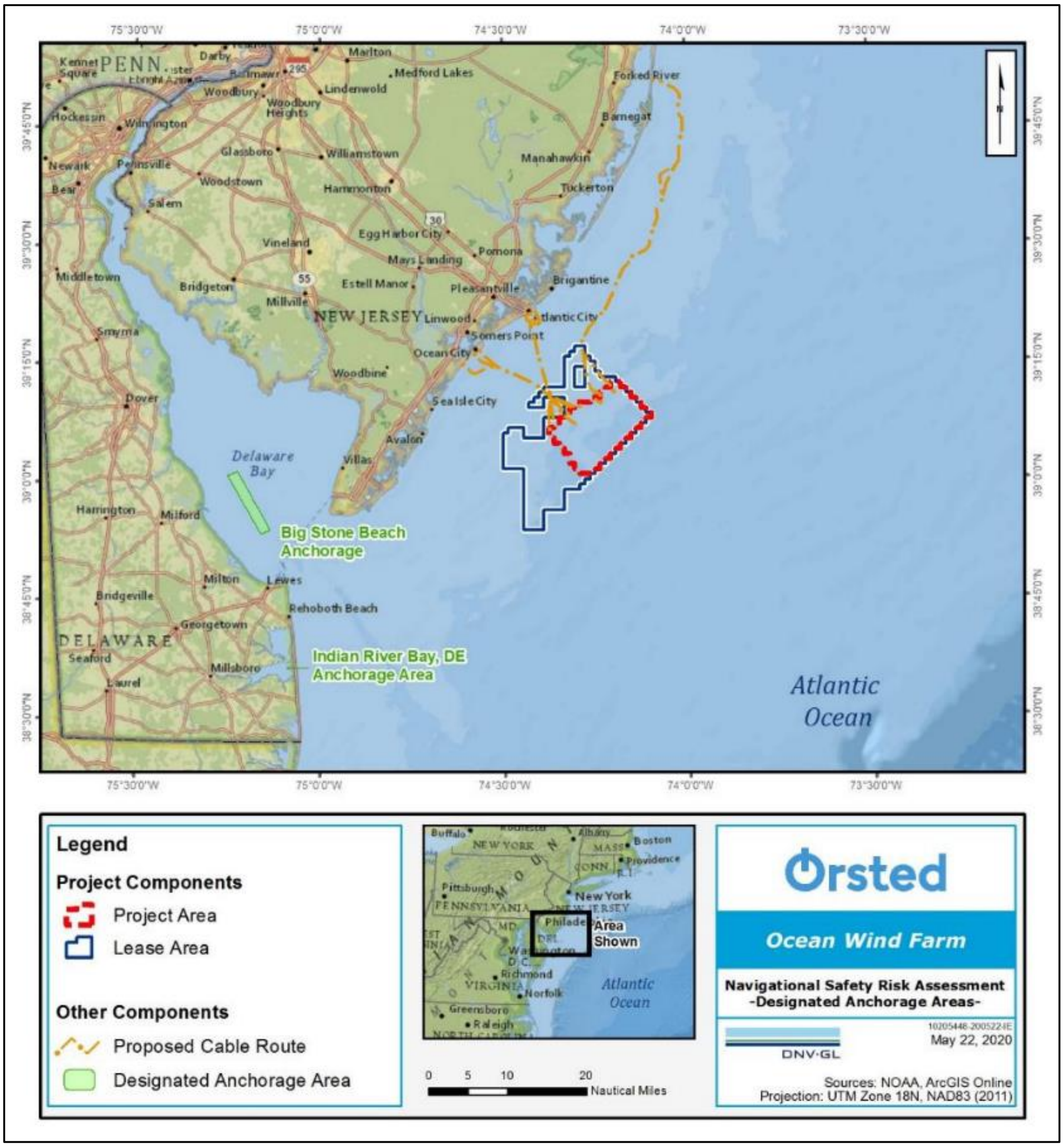


Figure 5-2 Designated anchorages in the Marine Traffic Study Area (NOAA, 2017)

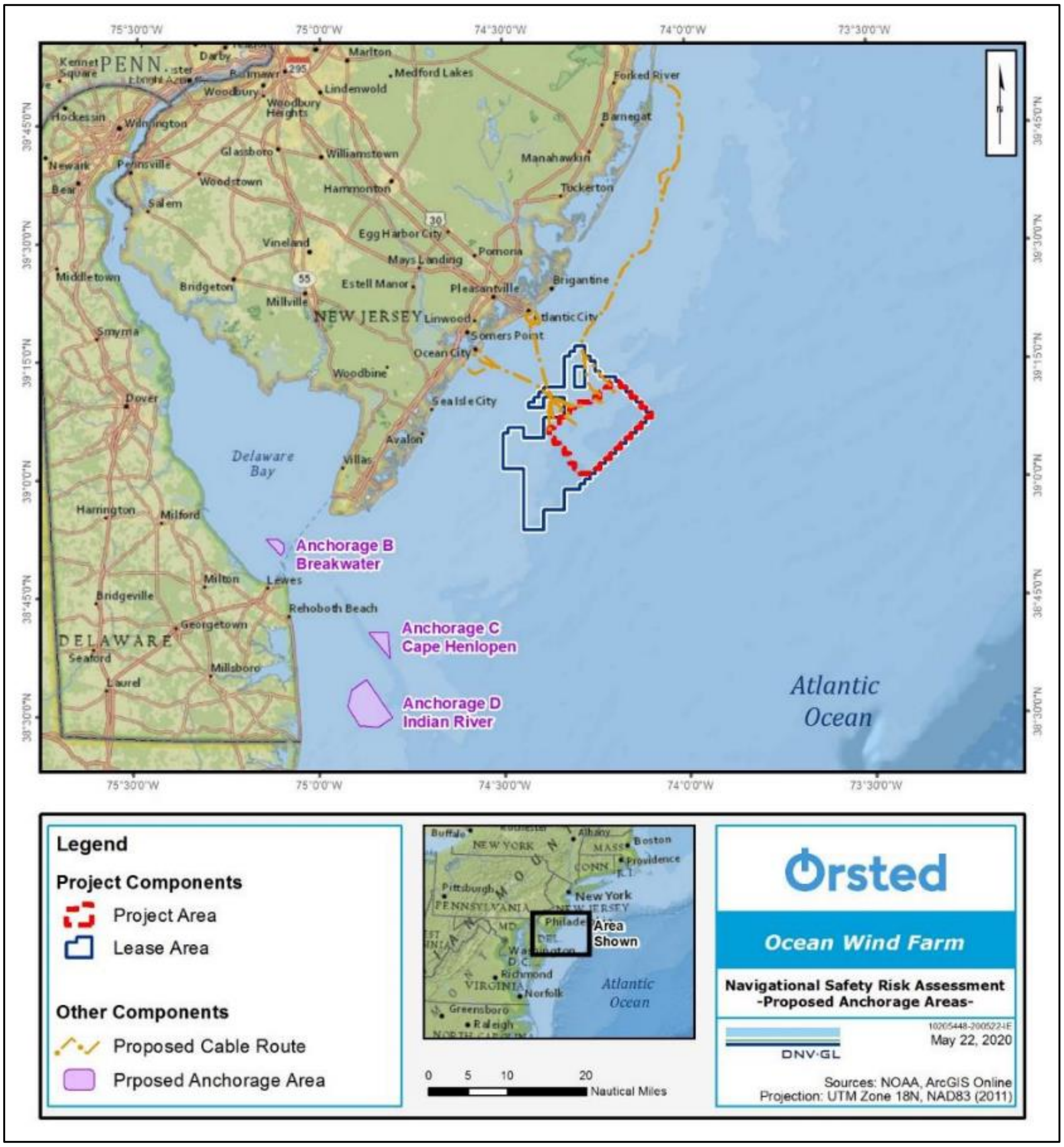


Figure 5-3 Proposed Anchorage Areas in the Marine Traffic Study Area (84 FR 65727)

Deviations from “normal” anchorage activities pose a potential hazard to subsea cables. Ships rarely drop anchors (even more unlikely outside of normal operations) but this can damage the cable if an anchor is dropped directly on top of a cable or dragged across a cable line (BOEM, 2011). Credible events that could cause damage to the cable line include human or mechanical failures leading to emergency anchoring of a deep draft vessel, and fishing activities discussed in Section 2.2.1.1.

Emergency anchorage has the potential to damage the export cable should an anchor penetrate the seabed to the applicable cable burial depth or penetrate applicable cable protections on the seabed to the extent the cable cannot reasonably be buried. Standard industry practice is that anchoring in a wind farm is a potentially hazardous activity and should be undertaken only by Project-related vessels or in emergency situations. To mitigate this risk, Project cables will be buried and/or protected on the seabed, marked on charts, and their location will be monitored periodically to detect any movement.

Based on the DWT of vessels in the AIS dataset (see Section 2.1.3), only the following AIS vessel types within 5-statute-mile area (4.34 NM, 8 km) have tonnage greater than 50,000 DWT:

- Bulk carriers (21 vessels)
- Container ships (439)
- Crude oil tankers (5)
- Oil/chemical tankers (38)
- Ro-Ro/container carriers (2)
- Tankers (8)
- Vehicles carriers (145)

A limited number of these large vessels transit in the vicinity of the Project Area (see previous Figure 2-40 for DWT summary data).

All other vessels in the AIS dataset are smaller and less likely to cause damage to the export cable even in an emergency anchoring situation. Fishing activities and cables that pose hazards to one another are discussed in Section 3.1.

Based on historical records, construction vessels can inadvertently damage a cable during anchoring or jacking up (BOEM, 2011). The risks can be mitigated through clear communication and awareness of the locations of cables.

6 EFFECT OF TIDES, TIDAL STREAMS, AND CURRENTS

This section discusses the potential issues of concern identified in the NVIC related to tides, tidal streams, and currents, and summarizes pertinent data in Sections 6.1 through 6.4.

The Project WTGs and OSS will be located approximately 13 NM (24 km) south of Atlantic City, New Jersey. The primary hazards to navigation along the coast are outlying sand shoals, fog (see Section 7.3) and the uncertain direction and speed of the current after high winds (NOAA, 2020a). Table 6-1 provides a summary of the waterways' characteristics and Figure 6-1 shows the Project on a nautical chart.

Water depths in the vicinity of the Project can affect maritime traffic flows and operations. Shallower depths near the coast are frequented by tug traffic, in contrast to the routes in deeper waters taken further offshore by most cargo/carrier vessels (Section 2.1.1) - outside of Barnegat Lighted Buoy B and Five Fathom Bank Lighted Buoy F (NOAA, 2020a)

Tidal influences on water depth are minor compared to average water depths in the vicinity of the Project Area: the tidal range is less than 1.5 m (5 ft) (see Table 6-1).

The tidal stream runs parallel to a major axis of the Project structures. Since the tidal stream is cyclical, given that there is a drifting vessel at a particular location, the tidal stream might reduce increase or decrease the likelihood or even the timeframe at which an allision could occur, depending on the timing of the loss of propulsion. About half of the time, the tidal current would increase the speed and/or likelihood of an allision for a vessel at a given location, and the other half of the time, the tidal current would reduce the speed and/or likelihood of an allision.

Concerning current, because wind direction has a much greater influence on the drift speed or a large vessel than current, the modeling conducted to estimate collision, allision, and grounding risk described in Section 11 (incorporating causes of engine failure and human error) includes the wind direction and speed distribution, but does not incorporate sea current speed and direction as an input. Surface ocean currents are primarily affected by wind patterns, but there can be misalignments. When currents and wind are not aligned, one can expect rough seas and an increased risk of allision should a drifting vessel be driven toward a structure by the combined force, and a decreased risk of allision if otherwise. Since the apparent density of pleasure vessel traffic based on AIS data and information about pleasure-related waterway uses is greater to the north of the Project Area than to the south, it is reasonable to expect that the overall effect of a predominant current from the north would be a small increase in risk, which would be negligible if offshore wind lease OCS-A 0499 to the north was developed.

The foundations of the Project offshore structures would not affect the set and rate of the tidal stream or direction and rate of the currents, or affect the air column, water column, seabed, or sub-seabed in ways that affect navigation safety.

Table 6-1 Summary of waterways characteristics

Site characteristic	Summary	Source
Tidal range	Not greater than 1.5 m (5 ft)	Atlantic City, NJ (NOAA station 8534720, NOAA Coastal Chart 12318) and Cape May Point, NJ (NOAA station 8536110, NOAA Coastal Chart 12214)
Tide height	Mean range 1.0 to 1.3 m (3.4 to 4.4 ft) along the coast	Coast Pilot 3 (NOAA, 2020a)
Tidal stream speed (surface)	Less than 1 kt (1.7 ft/s; 0.51 m/s)	Coast Pilot 3 (NOAA, 2020a) Department of Energy report on tidal energy resources (DOE, 2011)
Tidal stream direction (set)	NW (flood), SE (ebb)	Coast Pilot 3 (NOAA, 2020a)
Current speed (surface)	Maximum 3.9 kt (6.5 ft/s, 2 m/s)	OceanReports (marinecadastre.gov) (BOEM and NOAA, 2020)
Current direction (set)	Predominant: North Range: NNE to NNW	OceanReports (marinecadastre.gov), (BOEM and NOAA, 2020)
Water depth	16.5 m – 36.6 m (54 ft – 120 ft) [MSL]	NOAA National Geophysical Data Center (NGDC) (1999)
Waves	Average wave height: 1.2 m (3.9 ft) Average wave period: 7.2 seconds Approximately 95% of the time wave heights are below 2.0 m (6.5 ft) Maximum recorded wave height over 10 year period: 8.4 m (28 ft)	OceanReports (marinecadastre.gov), (BOEM and NOAA, 2020)

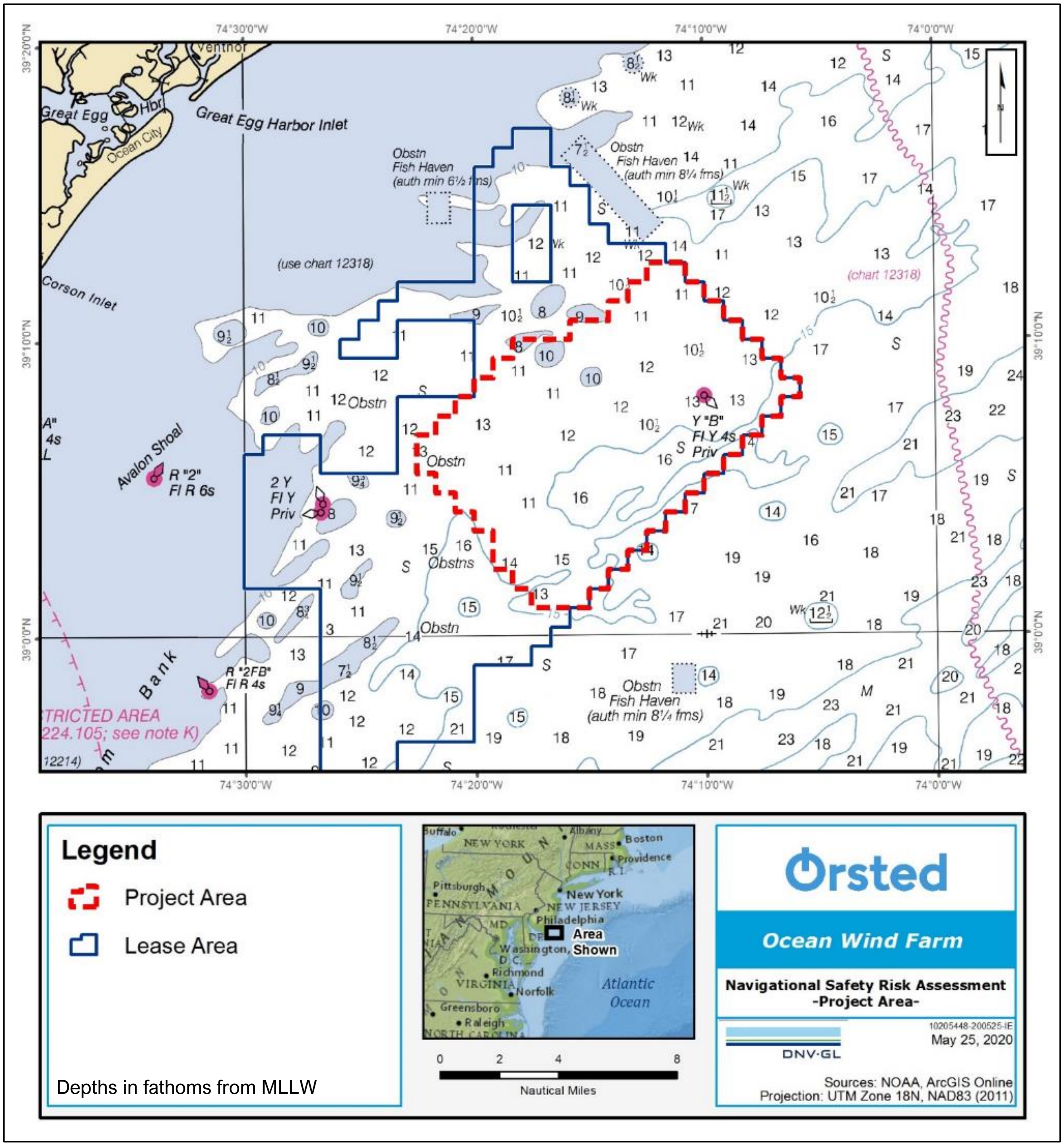


Figure 6-1 The Project on a navigation chart

6.1 Tides

Tides are not directly measured in the Project Area. The closest NOAA stations to the Project that offer tidal data are Atlantic City, NJ (NOAA station 8534720) and Cape May Point, NJ (NOAA station 8536110), which are 15 NM (28 km) northwest and 25 NM (46 km) southwest of the Project Area, respectively. Table 6-2 summarizes the tidal data.

Table 6-2 Summary of tides (NOAA, 2020b and 2020c)

Station	Mean Higher High Water	Mean High Water	Mean Low Water
Atlantic City	1.4 m (4.6 ft)	1.3 m (4.2 ft)	0.06 m (0.2 ft)
Cape May Point	1.6 m (5.4 ft)	1.5 m (5.0 ft)	0.06 m (0.2 ft)

Given the difference in water depth and geography, DNV GL would expect tidal ranges within the Project Area to be lower than those measured at these coastal stations.

6.2 Tidal stream and current

The currents in the Study Area are semidiurnal, with ebbs and floods that oscillate along a northwest and southeast axis. The regional currents are affected by the confluence of the Gulf Stream from the south and an offshoot of the Labrador Current from the north. The interaction between these currents strongly affects the regional weather patterns and climatology.

The Gulf Stream generally follows the contour of the continental shelf before being deflected offshore in the vicinity of Cape Hatteras, North Carolina approximately 230 NM (426 km) to the south of the Project Area. The exceptionally strong temperature gradients between the two currents form a distinct boundary line called the North Wall. Both currents begin to flow parallel to one another several hundred miles east-northeast of their original interaction point. The Project Area is well clear of this North Wall boundary; however, warm and cold-water eddies can cause rotary currents directly to the east and northeast of the Project Area. The geographic location of the North Wall changes due to the variability of the Gulf Stream, which is strongest in early summer and weakest in autumn (UK Hydrographic Office, 2017).

The data show that the current speed is low in the Project Area, with a maximum less than 3.9 kt (2 m/s, 6.5 ft/s), as shown in Figure 6-2 below. Current flow comes within a tight range of direction, from north-northeast to north-northwest, and predominantly from due north, as shown in Figure 6-3 (summaries and graphics taken from BOEM and NOAA, 2020).

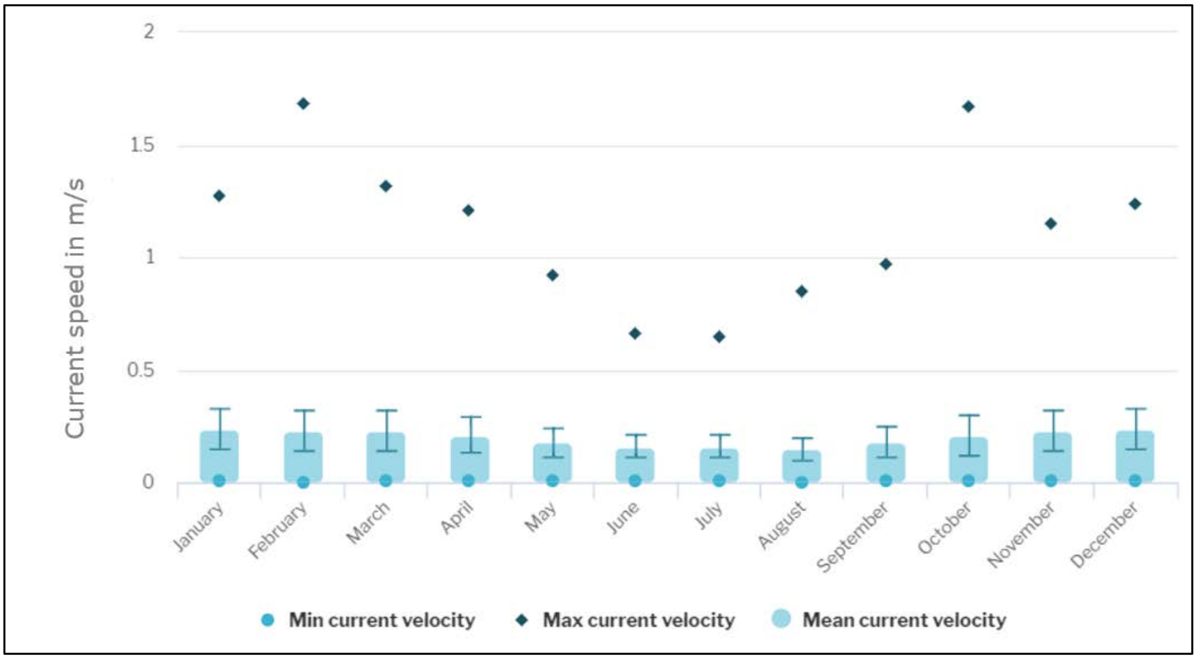


Figure 6-2 Speed of current in the Project Area (BOEM and NOAA, 2020)

Figure 6-3 Direction of currents in the Project Area (BOEM and NOAA, 2020)

6.3 Bathymetry

Data from the National Geophysical Data Center was used to determine water depths across the Project Area (1999). Water depths in the Project Area range from 16.5 to 36.6 m (54 to 120 ft).

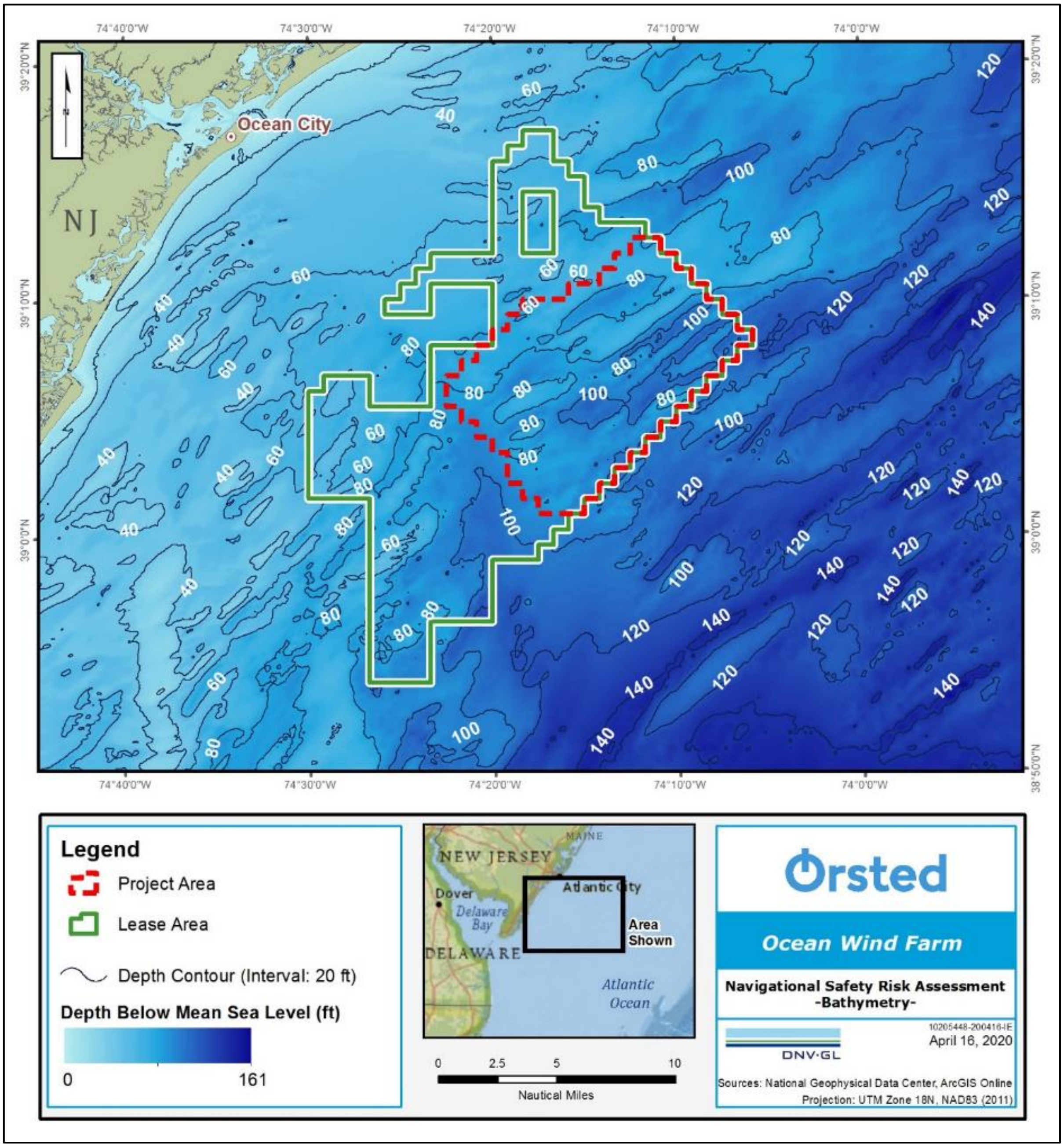


Figure 6-4 Bathymetry in the vicinity of the Project Area (NOAA, 1999)

6.4 Waves

The wave direction for the Project Area is from the northeast through to the southeast, as illustrated in Figure 6-5 below. Average monthly significant wave heights range from approximately 0.9 m to 1.3 m (3.0 to 4.3 ft), with the winter months experiencing the higher waves (BOEM and NOAA, 2020).

As shown in Figure 6-6, waves in the vicinity of the Project are short period wind-generated waves and longer period swells propagating from the open ocean. Winds coming from anywhere from the south to the east of the Project have unlimited fetch, and therefore can generate sea swells which can travel for thousands of miles (New Jersey, 2004).

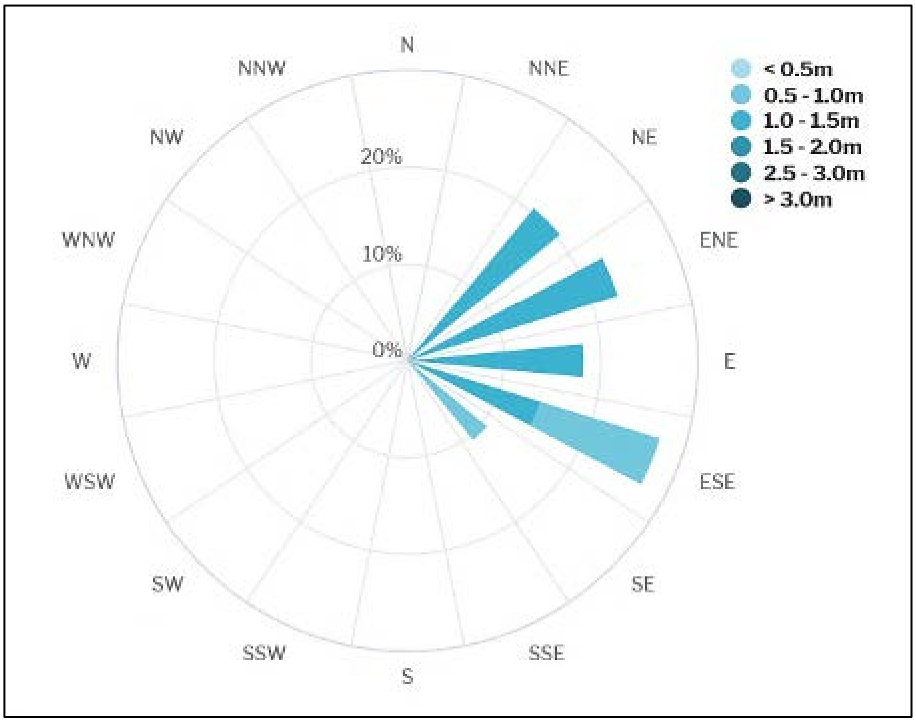


Figure 6-5 Project Area wave rose and monthly average significant wave height (BOEM and NOAA, 2020)

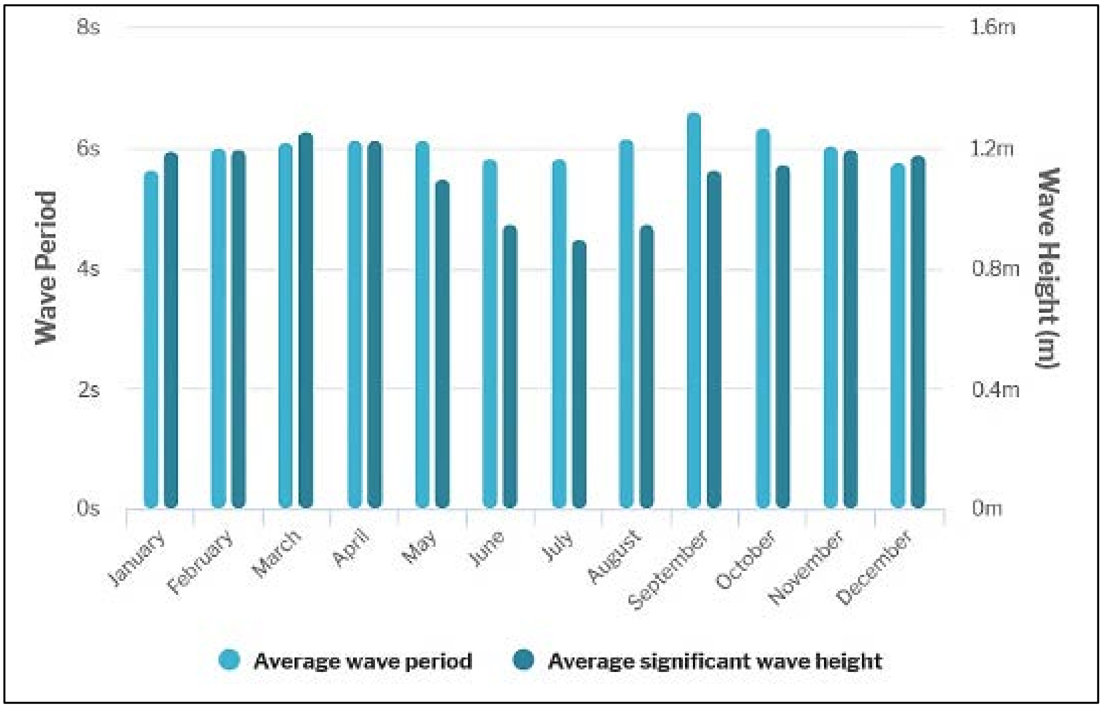


Figure 6-6 Project Area wave rose and monthly average significant wave height (BOEM and NOAA, 2020)

The closest offshore wave measurement stations to the Lease Area, with detailed historical data available for public use, are NBDC station 44009, which is located in the Delaware / Cape Henlopen traffic separation zone, approximately 35 NM southwest of the Lease Area, and NBDC station 44901, which is located approximately 40 NM north of the Lease Area. More than ten years of wind and wave data have been recorded at NBDC station 44009, but only five years of wave data have been recorded at NBDC station 44901. Thus, data from NBDC station 44009 was used for this analysis.

Average significant wave height was recorded at the NBDC station 44009 is 1.2 m (3.9 ft) over a ten-year period. Figure 6-7 presents the relative occurrence of recorded significant wave heights, which range from zero to a maximum recorded value of 8.4 m (28 ft). Figure 6-8 shows the monthly averages for significant wave heights during the same period. There is low variance between months, with the summer months having the lowest average significant waves.

The average wave period is 7.2 seconds. Figure 6-9 presents the average and dominant wave periods for each month of the year recorded over the ten-year period. By far, the wave periods in the month of February are the longest compared to all other months.

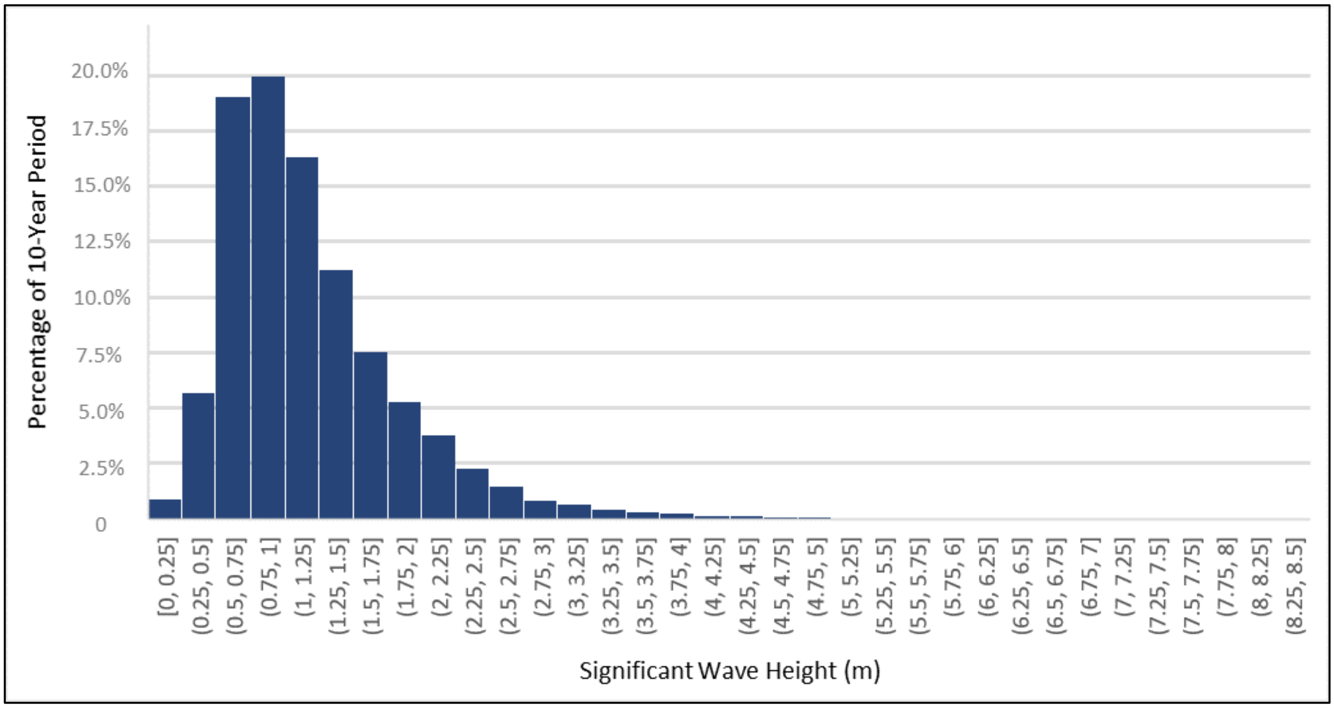


Figure 6-7 Significant Wave Heights at National Data Buoy Center Station 44009, Delaware Bay (NOAA, 2020d)

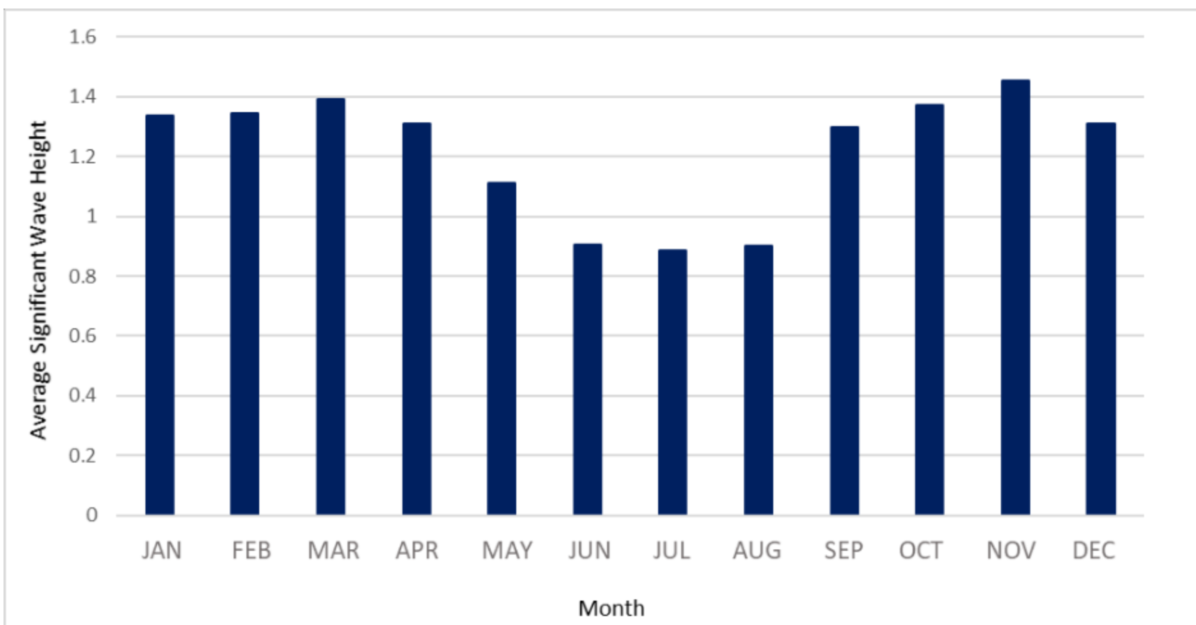


Figure 6-8 Average Significant Wave Heights per Month at National Data Buoy Center Station 44009, Delaware Bay (NOAA, 2020d)

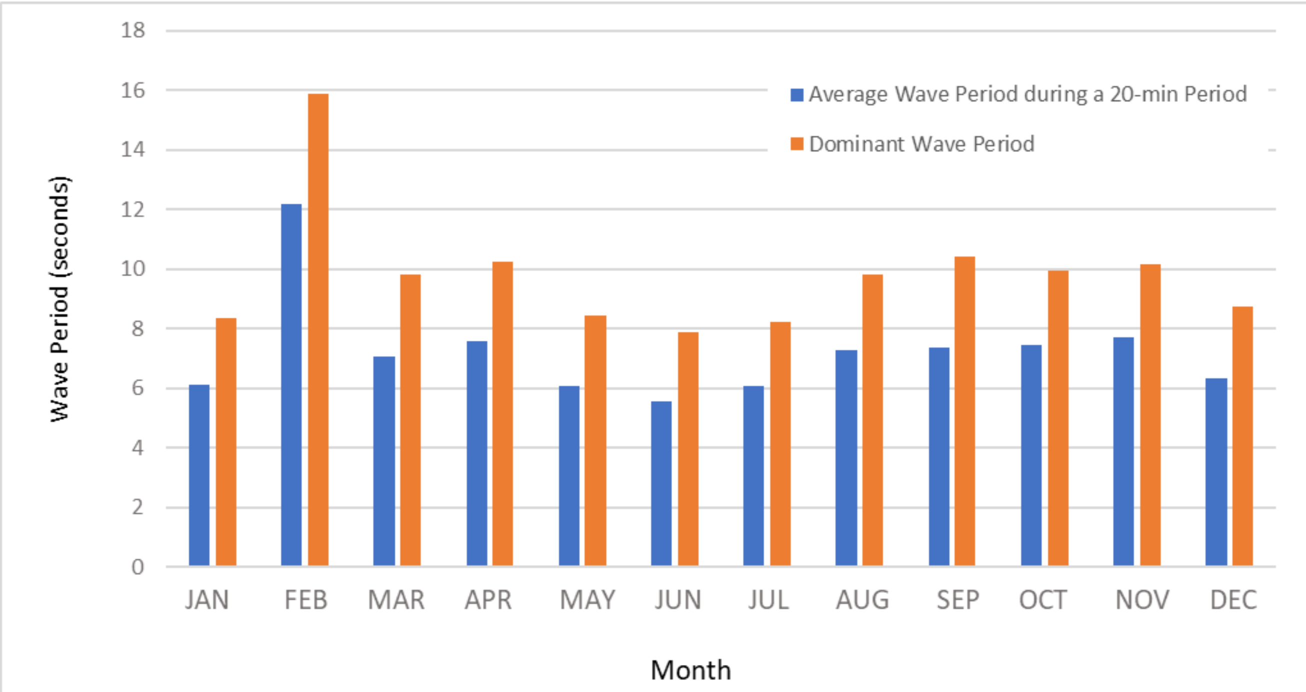


Figure 6-9 Average wave periods at National Data Buoy Center Station 44009, Delaware Bay (NOAA, 2020d)

7 WEATHER

Table 7-1 summarizes relevant weather characteristics in the Project Area.

Navigation along the coast is restricted in the winter by storms that come from the south and may include strong gusts, rain, or snow. The weather can be highly variable November through March. (NOAA, 2020a)

The effect of wind speed, wind direction, visibility, and possible engine failure are directly accounted for in the modeling described in Section 11 regarding the risk of collision, allision, and grounding.

Table 7-1 Summary of weather characteristics

Site characteristic	Summary	Source
Wind speed at 33 ft (10 m) height	15.5 knots (8.0 m/s) mean 85.0 knots (43.7 m/s) maximum hourly average recorded in 10-year record	Atlantic City Airport, ID: KACY (NOAA, 2020e)
Prevailing wind direction	South and west	Atlantic City Airport, ID: KACY(NOAA, 2020e)
Visibility	5.6% < 2 NM (3.7 km) visibility 79% > 8 NM (14.8 km) visibility	Atlantic City Airport, ID: KACY(NOAA, 2020e)
Ice	Floating ice is not expected to be present. Ice drop may occur, but risk will be mitigated with an ice hazard protocol, which is standard wind industry practice. Ice throw is unlikely due to turbine control strategy.	Coast Pilot 3 (NOAA, 2020a)

7.1 Winds

Winds have been measured in the Lease Area since July 2018. That data, plus additional data from the following reference stations was evaluated:

1. Wind rose plots and wind speed and direction data obtained from the Climatology of Global Ocean Winds (COGOW) website (2020) and were provided courtesy of Oregon State University's Cooperative Institute for Oceanographic Satellite Studies (CIOSS)[5] (Risien and Chelton, 2006). The data are smoothed daily averages of speed and direction from eight years of QuikSCAT measurements (1 January 2000 through 31 December 2008). The COGOW wind statistics were downloaded for the location shown in Figure 7-1.

[5] http://cioss.coas.oregonstate.edu

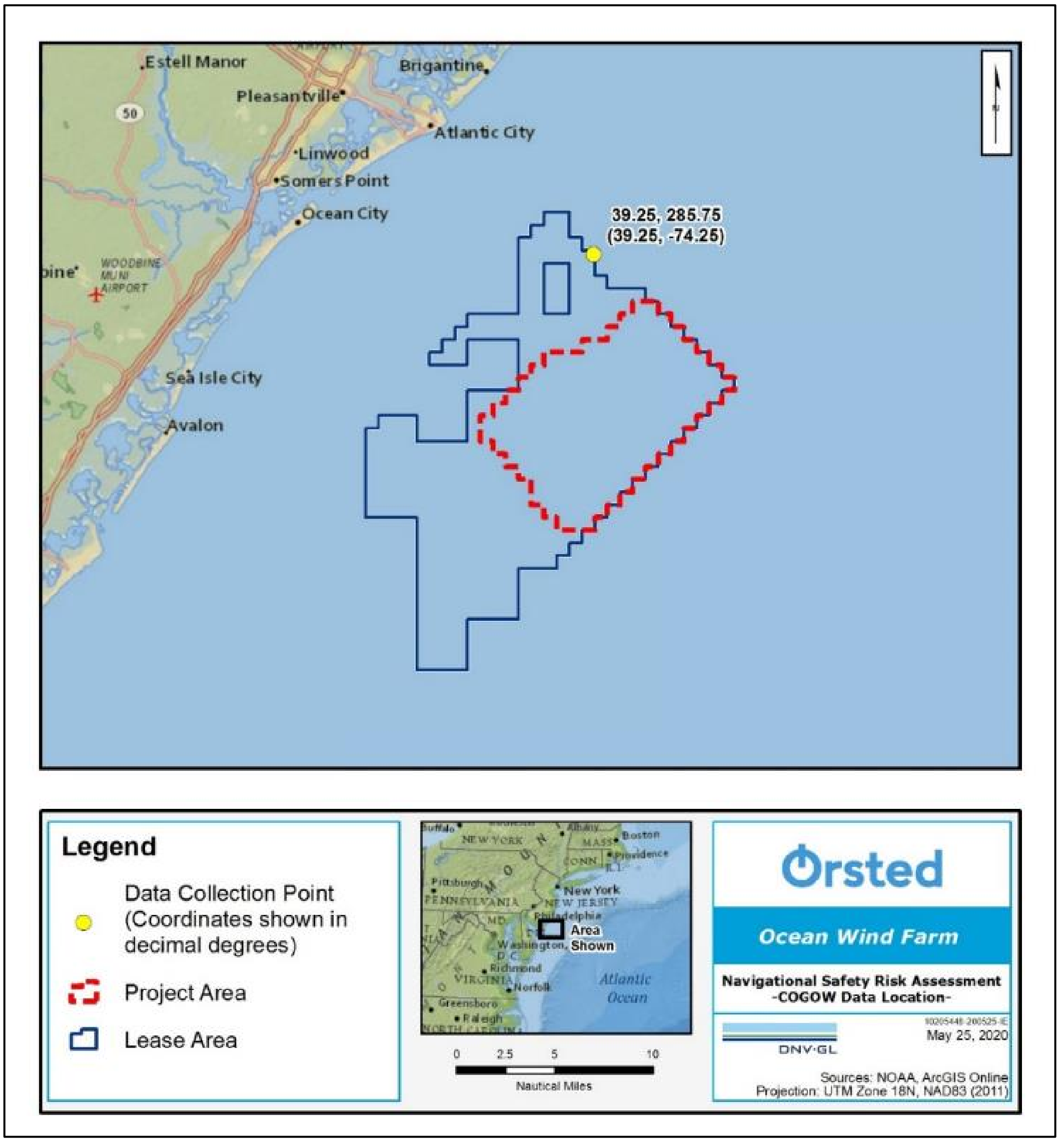


Figure 7-1 Location represented by downloaded COGOW wind data (2020)

2. The closest offshore wind speed measurement station to the Project is NBDC station 44009 located in the Delaware / Cape Henlopen traffic separation zone, approximately 35 NM southwest of the Project Area. This buoy station has collected more than ten years of wind data but given the relative lack of reported values during winter months, the COGOW data is considered to be of higher quality for purposes of risk modeling in this NSRA.

3. Statistical summaries of offshore wind speed data presented by Global Wind Atlas (2020) and Marine Cadastre's OceanReports (BOEM and NOAA, 2020) platforms.

The COGOW data were selected as the best available data based on its general congruity with the wind rose from measurements at the Project site and the lack of congruity shown in the other data sets.

Since the COGOW data provides only daily averages, it is expected that shorter periods of high winds would not be indicated in the data set. Maximum winds of 70 to 75 knot winds are indicated in Coastal Pilot 3 (NOAA, 2020a). Therefore, the wind speed distribution used in the MARCS model (see Appendix E) was based on the COGOW data, which was adjusted as follows:

- The detailed Project site data was summarized for each of the eight compass directions and proportions were determined for wind categories Calm (< 20 knots), Fresh (20 to 30 knots), Gale (30 to 45 knots), and Storm (> 45 knots).
- The COGOW data showed zero Storm winds, but it is reasonable to assume that Gale days might also have included parts of days with Storm winds. Therefore, a proportion of the Gale winds in the COGOW data summary were re-assigned to Storm based on the site-specific wind proportion of Gale:Storm.

The resulting wind speed/direction distributions are shown in Table 7-2.

Table 7-2 Wind speed distribution used in NSRA modeling

Wind Speed Category	North	Northeast	East	Southeast	South	Southwest	West	Northwest	Total
Calm	8.0575%	10.9333%	6.4026%	5.2360%	10.7976%	19.4791%	13.7276%	12.8595%	**87.5%**
Fresh	1.1666%	2.4145%	0.2713%	0.1085%	0.0271%	0.4341%	3.2827%	4.6120%	**12.3%**
Gale	0.0266%	0.0798%	0.0000%	0.0000%	0.0000%	0.0266%	0.0000%	0.0532%	**0.2%**
Storm	0.0005%	0.0016%	0.0000%	0.0000%	0.0000%	0.0005%	0.0000%	0.0011%	**0.0%**
Total	**9.3%**	**13.4%**	**6.7%**	**5.3%**	**10.8%**	**19.9%**	**17.0%**	**17.5%**	**100.0%**

The distribution of wind directions in the COGOW data is shown in Figure 7-2.

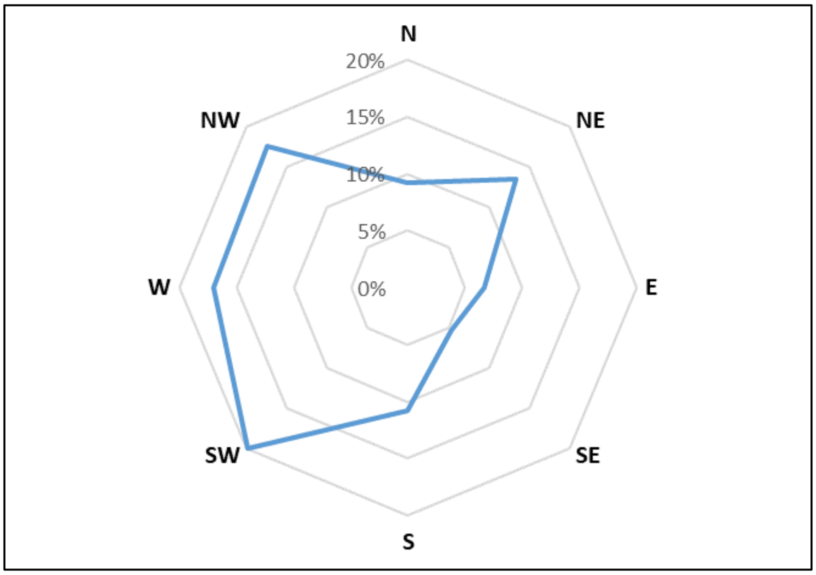


Figure 7-2 Wind direction distribution at 33 ft (10 m) height above MSL

The prevailing wind direction is from the south and west, with minor contributions from the northwest, north east, and south. The distribution of wind directions (the wind rose) shows that winds come from almost all directions over the course of a year, although the wind comes from the south and west the majority of the time.

Figure 7-3 presents the average hourly wind speeds for each month of the year over a ten-year period. It can be observed that the highest wind speeds occur in the winter months. The ten-year mean wind speed at 33 ft (10 m) elevation is 13.7 knots (7.0 m/s).

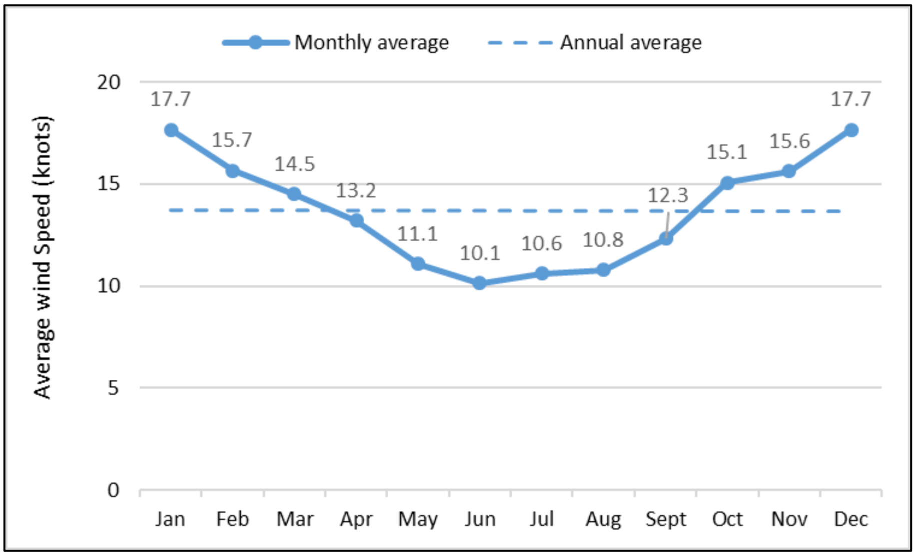


Figure 7-3 Average hourly wind speeds at 33 ft (10 m) height above MSL (COGOW, 2020)

The International Best Tracks for Climate Stewardship database provided the data for hurricanes that passed within five degrees of the Lease Area between 1969 and 2019 (shown in Figure 7-4).

Hurricanes are not common in the vicinity of the Project Area during the early summer months. In August and September there is a threat of tropical storms and tropical depressions. Extratropical storms in the winter can restrict navigation along this coast.

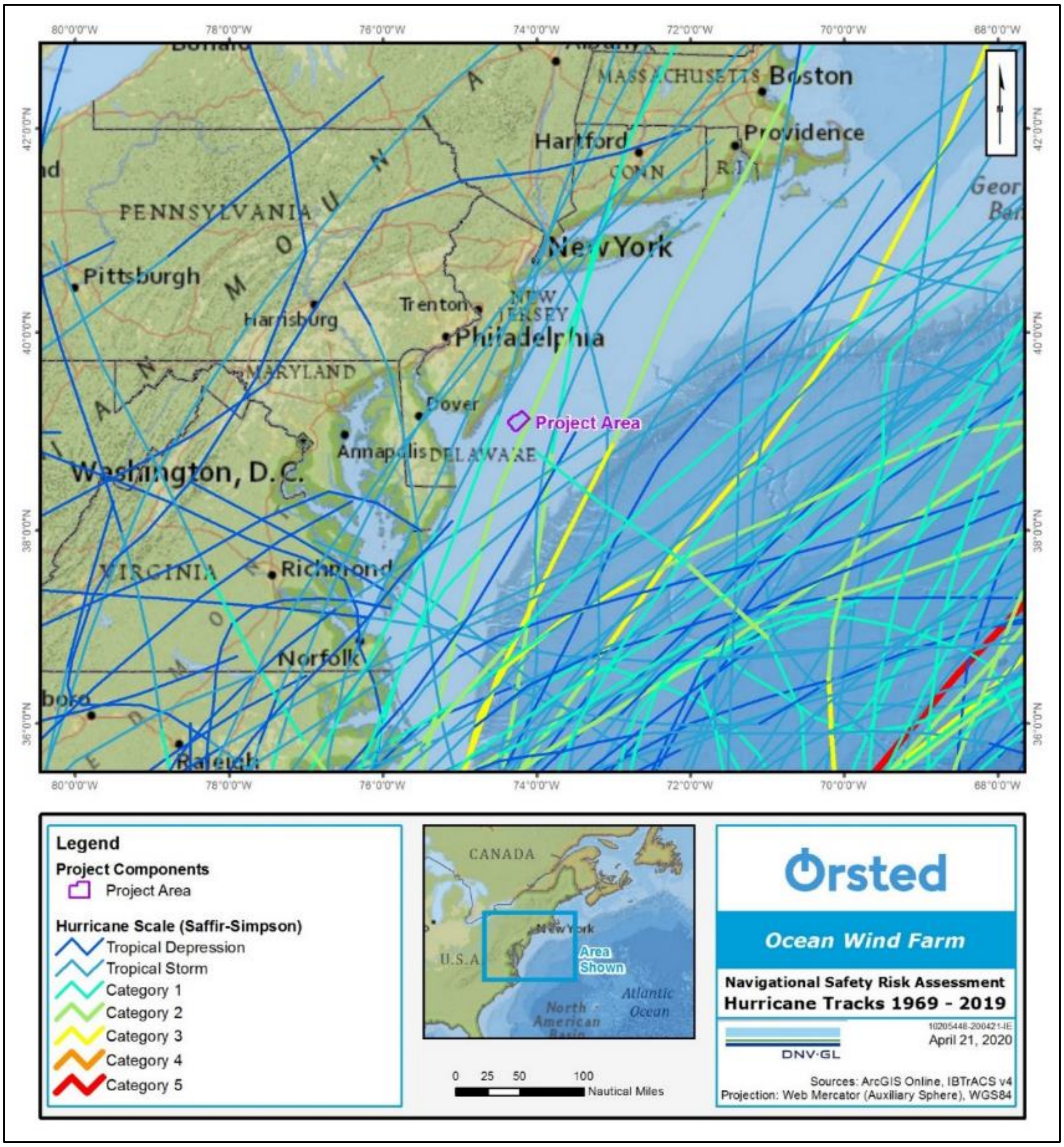


Figure 7-4 Tracks of cyclones within 5 degrees of the Project Area (1969-2019)(NOAA, 2020f)

7.2 Consideration of vessels under sail

Vessels under sail could enter the Project Area. In line with rules of prudent seamanship, vessels should proceed with caution near any man-made structure that decreases visibility. Potential hazards to vessels under sail from Project structures were reviewed, such as wind masking, turbulence, and sheer. In the expert judgment of experienced sailors, realization of these hazards requires the vessel to be closer to a turbine than prudent seamanship would advise, regardless of weather.

7.3 Visibility

Fog, haze, precipitation and smoke can hamper visibility. Visibility data were obtained from Climate Data Online for Atlantic City International Airport, station ID KACY. This is the closest station with available visibility data and is therefore taken to be the best available data for visibility conditions at the site.

Figure 7-5 summarizes 10 years of visibility data from the Atlantic City Airport station. Visibility was less than 2 NM 5.6 percent of the time. Summer months are most likely to have hours of visibility less than 2 NM due to any of several factors, including fog, haze, rain, etc.

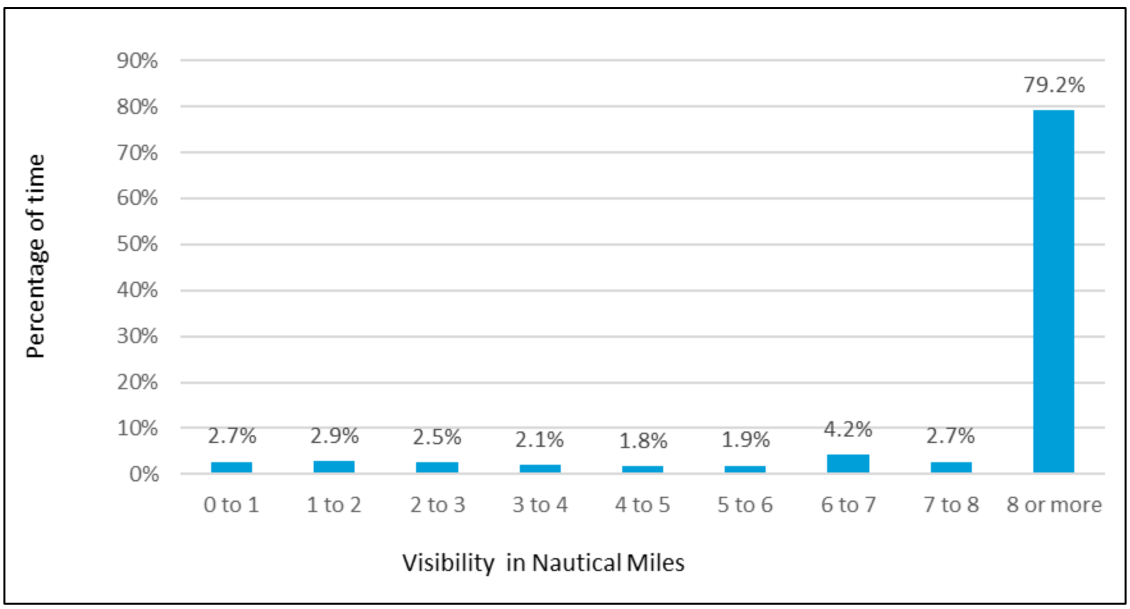


Figure 7-5 Summary of visibility measurements at Atlantic City Airport 2010 – 2019 (NOAA, 2020e)

7.4 Ice

Ice can impact navigation around offshore WTGs in two ways: floating ice can cause treacherous conditions for vessels, and ice can accumulate on a WTG structure causing potentially hazardous conditions for any people or vessels beneath should ice fall from the WTG.

Floating ice

Coast Pilot 3 (NOAA, 2020a) discusses ice within the New Jersey intercoastal waterway, waters of Delaware Bay and River, and other inland waterways. There is no discussion of ice accumulation in the vicinity of the Project Area. Admiralty Sailing Directions Volume 2 (UK Hydrographic Office, 2017) also describes floating ice as being extremely rare even during severe winter seasons. Pack ice usually lies well north of 40°N latitude and pack ice that does drift south is always well east of the Project Area. This assessment has found no other information to suggest that floating ice is present or poses a risk to navigation in the vicinity of the Project.

Falling ice

The term “ice drop” is used to describe ice falling from a structure such that it lands in the immediate vicinity of the structure. In contrast, the term “ice throw” describes ice being flung from a rotating WTG blade such that pieces of ice land some distance from the foundation.

No hazard to structural integrity is anticipated from ice accumulation on the structure because when ice builds up on WTG blades, the weight and center of mass of the blades changes, causing an imbalance in the rotor. Should the rotor continue to rotate, it will vibrate, and vibration sensors installed in the WTG would automatically trigger the WTG to shut down. As a result of the widespread use of this control strategy, ice throw occurs rarely, if ever, on modern WTGs; most ice drops to the base of the WTG.

Therefore, the greatest relative risk from ice shedding a Project structure is to a vessel or person in the immediate vicinity of the WTG. This includes maintenance, fishing, and recreational crews and vessels.

An effective and planned risk mitigation measure if icing is detected is automatic shutdown of turbines and issuance of a Notice to Mariners.

An ice hazard protocol is standard wind industry practice to reduce risk for the safety of maintenance/Project crew and vessels during conditions when icing could occur.

Risk to fishing and recreational vessels is expected to be low. Qualitatively, there is about a 1 in 100 years likelihood of ice throw, and even lower likelihood that a fishing or recreational vessel will be nearby and hit by a piece of ice. In addition, recreational vessel activity is reduced in the winter months.

As an additional precaution, DNV GL recommends that the wind farm owner communicate the hazard to mariners when icing conditions are present, when the WTGs are automatically shut down due to icing, and when ice build-up is observed.

8 CONFIGURATION AND COLLISION AVOIDANCE

Wind turbine layouts are traditionally designed to balance tradeoffs considering many factors, including geology of the seabed, water depth, foundation type, and wind direction and speed.

As the planned distance between WTGs increases, one can reasonably expect to see:

- A decreased risk to vessels or low flying aircraft in the area, particularly in bad weather/visibility.
- A reduction in the number of WTGs that can be located in a given lease area, and therefore a reduction of the potential maximum delivered power from a given lease area.
- An increase in delivered power from downwind turbines due to decreased wake effects. A general rule of thumb is a minimum separation distance of eight rotor diameters, which leads to distances between WTGs of slightly greater than 1 NM (almost 2 km) for notional 12 MW WTGs.
- An increase in the cost of array cable installation and maintenance.

This assessment is provided, together with other information from Orsted, to assist the Coast Guard with its own site-specific evaluation of the safety of Search and Rescue (SAR) services in and around the Project.

A Project risk mitigation most relevant to collision avoidance is the layout, which will be in linear rows and columns oriented both northwest-southeast and northeast-southwest. This will provide alternative routes for vessels or aircraft transiting the wind farm and provide multiple options in case of high winds or seas.

9 VISUAL NAVIGATION

This section presents an evaluation of the extent to which Project structures could:

- Block or hinder the view of other vessels underway
- Block or hinder the view of the coastline or of any other navigation feature
- Limit the ability of vessels to maneuver in order to avoid collisions

A geometric approach was used to determine potential visual obstruction caused by Project WTGs or OSS, with a focus on a mariner's ability to see another vessel. The WTG and OSS monopile foundations under consideration would obstruct the view at the water level significantly more than the jacket structures under consideration in the PDE. A jacket foundation is a tubular structure with substantial open space between the supporting elements. Therefore, the largest considered monopile foundation is the basis for this assessment.

The proposed layout minimizes visual obstruction caused by Project structures. This aligned layout, as opposed to a staggered layout, maximizes visual distances and uninterrupted lines of sight when passing in the vicinity of the Project.

The potential length of visual obstruction for a Project structure was estimated based on the effective diameter plus a buffer. The largest monopile foundation in the PDE has a tube diameter of 33 ft (10 m). An additional 1 m was added on either side to account for ancillary equipment, resulting in an effective diameter of 40 ft (12 m). A 40-ft vessel could be unobservable from an opposite position from the structure.

A safety buffer of 33 ft (10 m) was added to the effective diameter to account for the uncertainty in the distance between the unseen vessel and the structure that is impeding line of sight to it. The resulting diameter is 72 ft (22 m), representing the maximum potential for visual obstruction.

For a vessel travelling at 5 kt, the visual obstruction would be 8.6 seconds. This is the period of time that a foundation could potentially limit a vessel's visibility of a second vessel, assuming the second vessel was centered directly opposite it and was not moving.

This is a conservative approach since the structures are spaced so far apart, both vessels would need to be transiting on specific routes to lose sight of each other for very long.

Table 9-1 summarizes the potential duration of limited visibility for vessels transiting at various speeds. The distance travelled without the other vessel in sight is approximately 0.012 NM (22 m).

Table 9-1 Duration (in seconds) of potential visual obstruction based on vessel speed

Speed of vessel (kt)	Duration of obstructed visibility from a vessel (seconds)
5	8.6
10	4.3
15	2.9

The Project layout evaluated in this assessment (Figure 9-1) has a minimum of 0.8 NM between Project structures. This represents more than 70 vessel lengths for a 65-ft fishing vessel.

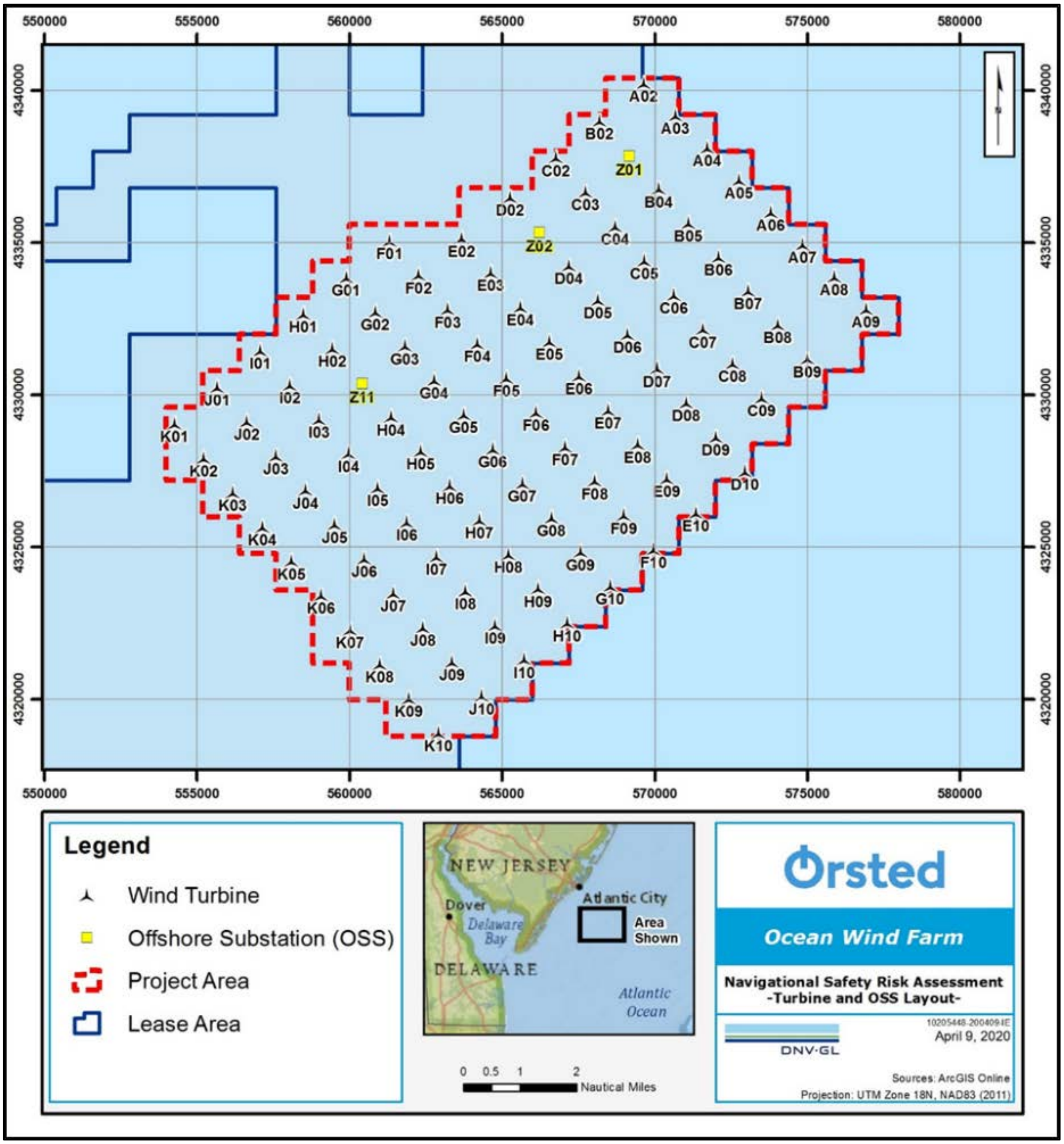


Figure 9-1 Project representative layout (WTGs larger than scale)

A more detailed discussion of the hazards associated with navigating within the boundaries of the Project is included in Section 5.

The Project is not anticipated to affect a mariner's ability to use marked ATON or the coastline, if visible, as reference for navigation due to the Project Area's relative location to marked aids and the coastline. To evaluate whether the Project will affect the ability of mariners to utilize ATON for navigation, a geospatial plot of current ATON, the coastline, and the Project was reviewed (Figure 9-2). No significant obstruction was noted.

During operation, each foundation will serve as an ATON for mariners as they are large structures that will be lighted and marked as required by applicable law and regulation and included in conditions the Coast Guard may impose in conjunction with its PATON permits. A conceptual marking scheme for Project structures is described in Section 13.

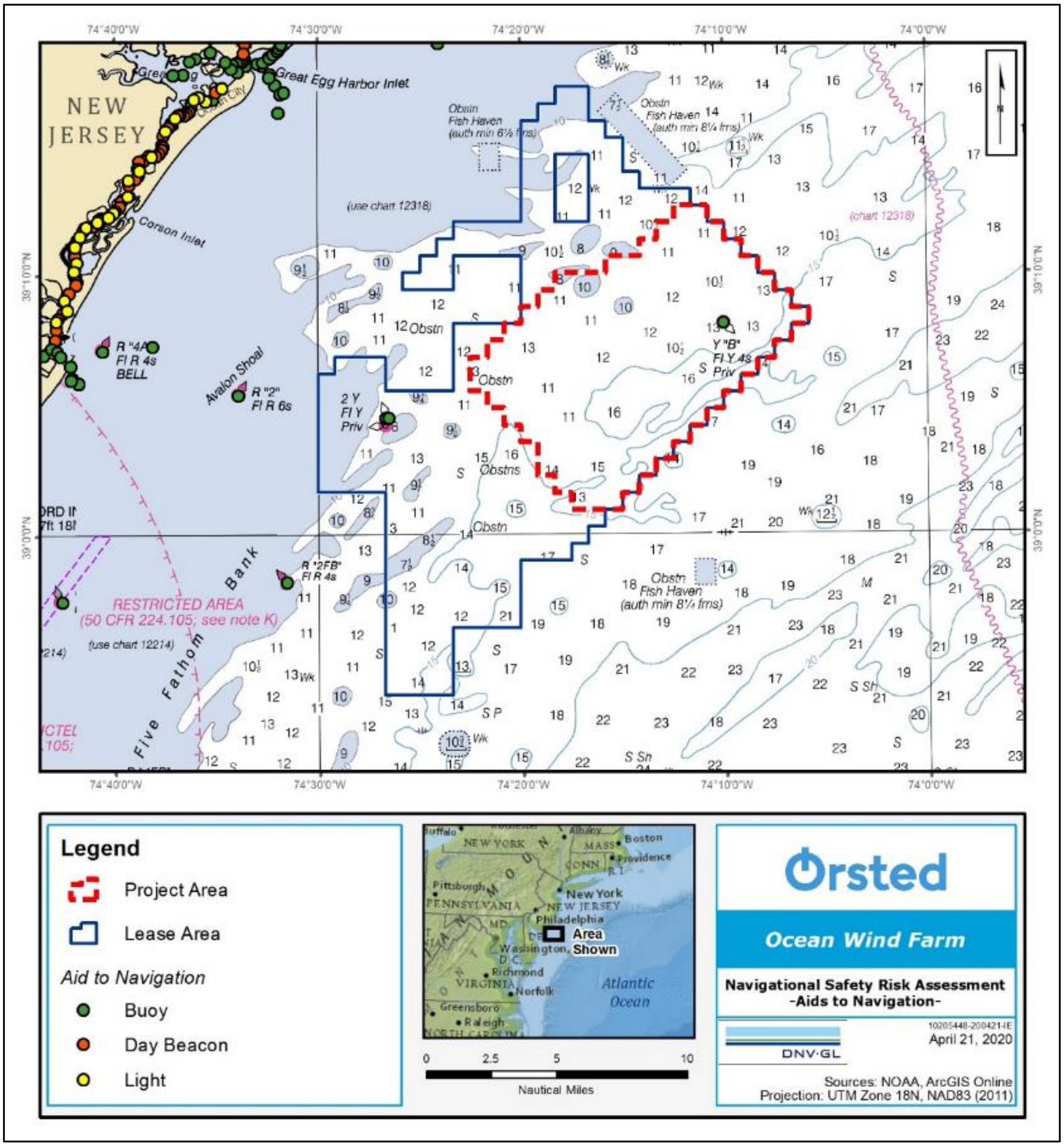


Figure 9-2 ATON in the Vicinity of the Project

10 COMMUNICATIONS, RADAR, AND POSITIONING SYSTEMS

WTGs and the movement of turbine blades can potentially interfere with communication signals from radio and radar transmitters by either blocking or reflecting the signals. Radar and radio systems send out pulses of electromagnetic energy and measure the signals that reflect back to the receiver. The relative speed of a radar target can be determined by a shift in the returned frequency.

Publicly-available literature and project-specific studies were reviewed concerning potential impacts of offshore WTGs on communication and navigation systems.

No risks to the health of vessel crews are anticipated from the power and noise generated by Project structures. The Project will comply with applicable law and regulation concerning electromagnetic interference and human health and safety (Orsted, 2021).

10.1 Effects on communications

This section describes potential wind farm effects on marine communications systems, including ship-to-ship and ship-to-shore communications systems. The published research includes evaluations of High Frequency (HF), Very High Frequency (VHF), and Ultra High Frequency (UHF) radio systems. In summary, the effects of offshore WTGs on marine communications are minor or not discernable.

Rescue 21, Digital Selective Calling (DSC), and AIS are all based on VHF radio communications. The characteristics of VHF radio wave propagation lends itself to quick recovery from structural interference due to its inherent wavelength (~1.8 m). The signal recovers within a few hundred yards. The Coast Guard's advanced command, control, and direction-finding system, "Rescue 21," is unlikely to experience any degradation from the Project. The Rescue 21 architecture and VHF propagation characteristics overcome interference associated with fixed structures such as wind turbines.

Relevant U.S. studies are discussed below.

U.S. Department of Energy

The U.S. Department of Energy conducted a generic study in 2013 to evaluate the effects of offshore wind farms on sea surface, subsurface, and airborne electronics systems (DOE, 2013). With respect to sea surface electronics, the study concluded that "Communications systems in the marine environments are unlikely to experience interference as the result of typical wind farm configurations, except under extreme proximity of operating conditions."

Horns Rev Wind Farm

In 2004, studies were performed of the Horns Rev Wind Farm in Denmark to measure the effects on marine radar, communications, and positioning systems. The studies were performed by QinetiQ and the UK MCA (Howard and Brown, 2004). The studies showed that the effect of wind farms on communications and positioning systems is minor.

North Hoyle Wind Farm

The effects of the North Hoyle Wind Farm in the UK on shipboard communications was studied in 2004 (Howard and Brown). The evaluation studied both ship-to-ship and ship-to-shore communications systems, as well as hand-held VHF transceivers. The wind farm had no noticeable effects on any voice communications systems.

10.2 Effects on marine radar

The potential impacts on marine radar are variable, with the most likely effect being signal degradation. Proximity to the WTGs is the primary factor that determines the degree of radar signal degradation. Due primarily to the quality of radars and the proficiency of professionally licensed crew, radar operations on commercial ships are not anticipated to be affected. Smaller vessels operating in the vicinity of the Project may experience radar clutter and shadowing.

Marine radar impact studies have been conducted and are ongoing in both Europe and the U.S. These studies have been sponsored by both industry and government, including the Coast Guard. In general, the studies found that offshore wind turbines impact marine radars and that effective and accessible mitigations are available to mariners.

The Coast Guard noted in its final MARI PARS report (2020) that various factors play a role in potential marine radar impacts noting,

> "The potential for interference with marine radar is site specific and depends on many factors including, but not limited to, turbine size, array layouts, number of turbines, construction material(s), and the vessel types."

The report summarizes potential impacts including radar clutter, radar saturation, and radar shadowing. The USCG notes however, that,

> "Vessels have different types of radar with varying capabilities. For example, radars that are off-center, or obstructed by railings, antennas, masts and the like are more likely to detect objects falsely. Additionally, radar operator proficiency plays an essential role in a radar system's ability to properly detect targets in and around a wind farm."

The report concludes that,

> "The UK studies also show that additional mitigation measures, such as properly trained radar operators, properly installed and adjusted equipment, marked wind turbines and the use of AIS, enable safe navigation with minimal loss of radar detection."

The MARI PARS findings are consistent with Coast Guard's conclusions regarding the proposed 130 turbine Cape Wind project (Salerno, 2009). Notably, the maximum distance between the proposed Cape Wind turbines was 0.54 NM, which is closer spacing than offshore wind projects currently being developed, which have larger turbines. The Coast Guard found the impacts to marine radar were manageable and vessels could safely navigate within the vicinity of the wind farm:

> "Affected waterways users may need to adjust somewhat to account for navigating within, and in the vicinity of, the proposed wind farm. Nevertheless, vessels operating within or near the proposed wind farm should be able to do so safely even in restricted visibility."

10.2.1 Block Island Wind Farm

The Block Island Wind Farm is the first operational offshore wind farm in the United States. It consists of five wind turbines which powered up in December 2016 and were connected to the mainland energy grid in May 2017.

Pre- and post-construction radar impact studies have been conducted at the Block Island Wind Farm, and no significant permanent radar interference was detected.

10.2.2 Skipjack Wind Farm

In 2019, QinetiQ performed an assessment of the Skipjack Wind Farm, modeling two different marine radar types that are typical for the vessels transiting within the vicinity of the Project Area. QinetiQ modeled X-Band and S-Band radar systems. X-Band systems operate within a frequency range of 8.0 GHz to 12.0 GHz and are generally installed on smaller vessels. S-Band systems operate within a frequency range of 2.0 GHz to 4.0 GHz and are generally installed on large vessels.

The study evaluated nine different scenarios with each of the radar types, for a total of eighteen scenarios. Three separate assessments were performed; radar clutter assessment, saturation assessment, and shadowing assessment (QinetiQ, 2019).

Radar clutter assessment

Radar clutter assessments were conducted for nine different scenarios. For each scenario, radar display simulations were shown at three locations illustrating the likely appearance of wind turbine clutter. Both direct clutter and multipath clutter were modeled. Two reference vessels were included in all modeling results.

Initial modeling without any form of gain control (GC) showed many of the expected, typical clutter impacts, including side lobe breakthrough and multipath clutter. For the majority of scenarios considered, multipath clutter is likely to be intermittent, and did not appear on every scan. In all examples considered, the severity of the turbine direct and multipath clutter could be reduced using GC desensitization. However, the radar desensitization also resulted in the loss of detection of the reference targets in some cases.

Saturation assessment

A saturation assessment showed that when no GC is applied, X-Band radar saturation is possible when the turbine is approximately 0.29 NM (0.54 km) or closer to the radar. The corresponding value for the S-Band radar is approximately 0.48 NM (0.89 km). For both radars, saturation in these cases can easily be avoided when the sensitivity is reduced using some form of GC. This is the same as normal radar use in the vicinity of large reflective objects such as port infrastructure and large flat-sided vessels.

Shadowing assessment

Shadowing estimates were made of the jacket foundation and tower. Significant shadowing zones were limited to narrow strips behind the turbines relative to the radar position. The likelihood of detection of vessels in the shadow zone can be reduced. The impact is likely to be largest for small targets at long range. In the scenarios considered, the width of shadow zones in the traffic separation scheme ranges from 400 ft (122 m) to 3,230 ft (1,000 m). The width of the zones in the vicinity of the turbines is much smaller.

Shadowing impacts will not be persistent due to the motion of the radar vessel and other vessels. The impact of the monopile foundation has not been modeled but is likely to be greater than the jacket option.

10.3 Effects on HF Radar

NOAA operates over 100 coastal SeaSonde HF radar sites designed primarily to collect sea surface wind, wave, and current data. Although the SeaSonde HF system radar has no role in vessel collision, allision, or grounding avoidance, data from the system is used by, among others, the Coast Guard in its SAR computer models for drift modeling to narrow search areas for people and vessels lost at sea (DOE, 2020).

BOEM commissioned a study (2018b) to examine the potential impacts to HF radar from offshore wind farms. The key findings of the study were:

- Wind turbine interference is caused by the amplitude modulation of the turbine's radar cross-section.
- The location of the wind turbine interference in the Doppler spectrum is predictable and can be determined from the rotation rate of the wind turbine.
- Wind turbine interference can be simulated in SeaSonde data using Numerical Electromagnetic Code tools for both assessing the impact of wind turbine interference as well as designing mitigation methods.
- Wind turbine interference impacts the SeaSonde ocean current measurements in three ways:
  - Biasing the measurement of the true background noise level (affecting the sea echo identification algorithms)
  - Changing the boundaries of the requisite sea echo peaks by mischaracterizing turbine echoes as part of the sea echo
  - Changing the bearing assignment for the radial current vectors by causing turbine echoes to be convolved within the sea echo.
- Mitigation techniques that remove wind turbine interference from the sea echo peaks alone are insufficient and still lead to errors in the current measurements. The wind turbine interference outside the sea echo must be filtered as well.
- Using known bearings and a filter will at best remove a small portion of the wind turbine interference.
- Mitigation methods that remove signals from the Doppler spectrum based on the wind turbine rotation rate estimates are effective methods of mitigating wind turbine interference. Wind turbine rotation rates can be estimated from SeaSonde cross-spectra; it would be more successful if turbine RPMs were provided by the turbine operator

10.4 Effects on positioning systems

Global Positioning Systems (GPS) are commonly used by mariners to track their position in real-time. The available literature is limited concerning measured effects of wind farm structures on marine GPS. The potential concern is that electromagnetic energy from the WTGs may interfere with satellite-based systems like GPS (The University of Texas, 2013).

Measurements were taken in the North Hoyle Wind Farm (Howard and Brown, 2004), with a finding that, "No problems with basic GPS reception or positional accuracy were reported during the trials."

10.5 Potential mitigation measures for radar effects

Concerning marine radar, most instances of interference can be mitigated through the proper use of radar gain controls. Further risk reduction can be achieved by regular communications and safety broadcasts from vessels operating in the vicinity of the wind farm. Placement of radar antennas to a favorable position on a vessel such as a commercial fishing vessel, has also been found to be an effective mitigation to adverse radar impacts (BWEA, 2007).

Given the nature of the interference, post-construction analysis is recommended to precisely identify effects on radar and best ways to mitigate them.

In 2019 correspondence to BOEM (Glander, 2019), the Coast Guard stated: "Radar impacts are a function of numerous issues, including turbine height and size, proximity to other towers, weather, atmospherics, shipboard radar quality, radar operator proficiency, target size and number, etc." The Coast Guard went on to discuss that computer modeling can only predict, not confirm, potential impacts and further stated that a post-construction research analysis may be appropriate to indicate whether the turbines "produce radar reflections, blind spots, shadow areas, or other effects that could adversely impact safety of navigation."

Orsted conducted a post-commissioning radar impact analysis of the Block Island Wind Farm (which found no significant impacts to marine radars) and is committed to conducting such analysis post-commissioning for all its U.S. projects and implementing appropriate mitigations to reduce its impact.

Concerning HF radar, the BOEM radar study (2018b) recommended four "Next Steps":

1. Extend the existing simulations to include interference from wind farms with an arbitrary number of in-homogeneously configured and rotating wind turbines.
2. Assess the impact of turbine interference on secondary data products (e.g., wave heights and tsunami warnings required by the National Weather Service).
3. Develop a real-time mitigation solution.
4. Continue monitoring and testing of mitigation techniques at Block Island as a primary test bed.

In conjunction with BOEM, NOAA, the American Wind Energy Association, and the DOE Wind Turbine Radar Interference Mitigation working group, Orsted is actively engaged in mitigating the potential impacts of its offshore wind projects to the SeaSonde HF radar system (Orsted, 2021).

11 COLLISION, ALLISION, AND GROUNDING ASSESSMENT

This section presents the results of a quantitative assessment of collision, allision, and grounding (i.e., a marine accident) in the vicinity of the Project Area from operation of the Project that builds upon earlier work conducted by the Coast Guard (e.g., 2015 and 2020). The risk assessment consists of estimates of frequency or probability of accidents and a “what if” consequence analysis.

The change in frequency is estimated by modeling how often a marine accident is estimated to happen with and without the Project. Risk models are generally conservative and, by design, predict higher numbers of events than come to fruition. Much of the value from a model is its future use to evaluate “what-ifs” and potential risk controls.

The consequence analysis discusses how severe an accident could be if it were to happen.

The results are presented by accident type, by vessel type, and by sub-area. For most vessel types, risk change from the Project is estimated in terms of the difference in frequencies of marine events based on multiple data inputs into the MARCS tool. MARCS has been utilized globally to assess navigation risk of more than 20 wind farms. The tool is used to calculate accident frequency and locations for collision between vessels, allision with Project structures, and grounding directly or indirectly resulting from the establishment of Project structures by taking differences between model calculation cases.

The Project model includes anchoring as a recovery mechanism to prevent drift allision (for non-tug ship types) but it does not include tugs of opportunity or similar towing ships as a save mechanism, so the drift grounding and drift allision results are certainly conservative.

The historical accident record for offshore wind farms is sparse. Offshore wind farms have been in operation in the EU for 29 years (Wind Europe, 2019). This study identifies three documented allisions in wind farms involving non-project vessels:

- The CTV Njord Forsesti struck a WTG in German waters on 23 April 2020.
- One accident involved a distracted fishing vessel (BOEM, 2018a).
- A container ship lost steerage because of a power failure (BOEM, 2018a).

11.1 Frequencies of marine accidents

This section presents the estimated changes in frequencies of marine accidents due to the Project. The supplementary traffic added to the AIS data is summarized in Table 11-1 and details are provided in Section 2.3 and Appendix E.

Table 11-1 Transits added to AIS data for modeling

Vessel type	Activity	Included in Base Case model (each way)	Included in Future Case model (each way)
Recreational boats without AIS (added to “Pleasure” AIS vessel type) (see Section 2.1.1.4)	Fishing or other pleasure activities	-	1,825
Pleasure, shallow draft (see Section 2.3)	Sightseeing	-	100
Commercial fishing vessels without AIS (see Section 2.1.1.2)	Fishing in Project Area	172	172
	Transiting through Project Area	172	172

The MARCS model is a set of risk parameters and calculation tools that have been developed to quantify marine risk. MARCS calculates the frequency per grid cell for marine accidents accounting for a wide range of factors identified over decades of studies into causal and mitigating factors for maritime accidents, including the following:

- Vessel speed
- Vessel direction/route
- Distance traveled on the route
- Probability of steering and / or propulsion failure
- Probability of error in navigation depending on risk controls applied
- Distribution of wind direction and effect on sea state
- Probability of visibility greater than 2 NM
- Whether another navigating vessel is within 0.5 NM (an encounter or critical situation)
- Whether a fixed object (allision) or coastline (grounding) is within 20 minutes of navigation (a dangerous course)
- Conditional probability that the crew will successfully take actions to recover from a dangerous situation

The MARCS model estimates frequencies for marine accidents accounting for Project- and location-specific environmental, traffic, and operational parameters. The model estimated the average annual frequency of occurrence for each accident type in each grid cell.

The general model is described in Appendix D to this NSRA. A detailed description of the Project-specific model for collision, grounding (drift and powered) and allision (drift and powered) is in Appendix E to this NSRA.

The decision concerning whether and how to account for the other (non-Ocean) wind lease areas involves a trade-off. If they are ignored, the risk estimate is purely the result of the Ocean Wind Farm in isolation. If instead, it is assumed that all of the leases are built upon, the risk estimate provided is a more realistic view of the potential future of navigation in the area. Both are valid options, and the resultant model's over-or under- prediction of collision or allision depends on the traffic density, traffic patterns, proximity to shallows, and the size of the leases. In practice, the main effect of taking account of additional, non-Ocean lease areas is that re-routed traffic (mainly deep draft ships) is more extensively modified compared to traffic routes today.

For this assessment, the future deep draft and tug vessel routes in the model were modified from the AIS-indicated routes to avoid the wind lease areas. This approach over-estimates the risk from the Project in isolation, and collision and grounding risk in particular, but gives an indication of the cumulative effect on risk. It captures the effects from maximum displacement of traffic and increases in traffic density around the leases. This approach may slightly under-estimate allision risk from deep draft and tug vessels. However, for this Project Area, there are relatively few deep draft and tug transits compared to other types of traffic, and the under-estimate in risk is small compared to the overall risk from the Project.

Table 11-2 provides a summary of the incremental risk results for the Project, reported as increases in the frequency of accidents in the Marine Traffic Study Area.

Table 11-2 Modeled change in accident frequencies from the Project

Vessel type	Increase in frequency of any accident (number per year)	Percentage of Total
Cargo	0.015	3.7%
Fishing	0.020	5.0%
Other	0.006	1.4%
Cruise ships and ferries	0.001	0.2%
Pleasure	0.265	65.8%
Tankers	0.002	0.6%
Tugs (all)	0.094	23.3%
Total	0.403	100%

The model shows that the frequency of marine accidents may increase by 0.4 accidents per year, an increase of 32 percent. Marine accidents involving pleasure vessels represent 66 percent of the total increase, and tugs represent 2 percent (Figure 11-1). Note this accident frequency increase is for all accidents and includes accidents with small and zero consequence such as brief grounding on a sandy bottom.

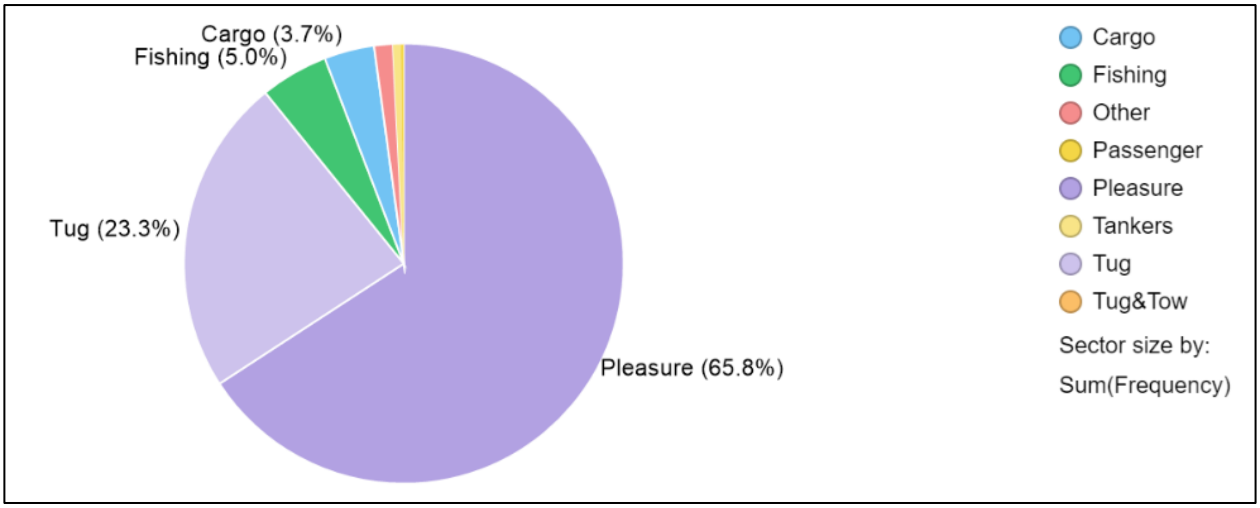


Figure 11-1 Risk contribution per vessel type

Table 11-3 shows the same results summarized per accident type.

Table 11-3 Modeled incremental change in accident frequencies from the Project for each accident type

Accident type	Increase in frequency of any accident (number per year)	Percentage of Total
Powered Grounding	0.148	36.8%
Drift Grounding	0.144	35.6%
Powered Allision	0.066	16.3%
Drift Allision	0.019	4.6%
Collision	0.027	6.7%
Total	**0.403**	100%

Grounding accidents of any severity comprise 72.4 percent of the increase in risk and are conservatively modeled to occur an additional 0.29 times per year (Figure 11-2) due to the presence of the Project.

The sensitivity study concludes that the modeled risk from the Project is not increased substantively by the configuration of the tows.

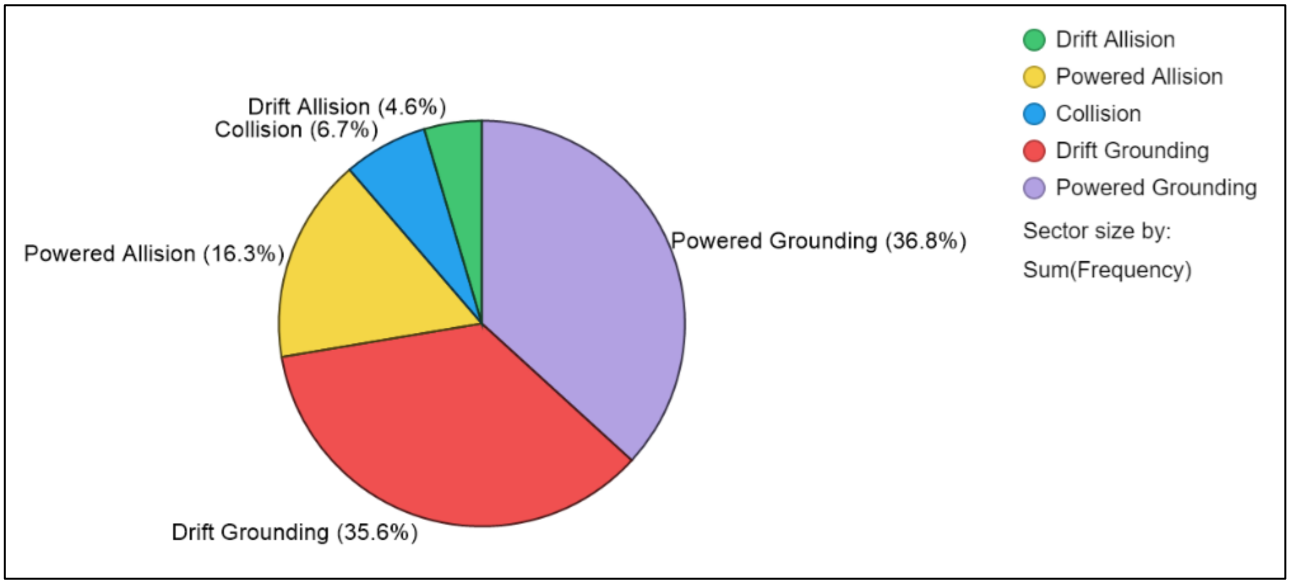


Figure 11-2 Risk contribution per accident type

The risk model accounted for risk control measures that are implemented today such as modern navigation equipment on vessels in international trade, electronic charts, and Port State Control. The model did not account for other risk controls that are widely regarded as beneficial, such as:

- PATON to be installed by the Project. Insufficient data are available to support quantifying the effects of this measure in the model.
- Tug capability and availability to intervene and prevent a drift allision or a drift grounding by a vessel that has lost power. Accounting for this measure would require a detailed evaluation of tug availabilities and capabilities in the region. Not accounting for it is a conservative approach to the modeling, resulting in higher risk estimates for drift allision than would be estimated with a model that included this measure.
- The effect of anchoring on reducing drift grounding frequency is also not taken into account as grounding risk is not the primary focus of this project.

The remainder of this section presents the risk for the Project area, northwest, and far south sub-areas defined for this NSRA (Figure 11-3). The sub-areas were defined based on expert opinion to allow differentiation between areas of varying levels of risk. The estimated risk increases for the remaining sub-areas (east, northeast, southwest, and outer “other” sub-area) are less than 0.0005 accidents per year each. They are briefly discussed in Appendix E.

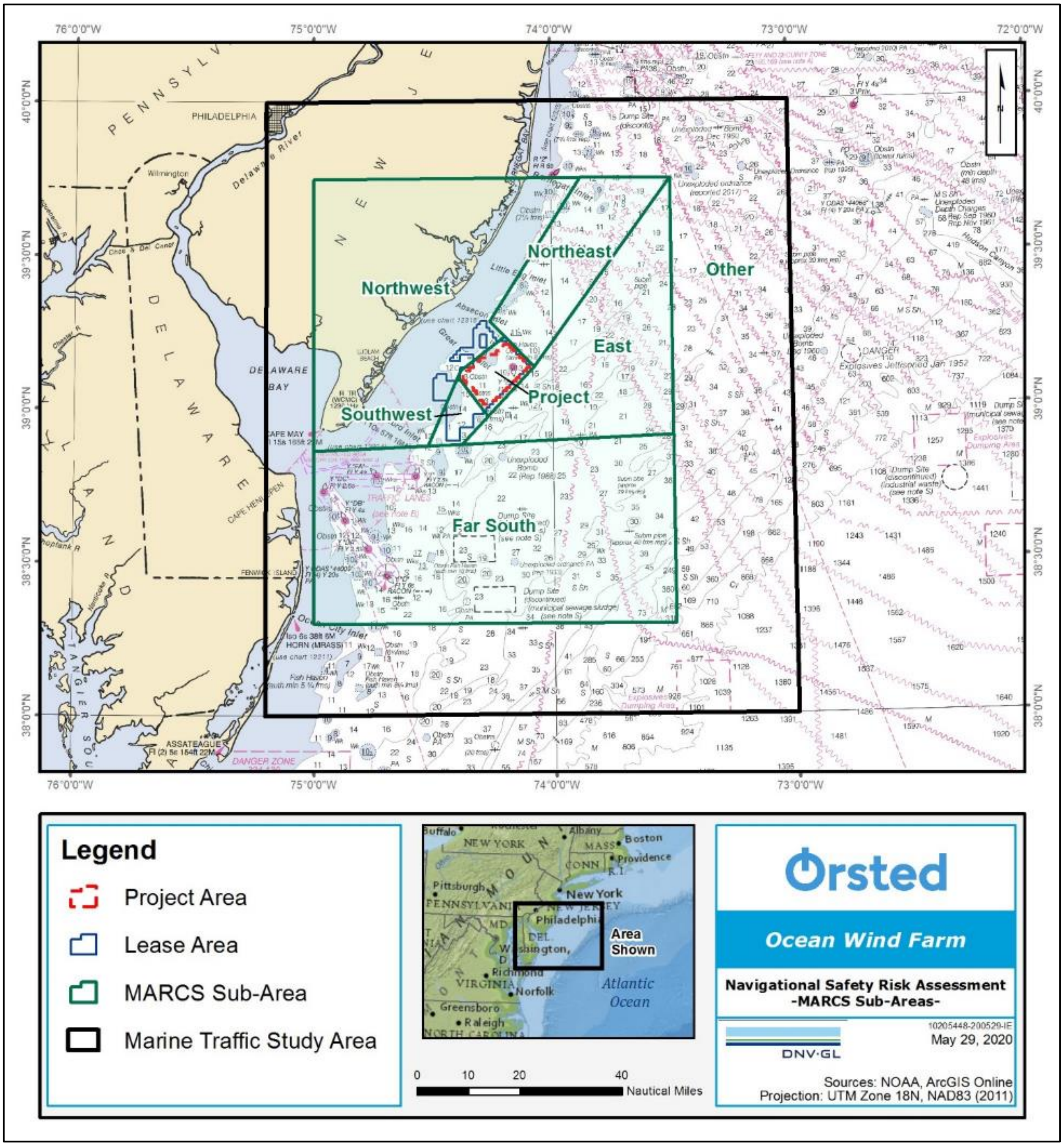


Figure 11-3 Definitions of sub-areas within the Marine Traffic Study Area

Nearly all of the risk increase from the Project is in the northwest sub-area and the Project Area (Figure 11-4). The risk changes in the northwest sub-area are related to re-routing of deep draft and tug vessels around the lease areas. The risk changes in the far south sub-area are related to the additional pleasure vessels assumed to transit to the Project Area in the future.

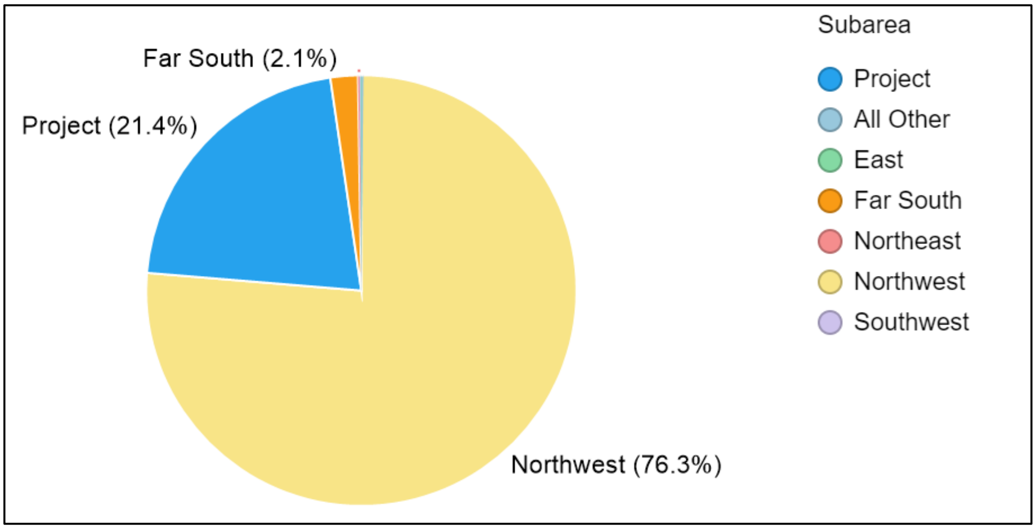


Figure 11-4 Distribution of risk change across sub-areas

11.1.1 Project Area

Table 11-4 shows the modeled difference in risk from the Project within the Project Area in order of decreasing contribution to the change in risk. The Project Area contains all the Project structures and hence all the allision accidents are within this sub-area.

There is zero frequency of powered grounding and drift grounding in this sub-area because there is no land or shallow water. Differences in frequency that round to less than 0.001 accidents per year are highlighted in grey.

Table 11-4 Risk increase in the Project Area (annual accident frequencies)

Vessel type	Drift allision	Powered allision	Collision	Drift grounding	Powered grounding	Total
Cargo	<0.0005	<0.0005	<0.0005	-	-	**<0.0005**
Cruise ships and ferries	<0.0005	<0.0005	<0.0005	-	-	**<0.0005**
Fishing	0.004	0.015	<0.0005	-	-	**0.019**
Other	0.002	0.003	<0.0005	-	-	**0.005**
Pleasure	0.005	0.048	0.002	-	-	**0.055**
Tankers	<0.0005	<0.0005	<0.0005	-	-	**<0.0005**
Tugs (all)	0.007	<0.0005	<0.0005	-	-	**0.007**
Total	**0.019**	**0.066**	**0.002**	-	-	**0.086**

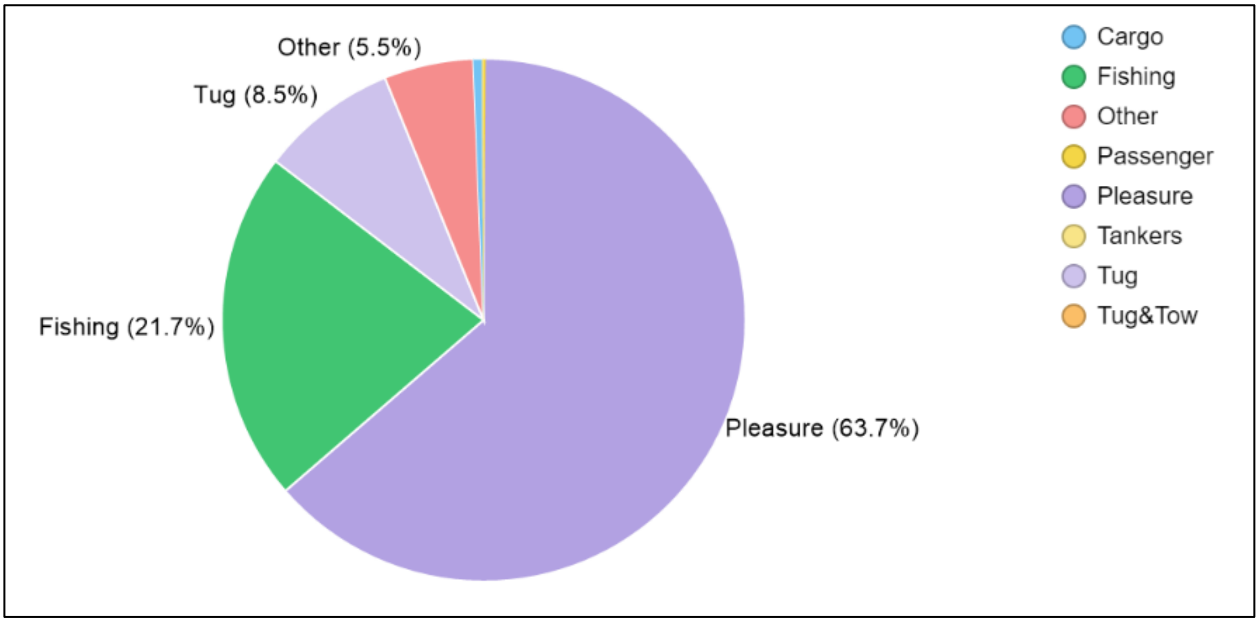


Figure 11-5 Risk contribution per vessel type in the Project Area

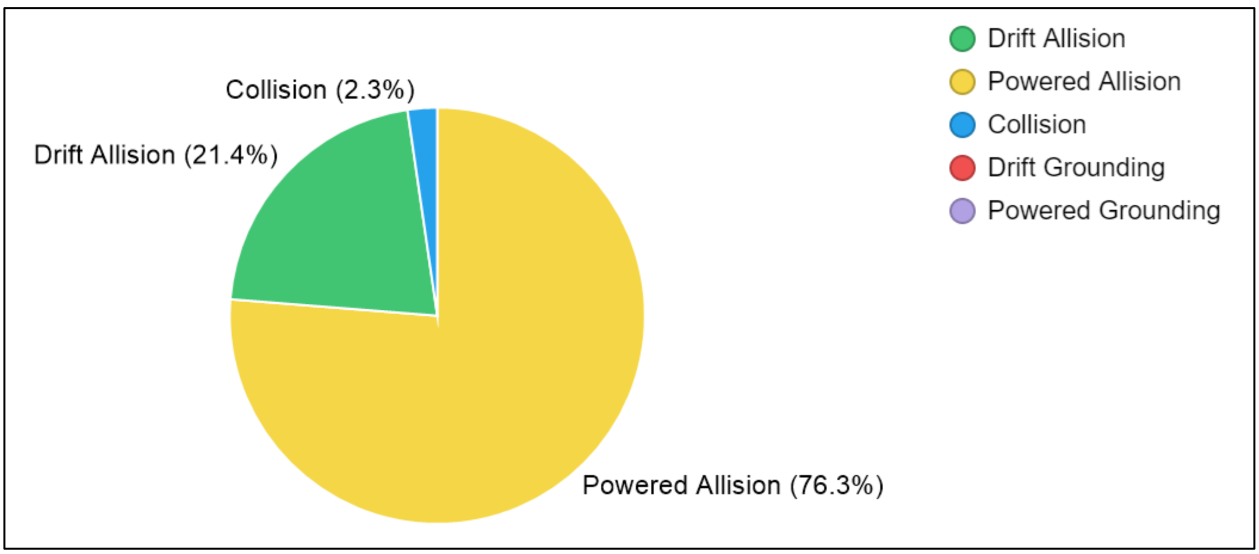


Figure 11-6 Risk contribution per accident type in the Project Area

11.1.2 Northwest sub-area

Risk increases from the Project in the northwest sub-area are presented in Table 11-5 in order of decreasing contribution to the change in risk.

Table 11-5 Risk increase in the northwest sub-area (annual accident frequencies)

Vessel type	Drift allision	Powered allision	Collision	Drift grounding	Powered grounding	Total
Cargo	-	-	<0.0005	0.002	0.012	**0.014**
Cruise ships and ferries	-	-	<0.0005	<0.0005	0.001	**0.001**
Fishing	-	-	0.001	<0.0005	<0.0005	**0.001**
Other	-	-	0.001	<0.0005	<0.0005	**0.001**
Pleasure	-	-	0.012	0.116	0.074	**0.203**
Tankers	-	-	<0.0005	<0.0005	0.002	**0.002**
Tugs (all)	-	-	0.002	0.025	0.059	**0.086**
Total	**-**	**-**	**0.017**	0.144	**0.148**	**0.308**

The modeled accident frequency related to the Project and adjacent lease areas increases by 0.3 per year in this sub-area, an additional 3 accidents in 10 years. Compared to a model baseline frequency of 1.3 accidents per year in the northwest sub-area, the effect from the Project represents a 24 percent increase.

Figure 11-7 shows that groundings involving any vessel contribute 95 percent to the risk increase. Groundings involving pleasure vessels contribute 62 percent of this increase.

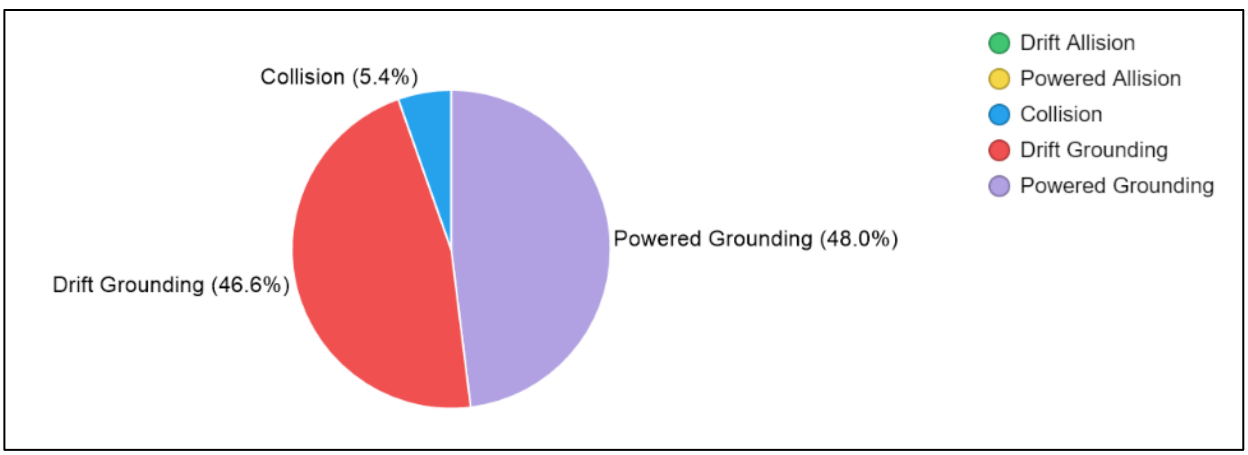


Figure 11-7 Risk contribution per vessel type in the northwest sub-area

11.1.3 Far south sub-area

Table 11-6 presents the risk effect from the Project in the far south sub-area, in order of decreasing contribution to the change in risk. In this sub-area, all of the risk increase is due to collision, and 86 percent of the modeled accidents involve pleasure vessels. The increase is a result of the assumption that an additional 10 vessels per day for six months of the year will visit the Project for recreational purposes

Table 11-6 Risk increase in the far south sub-area (annual accident frequencies)

Vessel type	Drift allision	Powered allision	Collision	Drift grounding	Powered grounding	Total
Cargo	-	-	<0.0005	-	-	**<0.0005**
Cruise ships and ferries	-	-	<0.0005	-	-	**<0.0005**
Fishing	-	-	<0.0005	-	-	**<0.0005**
Other	-	-	<0.0005	-	-	**<0.0005**
Pleasure	-	-	0.007	-	-	**0.007**
Tankers	-	-	<0.0005	-	-	**<0.0005**
Tugs (all)	-	-	0.001	-	-	**0.001**
Total	**-**	**-**	**0.008**	**-**	**-**	**0.008**

The modeled accident frequency related to the Project and adjacent lease areas increases by 0.008 per year in this sub-area, an additional 8 accidents in 1000 years.

All of the risk change in this sub-area is related to collisions. Figure 11-8 shows that pleasure vessels are struck in collision in 86 percent of the modeled accidents in the far south sub-area.

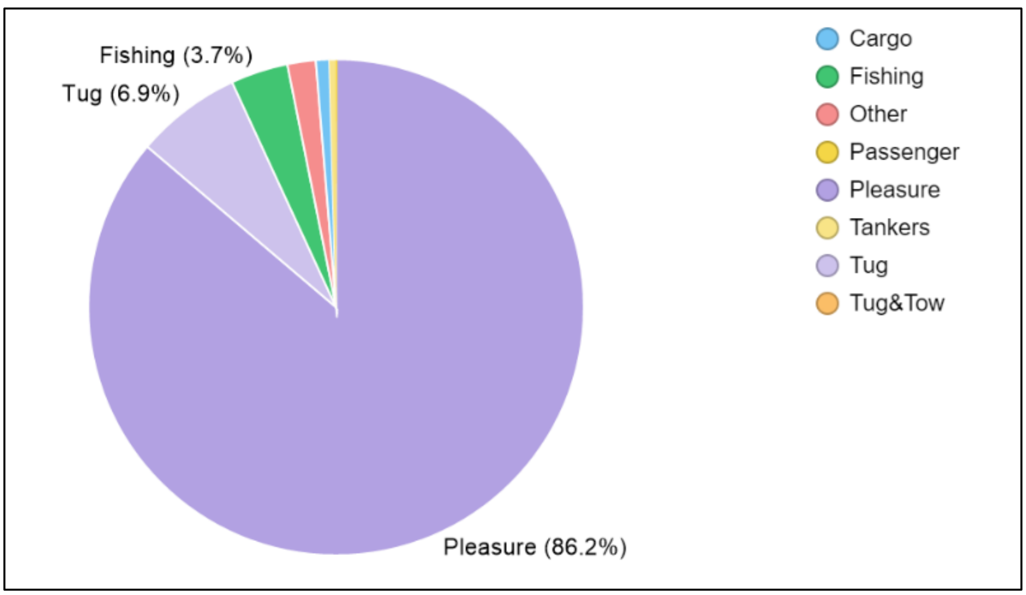


Figure 11-8 Risk contribution per vessel type in the northwest sub-area

11.1.4 Sensitivity of risk to proportion of tugs with towlines

The AIS data indicated that about two percent of the tug vessels in the Marine Traffic Study Area self-indentified as “pusher tugs”. A separate risk model was built to examine how sensitive the risk results are to the proportion of tugs that configured as tug-with-tow. The general Project risk model described in Sections 11.1.1 through 11.1.3 modeled all tugs as tugs without barges. The collision and grounding accident frequency results generated by MARCS do not depend on ship size, see Appendix D. In contrast, the powered allision accident frequency on the ship breadth and drift allision accident frequency depends on the ship length. The sensitivity of the allision results to ship size is presented in this section.

This section presents the towline sensitivity model that was built to provide insights concerning the effect on incremental risk from the Project if additional conservative assumptions were used to model half of the tugs on near-coast routes east of the Project area as tug-with-tow. Figure 11-9 shows a typical tug-and-tow configuration.

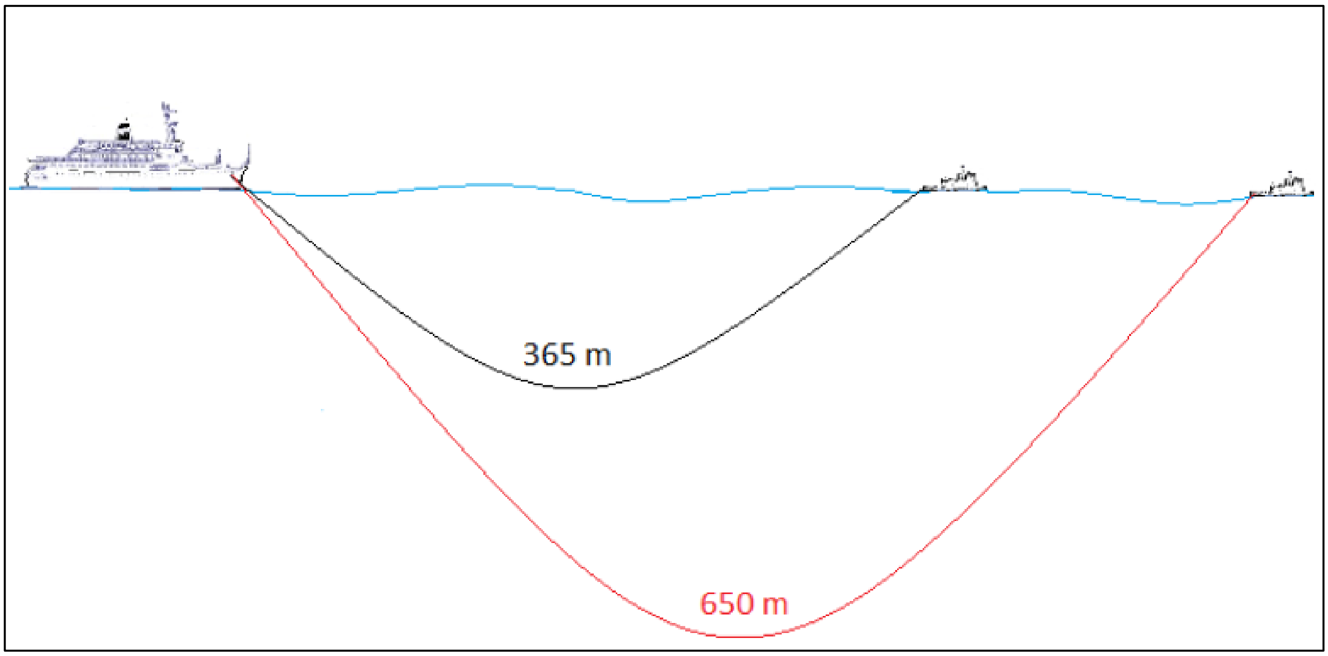


Figure 11-9 Tow wire tug and barge (taken from AWO, 2018)

The tug sensitivity model assumed that tug-and-tows represented about half of the tugs transiting coastwise, west of the Project Area (based on the Future Case routes). This proportion was selected based on discussions with AWO (Orsted, 2021).

Typical tug vessel lengths and widths were used in the general Project risk model; however, for this sensitivity model, the tug-and-tow vessels were assigned a length and breadth sufficient to represent the full tow length and the swept path (effectively the width of the tug and barge combination perpendicular to the tugs heading).

The ACPARS report (Coast Guard, 2016) incorporates a report from the U. S. Coast Guard/ American Waterways Operators Quality Action Team that states:

> *In general, …the swept path for towing a large 600-700' barge astern with 2,000' wire could easily be up to a ½ NM or more under typical adverse crosswind and crosscurrent conditions. For average tugboat and barge operations, the swept path would range from ¼- ½ NM.*

The MARCS model calculates the frequency of allisions based on the length and breadth of the vessels in the model together with other parameters discussed in Appendices D and E. The following dimensions were assigned to the tug-and-tow vessels in the tug sensitivity model as maximum reasonable values, and were applied for all wind conditions:

- An effective breadth of 0.25 NM (463 m, 1,519 ft)
- An effective length of 0.5 NM (926 m, 3,038 ft)

Table 11-7 provides a summary of the modeled risk increase due to the Project given the above assumptions. The risks are reported as increases in the frequency of accidents in the Project Area.

Table 11-7 Accident Frequency Difference (per year), Tug-with-tow included (tug sensitivity)

Vessel Type	Drift Allision	Powered Allision	Collision	Drift Grounding	Powered Grounding	Total
Cargo	0.000	0.000	0.000	0.000	0.000	0.000
Cruise ships and ferries	0.000	0.000	0.000	0.000	0.000	0.000
Fishing	0.000	0.000	0.000	0.000	0.000	0.000
Other	0.000	0.000	0.000	0.000	0.000	0.000
Pleasure	0.000	0.000	0.000	0.000	0.000	0.000
Tankers	0.000	0.000	0.000	0.000	0.000	0.000
Tug	0.000	0.000	0.000	0.000	0.000	0.000
Tug with Tow	0.022	0.000	0.000	0.000	0.000	0.022
Total	0.022	0.000	0.000	0.000	0.000	0.022

The overall difference is a small accident frequency increase or 0.022 per year, or 1.3 percent for the Marine Traffic Study Area.

For tug-with-tow drift allision the accident frequency increases by a factor of 7.8, but from a relatively low base frequency. This is as expected, because the longer tug-with-tow has a larger impact cross section.

The reason why powered allision is not significantly increased is because in the Future Case all tugs, including tugs-with-tows, are routed around the wind farm.

11.2 Consequences of marine accidents

11.2.1 Consequences from an allision

A wide range of potential consequences exists should an allision occur. The least severe consequence is that a drifting vessel grazes a project structure. In this event, there may be minor damage to both the vessel and the WTG. It is likely that all personnel, passengers, and structures would not experience any injury or damage. The severity of consequences from an allision increases with the speed of impact and size of the vessel, and depends on the impact geometry.

A powered allision (i.e., occurring at speed) has potential for severe consequences to both the vessel and the Project structure. The maximum design case scenario for a powered allision could result in the following:

- Personnel/passenger injury or fatality.
- Major damage to the vessel. The damage could potentially be so severe that vessel sinking is possible. Damage could also result in a release of cargo or fuel.
- Major damage to a WTG or OSS. The severity of the damage is dependent on the design and the specific nature of the strike.

Although drift allision generally involves lower impact energies than powered allision; a drifting ship is likely to drift with its highest point away from the wind. As a result, a drifting oil tanker might contact a WTG on its stern quarter, also creating the potential for a cargo or bunker fuel spill.

11.2.2 Consequences from a grounding

Groundings are a common marine event near the coast. Groundings have occurred in the coastal waters to the west of the Project, and the Project has the potential to increase grounding risk. The water depths in the vicinity of the Project are not limiting for vessels transiting around the Project Area, so the Project effectively poses no increase to grounding risk within the Project Area.

The potential consequences from a grounding are similar to those from allision, personnel/passenger injury or fatality and damage to the vessel. Since the subsurface substrate at the coastline is primarily soft rather than rocky, the most severe consequences such as major damage to the vessel or hull failure are less likely, but also dependent on location specific factors. For example, a powered or drift grounding at high tide could result in a ship becoming stranded on the shoreline. With a high tidal range the ship may be damaged by its own weight or by subsequent severe storms.

In addition to the substrate type, the energy associated with the impact is another determinant of the level of immediate consequences from a grounding. Powered groundings on hard substrates have the potential for higher levels of vessel damage and harm to the crew.

11.2.3 Consequences from a collision

In a collision, the consequence can range from minimal (almost no consequence) to catastrophic. The level of consequence depends on vessel speed, vessel size (DWT), collision angle, and location of contact on the vessels. Fire or explosion can result from collision and this increases the consequence significantly. The most extreme collisions in the historical data resulted in fatalities and total loss of a vessel.

11.3 Risk mitigation of marine accidents

This section provides an overview of existing maritime and offshore wind industry practices that control risks. Risk controls are most readily identified and implemented during early concept phases. Selection of location and completion of early phase design place additional constraints on the availability and costs of some controls.

Aspects that affect the risk level for Ocean Wind include:

- Generally low traffic density
- Predominantly smaller vessels in the traffic
- Sufficient distance from ports, coastlines, and shoaling water
- Availability of ATON / PATON– Enhanced navigation aids may assist vessels in more accurately determining vessel position as well as identifying potential hazards.

Risk controls – Maritime

In the larger view of history, safe marine transit of crew, passengers, and cargo has been a focus area for a wide range of parties, including mariners, shippers, commercial fishing operators, owners of shipped goods, insurers, nations, and international bodies. Some of the first international requirements related to vessel design and construction, resulting in the creation of ship classification societies in the mid-1800s.

The primary governance for every ship is its flag state, the country in which the ship is registered. The government of the flag state adopts standards of design, construction, maintenance, and operation.

In addition, the port state, the government of the ports or anchorages at which a ship calls, may enforce international standards and its own regulations.

To facilitate general adoption of the highest practicable standards in matters concerning maritime safety and related purposes, the United Nations created the IMO in 1948 (IMO, 2019b). Because of the global nature of shipping, many requirements relating to maritime safety in U.S. waters have their foundations in IMO conventions and codes. Today, these are considered industry standard practices and are accounted for in this risk assessment.

The U.S. has promulgated regulations in line with the key IMO conventions that include:

- SOLAS – The International Convention for the Safety of Life at Sea requires certain equipment and practices to increase the safety of people on board (various parts of 46 CFR)
- COLREGs -Convention on the International Regulations for Preventing Collisions at Sea. Requirements include vessel-to-vessel communication and safe transit speeds (primarily 33 CFR 80 et. seq.)
- STCW - International Convention on Standards of Training, Certification and Watchkeeping for Seafarers and International Convention on the Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (46 CFR 11 et. seq.)

The IMO also establishes routing measures to increase the safety of vessels on approach to and departure from major ports. Routing measures are particularly effective in congested port waterways:

> "Traffic separation schemes and other ship routing systems have now been established in most of the major congested, shipping areas of the world, and the number of collisions and groundings has often been dramatically reduced." (IMO, 2019a)

As noted in Section 2, routing measures have been established by the Coast Guard, which has the primary responsibility to ensure safety of life and property at sea. The Coast Guard administers navigation and vessel inspection laws and regulations governing marine safety and environmental protection. The Coast Guard accomplishes this by prescribing regulations published in CFR Titles 33, 46, and 49. These regulations incorporate international laws to which the United States is a signatory, as well as various classification society and industry technical standards.

The Coast Guard also manages ATON in the Marine Traffic Study Area, including an array of audio, visual, radar, and radio aid to navigation, such as lights, buoys, sound signals, range markers, and radio beacons. The Coast Guard conducts studies and consults with federal agencies, state representatives, waterway users, and the general public, to study waterways for safety and efficiency.

One type of study conducted by the Coast Guard is a Port Access and Route Study (PARS), which reviews potential traffic density and the need for safe access routes for vessels. A primary purpose of this study is to reconcile the need for safe access routes with other waterway uses. A PARS study is typically conducted before the Coast Guard establishes or changes Regulated Navigation Areas or Traffic Separation Schemes.

The most recent completed PARS studies relevant to this assessment are:

- Areas Offshore of Massachusetts and Rhode Island Port Access Route Study (Coast Guard, 2020)
- Atlantic Coast Port Access Route Study (Coast Guard, 2016)
- Buzzards Bay Port Access Route Study (Coast Guard, 2004)

Ongoing studies relevant to traffic off the Mid-Atlantic coast are:

- Atlantic Coast: Port Approach and International Entry and Departure Areas, which was announced in March 2019 (84 FR 9541)
- Port Access Route Study of the seacoast of New Jersey and approaches to the Delaware Bay, which was announced on 5 May 2020 (Docket ID USCG-2020-0172)

Results in PARS reports, including recommendations, "help program managers establish traffic routing measures, fairways, TSS, limited access areas, recommended routes and regulated navigation areas. They may provide justification for regulatory projects or submissions to the IMO. If the PARS recommends vessel routing measures, Commandant (CG-NAV) will validate the recommendations and initiate the Federal rulemaking process and/or IMO's ships routing measures process." (Coast Guard, 2019c)

In addition, on 19 June 2020, the Coast Guard announced an Advance Notice of Proposed Rulemaking concerning potential establishment of shipping fairways identified in the 2016 Atlantic Coast PARS. Among the fairways included in the Notice is the tug route shown in previous Figure 11-11.

NOAA also plays an important role in marine safety, providing weather reports, forecasts, warnings, nautical charts and navigational information, and other data. Two NOAA offices, the National Ocean Service and the National Weather Service, offer data and services that directly support safe navigation.

The National Ocean Service provides real-time oceanographic data, mapping, charting, and water level information. The National Weather Service provides weather, water, climate data, forecasts, and warnings and operates the National Data Buoy Center buoys.

Risk controls – Offshore wind farms

Offshore wind farms have been operation since 1991. Standard industry practices have developed, and like the above maritime safety practices, continue to evolve and improve over time.

During the design and construction stages of a wind farm, a set of design and construction standards lay out minimum requirements. An independent Certified Verification Agent checks and confirms that the design and all aspects of construction conform to the agreed set of standards (30 CFR 585).

In the operational stage of a wind farm, some risk controls have become standard practice, but others are still in development.

Good industry operational practices include:

- Marking of structures such as lighting, sound signals, structure identification, air gap
- Providing timely notices to mariners regarding construction, operation, and decommissioning
- Remotely-activated locking of turbine blades in rotation and in yaw / feathering the blades

Spacing of WTGs is generally guided by energy production targets, turbine size, available area, wind distributions, and other factors. Regularly spaced turbines can facilitate use of helicopters for SAR and radar-assisted search. Management of risk due to adjacent location of several large wind farms is a nascent challenge in the industry, and many options are being evaluated (see Section 11.4).

Vessel safety for shallow draft vessels (i.e., all vessels that are not defined as deep draft) is a potential concern. Within a wind farm, this is particularly true in poor visibility or high sea states. Advance warnings to mariners and education initiatives could reduce the likelihood of a vessel in peril in the wind farm under such conditions.

The final U.S. Coast Guard MARI PARS report recommends that mariners desiring to transit the area should use extra caution, ensure proper watch, and assess risk prior to entering an offshore wind farm. Additionally, the report recommends that “mariners transiting through [an offshore wind farm] should make a careful assessment of all factors associated with their voyage. These factors at a minimum should include:

1) The operator’s experience and condition with regard to fitness and rest.
2) The vessel’s characteristics, which should include the size, maneuverability, and sea keeping ability. The overall reliability and operational material condition of propulsion, steering, and navigational equipment.
3) Weather conditions – both current and predicted including sea state and visibility.

4) Voyage planning to include up-to-date information regarding the positions of completed wind towers or wind towers under construction and their associated construction vessels. A great deal of consideration should also be given to whether the transit will be conducted during day or night.

Countries with high level of offshore wind deployment in Europe generally take two different approaches to regulating maritime safety. In Belgium, Germany, and The Netherlands fishing and transiting are restricted in wind farms, although this is not related to the towers being a hazard to navigation. This reduces the frequency of SAR operations in the wind farm and damage to wind farm structures from allision. In contrast, the UK and Denmark allow commercial and recreational vessels to transit and fish in wind farms; however, they implement additional risk mitigation measures such as monitoring of vessels in the wind farm and safety zones around each WTG.

Historically, The Netherlands has used risk-based reviews to inform policies and project approval decisions. The Dutch government is currently considering allowing fishing and vessel transit in proposed wind farms. A quantitative risk assessment identified risks and first-estimates of costs and benefits of mitigation measures (MIeM-RWS, 2015). Further refinement of costs and benefits is in progress to support ALARP-informed decision-making by the Dutch government.

In general, risk controls fall into three categories:

1. Avoidance, such as:
    - Exclusion zone around a wind farm
    - Not allowing deep draft vessels to transit within a wind farm
    - Not allowing fishing in a wind farm using bottom-type gear
2. Reducing likelihood, such as:
    - Vessel design and equipment maintenance
    - Routing measures
    - Sea state / visibility restrictions
    - Training
    - Safety zones around WTG
    - Additional AIS requirements
    - Enhanced radar and traffic control, warning systems
    - Real-time cable location monitoring
3. Preventing or reducing consequences, such as:
    - Highly robust subsea cable protection
    - Life safety equipment onboard all vessels
    - Standby tug in the vicinity of the wind farm

11.3.1 ALARP evaluation of risk mitigation measures

The general goals of risk assessment are to:

- Identify and prioritize any significant risks and recommend appropriate mitigation strategies
- Enable risk reduction by identifying, understanding, and appropriately managing all major threats
- Inform decisions related to optimization of costs and benefits (ALARP process)
- Enhancing alignment between varying interests concerning residual risks

A demonstration of ALARP requires weighing the potential benefits of a measure with the costs of implementing the measure. For most scenarios not involving risk to human life, this is a straightforward cost-benefit calculation.

The challenges include:

- Estimating the all-in cost to all parties and quantifying the change in risk from the mitigation
- Balancing costs and benefits across multiple stakeholders. If one party bears all the costs and another all the benefits, then acceptance is less likely.
- Practicality. A control that can be implemented by a single party is easier to agree upon than one that needs the consensus of many stakeholders to be effective.

The ALARP process need not be fully rigorous and comprehensive in scope, fully evaluating every potential option. Instead, an initial list of mitigations can be developed and assigned qualitative measures of benefit and cost. The list can then be filtered into “meets ALARP criteria”, “does not meet ALARP criteria”, and “further study is needed”. Some rules of thumb are:

- Any mitigation that is “industry good practice” is considered ALARP
- Any mitigation with measurable benefit and negligible cost immediately meets the ALARP criteria
- Any mitigation with a cost greater than the benefit does not meet the ALARP criteria

11.3.2 Potential mitigation measures

This assessment provides risk information to enable the Coast Guard to evaluate whether Project risks are reduced to meet ALARP criteria. Any risk control that is standard industry practice or is good industry practice, by definition, should be implemented per ALARP principles. In the U.S., standard practices are still being developed.

This study has identified various risk mitigation measures that have been considered or are used in some jurisdictions. These are not necessarily standard or best practices, nor are they necessarily recommended for the Project. The measures listed in alphabetical order are:

- Additional ATON
- AIS transponders on Project structures
- Additional cable protection measures, such as armored ducting, rock placement, or concrete mattresses
- Communications repeaters on Project structures

- Designation of additional anchorages
- Designation of additional routing measures
- Designation of areas to be avoided or limited access areas
- Designation of routes for specific vessel types
- Emergency response planning and exercises
- Extension of cellular service
- Federal controls on specific designs/kinds of commercial fishing gear
- Fishing / transits limited to daytime
- Highly robust subsea cable protection
- Ice hazard protocol
- Increased requirements for life safety equipment onboard all vessels
- Larger or additional precautionary areas
- Maximum LOA for vessels allowed to transit the wind farm
- Measures to reduce safety risk for highest risk vessels in the area, i.e., USCG inspections
- No seabed disturbing activities
- Offshore cameras (to facilitate SAR)
- Offshore structures are accessible and can be used as a potential place of refuge
- Pilotage of deep draft vessels near the Project
- Project structures along perimeter equipped with radar beacon to allow clear identification via radar
- Real-time vessel monitoring in the wind farm
- Require that only specified designs/kinds of commercial fishing gear can be used in the wind farm
- Safety zone of 500 m (1,642 ft) around construction vessels during wind farm construction
- Safety zone of 50 m (164 ft) or 500 m (1,642 ft) around offshore structures during wind farm operations
- Transit or fishing only with a functioning and active VHF and AIS installation
- Tug on standby to assist vessels in distress
- Vessel design and equipment maintenance requirements for all vessels entering a wind farm
- Vessel traffic services
- Visible and consistent marking and lighting of each structure
- WTG platforms are accessible and can be used as a potential place of refuge

The Project has committed to specific measures that are listed in Section 17.

11.4 Cumulative effects

Cumulative effects on navigation were evaluated on a qualitative basis for the five BOEM offshore wind lease areas in the Marine Traffic Study Area (Figure 11-10):

- Ocean Wind Farm
- OCS-A 0482
- OCS-A 0490
- OCS-A 0499
- OCS-A 0512

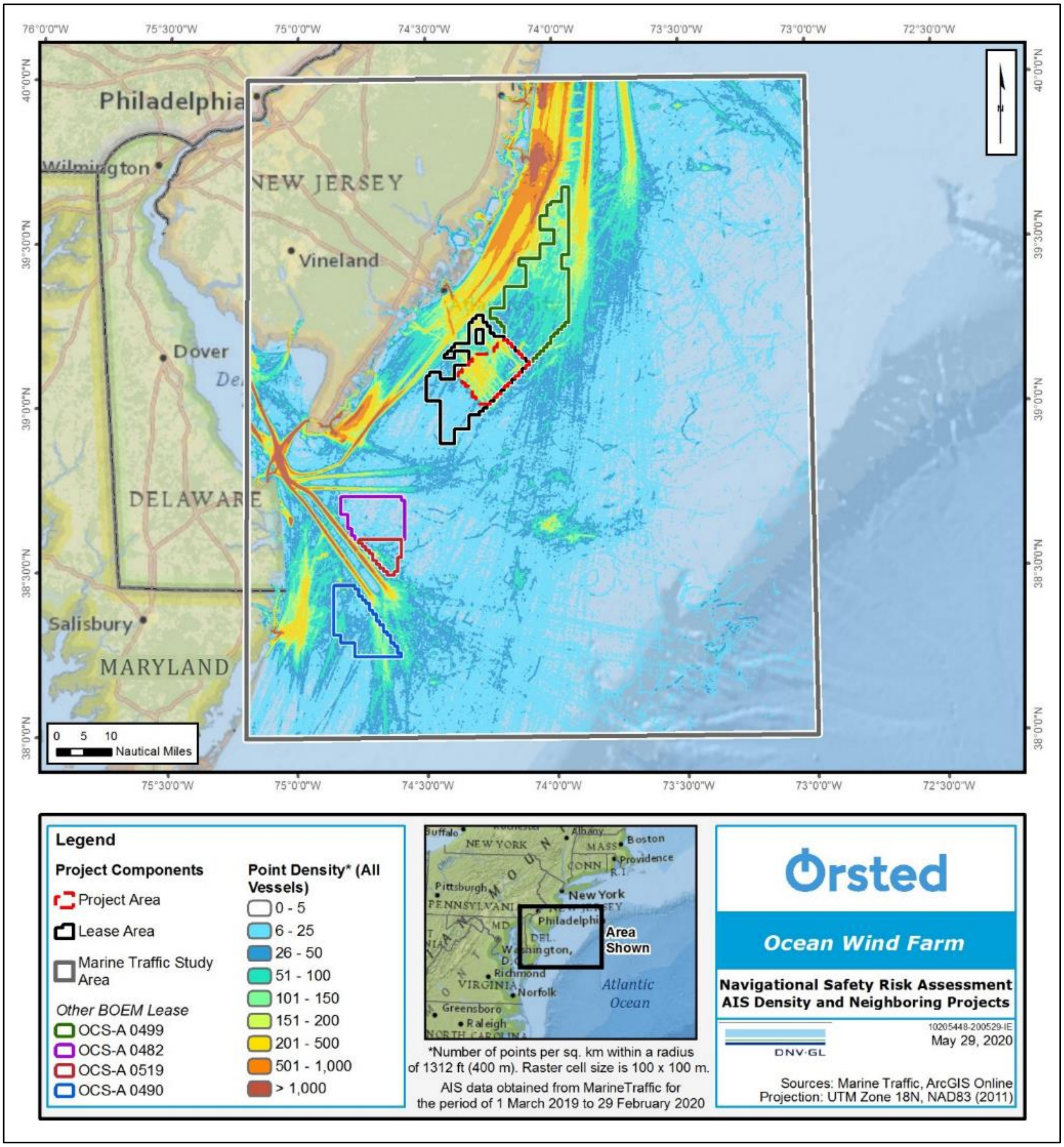


Figure 11-10 AIS traffic and BOEM wind energy leased areas in the Marine Traffic Study Area[2]

Likely route deviations from historical routes related to navigation safety resulting from combination of wind farms in the four leases may include:

1. Towing vessels transiting coastwise as described in the ACPARS report (Coast Guard, 2016). This study estimated the potential increase in risk from deviations related to the Project and the lease area to the north of the Project (OCS-A 499). Slightly greater effects could be anticipated from the deviations to the west around the combination of the two southern leases in the Marine Traffic Study Area (Figure 11-11). Assuming wind farms are built in all four leases, the following effects are reasonably anticipated:
    - An increase in distance transited. The preliminary identified effects are:
        - Use of additional fuel leading to increased fuel cost and air emissions
        - Longer vessel transit time resulting in increased exposure time for the potential for equipment failure (towlines, propulsion, and steerage equipment). This increases the risk of a vessel being adrift approximately in proportion to the additional amount of time it spends transiting.
    - Additional course changes assuming the future route is similar to the ACPARS alternate route.
2. Tanker and cargo vessels departing the New York Ambrose to Barnegat outbound lane transiting to the Delaware Bay Eastern Approach. This NSRA estimated the potential increase in risk from these deviations.
3. Tanker and cargo vessels outbound from the Southeastern Approach transiting to the south. A significant portion of these vessels change course immediately on exiting the TSS and transit through BOEM lease OCS-A-0490, the southernmost lease in Figure 11-11. If a wind farm were built in that lease, these deep draft vessels would change course further from shore, taking a route farther from the coast. The reasonably anticipated effects are similar to those related to tugs transiting longer distances.
4. Changes to commercial and recreational fishing patterns, which are largely unpredictable at this time. This study estimated a reasonable upper bound for additional recreational activity in the Project lease. To assume similar increases for all of the leases would likely be overly conservative.

In addition, SAR efforts in the vicinity of wind farms may be more challenging in bad visibility or in high seas; however, given that the two southern leases are more than 23 NM (43 km) southwest of the Project lease, the only leases likely to present cumulative effects on SAR efforts are the two leases off the New Jersey coast, assessed in this NSRA.

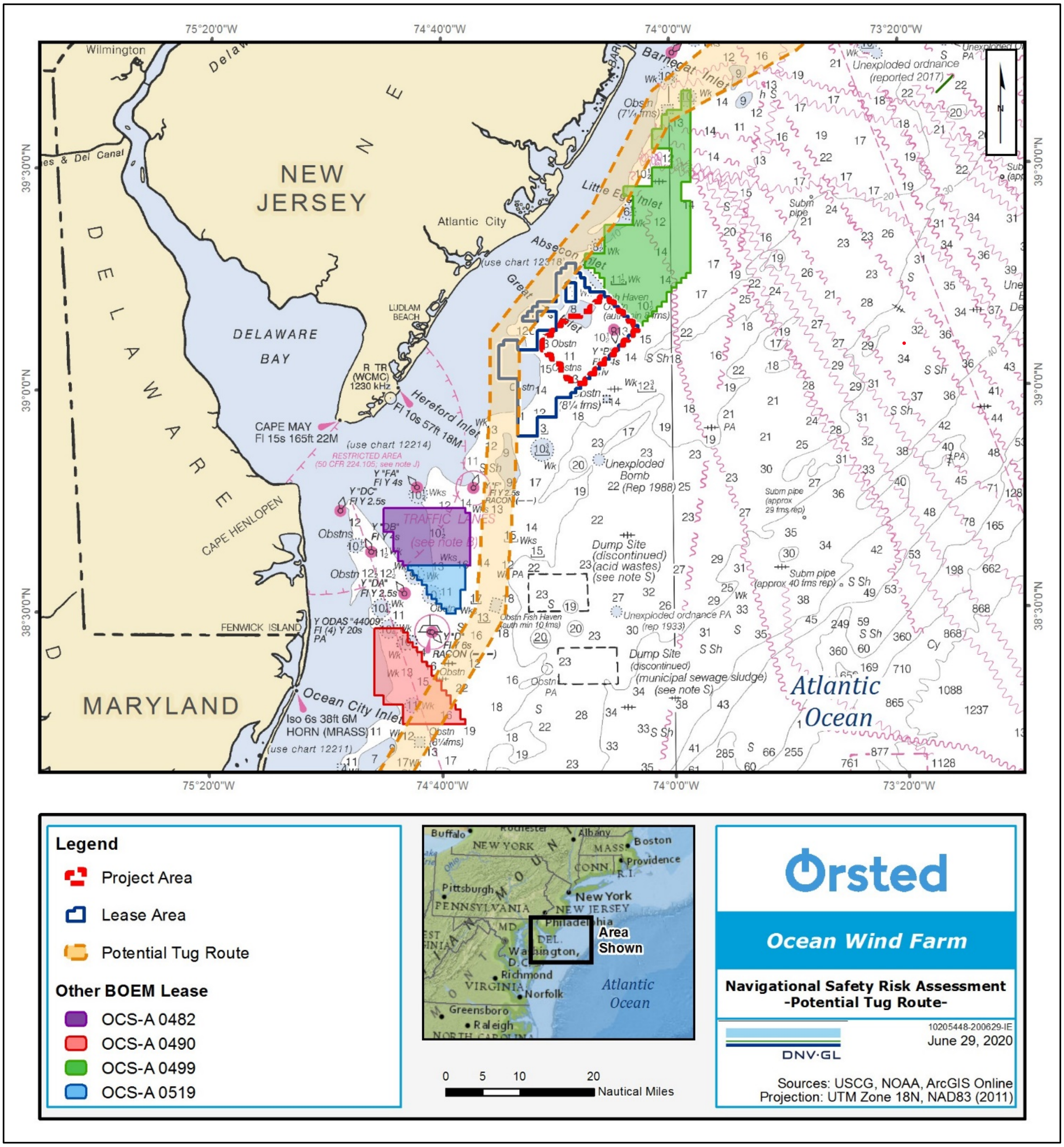


Figure 11-11 Potential tug route (85 FR 37034) given construction of wind farms in existing leases

12 EMERGENCY RESPONSE CONSIDERATIONS

To determine the impact on Coast Guard and other emergency responder missions, SAR and marine environmental protection/response were assessed. Coast Guard mission data specific to the Project was provided for the period 2008 through 2018 (Orsted, 2021). All of the missions in the data were SAR missions and none were marine environmental protection missions.

Over that eleven-year period, the Coast Guard executed 5 missions in the Project Area, all of which were SAR missions. This represents an average of 0.5 SAR missions per year in the Project Area. The extent of each SAR mission is case-dependent; it may initially encompass an area approximately 12 NM x 12 NM. Based on the data provided, up to 40 responses may have covered some portion of the Project Area, representing an average of 4 SAR missions per year that could include some portion of the Project Area.

Information about the SAR missions is summarized in Table 12-1.

Table 12-1 Summary of SAR cases

Situation	Number of occurrences 2006 - 2016
SAR cases conducted by Coast Guard in the proposed Project Area over a ten-year period	5 to 40 cases
Cases involving aircraft (helicopter, fixed-wing) searches	1 to 12 cases
Cases involving helicopter hoists	Not specified in the available data
Cases at night or in poor visibility/low ceiling	6 cases at night 1 case with visibility less than 2 NM
Number of times commercial salvors (for example, BOAT US, SEATOW, commercial tugs) responded to assist vessels in the proposed structure region over the last ten years	Not specified in the available data; information source not identified
Additional SAR cases estimated by modeling due to allision with the Project structures	1 allision per 11 years, with the vast majority not requiring rescue (conservative maximum estimate based on modeling described in Section 11)

Concerning potential Project impacts to radar that supports SAR, NOAA's SeaSonde HF radar system supports Coast Guard's SAROPS computer model search pattern design tool (DOE, 2020). As discussed in Section 10.4, Orsted is actively engaged with NOAA and other agencies to assess and address potential impacts to the SeaSonde system emanating from offshore wind farms. While impacts to the SeaSonde system may be determined and mitigated, the Project's SeaSonde-related impacts to the Coast Guard's SAROPS model can only be determined by the Coast Guard.

Turbines will have easily identifiable markings that will aid SAR. One OSS within the Project may provide helicopter refuge to facilitate SAR.

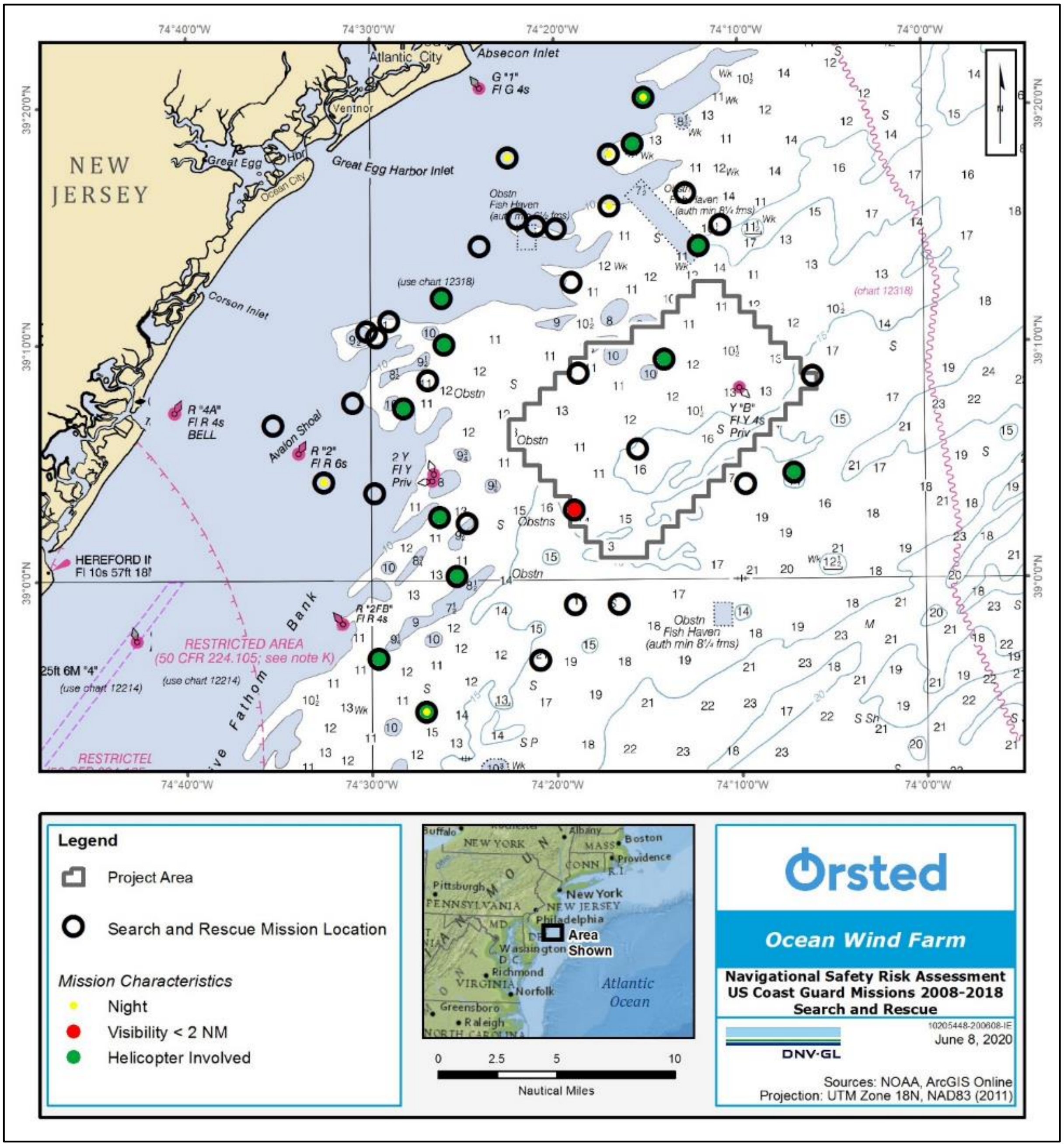


Figure 12-1 Coast Guard SAR missions in the vicinity of the Project (Orsted, 2021)

Orsted is working to bring a suite of capabilities and mitigations to reduce or potentially eliminate the need for search for SAR operations within the Project. These might include:

- Marking each above water structure with a unique identifier to simplify search and rescue operations.
- Equipping one or more substations with a helicopter platform.

- Equipping selected above water structures with an AIS transponder clearly identifying the structure.
- Installing appropriate marine navigation lights on every above water structures and aeronautical warning lights on each WTG.
- Installing a continuously manned Operations Center.
- Coordinating with the USCG units to conduct search and rescue training in or near the proposed WTG array as necessary
- Exercising shutdown protocols and procedures.
- Extended cell phone coverage
- 24/7 monitoring of the project area
- Extended Rescue 21 VHF coverage
- Vessel traffic coordination
- Radar
- Thermal imaging
- Drone use

13 FACILITY CHARACTERISTICS

In general, marking of offshore wind farm structures is specified in international standards and regulations. The most relevant standards include:

- IALA Recommendation O-139 on the Marking of Man-Made Offshore Structures released by the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA, 2013)
- The Convention on International Civil Aviation Annex 14 (ICAO, 2013), released by the International Civil Aviation Organization for marking of wind turbines with regard to safety of aviation
- Fifth Coast Guard District Local Notice to Mariners 44/20, “NC – VA – MD – DE – NJ -ATLANTIC OCEAN - OFFSHORE STRUCTURE PATON MARKING GUIDANCE” (USCG, 2020b)

A comprehensive list of international standards and national regulations is available in the DNV GL specification for certification of navigation and aviation aids of offshore wind farms (DNV GL, 2017).

Marking and lighting of offshore structures will conform to USCG guidance at the time of Project approval. This includes any/all requirements that may be imposed in conjunction with BOEM’s anticipated permit conditions requiring the Project to submit to the USCG for review and approval a comprehensive ATON plan for marking and lighting of all structures, to include:

- Identification marking
- Lighting
- Sound signals
- AIS transponder signals
- Other appropriate aids to navigation
- Maintenance to the Coast Guard’s availability standards

In 2019, BOEM published “Draft Proposed Guidelines for Providing Information on Lighting and Marking of Structures Supporting Renewable Energy Development” (BOEM, 2019). Should BOEM finalize these guidelines by the time of COP approval, the Project will comply (Orsted, 2021).

No effects are anticipated to existing Federal ATON in the vicinity of the Project, shown in previous Figure 2-2. The luminous intensity of WTG lights are expected to be clearly distinguishable from lights ashore. No adverse effects on visual navigation are expected due to interactions of lights, backscatter, geographic versus visible horizon, or turbine spacing.

Aviation lights will be controlled by an Aircraft Detection Light System (ADLS) to assure they are lit when required and off when not needed (ICAO, 2013). As far as practicable, aviation lights will not be visible below the horizontal plane of the lights. (Orsted, 2021)

A decommissioning plan will be developed and submitted to relevant agencies at the appropriate time (Orsted, 2021). It is industry practice to remove wind turbine foundations at or just below the seabed during decommissioning. No marking or lighting requirements for offshore structures post-decommissioning are foreseen at this time.

14 DESIGN REQUIREMENTS

All Project structures will be marked with clearly visible unique identification characters (for example, alpha-numeric labels). The identification characters will be illuminated by a low-intensity light or be coated with a phosphorescent material. They will be designed and installed to be clearly readable at a distance of at least 150 yards (Orsted, 2021).

The Project will have a 24-hour operational monitoring center to verify safe operating conditions are being maintained. The monitoring center will have the ability to remotely operate and shut down WTGs and OSS and fix/maintain the position of the turbine blades and hub in an emergency situation (Orsted, 2021).

Emergency operating procedures for the monitoring center will be agreed in consultation with the Coast Guard and other emergency support services. Offshore enclosed spaces will be capable of being opened from the outside to allow emergency access (Orsted, 2021).

15 OPERATIONAL REQUIREMENTS

The operations center will be manned 24 hours per day and have an electronic chart indicating the position and identification numbers of each of the offshore Project structures. Figure 15-1 shows a display from the Ørsted Marine Coordination Centre in Grimsby, England.

Figure 15-1 Display at Ørsted Marine Coordination Center in Grimsby, England

The Project operator will ensure that all applicable Coast Guard command centers (District and Sector) are advised of the contact telephone number of the operations center and that correct positions and identifiers of offshore Project structures have been provided to NOAA to include on navigation charts (Orsted, 2021).

16 OPERATIONAL PROCEDURES

Orsted anticipates that the Coast Guard will recommend, and BOEM will include, a condition in its Ocean Wind Farm permit (if issued) to require Orsted to submit to the Coast Guard an acceptable emergency shutdown procedure/plan similar to requirements in the Block Island Wind Farm permit issued by the U.S. Army Corps of Engineers. Additionally, Orsted will work in conjunction with the Coast Guard to develop an acceptable emergency shutdown procedure and emergency response plan that draw on the lesson learned from joint Orsted-Coast Guard emergency shutdown exercises conducted at the Block Island Wind Farm. (Orsted, 2021).

17 CONCLUSIONS AND PROJECT RISK MITIGATIONS

The primary conclusions of this study are as follows:

1. Site location and coordinates
    - The distance between offshore structures evaluated in this assessment is 0.8 NM x 1.0 NM (Orsted, 2021)

2. Traffic survey
    - The coastal traffic west of the Project Area is predominantly comprised of tug transits, while the majority of the coastal traffic further south is predominantly pleasure and fishing vessels.
    - Vessel traffic in the vicinity of the Project is much less dense than near the coast.
    - Traffic east of the Project Area is predominantly deep draft vessels.
    - AIS data for March 2019 to February 2020 (MarineTraffic, 2020) show that about 5 transits per day enter the Project Area, 1632 per year in total, including some minor double-counting.
    - Deep draft vessels and tugs are not expected to enter the wind farm, except in emergency circumstances.

3. Offshore above water structures
    - Project structures will pose an allision and height hazard to vessels passing close by, and vessels will pose a hazard to the structures. Allision risk is specifically discussed in (11) below. Typical good practice is to mark any structure that constrains the air gap over a waterway; and in line with this practice, the air gap will be indicated on each Project structure.
    - Risk related to some types of fishing gear suggests that risk to vessels/crew and to the Project can be controlled by assuring the cable is buried at sufficient depth, assuring sufficient cable protection for relevant gear types, and/or using fishing gear that has limited penetration depth when fishing in the wind farm.
    - Spacing between WTGs in the evaluated layout provides sufficient sea room for maneuvering for vessel types expected to transit and fish in the wind farm.
    - Emergency rescue procedures will likely be adjusted to account for the Project structures once they are in place. In particular, helicopter-aided SAR will be a higher-risk activity in poor visibility, particularly within the Project Area.
    - Noise from construction activities or operation of WTGs is not anticipated to have negative effects on safe navigation or on the health of crew/personnel of passing vessels.

	• In general, Project structures with monopile foundations could sustain significant damage from an allision by a deep draft vessel at speed; immediate collapse is not anticipated. A jacket foundation is a weaker structure relative to horizontal loads. If the final foundation design for the OSS is a jacket, structural collapse from allision by a deep draft vessel at speed cannot be ruled out. Modeling shows it to be at most a 1-in-2000-years event.
4. Offshore under water structures	• The Project components will not affect underkeel clearance for vessels transiting in the Project Area. No Project structures will lie above the seabed except those that rise above sea level.
5. Navigation within or close to a structure	• In general, any offshore structure poses a potential risk of allision. During construction, global good industry practice is to implement a safety zone around construction activity. It is likely that similar risk controls will be used during decommissioning/removal of the structures. • During operations, the safety of vessels and crews will rely on good seamanship as well as enhanced ATON. • Standard industry practice is that anchoring in a wind farm is a potentially hazardous activity and should be undertaken only by Project-related vessels or in emergency situations. To control this risk, Project cables will be buried and / or protected on the seabed, marked on charts, and their location will be monitored periodically to detect any movement.
6. Effect of tides, tidal streams, and currents	• Tides, tidal streams and currents in the Project Area have a low level of influence on navigation risk related to the Project.
7. Weather	• Weather may have a significant effect on navigation risk in a wind farm. Based on ten years of data at the Atlantic City Airport, visibility is less than 2 NM about 5.6% of a given year.
8. Configuration and collision avoidance	• Wind farm layout may have a significant influence on navigation risks post-construction of the Project. An optimal configuration of offshore wind farm structures is sought through balancing many factors, including physical, environmental, technical, economic, and political aspects. • The WTG layout will be in linear rows and columns. This will provide alternative routes for vessels or aircraft transiting the wind farm and provide multiple options in case of high winds or seas. (Orsted, 2021).

9. Visual navigation	• Project structures are not anticipated to significantly obscure view of other vessels, ATON, or the coastline. • Project structures may serve as information navigation aids for mariners, particularly at night because they will be lit and marked on navigation charts.
10. Communications, radar, and positioning systems	• The impacts on marine radar are variable, with the most likely effect being some signal degradation. Proximity to the WTGs is the primary factor that determines the degree of radar signal degradation. • The Coast Guard's advanced command, control and direction-finding system, "Rescue 21," is unlikely to experience degradation from the Project. • Due primarily to the quality of radars and the proficiency of professionally licensed crew, radar operations on commercial ships are not anticipated to be adversely affected by the Project. • Smaller vessels operating in the vicinity of the Project may experience radar clutter and shadowing. Risk controls relevant to this effect are: vessel operator awareness and competence regarding radar effects and corrections; placement of radar antenna at a favorable position on a vessel; regular communications regarding changes and activities in the wind farm; and, safety broadcasts from vessels operating in the vicinity of the wind farm.

11. Risk of collision, allision, or grounding	• In this assessment, the modeled increase in risk is 0.4 accidents per year, an increase of 32 percent from the baseline. The accident frequency increase is for all accidents and includes accidents with small and zero consequence such as brief grounding on a sandy bottom. The the estimate assumes that pleasure vessels take 1,925 additional trips to the Project Area for recreational purposes, which is a maximum reasonable conservative approach to the modeling. • Marine accidents involving pleasure vessels represent 66 percent of the total increase, and tugs represent 2 percent of the increase. • The Project poses very little risk outside the Project Area plus the coastal waters to the west: 98% of the estimated risk increase occurs within these two areas. • A list of risk controls and risk mitigations which the Project is considering is provided in discussion below.
12. Emergency response considerations	• An estimated maximum of 0.1 SAR missions per year are anticipated in the Project based on the modeling results for allisions. However, this is a conservative estimate because most allision events do not require emergency rescue operations.
13. Facility characteristics	• The Project will comply with Coast Guard requirements for lighting, sound signals, and marking of structures, as applicable and as determined in consultation with the Coast Guard (Orsted, 2021). • No effects are anticipated to existing Federal ATON near the Project. • PATON will be maintained to meet conditions the Coast Guard may impose in conjunction with its PATON permits (Orsted, 2021).
14. Design requirements	• Industry good practices will be utilized concerning visible markings, lighting, and safe emergency shutdown (fixing blade and hub positions), emergency access to structures, and emergency preparedness involving relevant agencies (Orsted, 2021).
15. Operational requirements	• Project operations will be monitored 24 hours per day every day and Project emergency contact channels will be provided to the Coast Guard and other relevant agencies (Orsted, 2021).
16. Operational procedures	• Emergency procedures will be developed and reviewed with relevant agencies, including the Coast Guard (Orsted, 2021).

Potential Project mitigation measures

Table 17-1 summarizes the navigation risk mitigation measures that the Project may implement (Orsted, 2021). The "Type" and "Threat or Hazard" columns are intended to provide context; however, nearly all of the mitigation measures would reduce risks from several threats. The complex interrelationships between risk mitigation benefits can be taken into account during the ALARP review.

Table 17-1 Summary of potential Project mitigation measures (Orsted, 2021)

Type*	Threat or hazard	Primary mitigation
D	Allision of a vessel with a WTG	Uniform minimum spacing between Project structures and alignment of structures.
D	Vessel anchor or fishing gear snag on Project subsea cable	To reduce the risks associated with these hazards, the cable target burial depth is one meter (3.28 ft) and includes at least a single armor layer. Where possible, the cable will be buried to a depth of four to six ft deep. Cable protection measures will be employed where cable burial depth is not adequate. To ensure the risk is sufficiently mitigated, a separate cable burial risk assessment will be conducted for the Project, and the results of that study will inform the depth of burial as well as cable protection measures for the Project.
E	Vessel less certain of its location; Coast Guard locating a vessel	Lighting and marking of project structures according to U.S. requirements.
E	Vessel less certain of its course or location relative to the wind farm	Additional ATON associated with the Project.
E	Vessel less certain of its course or location relative to the wind farm	Project structures equipped with AIS technology.
P	Vessel close to Project construction activity	Safety zones around Project construction activities.
P	Vessel not aware of high level of activity in the Project Area	Notices to Mariners during construction, operation, and decommissioning activities. These may be published on and broadcasted though regular radio communications, online information for mariners, and Notices to Mariners from the Coast Guard.
P	Project construction activities in unsafe conditions	A Project construction guideline will define a window related to wind, sea state, and other constraints under which construction activities will start/continue or will stop/be discontinued. Conditions and forecasts will be monitored to enable proactive planning and early warning of future unsafe conditions.
P	Unsafe operation of the wind farm or continued operation of the wind farm during emergency conditions	A 24-hour operational monitoring center is planned to verify safe conditions are being maintained. The monitoring center will have the ability to remotely operate and shut down WTGs if required.
P	Vessel not aware of Project-related hazards	Locations and details of offshore Project components will be provided to NOAA so they can be included on nautical charts. The Project intends to work closely with Coast Guard and NOAA to chart all elements of the Project and have frequent communication with local mariners on location and status of Project activities, vessels, and components.

Type*	Threat or hazard	Primary mitigation
P	Fishing vessel not aware of Project-related hazards	Frequent updates on offshore activities to fishing operators will be provided via: • Project fisheries liaisons and local fisheries representatives based in regional ports • Online updates for mariners • Twice-daily updates on VHF channels.
O	Fishing gear snag on Project component	Project process for gear-loss/damage claims.
O	Ineffective emergency procedures	Emergency communication protocols and shut-down procedures will be exercised.
O	Delay in reaching injured worker in a WTG	Offshore enclosed spaces will be capable of being opened from the outside to allow emergency access.

* (D) Design; (E) Equipment; (P) Procedures and Communication; (O) Other.

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APPENDIX A – AIS MAPS

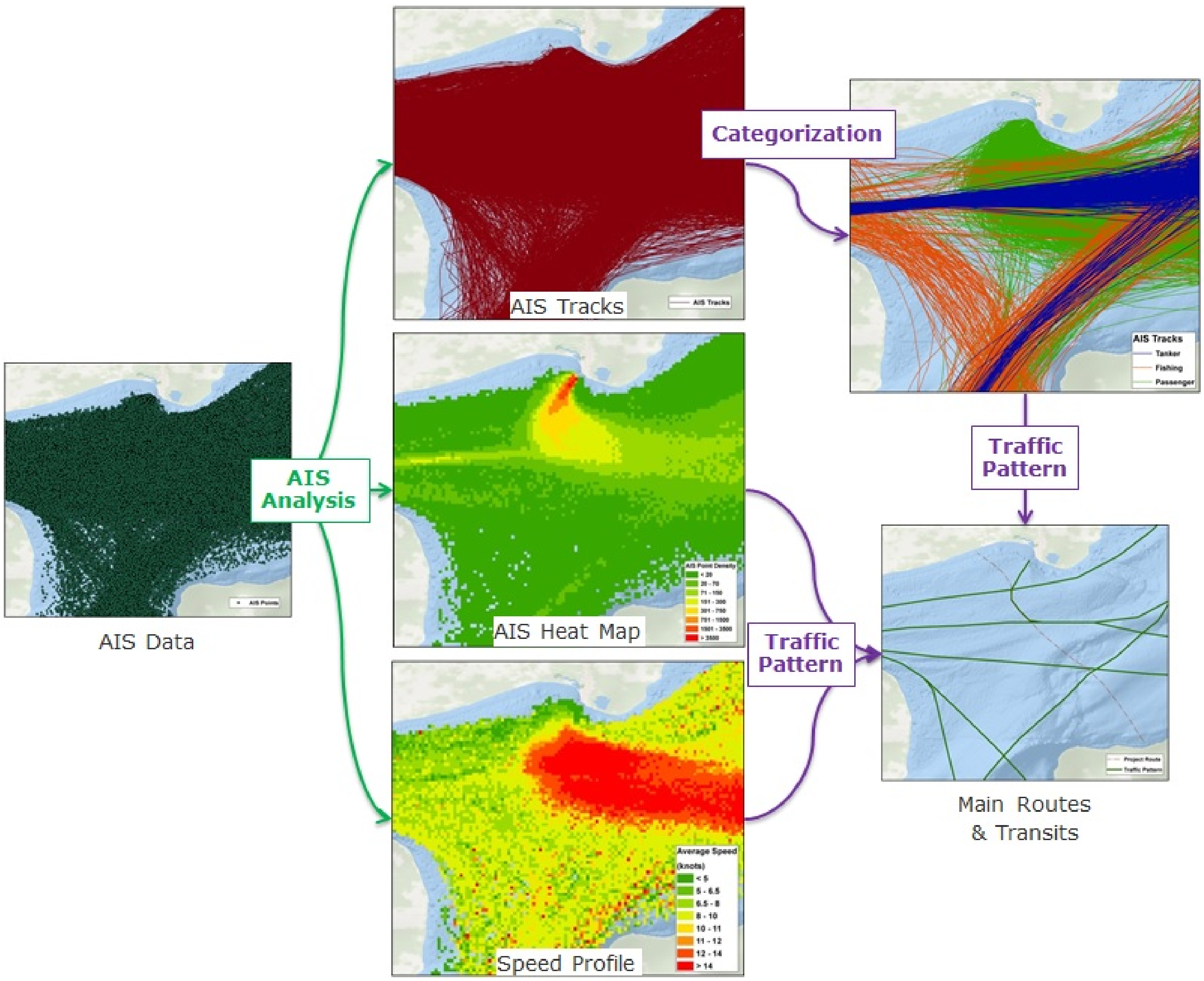
This appendix contains maps of marine traffic showing AIS tracks, AIS density, and vessel speed.

AIS data analysis

The marine patterns and traffic statistics in the Study Area were determined utilizing AIS data. One year of AIS data typically provides a quantifiable and reliable set of data to determine the primary traffic patterns and analyze the size, speed, and movements of vessels in a region. For the Marine Traffic Study Area, AIS data were evaluated for a full-year period, 1 March 2019 to 29 February 2020 (MarineTraffic, 2020).

AIS data were converted into vessel tracks (Section A.1), vessel densities (Section A.2). Speed profiles were also developed from the data (Section A.3)

The AIS treatment methodology is schematically represented below:



A.1 AIS track maps by vessel type

The data were spatially analyzed based on timestamp and proximity to create vessel tracks. Each vessel track represents a transit of a single vessel in the Marine Traffic Study Area.

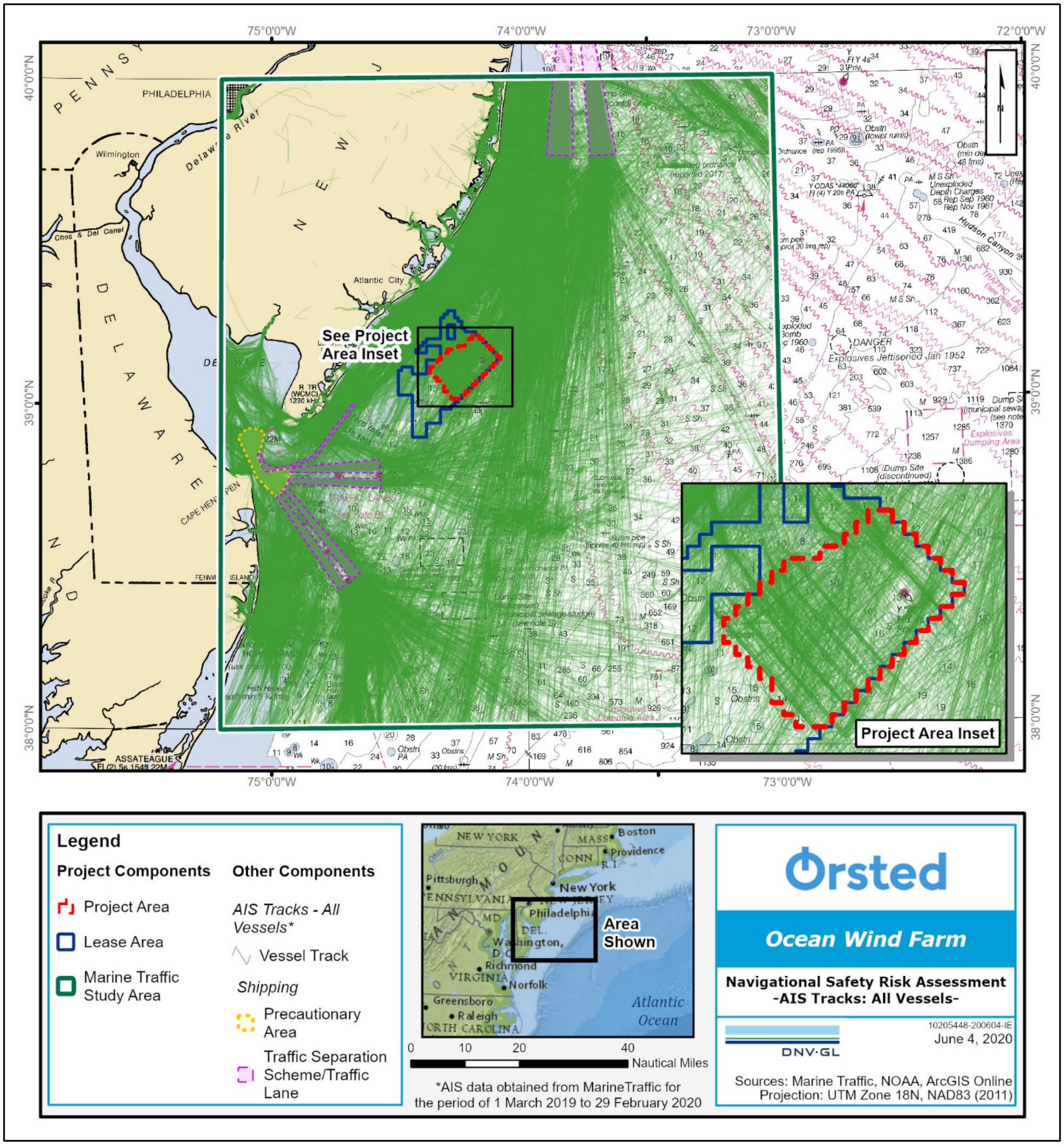


Figure A-1 AIS tracks for all vessels

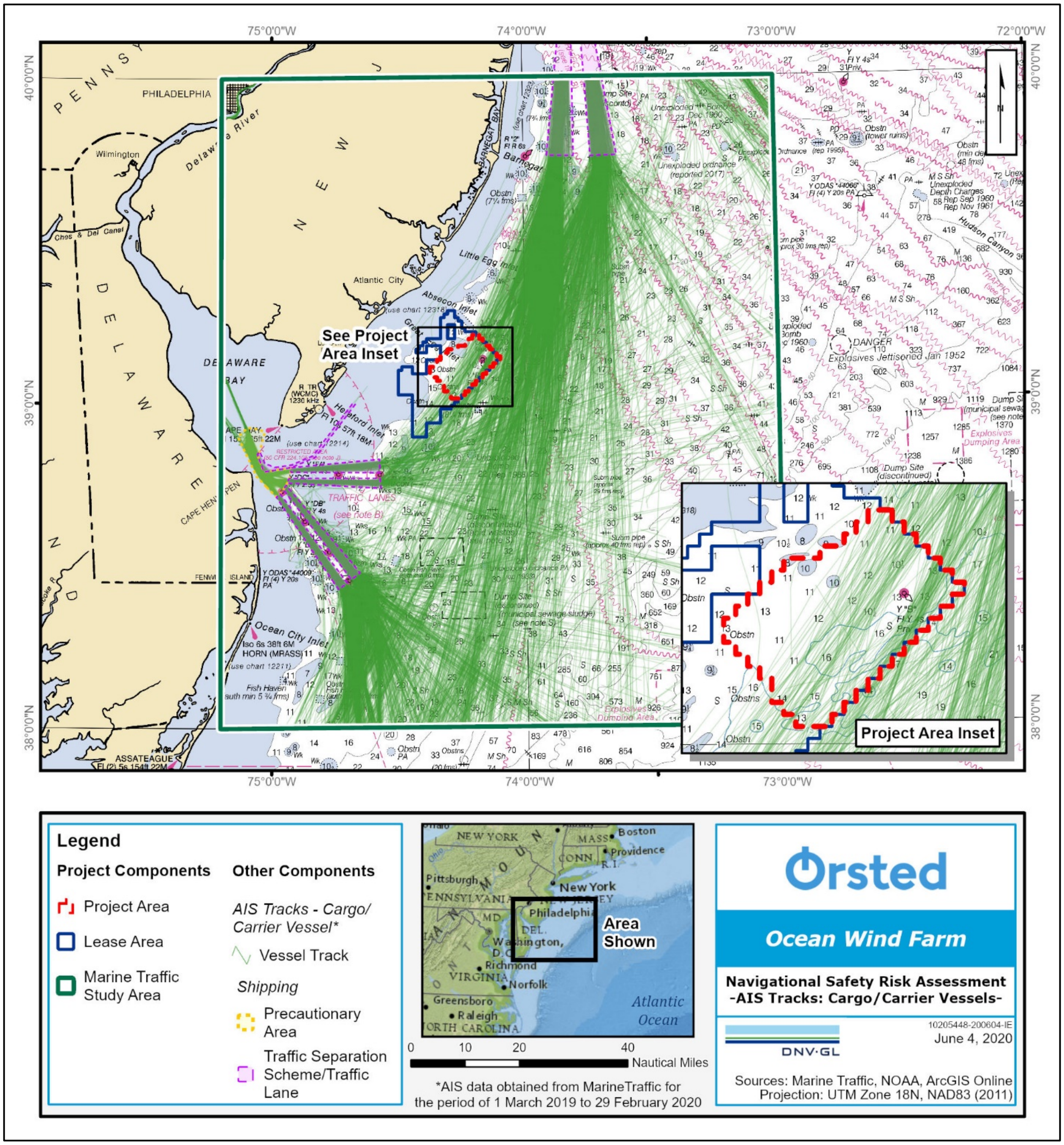


Figure A-2 AIS tracks for cargo/carrier vessels

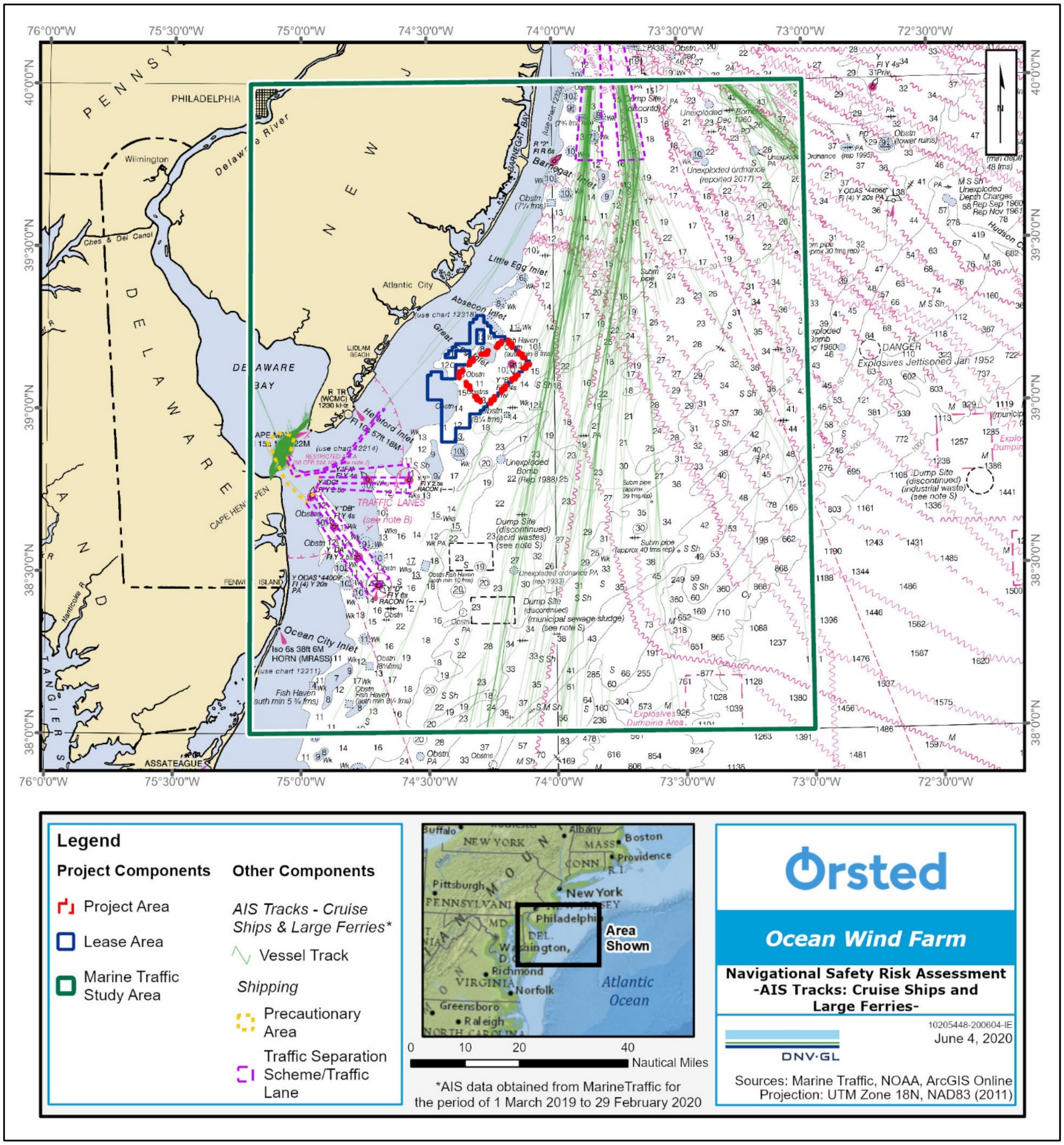


Figure A-3 AIS tracks for cruise ship and large ferry vessels

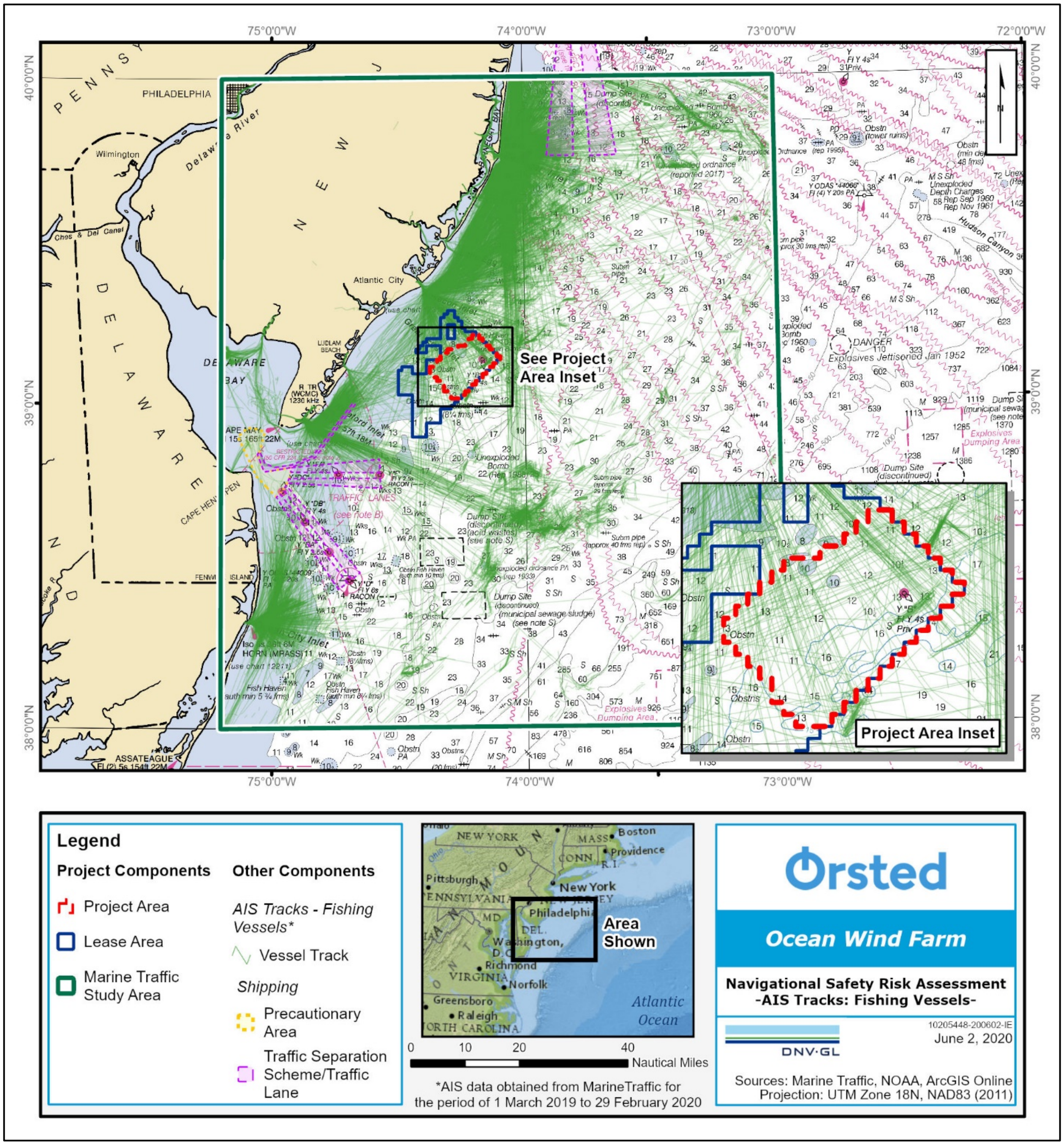


Figure A-4 AIS tracks for fishing vessels

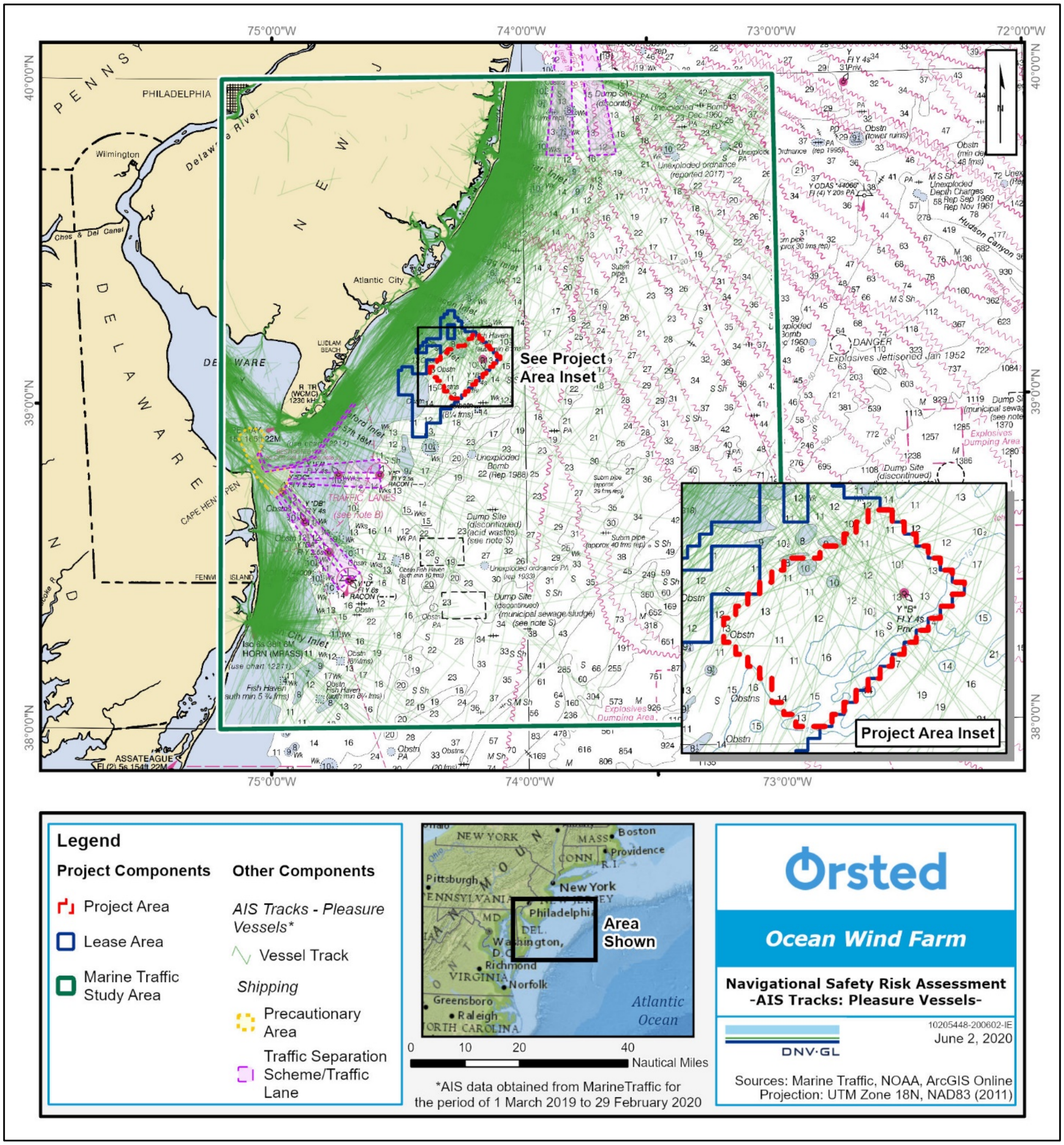


Figure A-5 AIS tracks for pleasure vessels

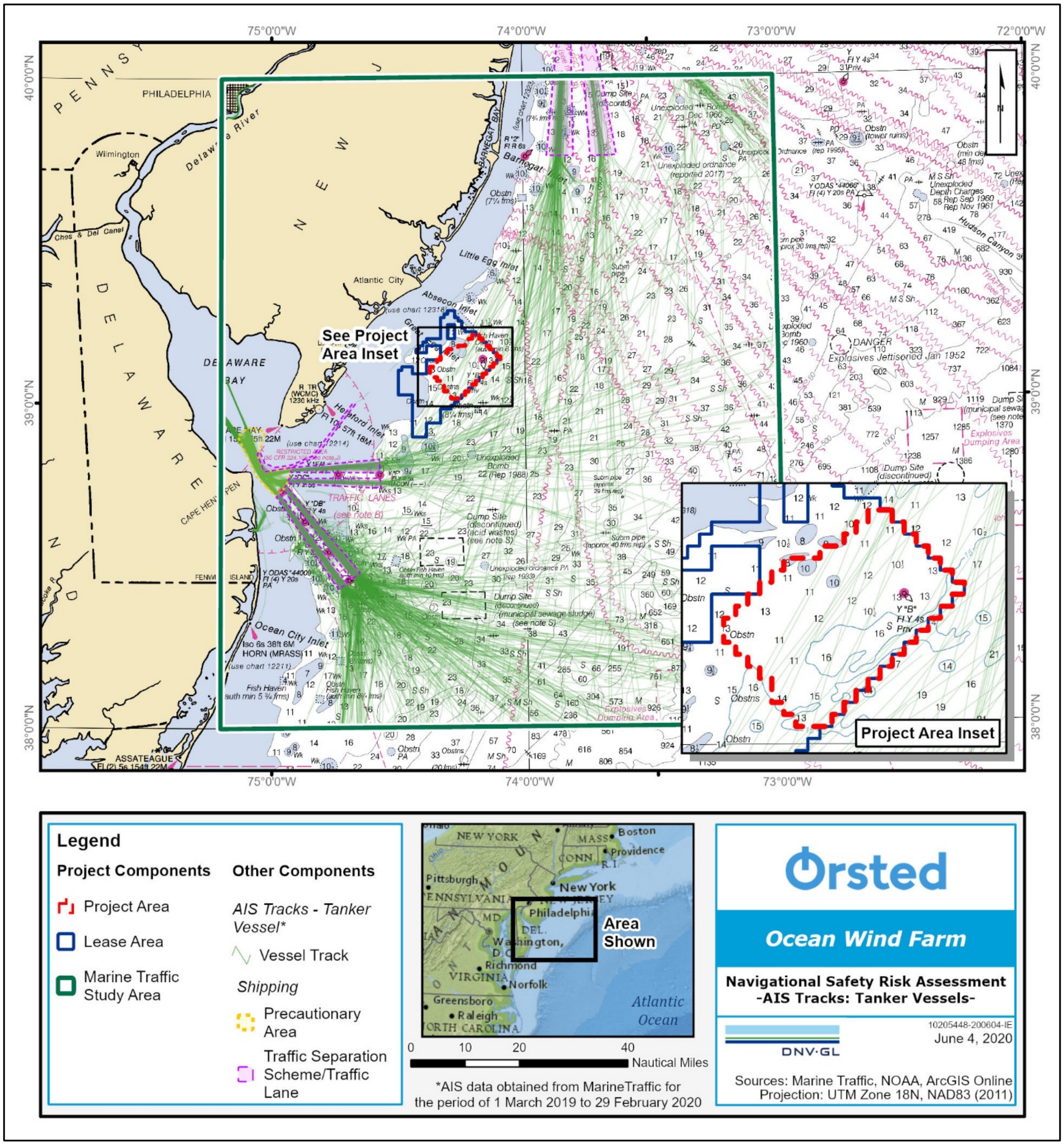


Figure A-6 AIS tracks for tanker vessels

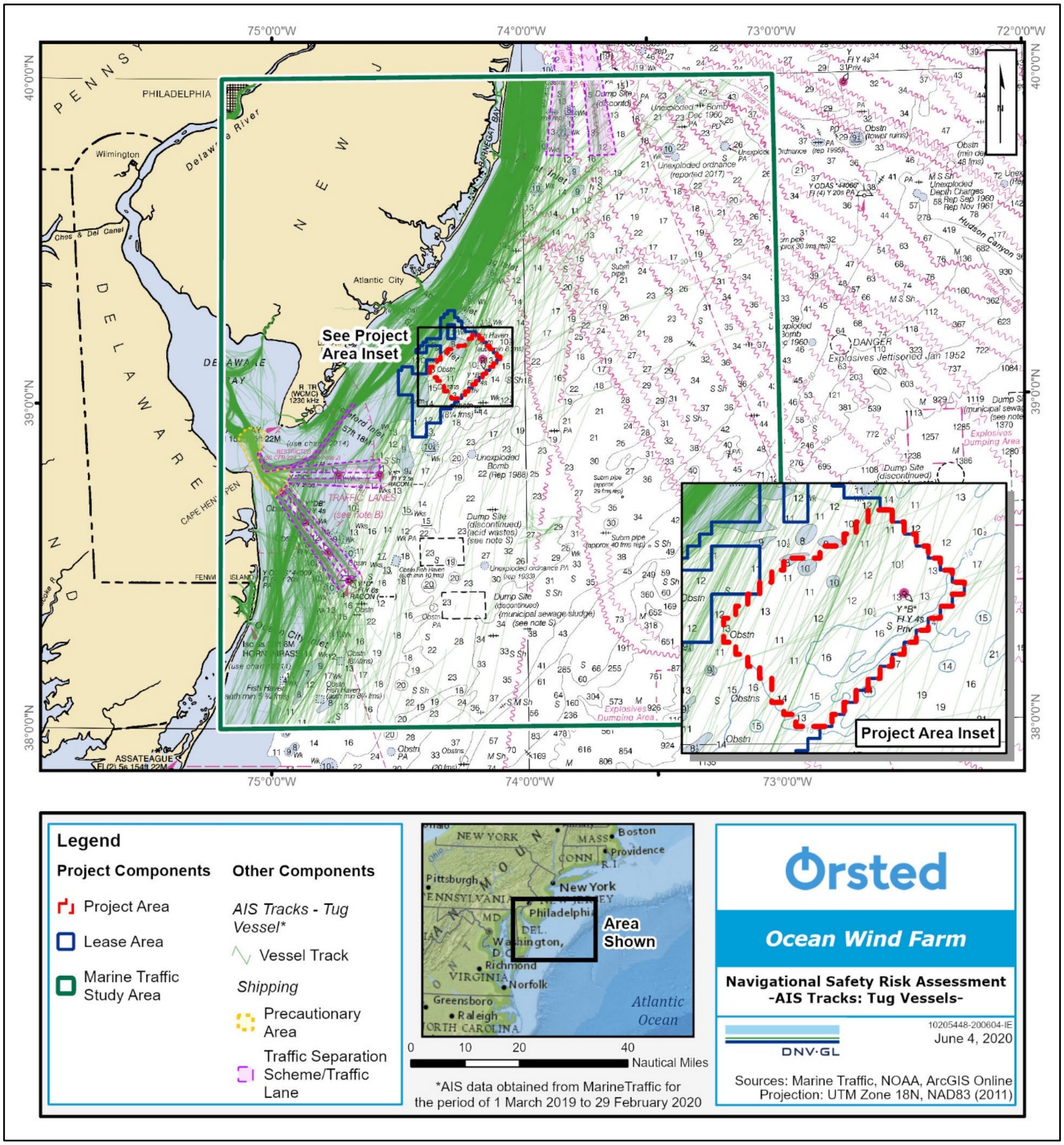


Figure A-7 AIS tracks for tug vessels

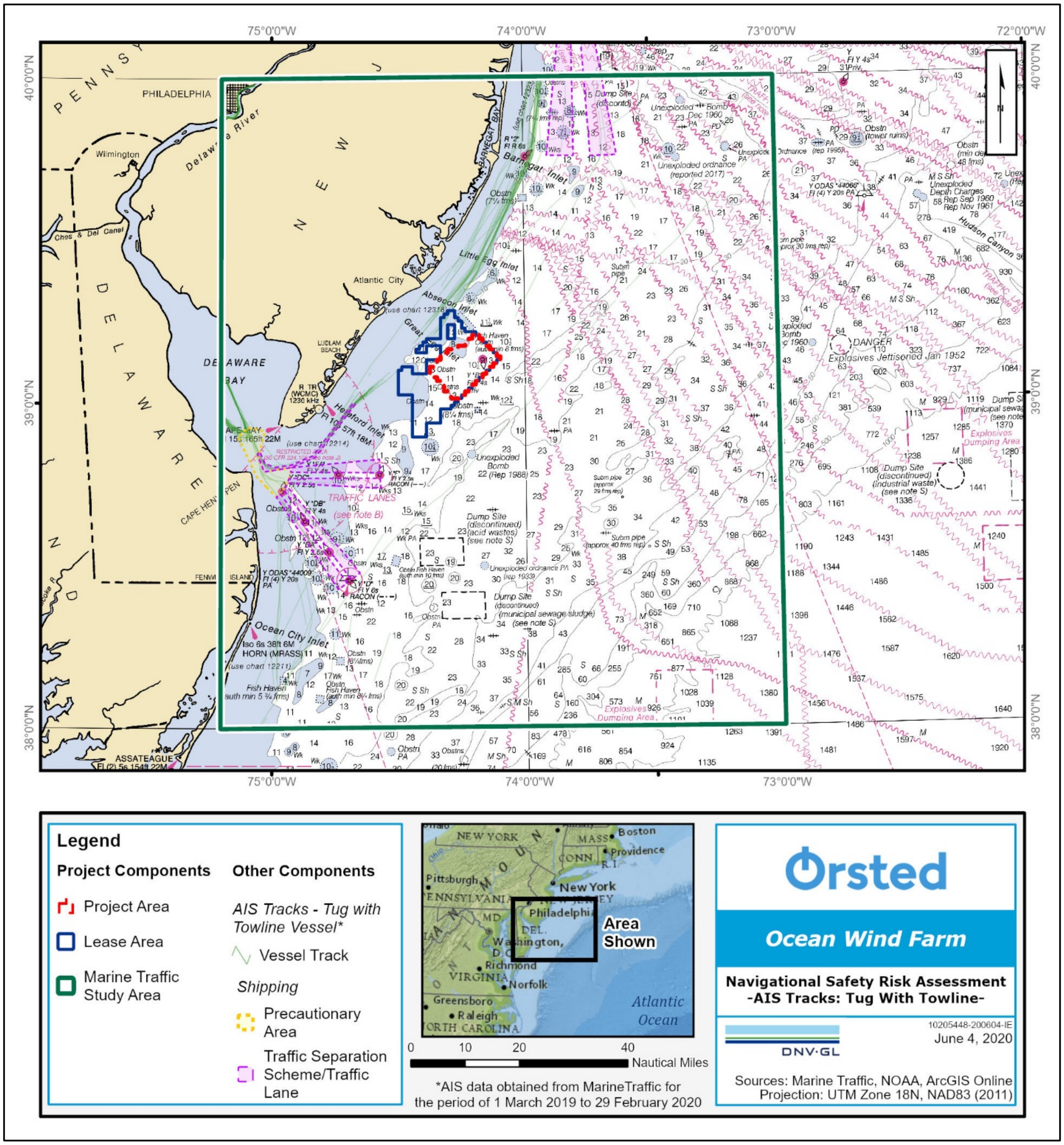


Figure A-8 AIS tracks for tug with towline vessels

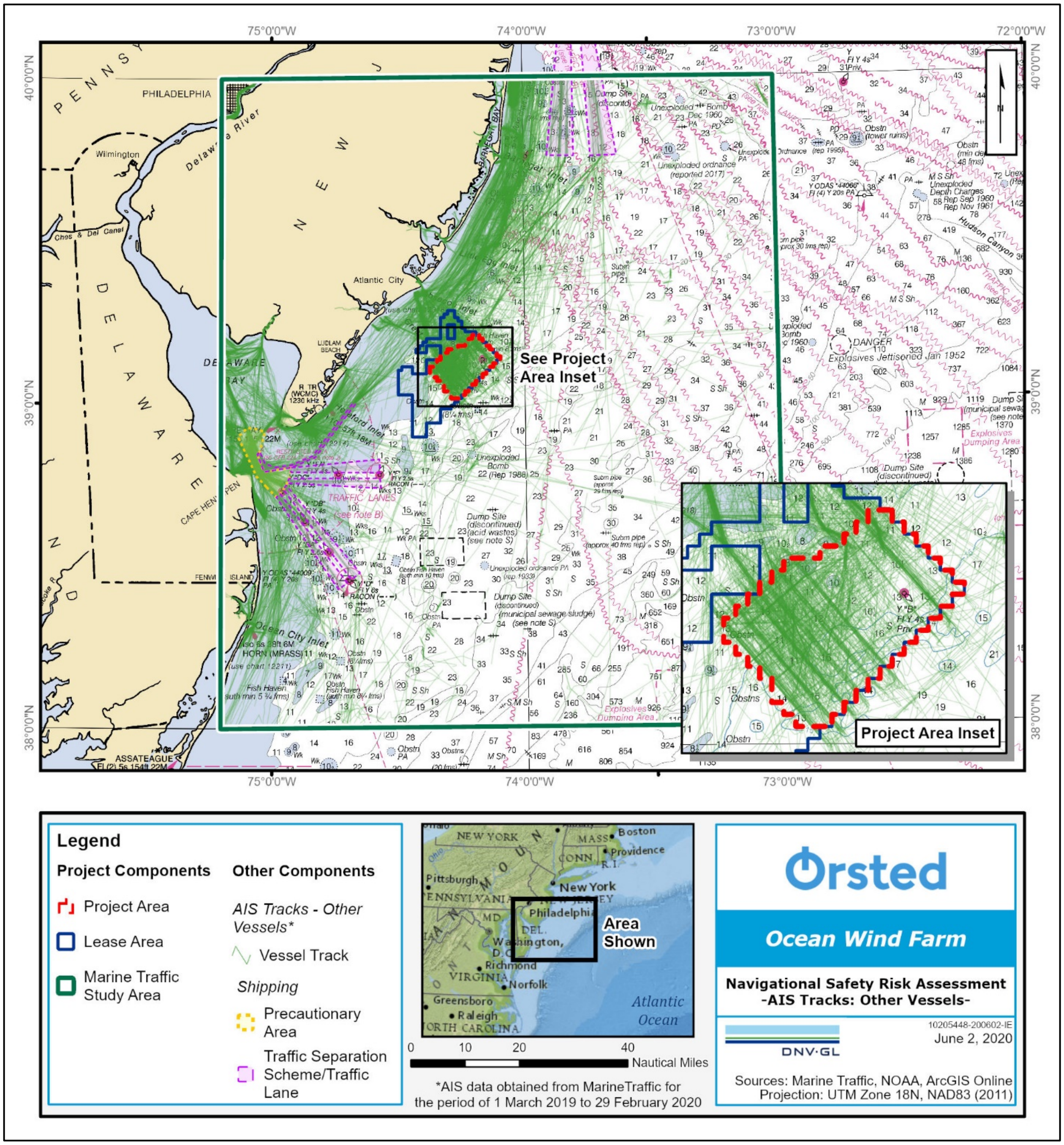


Figure A-9 AIS tracks for other vessels

A.2 AIS point density maps by vessel type

The figures in this section present density heat maps for all AIS points in the Study Area. The density is calculated by determining the number of AIS data points per square kilometer within a search radius of 1,312 ft (400 m) around each grid cell.

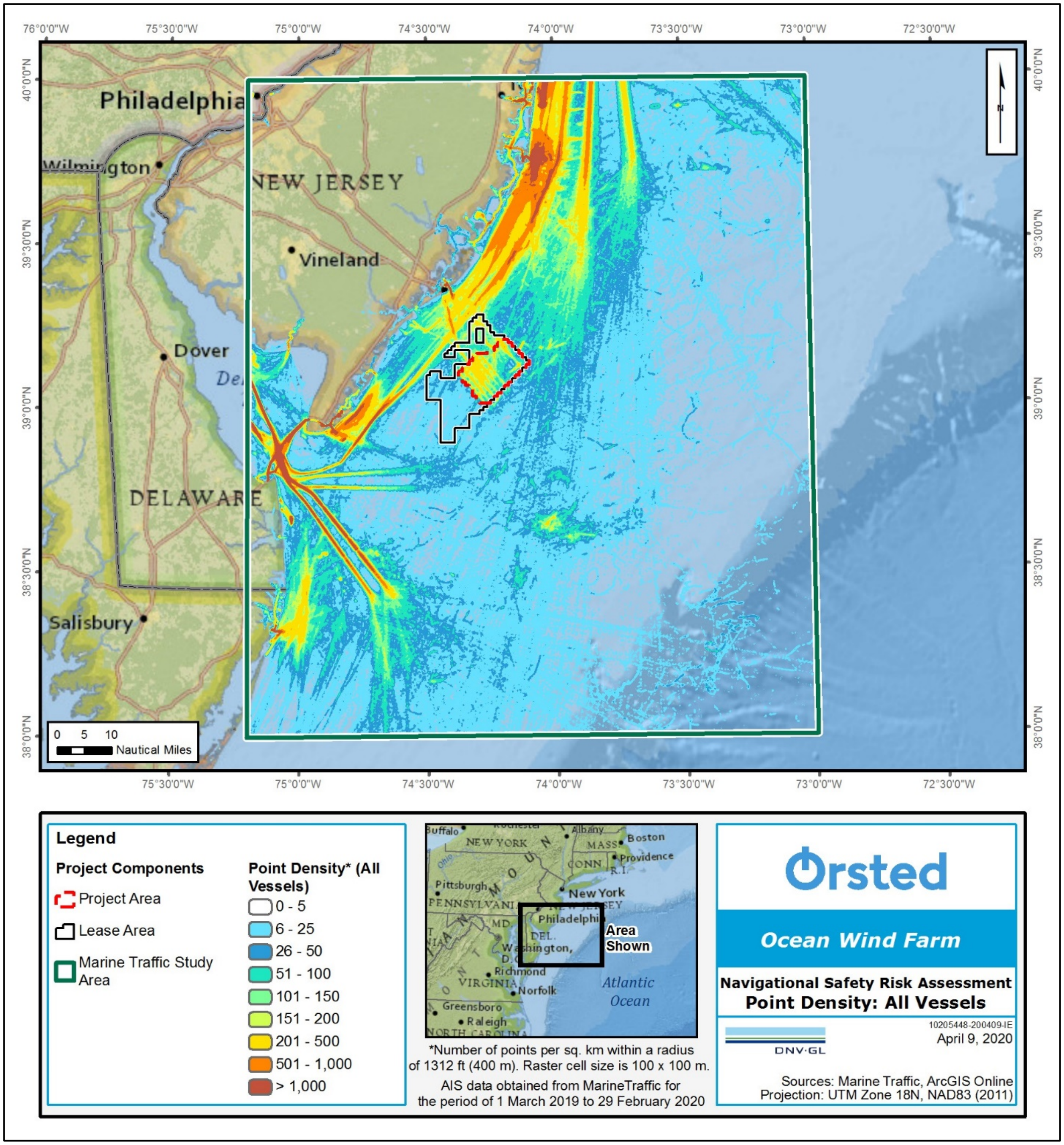


Figure A-10 Density of AIS points for all vessels

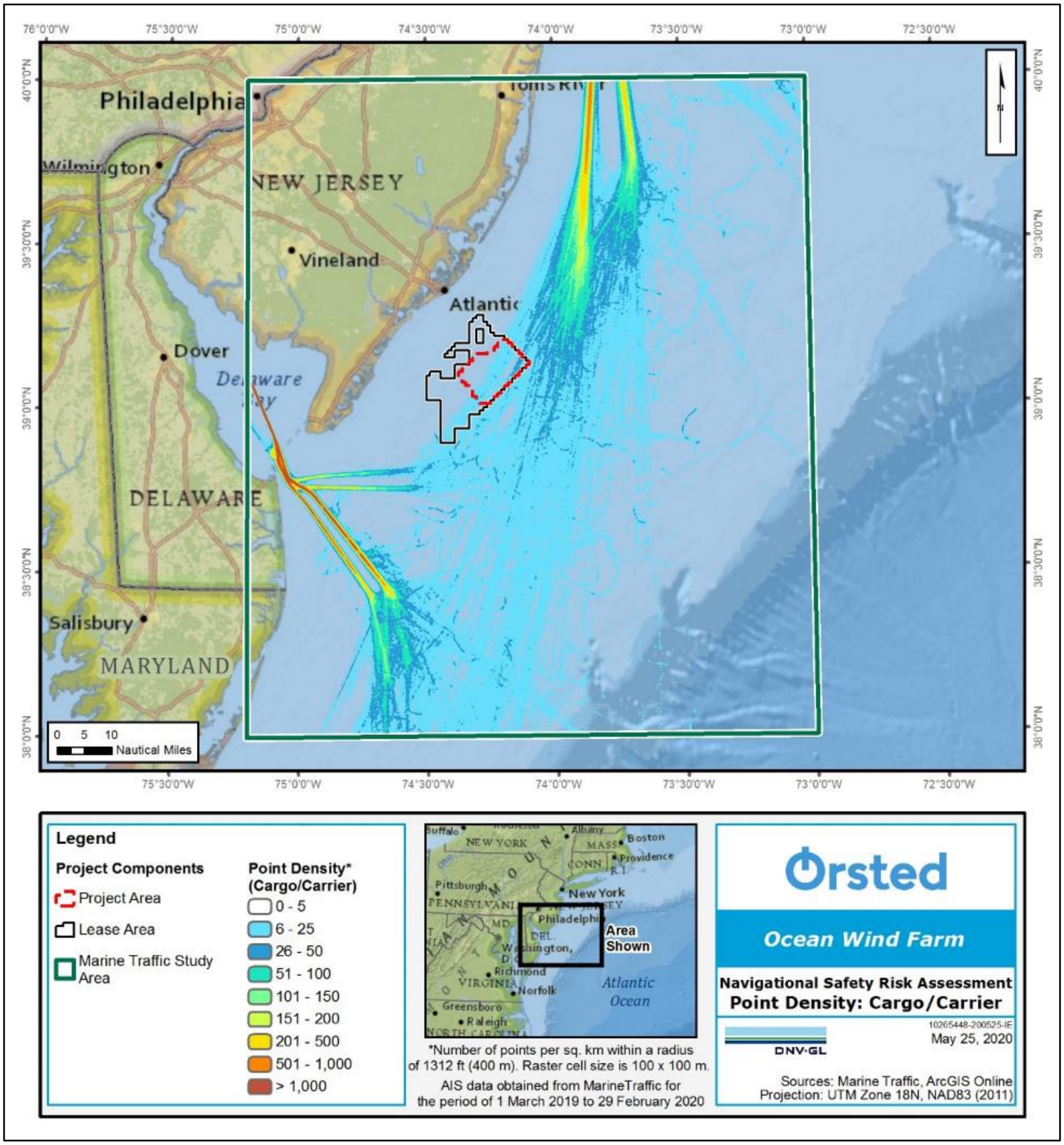


Figure A-11 Density of AIS points for cargo/carrier vessels

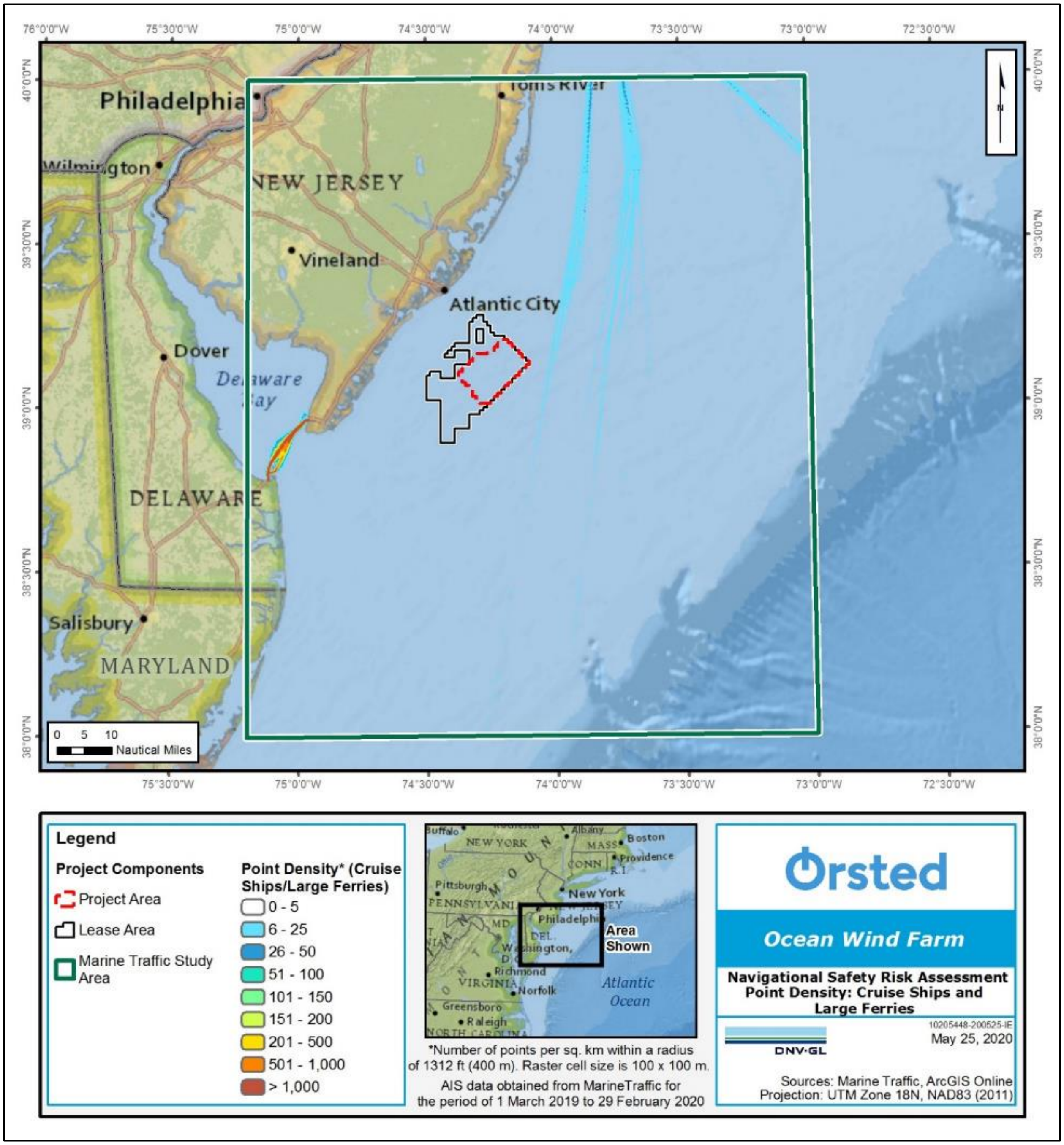


Figure A-12 Density of AIS points for cruise ship and large ferry vessels

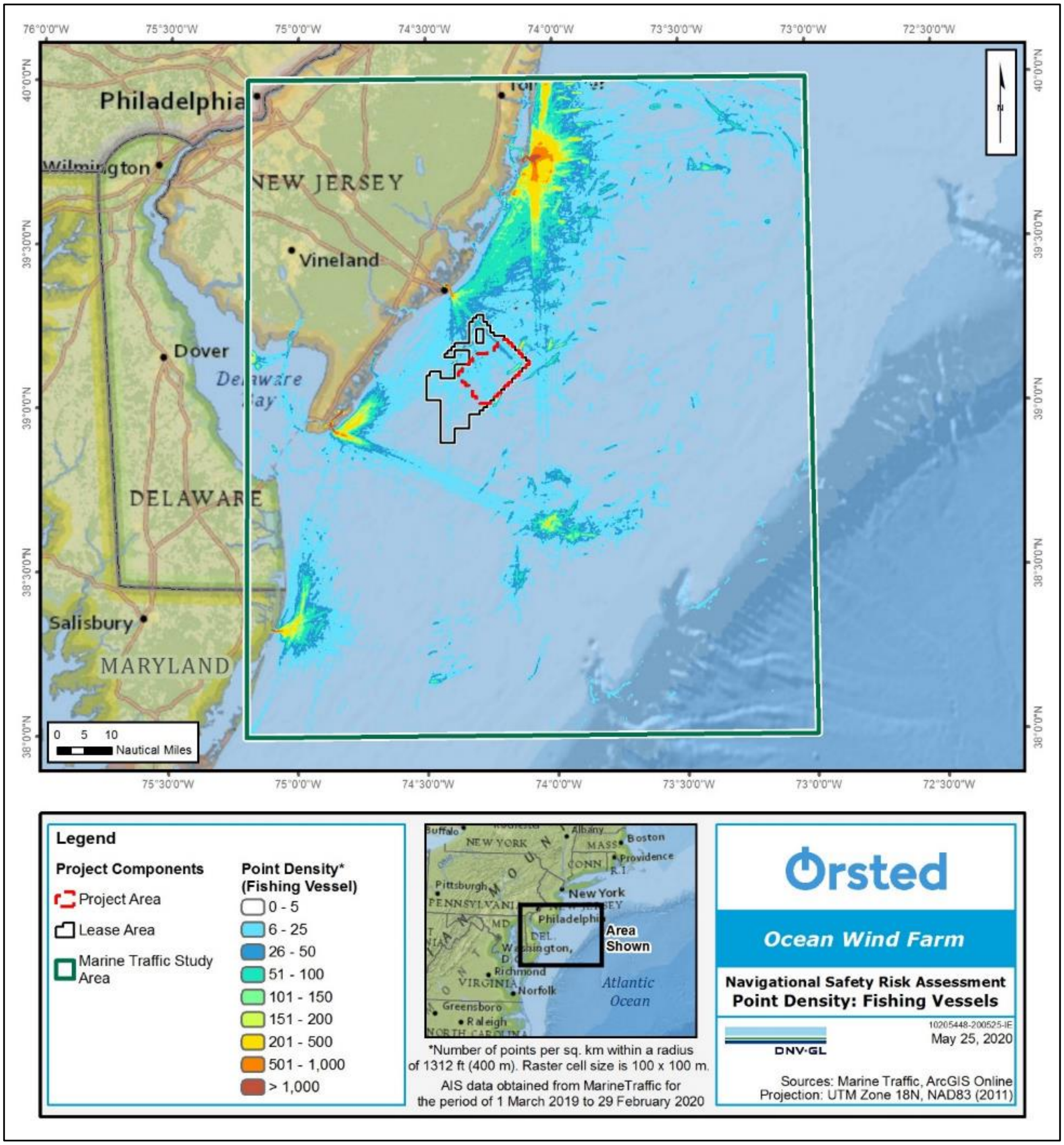


Figure A-13 Density of AIS points for fishing vessels

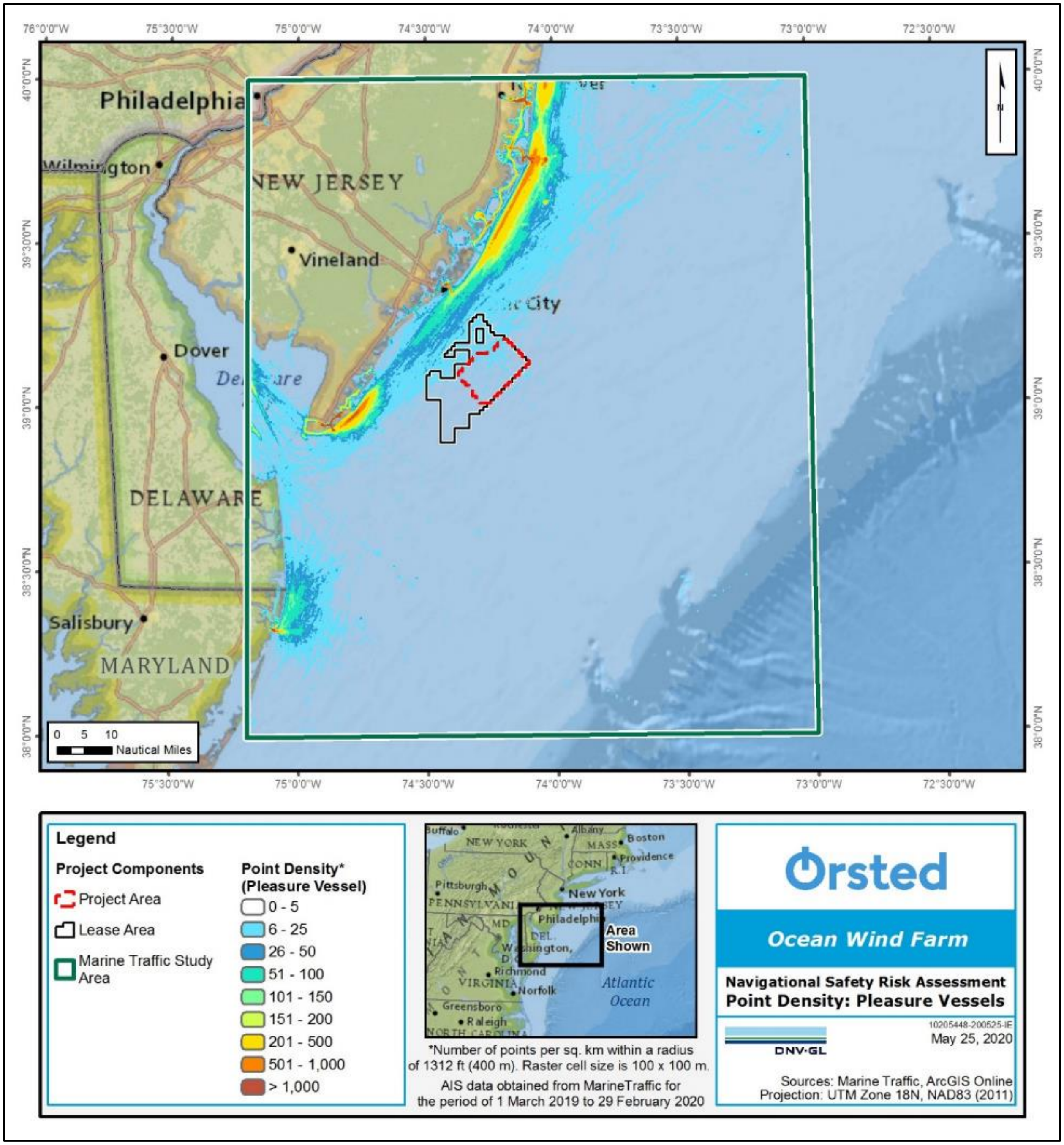


Figure A-14 Density of AIS points for pleasure vessels

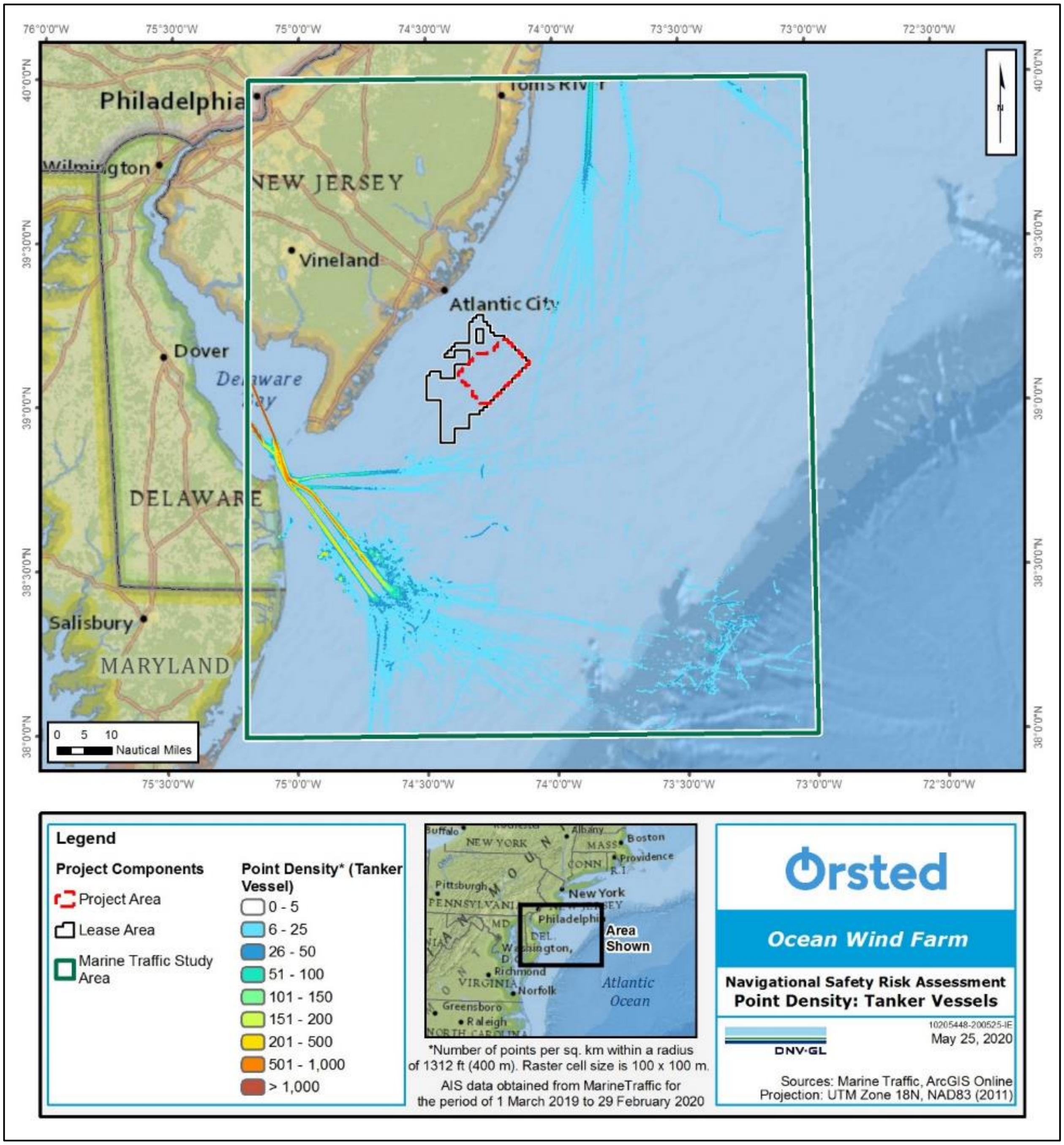


Figure A-15 Density of AIS points for tanker vessels

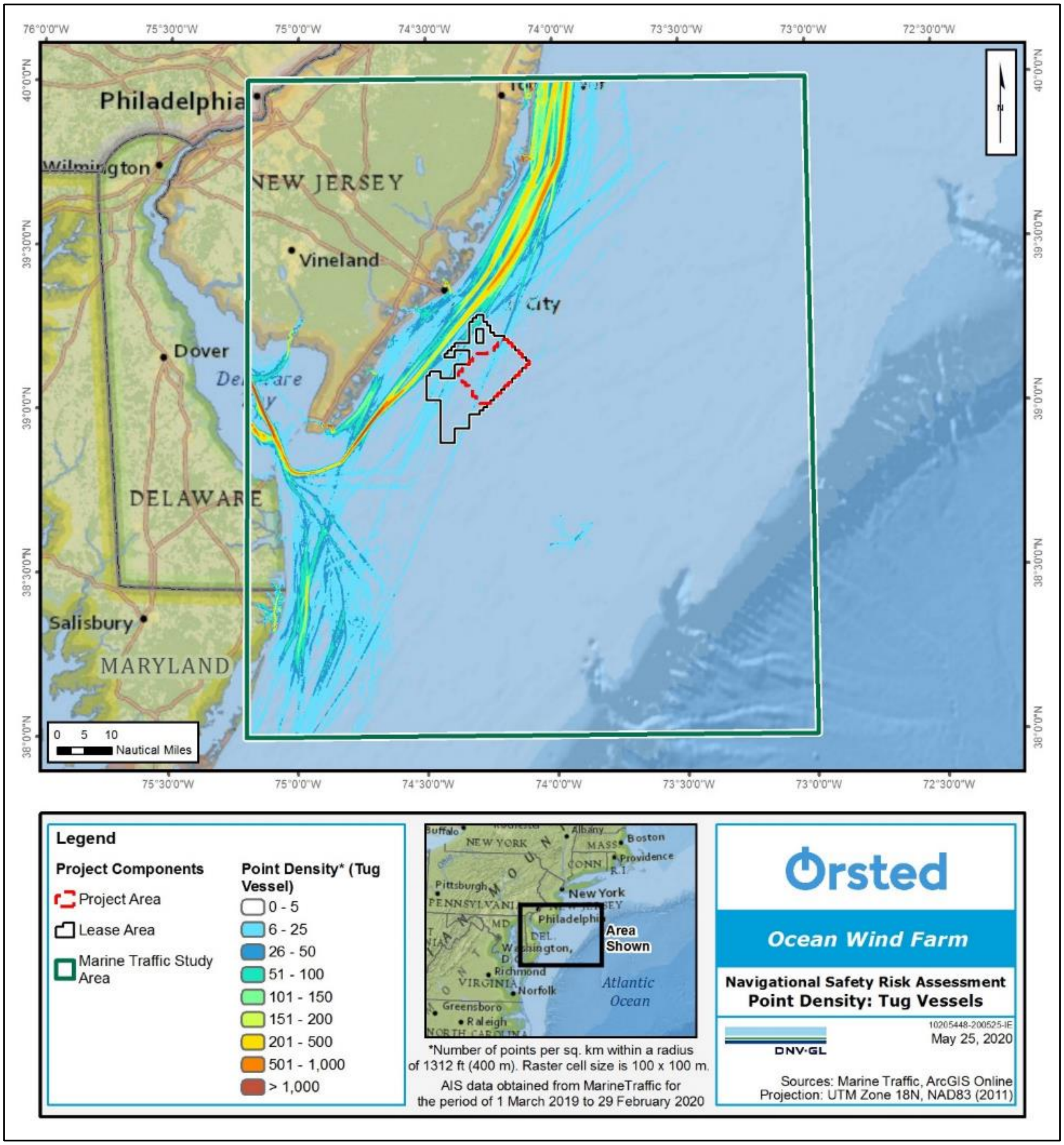


Figure A-16 Density of AIS points for tug vessels

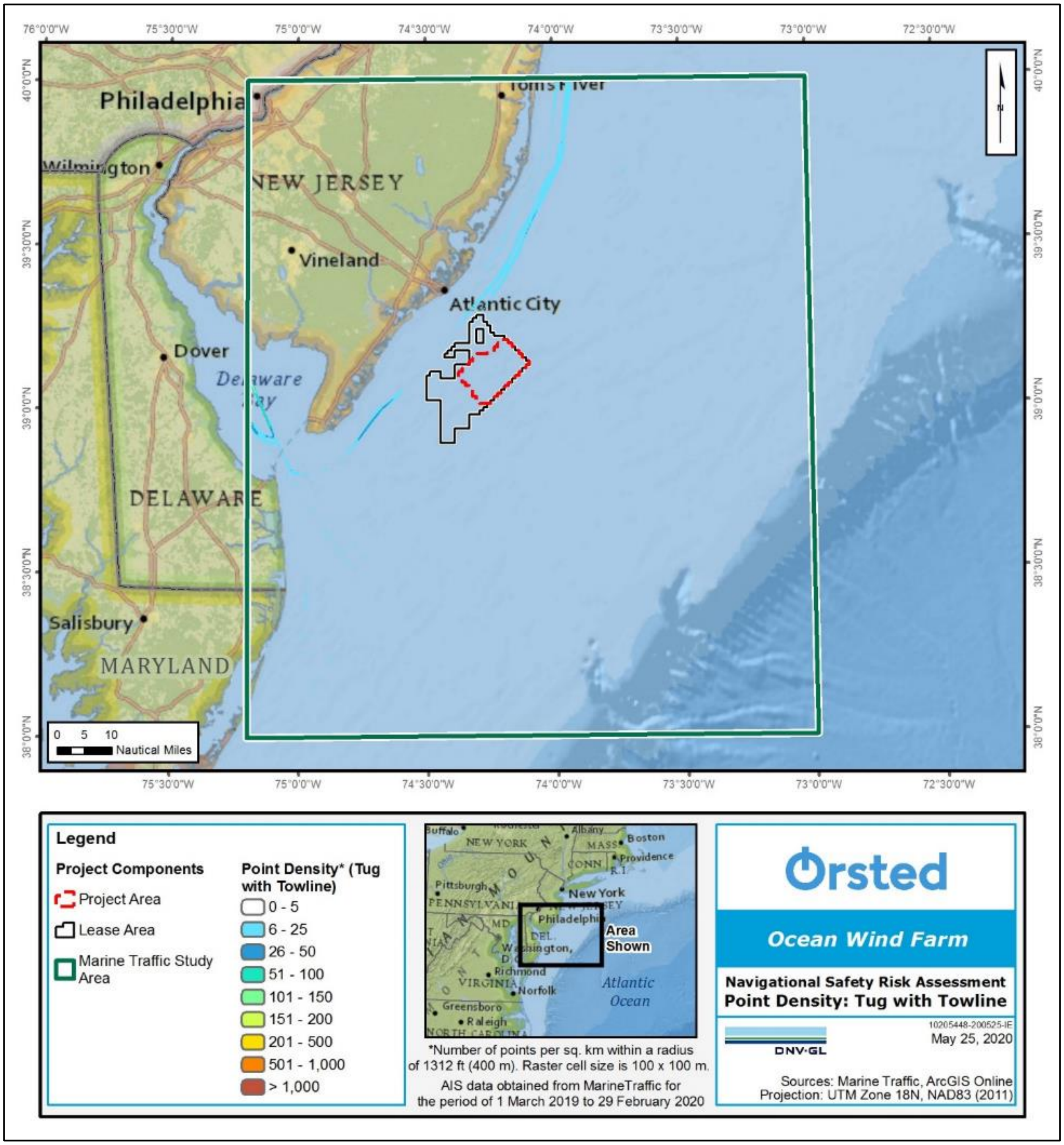


Figure A-17 Density of AIS points for tug with towline vessels

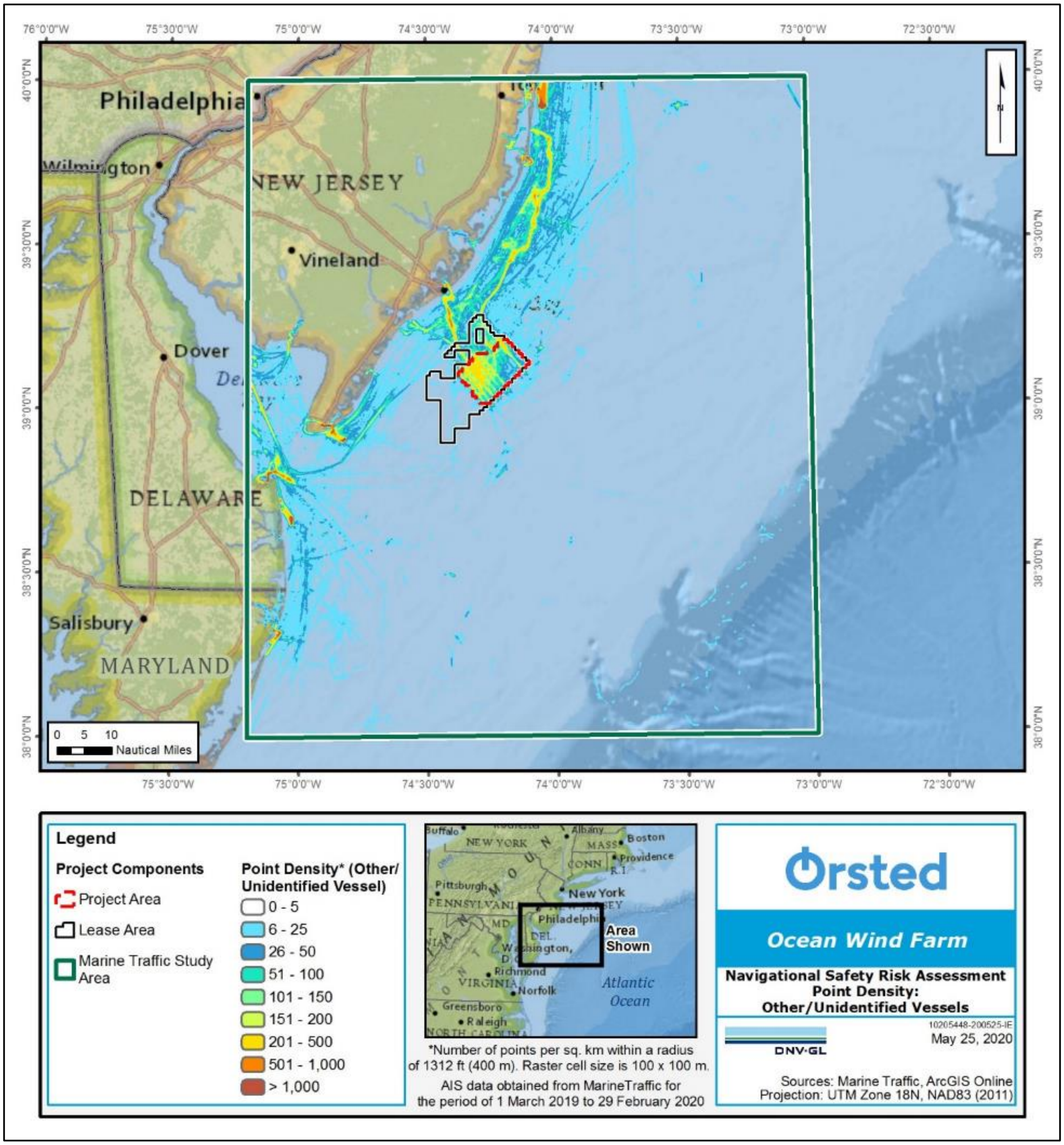


Figure A-18 Density of AIS points for other / unidentified vessels

A.3 AIS speed profile by vessel type

The figures in this section present density heat maps for all AIS points in the Study Area. The density is calculated by determining the number of AIS data points per square kilometer within a search radius of 1,312 ft (400 m) around each grid cell.

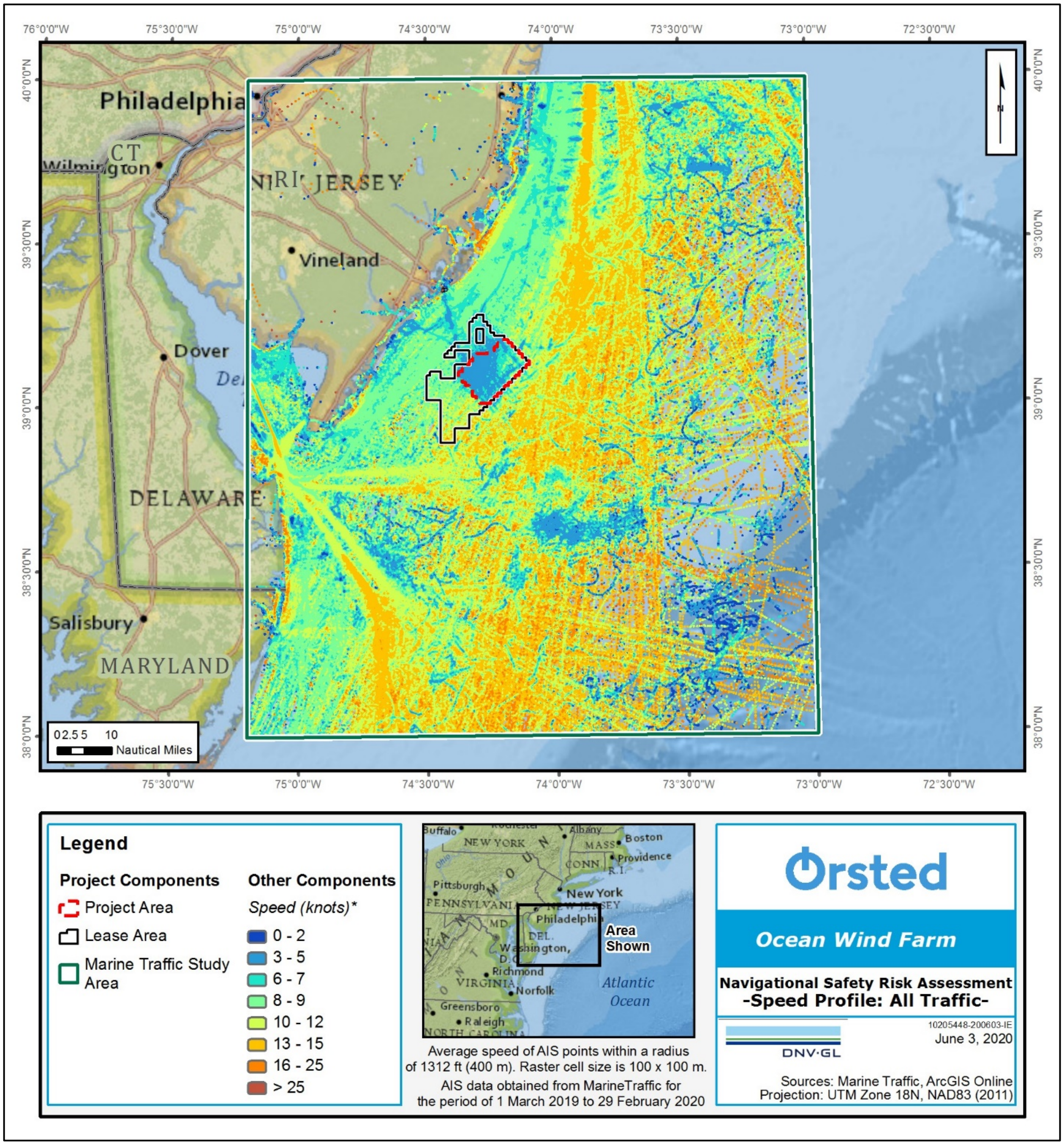


Figure A-19 Average speed of AIS points for all vessels

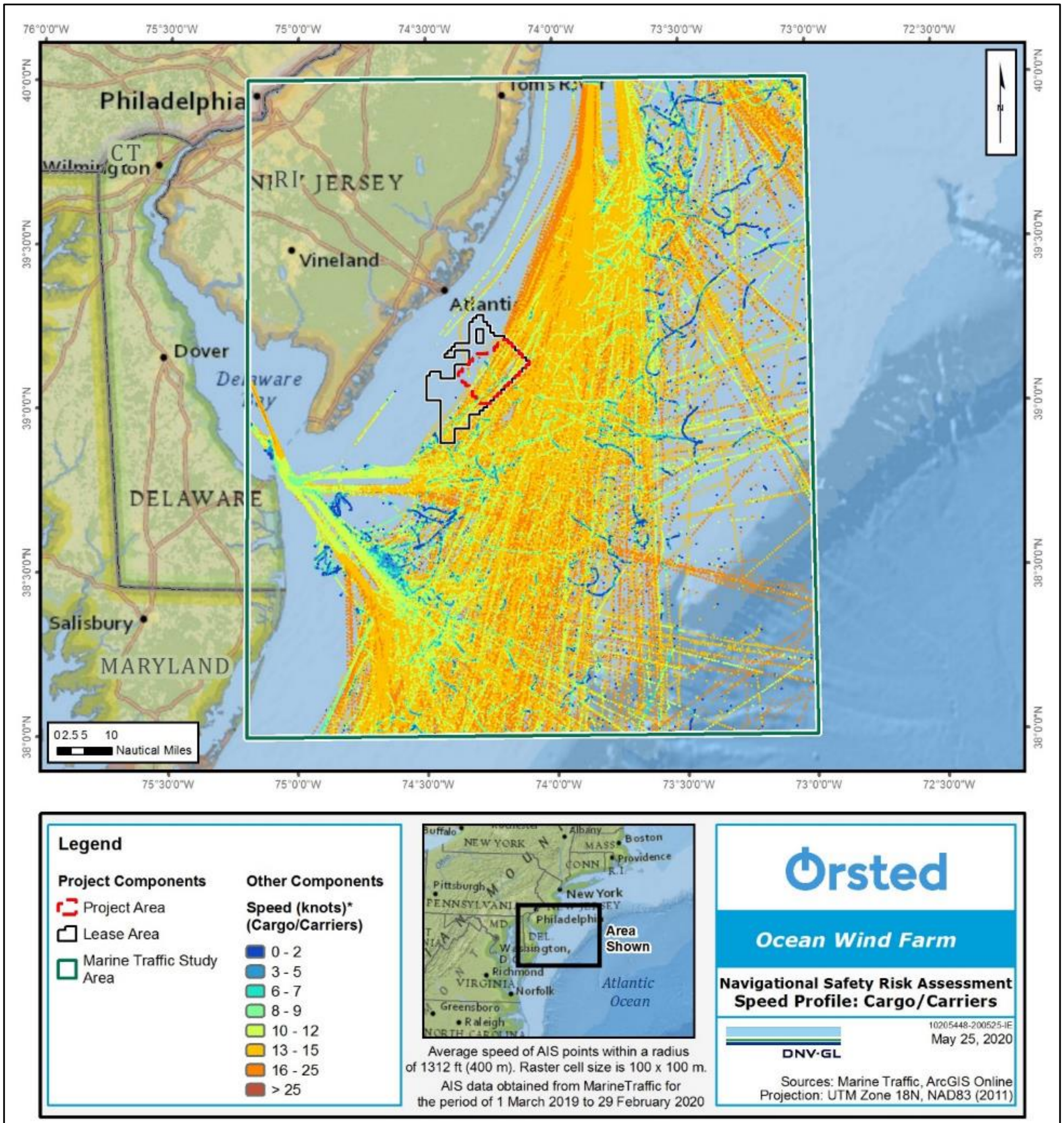


Figure A-20 Average speed of AIS points for cargo/carrier vessels

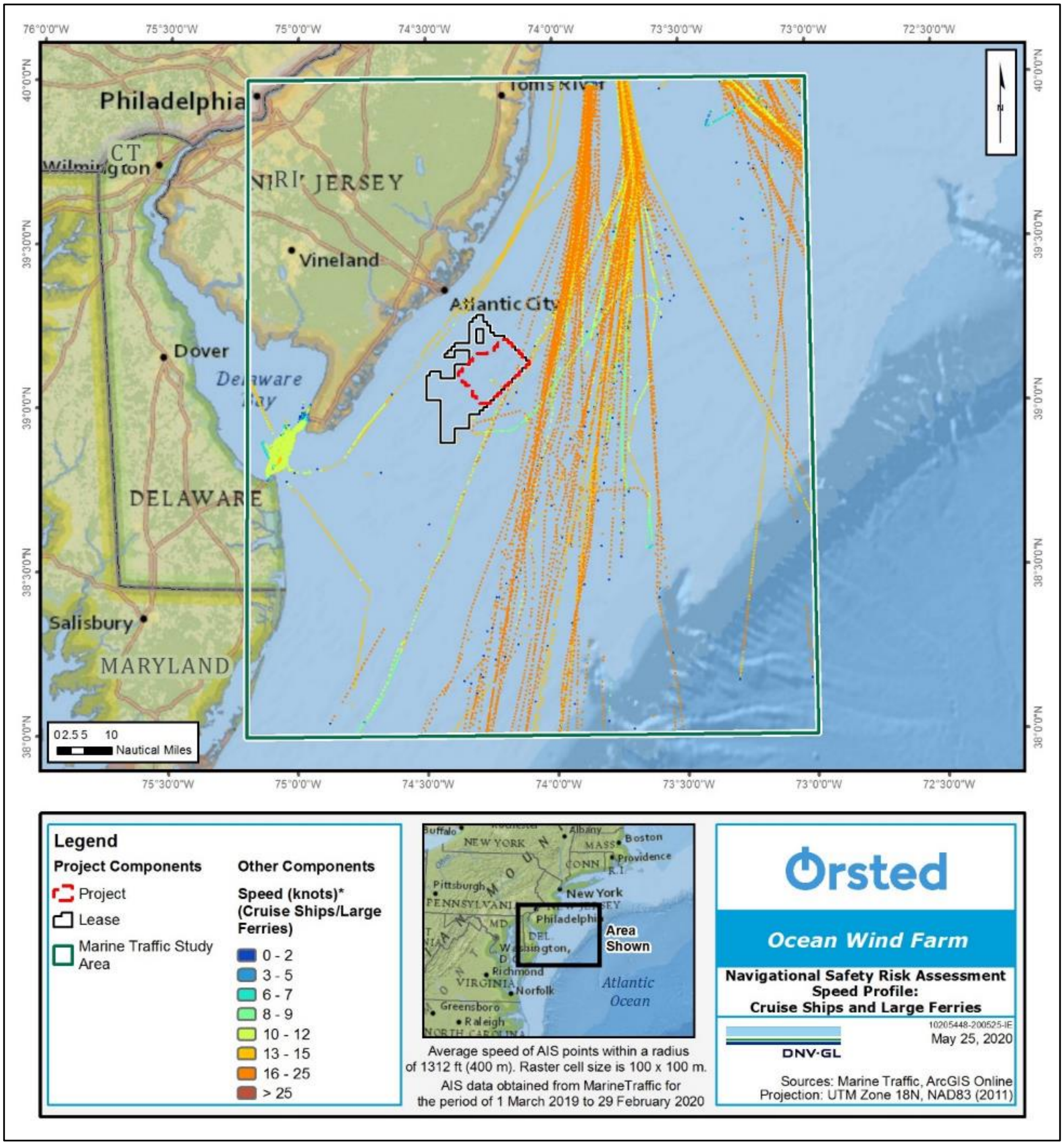


Figure A-21 Average speed of AIS points for cruise ship and large ferry vessels

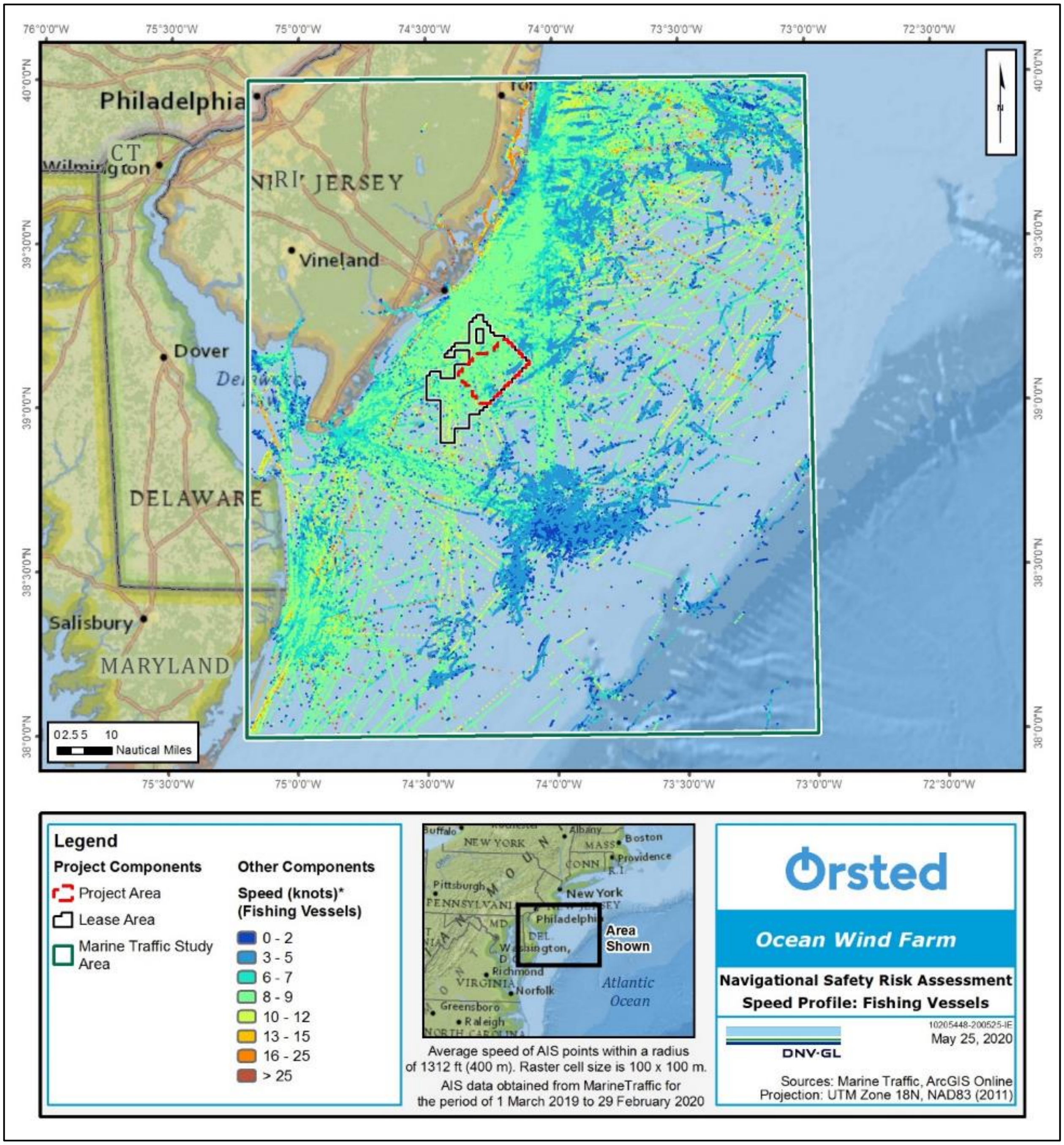


Figure A-22 Average speed of AIS points for fishing vessels

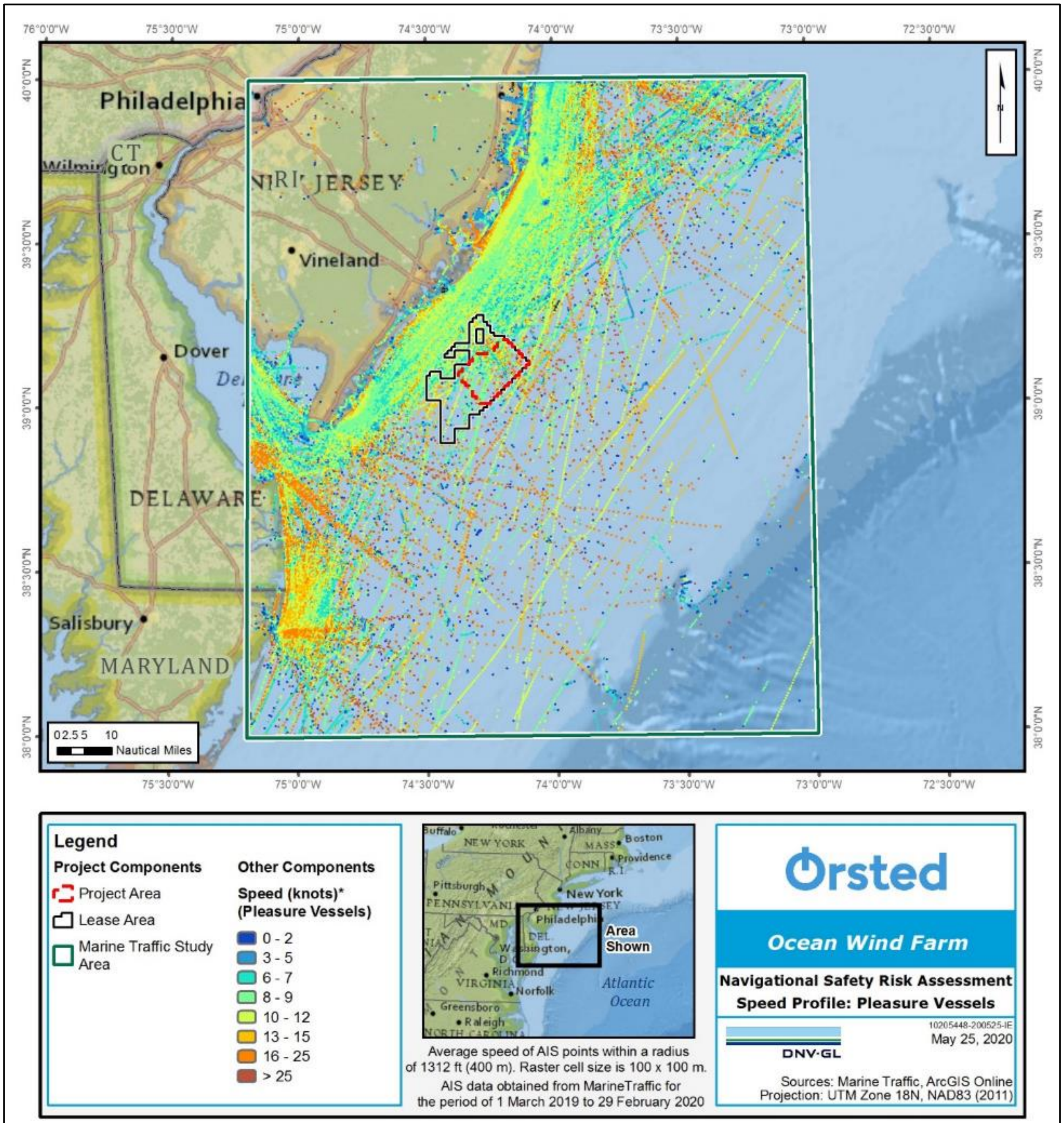


Figure A-23 Average speed of AIS points for pleasure vessels

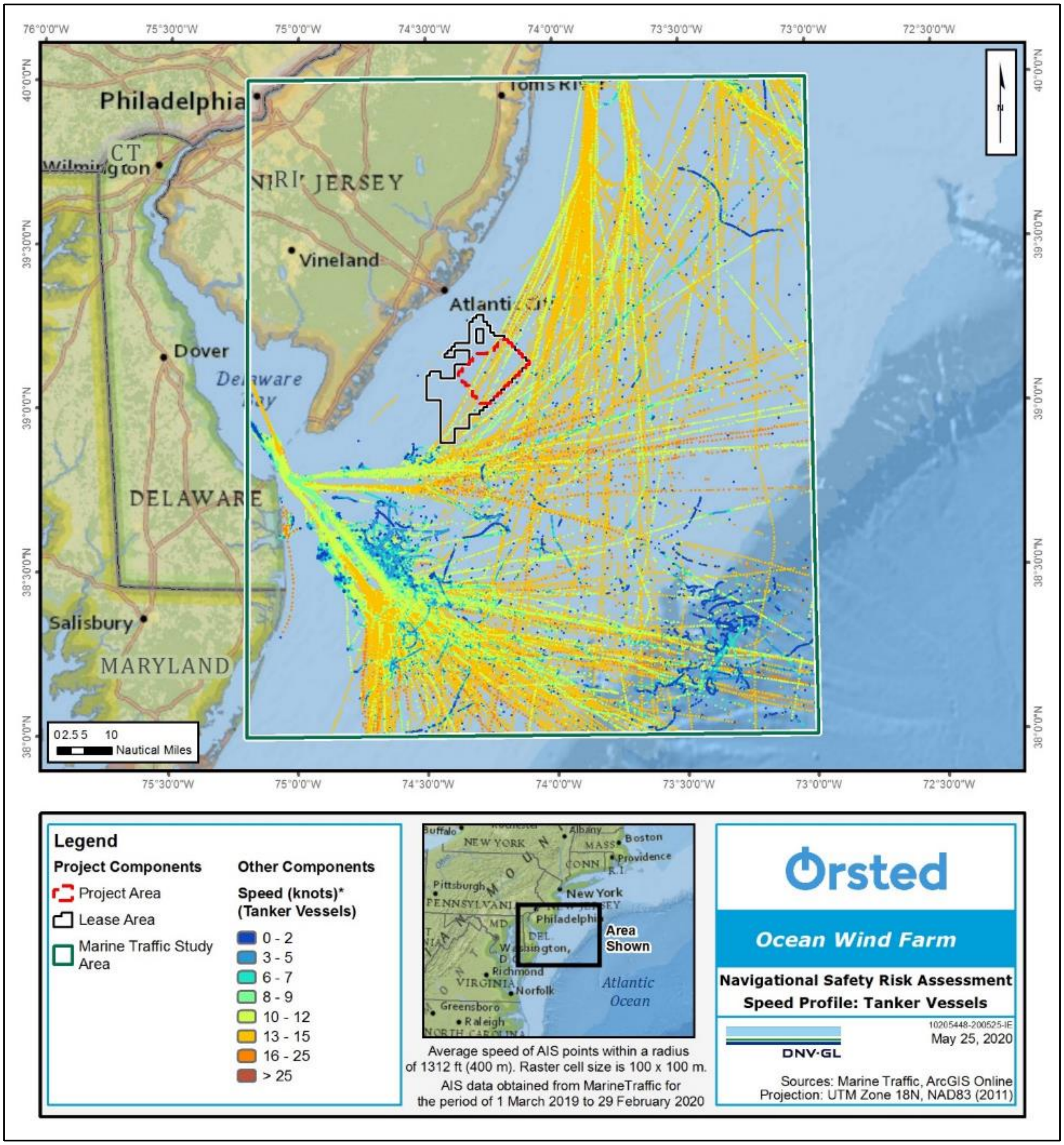


Figure A-24 Average speed of AIS points for tanker vessels

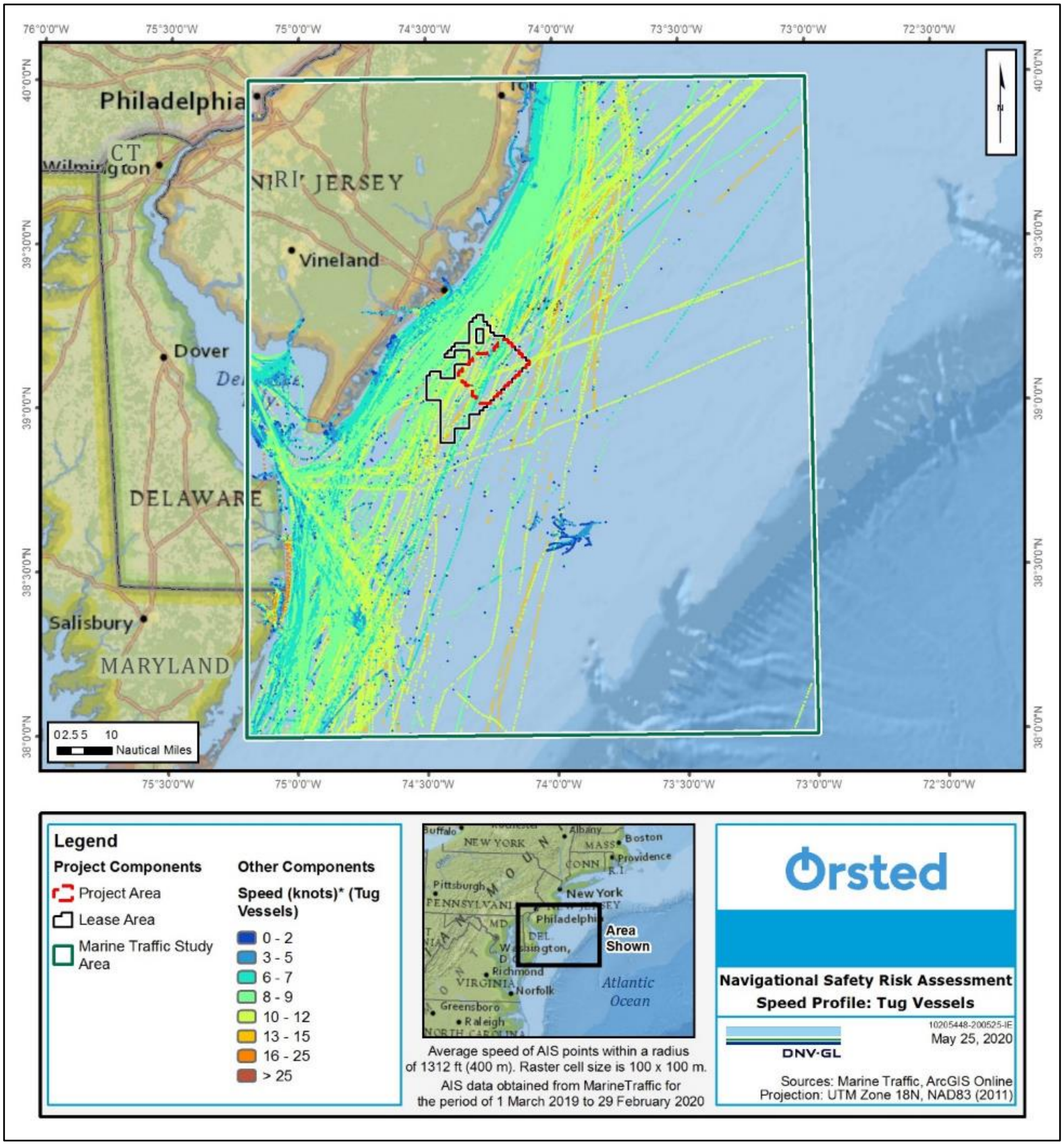


Figure A-25 Average speed of AIS points for tug vessels

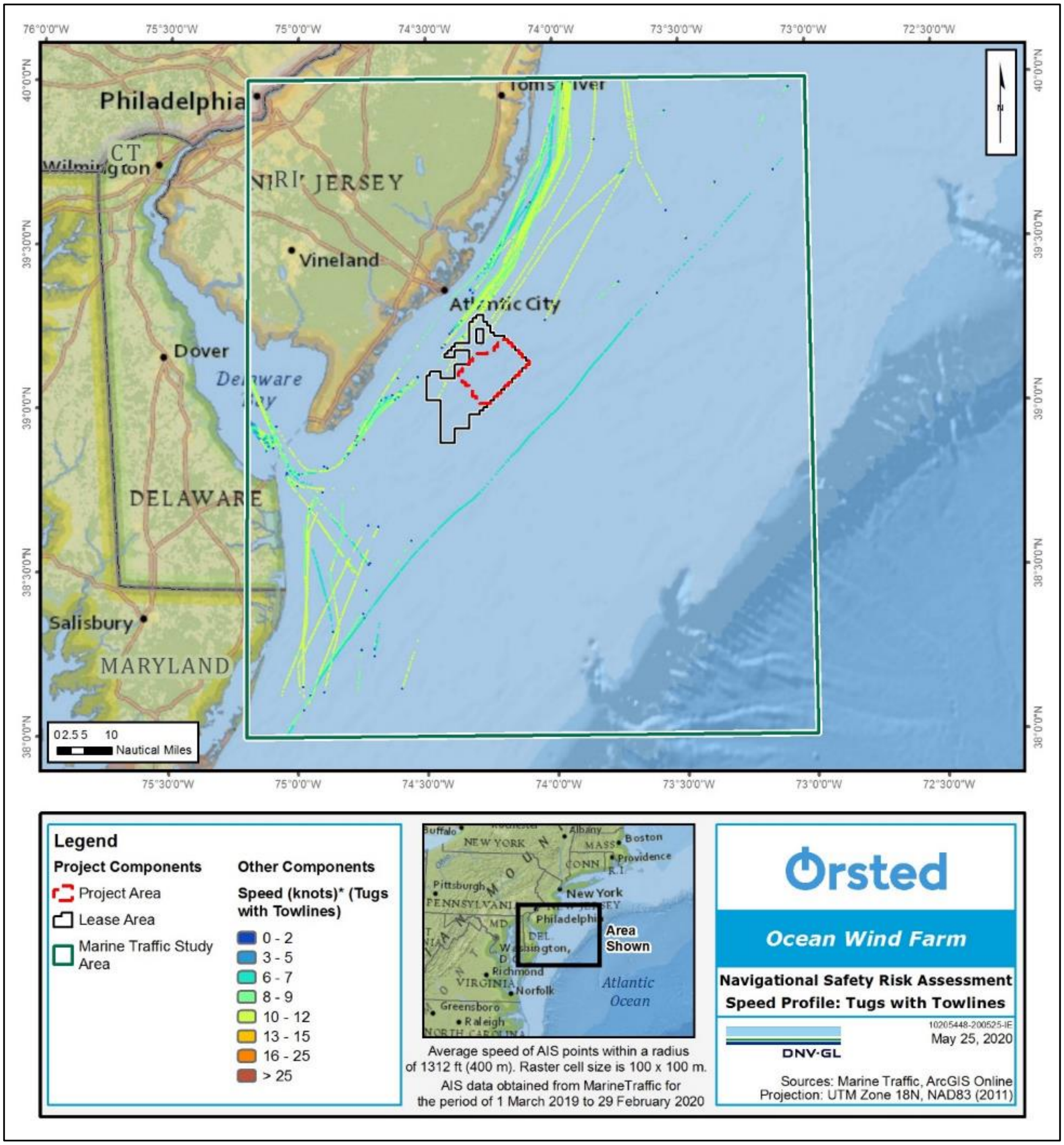


Figure A-26 Average speed of AIS points for tug with towline vessels

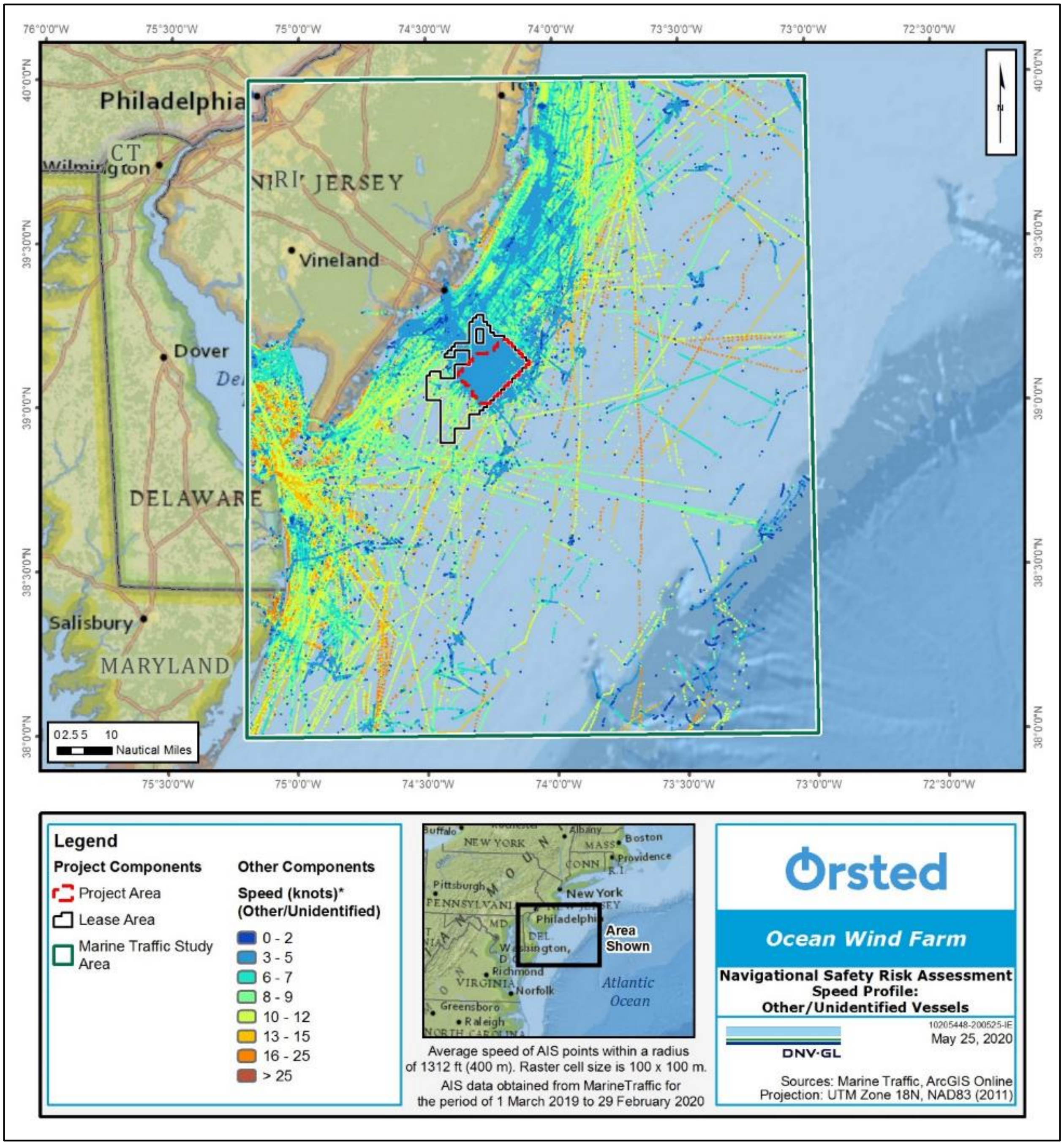


Figure A-27 Average speed of AIS points for other / unidentified vessels

APPENDIX B LIST OF PARTIES CONTACTED

Stakeholder engagement is an important aspect of assuring maritime safety. Orsted has contacted the below entities regarding marine use / safety:

1. Aeros Cultured Oyster Co.
2. Atlantic Capes Fisheries
3. Atlantic Coastal Sportsfishing Association
4. Audubon Society
5. Axelsson Seiner Inc
6. Baywater Oyster
7. Bingo fishing charter
8. Bitchin Fishing Charters
9. Blue Bill Fisheries
10. Blue Island Oyster Company
11. Blue Water Fishermen's Assoc
12. Bumble Bee Seafood; Snow clam Chowder
13. Cape May County Party & Charter Boat Association
14. Captain Lou fleet
15. Captain Ockers Oyster Co, Inc.
16. Carrie Lynn Fishing charters
17. Celtic Quest Fishing
18. Chesapeake Bay Sportfishing Association (CBSFA)
19. Codfather Charters
20. CONSCIENCE POINT SHELLFISH HATCHERY CORP
21. CORNELIUS & LITTLE RAM OYSTER COMPANY LLC
22. DE Surf Fishing
23. Defend H2O
24. Delaware Center for Inland Bays
25. Dock to dish
26. Dorchester ship yard
27. Dune Fisheries

28. East Hampton Fisheries Advisory Committee

29. EH Town Republican Party

30. Environmental Stewardship Concepts, MAFMC

31. Fire Island Oyster Co.

32. Fishermen's Dock Co-op

33. Five Fathom Inc.

34. Frank Flower and Sons Inc

35. Garden State Seafood Assn

36. Gone Fishing

37. GREAT ATLANTIC SHELLFISH FARMS LLC

38. GREAT GUN SHELLFISH LLC

39. GREAT SOUTH BAY OYSTER COMPANY INC

40. Greenport Oyster Company

41. H&L Axelsson Inc.

42. Heins Fisheries Consulting, MAFMC

43. Hinch Marina, Inc.

44. Inlet seafood

45. Island princess

46. Jim’s Bait and Tackle

47. JW Commercial Fishing Inc

48. Lamonica fine foods

49. Laura lee fleet

50. Long Island Commercial Fishing Association

51. Loper Bright

52. Lund's Fisheries

53. MAFMC

54. Mariners Advisory Committee

55. Maryland Coastal Conservation Association

56. Mayor of Beach Haven New Jersey

57. MD DNR

58. Mid-Atlantic Regional Center National Wildlife Federation
59. Miss Chris Charter Fleet
60. Montauk Boatman's & Captain's Association
61. Montauk Marine Basin
62. Multi Aquaculture Systems Inc
63. Nassau Rescue Team
64. NJ DEP
65. NYC Charters
66. NYS Department of Environmental Conservation
67. Ocean City Fishing and Cruising Fleet
68. Ocean Pines Anglers Club
69. Oceanside marine
70. OMEGA Protein
71. Osprey Fishing Fleet
72. Point Pleasant Fishermen's Supply
73. Providence Fisheries
74. Reel Busy Sport Fishing Inc.
75. Rocket Charters
76. RODA
77. Safina Center
78. Save Our Baymen
79. Sea Gear, Cape May NJ
80. Shinnecock Fish Dock
81. SHINNECOCK STAR CHARTERS
82. South Jersey Marina
83. Southampton Town Council
84. Star Island Marina
85. Starlight Charter Fleet
86. Surf Side Foods
87. T&S Fisheries

88. The Delaware Nature Society
89. The Nature Conservancy
90. Truex Enterprises / Sea Watch Inc
91. Two Cousins Fish Market
92. Uihlein's Marina
93. University of Delaware,
94. US Coast Guard
95. Viking Fleet
96. Viking Village
97. Village Marina
98. Wallace & Associates
99. West Lake Marina
100. Westlake Fishing Lodge
101. Woodcleft Fishing Station

APPENDIX C MARINERS' PERSPECTIVES OF PROJECT IMPACT

The Project has engaged and continues to engage numerous stakeholders regarding the potential impacts—both positive and negative—that the proposed Project may have on their particular waterway uses. Orsted (2021) provided the below summary of stakeholder feedback.

Appendix B lists major stakeholder organizations with which the Project regularly engages. The list is not all-inclusive. Additionally, the Project has conversed with nearly 200 individual stakeholders, mostly from the commercial fishing industry, to receive their input.

The combined stakeholder group (organizations and individuals) represents a comprehensive cross-section of waterway users in the Project Area, including representatives from the recreational boating and fishing, commercial fishing, commercial vessel operators and pilot organizations, and port authorities.

Anecdotal feedback from stakeholders falls generally into one or more of the following categories:

- Recreational boating: Recreational boaters are expected to visit the Project Area to view the novelty of an offshore wind farm. After an initial uptick of recreational vessel traffic to the Project Area, it is expected that little recreational traffic would regularly operate in the vicinity.
- Recreational fishing: Recreational fishing is expected to increase as fish congregate around the artificial reef associated with each turbine and OSS.
- Commercial fishing: Commercial fishing stakeholders expressed concerns about lines of orientation (rows and columns) and spacing between turbines. Based on feedback received from this constituency, the Project plans an array with three lines of orientation, east/west and north/south, and northeast/southwest, and a minimum of 0.8 nautical mile separation between towers.
- Commercial vessel operators/pilots: Commercial vessels will make slight adjustments to their traditional courses to avoid the Project Area completely.
- Port Authorities: Port authorities are generally supportive of the Project provided sufficient mitigations, many discussed in this assessment, are implemented to maintain navigation safety and minimize potential impacts the Project may have on port operations.

APPENDIX D DESCRIPTION OF MARCS MODEL

D.1 Introduction

The Marine Accident Risk Calculation System (MARCS) is a set of risk parameters and calculation tools that have been developed to support DNV GL's marine risk services. MARCS calculates the frequency and consequence of accidents due to the following "standard" navigation hazards:

- Collision between two ships both underway
- Powered grounding, where a ship strikes the grounding line due to human error (steering and propulsion not impaired)
- Drift grounding, where a ship strikes the grounding line due to mechanical failure (steering and/or propulsion failed)
- Powered impact, where a ship strikes a man-made structure (e.g., platform or wind turbine) due to human error (steering and propulsion not impaired)
- Drift impact, where a ship strikes a man-made structure (e.g., platform or wind turbine) due to mechanical failure (steering and/ or propulsion failed)

The frequency of each hazard is calculated by MARCS as a function of geographical position, for each accident type, and for each ship type included in the input data. The marine accident frequency assessment for marine transport or turbine/platform installation can be performed by assessing the frequency of the above accident types in a defined study area. The analysis results can then be assessed to determine if the estimated accident frequencies are acceptable or if mitigation measures are justified or required.

D.2 Overview of MARCS

The MARCS accident frequency model provides an estimate of the frequency of accidents that may occur at sea. A block diagram of the model is shown in Figure D-1.

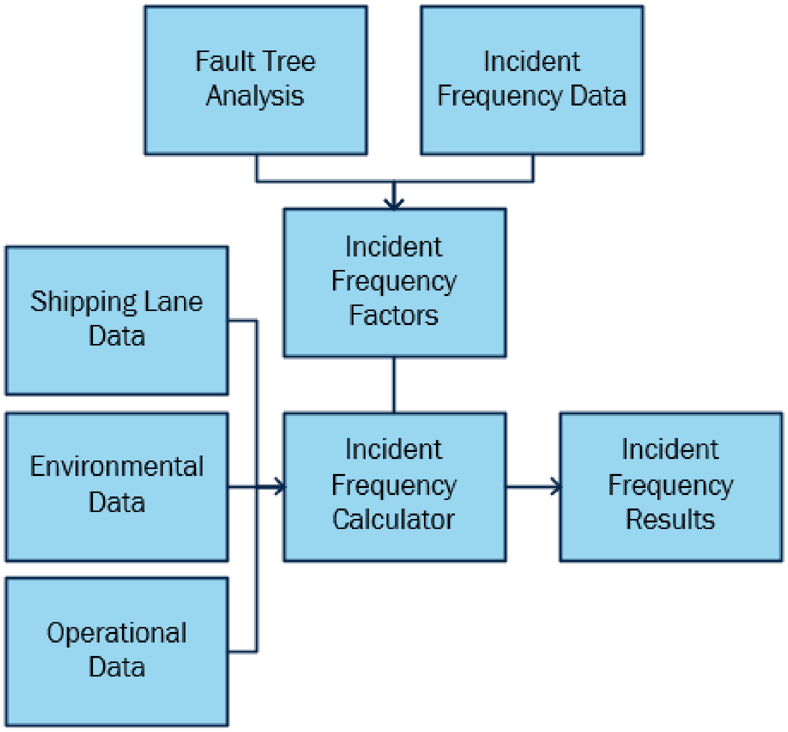


Figure D-1 Block diagram of MARCS incident frequency model

The MARCS model classifies data into four main types:

- Shipping lane data describes the movements of different marine traffic types within the study area.
- Environmental data describes the conditions within the calculation area, including the location of geographical features (land, offshore structures, offshore wind farms, etc.) and meteorological data (visibility, wind rose, water currents, and sea state).
- Operational data represents how shipping operations are performed. This includes ship speed data, use of pilots, use of Vessel Traffic Services, etc.

A MARCS calculation is performed in a study area. The study area is a rectangle defined by the coordinates of the northwest and southeast corners. Marine accident risks are calculated within the study area, as shown in Figure D-2.

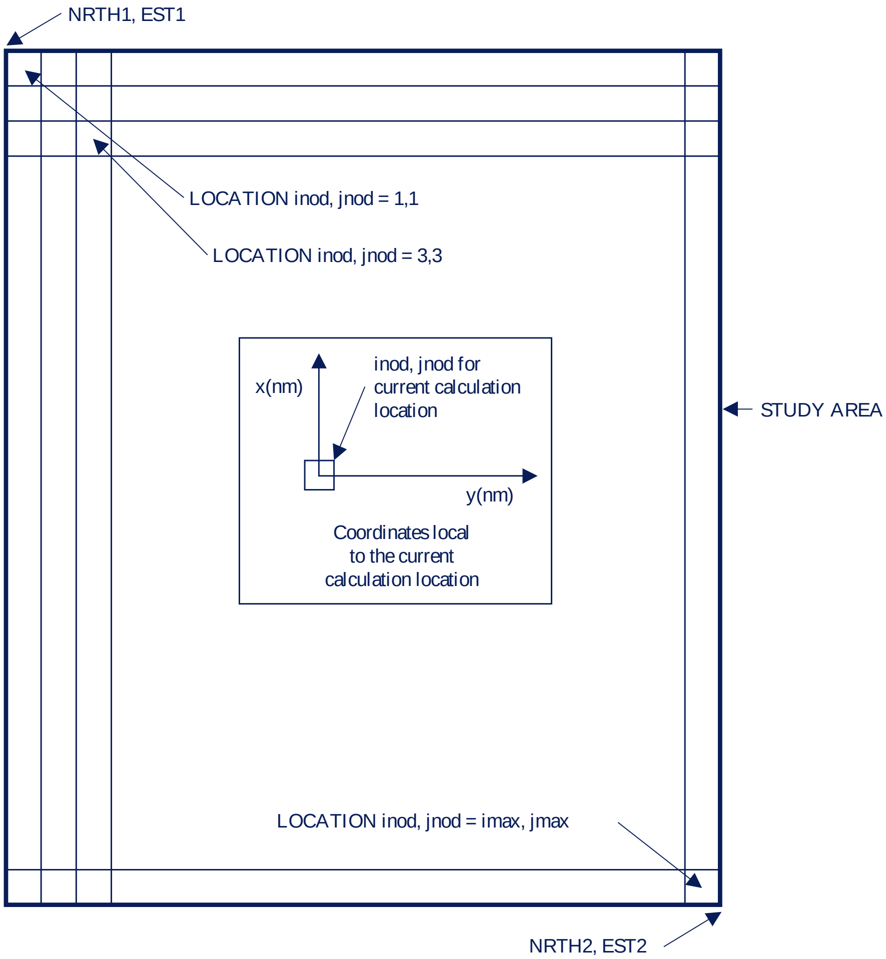


Figure D-2 Basic definitions and coordinate sets

The study area is divided into a large number of small locations (or pixels). The marine accident risk is calculated at each location in sequence. The study area and the calculation resolution (how many locations to put into the study area – the values of imax, jmax) is usually one of the first decisions made on starting a new project.

Three coordinate systems are used by MARCS:

- Absolute coordinates are specified in decimal degrees east of Greenwich, England and decimal degrees north of the equator.
- Calculation locations are specified in terms of their row number (inod [1.imax]) and column number (jnod [1.jmax]), where location (1,1) is at the top left hand corner of the study area. Calculation locations are equally spaced in terms of decimal degrees.
- Local distance coordinates are defined in terms of pseudo x,y Cartesians relative to the calculation location (Ninod, Ejnod).

D.2.1 Critical situations

To calculate the incident frequency, MARCS first identifies critical situations. The definition of a critical situation varies with the incident type. It first calculates the location dependent frequency of critical situations (the number of situations which could result in an incident – "potential incidents" – at a location per year; a location is defined as a small part of the study area, typically about one nautical mile square, but dependent on the chosen calculation resolution). The definition of a critical situation varies with the incident type).

Fault tree analysis (Henley and Kumamoto, 1981; Cooke, 1995) can be described as an analytical technique, whereby an undesired state of a system is specified, and the system is then analyzed in the context of its environment and operation to find all credible ways in which the undesired event can occur. This undesired state is referred to as the top event of the fault tree. It expresses the frequency or probability for the occurrence of this event or incident.

The basic events of a fault tree are those events that make up the bottom line of the fault tree structure. To perform calculations of the top frequency or probability of a fault tree, these basic events need to be quantified. The fault tree structure is built up by basic events and logical combinations of these events that are expressed by AND and OR gates. The outputs of these gates are new events, which again may be combined with other events / basic events in new gates. The logic finally results in the top event of the fault tree.

The different symbols in the fault tree are defined in Figure D-3.

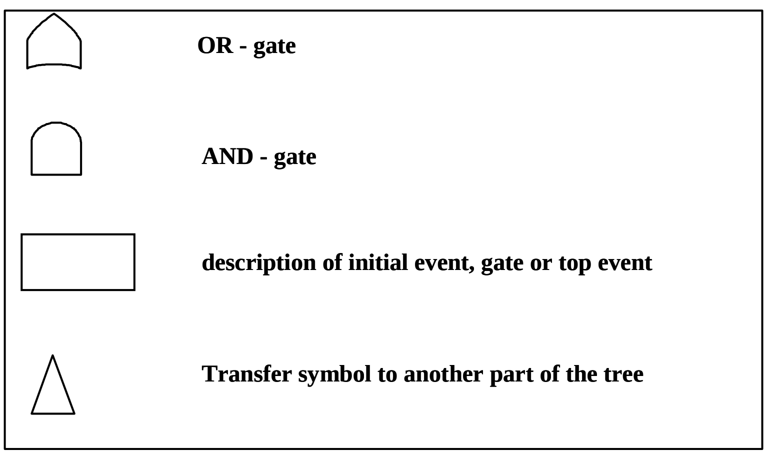


Figure D-3 Fault tree symbols

The OR gate (Figure D-4) expresses the probability of occurrence of Event 1 or Event 2, and is calculated as the sum minus the intersection of the two events:

$$P(\text{Event 1 OR Event 2}) = P1 + P2 - P1*P2$$

Usually the intersection probability can be neglected, as it will be a very small number (if $P1 = P2 = 10^{-2}$, then $P1*P2 = 10^{-4}$).

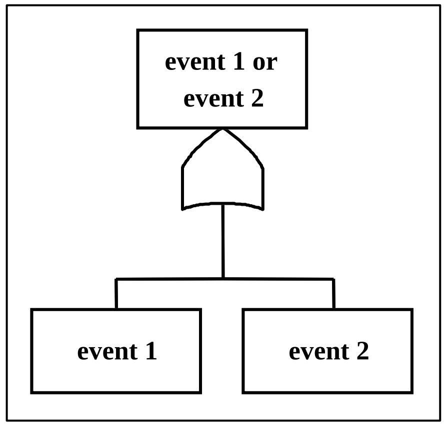


Figure D-4 OR gate

The AND gate (Figure D-5) expresses the probability that Event 1 and Event 2 occur simultaneously, and is calculated as the product of the two events:

P(Event 1 AND Event 2)= P1*P2

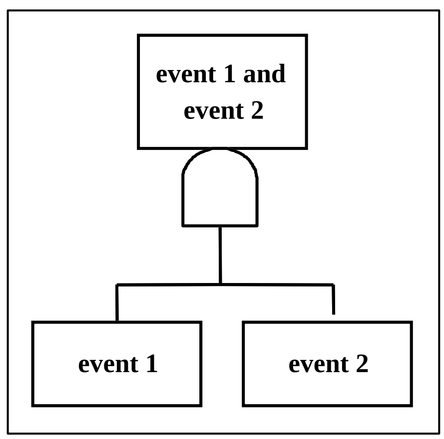


Figure D-5 AND gate

It should be emphasized that the quality of the results produced by fault tree analysis is dependent on how realistically and comprehensively the fault tree model reflects the causes leading to the top event. Of course, it is never possible to fully represent reality, and therefore the models will always only represent a simplified picture of the situation of interest. The top event frequencies will generally be indicative, and hence relative trends are more reliable than the absolute values.

Fault tree models have been constructed to assess a number of parameters within MARCS, including collision probabilities per encounter (collision model) and failure probabilities to avoid a powered grounding given a critical situation (powered grounding model) (Det Norske Veritas, 1998b and 1999b).

D.3 Data used by MARCS

This section describes the various data inputs used by MARCS.

D.3.1 Traffic image data

The marine traffic image data used by MARCS is a representation of the actual flows of traffic within the calculation area. Marine traffic data is represented using lane data structures.

A typical shipping traffic lane is shown in Figure D-6. The following data items are defined for all lanes:

- The lane number (a unique identifier used as a label for the lane)
- The lane width distribution function (e.g., Gaussian or truncated Gaussian)
- The lane directionality (one-way or two-way)
- The annual frequency of ship movements along the lane
- A list of waypoints, and an associated lane width parameter at each waypoint
- The vessel size distribution on the lane

Additional data may be attached to the lane, such as: the hull type distribution (single hull, double hull, etc.) for tankers; the loading type (full loading, hydrostatic loading) for tankers; ship type, etc.

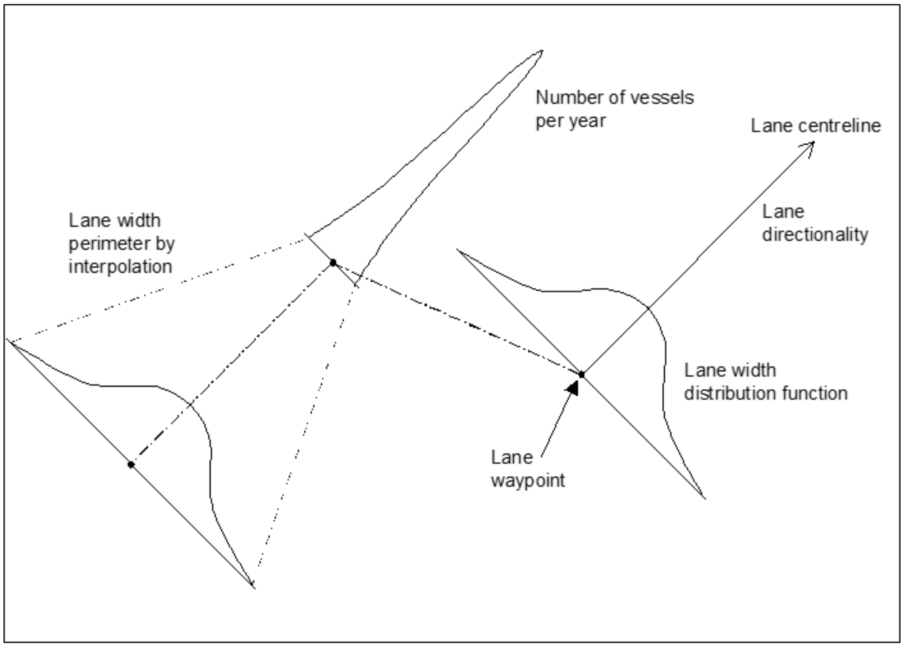


Figure D-6 Shipping lane representation used in MARCS

Detailed surveys of marine traffic in UK waters in the mid-1980s concluded that commercial shipping follows fairly well-defined shipping lanes, as opposed to mainly random tracks of individual ships. Further detailed analysis of the lanes showed that the lateral distribution across the lane width was approximately Gaussian or truncated Gaussian for traffic arriving in coastal waters from long haul voyages (e.g., from Europe or Asia). The shipping lane distributions used in MARCS are shown in Figure D-7.

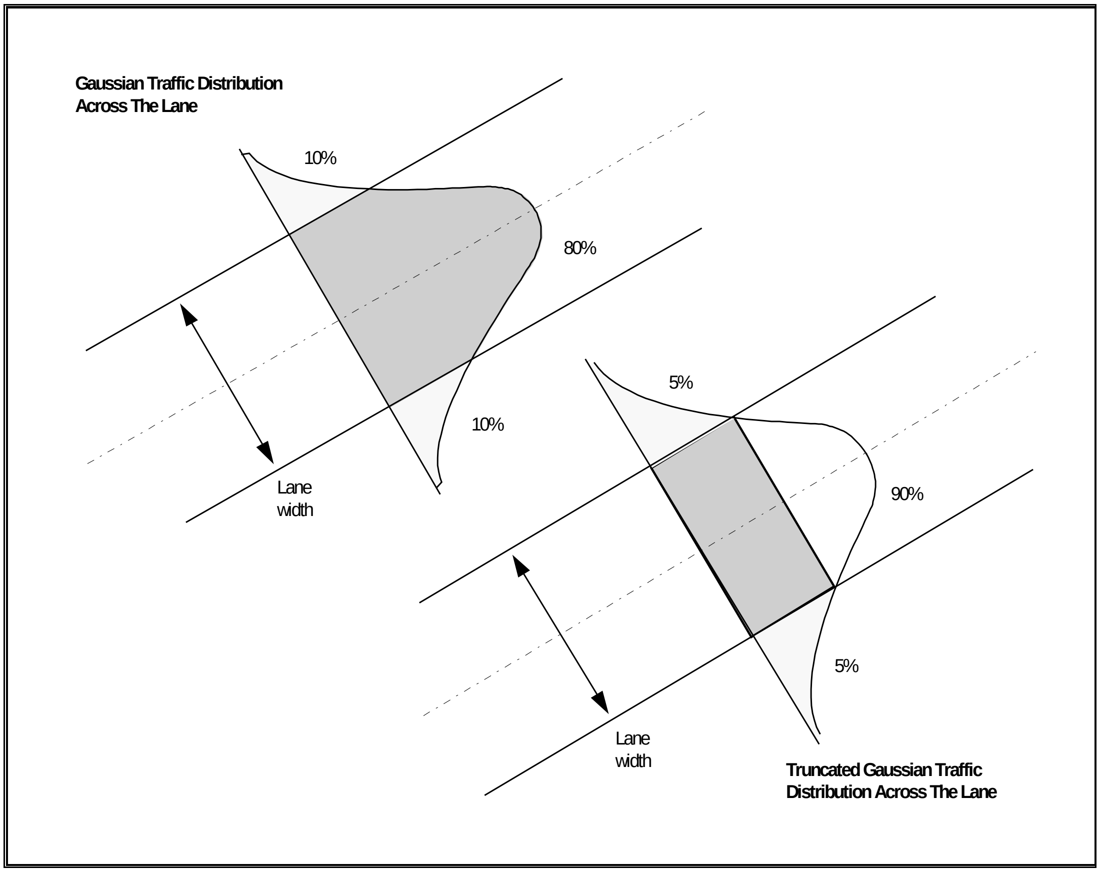


Figure D-7 Shipping lane width distribution functions used in MARCS

The marine traffic description used by MARCS is completed by the definition of four additional parameters for each type of traffic:

- Average vessel speed
- Speed fraction applied to faster and slower than average vessels (generally ± 20 percent)
- Fraction of vessels travelling faster and slower than the average speed (generally ± 20 percent)
- Fraction of vessels that exhibit “rogue” behavior (generally set to 0 percent, though historical incident data in many geographical areas shows a small proportion of (usually) smaller vessels undergo incidents through lack of watchkeeping (bridge personnel absent or incapacitated)

A rogue vessel is defined as one that fails to adhere (fully or partially) to the Collision Avoidance Rules. (Cockroft and Lameijar, 1982) Such vessels are assumed to represent an enhanced collision hazard. These four parameters can be specified as a function of location within the study area for each traffic type.

The marine traffic image is made up by the superposition of the defined traffic for each contributing traffic type.

D.3.2 Operational data

Internal operational data is represented within MARCS using either worldwide data or frequency factors obtained from fault tree analysis or location specific survey data. Fault tree parameters take into consideration factors such as crew watchkeeping competence and internal vigilance (where a second crew member, or a monitoring device, checks that the navigating officer is not incapacitated). Examples of internal operational data include:

- The probability of a collision given an encounter
- The probability of a powered grounding given a ship's course close to the shoreline
- The frequency (per hour at risk) of fires or explosions

Internal operational data may be defined for different traffic types and / or the same traffic type on a location-specific basis.

External operational data generally represent controls external to the traffic image, which affect marine risk. In MARCS, it relates mainly to the location of Vessel Traffic Service zones (which influence the collision and powered grounding frequencies by external vigilance, where external vigilance means that an observer external to the ship may alert the ship to prevent an incident) and the presence and performance of emergency towing vessels (tugs) which can save a ship from drift grounding or allision.

D.3.3 Environmental data

The environmental data describes the location of geographical features (land, turbines, offshore structures, etc.) and meteorological data (visibility, wind rose, sea currents, and sea state).

Poor visibility arises when fog, snow, rain, or other phenomena restrict visibility. In the MARCS model, poor visibility is defined as less than 2 NM. It should be noted that night-time is categorized as visibility greater than 2 NM unless any phenomenon restricting visibility is present.

Wind rose data is defined within 8 compass points (north, northeast, east, etc.) in four wind speed categories: calm (0 to 20 kt, Beaufort 0 to 4); fresh (20 to 30 kt, Beaufort 5 to 6); gale (30 to 45 kt, Beaufort 7 to 9); and storm (greater than 45 kt, Beaufort 10 to 12). Sea state (wave height) within MARCS is inferred from the wind speed and the nature of the sea area (classified as sheltered, semi-sheltered, or open water).

In order to avoid over-prediction of grounding or impact frequencies MARCS needs to know if a line of sight (LOS) exists between the location of a ship and the grounding or impact location. This is achieved by assigning every calculation location one of three types:

- Clear water location. Here ships can always pass through. Groundings or impacts cannot occur in clear water locations.
- Coastal location. Here groundings occur and ships cannot pass through.
- Clear water location plus man-made object (e.g., offshore platform or wind turbine). Here ships can always pass through the location but some ships may impact on the man-made object.

For “clear water locations plus a man-made object” data describing the size of the object enables MARCS to calculate the size of the object relative to the size of the location.

To determine if a LOS exists, MARCS calculates all the locations through which a ship must move in order to impact a specified object (or ground at a specified coastal location). If any one of these locations is another coastal location, then a LOS does not exist and the impact (or grounding) accident frequency is set to zero. If one of more of these locations is a “clear water locations plus a man-made object” location, then the accident frequency is multiplied by the proportion of clear water in the location ((size of the location – size of the man-made object)/size of the location). In this way, the accident frequency for turbines at the edge of a large array is higher than that for turbines in the center of the array. This mechanism is sometimes called the “shadow effect”.

D.4 Description of incident frequency models

This section describes how MARCS uses the input data (traffic image, internal operational data, external operational data and environment data) to calculate the frequency of serious incidents in the study area.

D.4.1 The collision model

The collision model calculates the frequency of serious inter-ship powered collisions at a given geographical location in two stages. The model first estimates the frequency of encounters (critical situations for collision - when two vessels pass within 0.5 nautical miles of each other) from the traffic image data using a pair-wise summation technique, assuming no collision-avoiding actions are taken. This enables the calculation of either total encounter frequencies, or encounter frequencies involving specific vessel types.

The model then applies a probability of a collision for each encounter, obtained from fault tree analysis, to give the collision frequency. The collision probability value depends on a number of factors including, for example, the visibility or the presence of a Pilot.

Figure D-8 shows a graphical representation of the way in which the collision model operates.

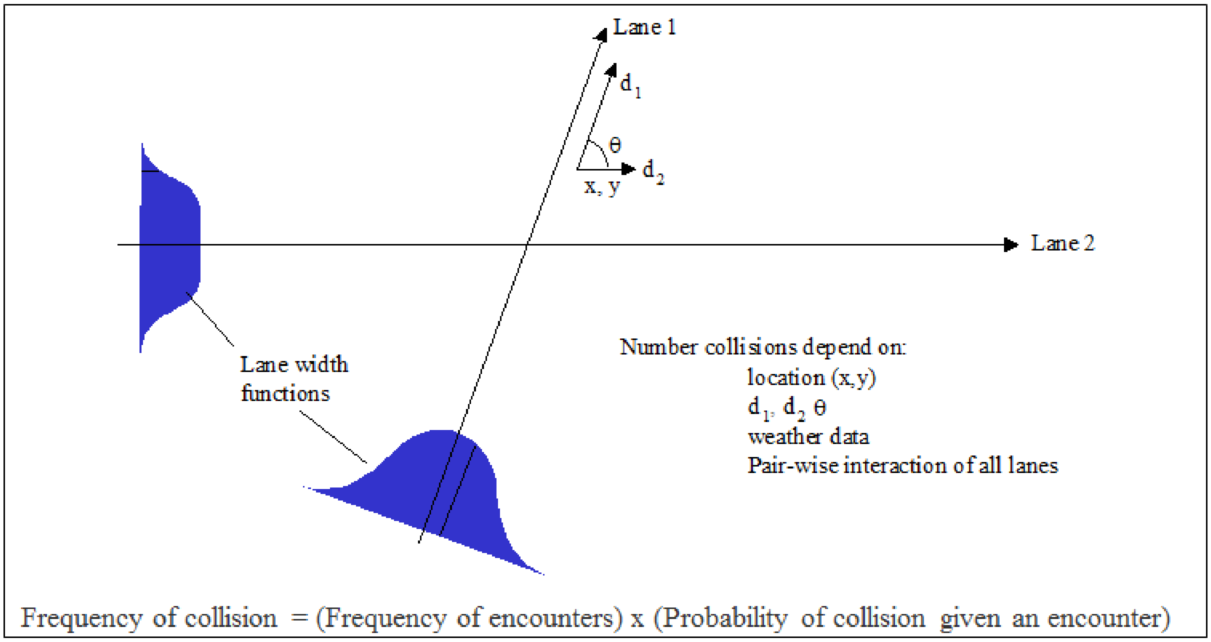


Figure D-8 Graphical representation of the collision model

In Figure D-8, d_1 refers to the density of traffic associated with Lane 1 at the location (x, y). The frequency of encounters at location (x, y) through the interaction of Lanes 1 and 2 is proportional to the product of d_1, d_2 and the relative velocity between the lane densities.

It should be noted that the MARCS collision accident frequency does not depend on the sizes (lengths and breadths) of the encountering ships. This is because MARCS uses a probability of avoiding collision given an encounter which assumes that the navigators on one or both ship's may maneuver to attempt to avoid collision. These collision avoidance probabilities are not available as a function of encountering ship sizes.

D.4.2 The powered grounding model

The powered grounding frequency model calculates the frequency of serious powered grounding incidents in two stages. The model first calculates the frequency of critical situations (sometimes called "dangerous courses" for powered grounding incidents). Two types of critical situations are defined as illustrated in Figure D-9. The first critical situation arises when a course change point (waypoint) is located such that failure to make the course change would result in grounding within 20 minutes' navigation from the planned course change point if the course change is not made successfully. The second critical situation results when a grounding location is within 20 minutes' navigation of the course centerline. In this case, crew inattention combined with wind, current, or other factors could result in a powered grounding.

The frequency of serious powered groundings is calculated as the frequency of critical situations multiplied by the probability of failure to avoid grounding.

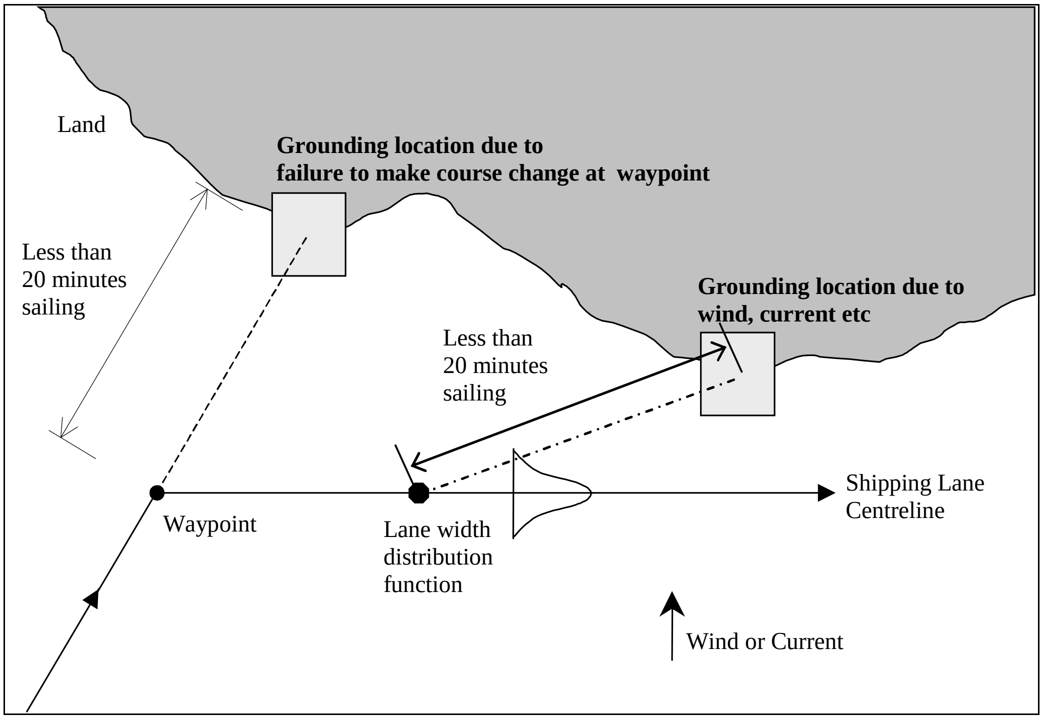


Figure D-9 Graphical representation of the powered grounding model

The powered grounding probabilities are derived from the fault tree analysis of powered grounding. The powered grounding fault tree contains two main branches:

- Powered grounding through failure to make a course change whilst on a dangerous course. A dangerous course is defined as one that would ground the vessel within 20 minutes if the course change were not made.
- Powered grounding caused by crew inattention and wind or current from the side when the ship lane runs parallel to a shore within 20 minutes sailing.

Both these branches are illustrated in Figure D-9. The powered grounding frequency model takes into account internal and external vigilance, visibility, and the presence of navigational aids in deducing failure parameters.

It should be noted that the MARCS powered grounding accident frequency does not depend on the size (length and breadth) of the ship on a dangerous course.

D.4.3 The drift grounding model

The drift grounding frequency model consists of two main elements: first, the ship traffic image is combined with the ship breakdown frequency factor to generate the location and frequency of vessel breakdowns; second, the recovery of control of drifting ships can be regained by one of three mechanisms:

- Repair
- Emergency tow vessel assistance

- Anchoring

Those drifting ships that are not saved by one of these three mechanisms (and do not drift out into the open sea) contribute to the serious drift grounding incident frequency results.

The number and size distribution of ships which start to drift is determined from the ship breakdown frequency, the annual number of transits along the lane and the size distribution of vessels using the lane. The proportion of drifting vessels that are saved (fail to ground) is determined from the vessel recovery models. The drift grounding frequency model is illustrated in Figure D-10.

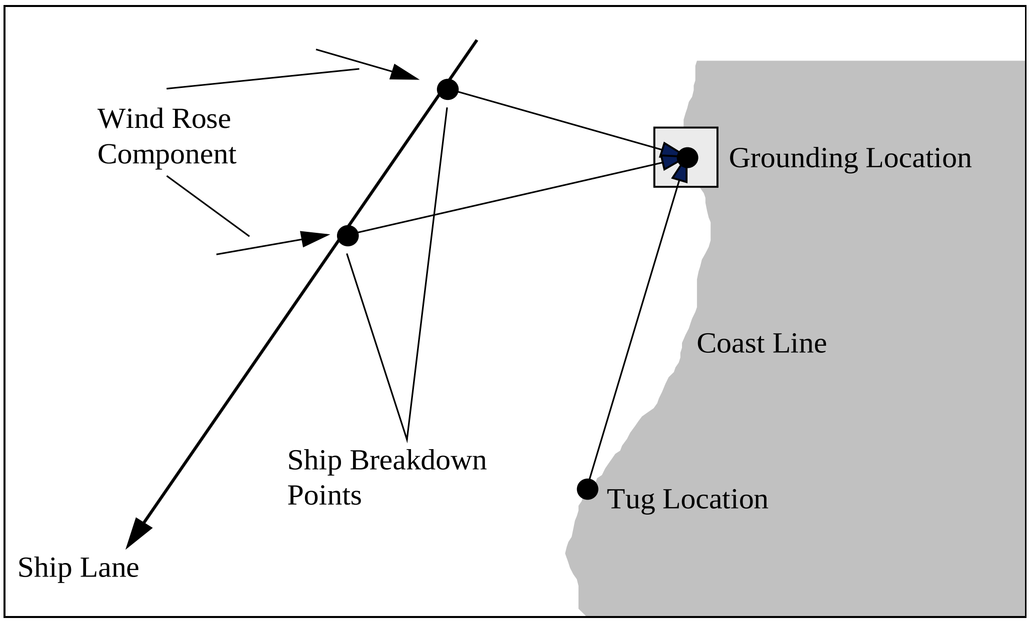


Figure D-10 Graphical representation of the drift grounding model

Implicit in Figure D-10 is the importance of the time taken for the ship to drift aground. When this time is lengthy (because the distance to the shore is large and/or because the drift velocity is small) then the probability that the ship will recover control before grounding (via repair or tug assistance) will be increased.

It should be noted that the MARCS drift grounding accident frequency does not depend on the size (length and breadth) of the drifting ship.

D.4.3.1 The repair recovery model

Vessels that start to drift may recover control by effecting repairs. For a given vessel breakdown location, grounding location, and drift speed, there is a characteristic drift time to the grounding point. The proportion of drifting vessels that have recovered control by self-repair is determined from this characteristic drift time and the distribution of repair times.

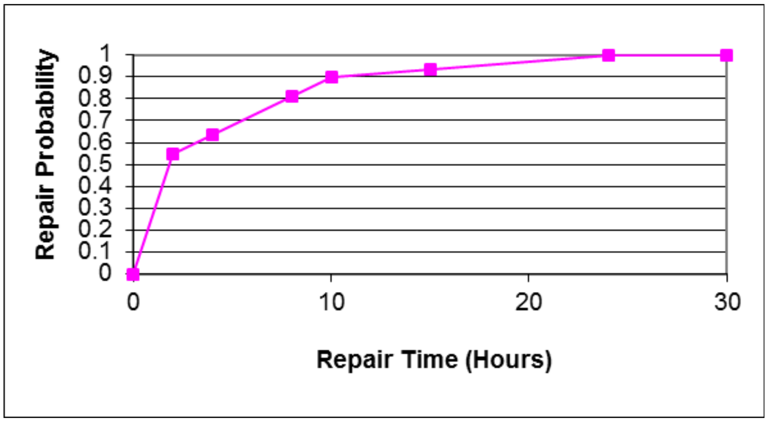


Figure D-11 Graphical representation of the self-repair save mechanism

D.4.3.2 Recovery of control by anchoring

The anchor save model is derived with reference to the following:

- Anchoring is only possible if there is a sufficient length of suitable water to prevent the ship running aground. Suitable water is defined as a depth between 30 fathoms (about 60 m - maximum for deployment of anchor) and 10 fathoms (about 20 m - minimum for ship to avoid grounding). Sufficient length is calculated as 100 m for the anchor to take a firm hold of the seabed + 300 m to stop the ship + 300 m for the length of ship + 100 m for clearance = 800 m, or 0.5 nautical miles (to be slightly conservative).
- If such a track exists, then the probability that the anchor holds is calculated as a function of the wind speed and the sea bottom type (soft seabeds consist predominantly of sands, silts, and muds). If the anchor holds, then an anchor save is made.

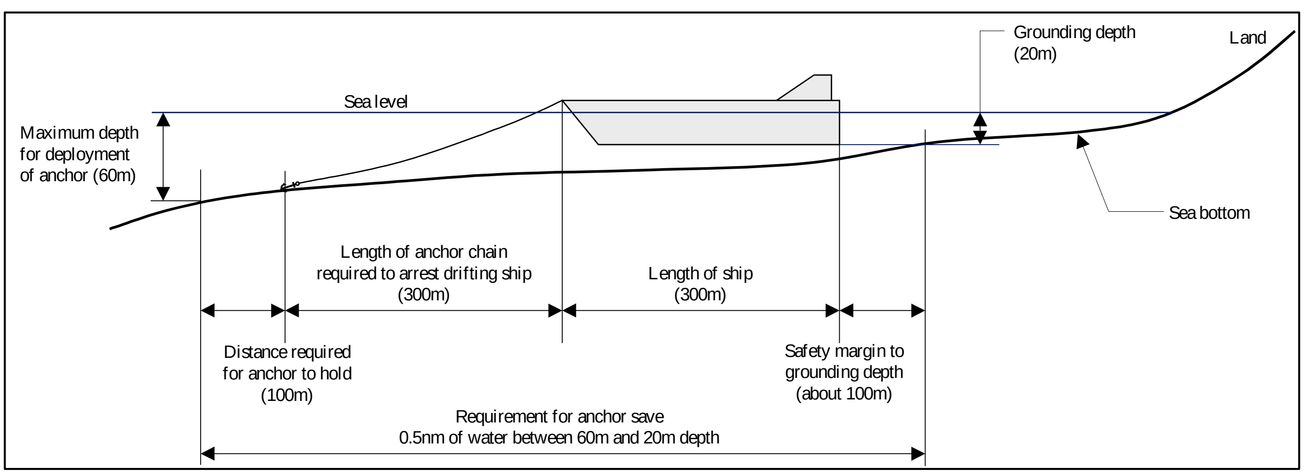


Figure D-12 Graphical representation of the anchor save mechanism

The anchor save model is conservative in that it under-predicts the effectiveness of this save mechanism for average and smaller ships.

D.4.4 The powered impact model

The powered impact frequency model calculates the frequency of serious powered impact accidents in two stages. The model first calculates the frequency of critical situations (sometimes called “dangerous courses” for powered impact accidents). Two types of critical situation are defined as illustrated in Figure D-13. The first critical situation arises when a course change point (waypoint) is located such that failure to make the course change would result in impact within 20 minutes’ navigation from the planned course change point if the course change is not made correctly. The second critical situation results when an impact object is within the lane width distribution. In each case the overlap integral of the lane width distribution aligned with the size of the impact object is calculated.

The frequency of serious powered impacts is calculated as the frequency of critical situations multiplied by the probability of failure to avoid impact. This probability may be similar to that used for powered grounding, or it may be modified to take account of wind farm specific risk controls, such as guard ships or fired pyrotechnics should a dangerous course be detected by the wind farm. In contrast to powered grounding, the frequency of powered impacts does depend on the breadth of the impacting ship.

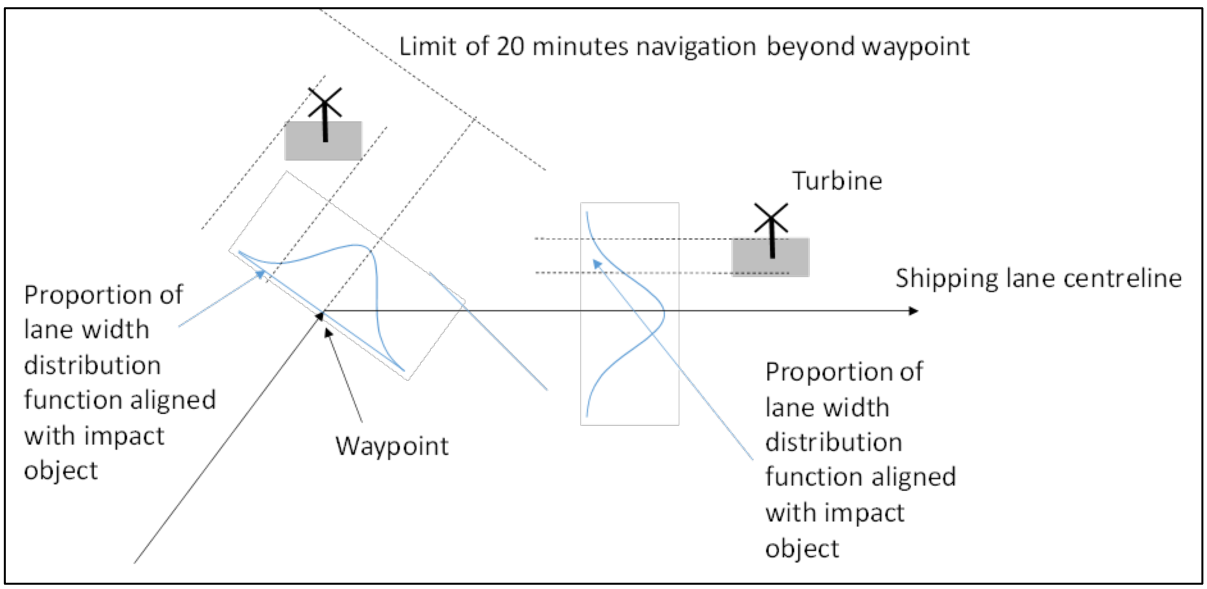


Figure D-13 Graphical representation of powered impact model

D.4.5 The drift impact frequency model for offshore wind turbines or offshore platforms

The drift impact frequency model consists of two main elements as follows: first, the ship traffic image is combined with the ship breakdown frequency to generate the location and frequency of vessel breakdowns; second, the recovery of control of drifting ships can be regained by one of three mechanisms:

- Repair
- Emergency tow vessel assistance
- Anchoring

Those drifting ships that are not saved by one of these three mechanisms (and do not drift out into open water) contribute to the serious drift impact accident frequency results.

The number and size distribution of ships which start to drift is determined from the ship breakdown frequency, the annual number of transits along the lane, and the size distribution of vessels using the lane. The proportion of drifting vessels which are saved (fail to impact) is determined from the vessel recovery models. The drift impact frequency model is illustrated in Figure D-14.

In order to avoid over prediction of grounding or impact frequencies MARCS needs to know if a LOS[6] exists between the location of a ship and the grounding or impact location. This is achieved by assigning every calculation location one of three types:

- Clear water location. Here ships can always pass through. Groundings or impacts cannot occur in clear water locations.
- Coastal location. Here groundings occur and ships cannot pass through.
- Clear water location plus man-made object (e.g., offshore platform or wind turbine). Here ships can always pass through the location but in addition some ships may impact on the man-made object.

For “clear water locations plus a man-made object” data describing the size of the object enables MARCS to calculate the size of the object relative to the size of the location.

To determine if a LOS exists, MARCS calculates all the locations through which a ship must move in order to impact a specified object (or ground at a specified coastal location). If any one of these locations is another coastal location, then a line of sight does not exist and the impact (or grounding) accident frequency is set to zero. If one of more of these locations is a “clear water locations plus a man-made object” location, then the accident frequency is multiplied by the proportion of clear water in the location ((size of the location – size of the man-made object)/size of the location). In this way, the accident frequency for turbines at the edge of a large array is higher than that for turbines in the center of the array. This mechanism is sometimes called the “shadow effect.”

[6] “Line of sight” is defined as a straight line of clear water through which a ship can navigate or drift to a grounding or impact location.

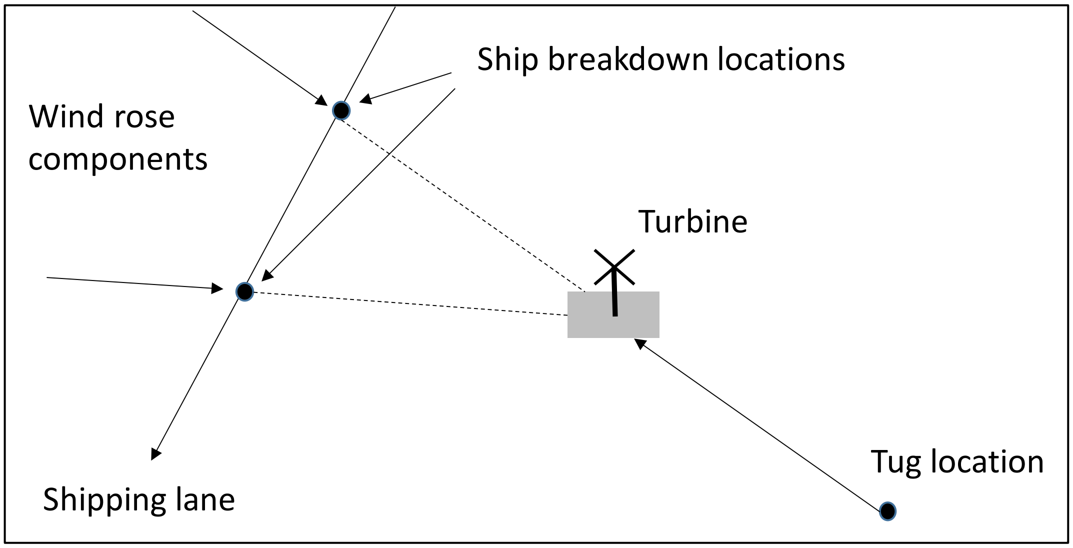


Figure D-14 Graphical representation of the drift impact model

Implicit in Figure D-14 is the importance of the time taken for the ship to drift to the impact object. When this time is large (because the distance to the object is large and/ or because the drift velocity is small) then the probability that the ship will recover control before impacting (via repair or tug assistance) will be increased.

In contrast to drift grounding, the frequency of drift impacts does depend on the length of the impacting ship.

Recovery methods described in the Drift Grounding Frequency Model are applicable to the Drift Impact Frequency Model.

D.5 Risk control quantification

All risk controls reduce the frequency of critical situations and/or reduce the probability of an incident given a critical situation (e.g., pilotage will reduce the probability of collision given a critical situation). The performance parameters, such as the probability of human error leading to a collision, were derived in previous work by DNV GL in research projects for the European Union (EU) on Safety of Shipping in Coastal Waters (SSPA Sweden, 2012 and IMO, 2007). This was done by reference to historical incident rates. The effect of different risk controls on the performance parameters was derived by a mixture of methods; including historical data, where available, in addition to fault trees and expert judgment. The following sections describe the effect of risk controls applied in this study.

D.5.1 Coastal Vessel Traffic Service

Vessel traffic service is expected to reduce the frequency of collision and of powered grounding. Several studies have assessed its effectiveness with relative risk for collision and groundings estimated to be 0.8 to 0.33 (i.e., risk reduction of 20 to 67 percent, respectively) (CEC, 1988; Lewison, 1980; Larsen, 1993; Det Norske Veritas, 1998).

Under the SAFECO program, through a review of numerous studies with differing results, the default relative risk for a vessel traffic service was concluded to be 0.8 (Det Norske Veritas, 1999a). According to the references mentioned above, some studies showed vessel traffic service to be more effective in some circumstances, but 0.8 was and continues to be a sound basis for risk assessment. Based on this, DNV GL's MARCS model conservatively uses a relative risk factor for external vigilance of 0.8 with respect to human performance and incapacitation, which give an overall relative risk of 0.8 (i.e., a 20 percent reduction) for collisions assuming both ships in the encounter participate in the vessel traffic service and for powered grounding.

D.5.2 Pilotage

The use of pilots has two main benefits:

- Their navigational expertise and familiarity with local conditions reduces the chance of error due to unfamiliarity with the navigation or poor performance by the officer of the watch.
- Their presence increases the number of people on the bridge, so reducing the chance of incidents due to omission or incapacitation.

Several factors are considered that might modify the benefits of pilotage:

- The navigational complexity and uniqueness of the route. In the open sea, a pilot would have smaller benefit, as local familiarity would have little value. Most areas with mandatory pilotage are assumed to have significant navigational complexity.
- The navigational expertise and local knowledge of the ship's crew. If the bridge team is already well managed and knowledgeable, the pilot's expertise would have relatively less benefit. This is acknowledged by pilotage exemptions for some ship's masters.
- The navigational expertise and local knowledge of the pilot.

A pilot's Portable Pilot Unit (PPU) is an auxiliary device brought aboard and used by pilots to support safe navigation of vessels the pilots assist. A PPU is a support tool that may enhance the pilot's navigational performance, due to their familiarity with their own equipment. The PPU also provides some additional redundancy against ship navigational equipment failure or incorrect calibration and in some cases a greater degree of accuracy than from the ship's own equipment.

The effect of pilotage on the collision and grounding risk has been evaluated in several studies (Larsen, 1993; Det Norske Veritas, 1998a; Det Norske Veritas 1999a; SSPA Sweden, 2012). Reviewing the estimates from these studies, a conservative consensus was reached for the relative risk estimates for vessels with pilotage due to human error and incapacitation are 0.5 and 0.25, respectively. No credit was given for reducing drift grounding incidents with pilotage. In addition, the MARCS model uses relative risk factor for internal vigilance of 0.5 with respect to human performance and 0.24 with respect to incapacitation.

A PPU is only effective in prevention of powered grounding incidents that result from human error. In the absence of any data, it is provisionally assumed that a PPU will improve the pilot's human error performance with respect to powered groundings by another 10 percent. The effect on collisions is assumed to be negligible. The effect of a PPU is modeled by an additional relative risk factor of 0.90 (i.e., a 10 percent reduction) applied to human performance errors in powered groundings and allisions when at least one pilot is present.

D.5.3 Aids to navigation

D.5.3.1 Electronic chart display and information system

A formal safety assessment (FSA) was submitted to IMO MSC in 2006 in connection with a proposal for Electronic Chart Display and Information System (ECDIS) carriage requirements (IMO, 2007). The assessment investigated three cargo ship types using a Bayesian network model. It concluded that ECDIS reduced grounding risk by approximately 36 percent. This was due to a combination of more time available on the bridge for situational awareness, more efficient plotting of the ship's position and more efficient updating routines. ECDIS is assumed to have the same effect on allision risk in the modeling.

D.5.3.2 Conventional aids to navigation

Causal data on groundings provide some indication of the potential benefit of improving conventional ATON. In the absence of recent data, the relative risk factors in Table D-1 are used over the entire length of the route studied. Causes that might be prevented by improved conventional ATON are represented by "fault/deficiency of lights/marks" and amounted to 6.4 percent of incidents. Improving conventional ATON would not necessarily prevent all such incidents, but might have indirect benefits on other navigational errors. Therefore, this study uses a reduction in groundings and allisions by 6 percent, which is justified by this data.

The relative risk factors applied in MARCS for ATON are shown in Table D-1.

Table D-1 Relative risk factors for aids to navigation

Incident	cATON
Powered grounding or powered allision – human error	0.94
Powered grounding or powered allision- incapacitation	1.00

D.6 Additional background on MARCS

The Marine Accident Risk Calculation System (MARCS) was first developed by DNV GL during the mid-1990s. Since then it has been further developed and applied to different types of projects worldwide. The number of distinct projects performed probably exceeds 40. This section lists and summarizes the more significant projects relevant to wind farm navigation safety assessments.

D.6.1 Selected wind farm projects

All wind farm navigation safety assessments follow a similar pattern. The risk level prior to the wind farm installation is evaluated as the base case and the risks are re-evaluated after the addition of the proposed wind farm array.

2018 Skipjack
2017 South Fork
2015 Baltic Eagle in the Baltic Sea
2013 Iberdrola in the Baltic Sea
2013 Kriegers Flak in the Baltic Sea

2012 Baltic Eagle in the Baltic Sea
2011 Iberdrola in the Baltic Sea
2010 Iberdrola in the Baltic Sea
2010 Arcadis in the Baltic Sea
2009 Arcadis In the Baltic Sea
2009 Aldlergrund in the Baltic Sea
2008 Frederic Haven in the Baltic Sea
2008 Stignaes in the Baltic Sea
2007 Aldlergrund in the Baltic Sea
2006 Arcadis in the Baltic Sea
2006 Roedsand in the Baltic Sea
2005 Horns Rev in the Baltic Sea
2003 Adlergrund and Pommersche Bucht in the Baltic Sea
2003 Arkona in the Baltic Sea

D.6.2 Selected navigation risk projects

North East Shipping Risk Assessment, PP042653, 2012-2013

The Australian Maritime Safety Agency (AMSA) is the Australian government agency with prime responsibility for the safety of shipping in Australian waters and for the protection of the marine environment from ship-sourced pollution. The Great Barrier Reef is a World Heritage Area located off the northeastern coast of Australia. In order to support its responsibilities to protect the reef while at the same time promoting safe and efficient shipping operations, AMSA commissioned DNV to perform a risk assessment of navigational accidents due to shipping traffic in the area.

The risk assessment entailed: the derivation of ship movement frequency data from AIS data; the assessment of the effectiveness of currently applied risk controls and more than 12 possible risk reduction options; the prediction of shipping traffic levels in 2020 and 2032; and the analysis of 12 distinct cases to estimate the relative effectiveness of the proposed risk reduction options for the NE area of Australia. The results will be used to guide AMSA's decision making processes.

Aleutian Islands Marine Risk Assessment, EP007543, 2009-2011

The Aleutian Island chain to the south west of Alaska is located on the major great circle marine trade route between the west coast of North America and the Far East. The region contains rich and diverse marine resources, including highly significant commercial fisheries.

In 2004 the M/V Selendang Ayu went aground off the Aleutians. The resulting fine established funding for a risk assessment managed by the U.S. National Fish and Wildlife Foundation, Alaska Department of Environmental Conservation and the U.S. Coast Guard. A team from Environmental Resources Management and Det Norske Veritas was awarded the risk assessment contract.

The risk assessment involved a detailed ship traffic study to establish the ship trading patterns used in 2008/09 and estimated in 2034. This information included: routes used (waypoints, lane widths); the annual frequency, size and type of ships on each route; cargoes carried; ship speeds; etc. For 2008/09, this information was obtained from AIS data where this was available and was estimated where no information existed. Future traffic in 2034 was estimated from the traffic pattern today and estimates of economic growth.

The traffic study was combined with DNV's marine risk model MARCS (Marine Accident Risk Calculation System) to calculate cargo and bunker fuel oil spill risks. ERM's spill trajectory model was then used to assess detailed accident consequences for a small group of agreed spill scenarios. Risk Reduction Options (RROs) were identified and subjected to an assessment of their risk reduction effectiveness, practicality and cost effectiveness by an expert judgement process at a DNV-led four-day workshop in Anchorage. The outputs from the study were published in a 60-page summary report in August 2011.

The entire risk assessment process was subjected to and validated by a peer review process by 6 marine risk experts appointed through the U.S. National Academy of Science.

Prince William Sound Risk Assessment, 1995-1997

Prince William Sound in Alaska is famous as the location of the most expensive oil spill in history; the crude oil tanker Exxon Valdez went aground on Bligh Reef in March 1989. The Prince William Sound Risk Assessment project was performed by a group of contractors headed by DNV for a client consortium of oil shippers and citizens action groups along with state and federal regulators. The project mission statement was, "To improve the safety of oil transportation in Prince William Sound".

The risk assessment team was committed to make the best possible scientific estimate of the absolute risk of the present-day oil transportation system, as well as evaluating the effect of over 150 proposed risk reduction measures. Since the goal was to make the system safer, the majority of these risk reduction measures were prevention-based. That is, they were aimed at preventing accidents rather than responding to oil spills once they occur.

The project was subject to peer review by the American National Academy of Sciences to ensure that results of the highest quality were achieved. This was important, since the results of the study were used as the basis of a fully costed Risk Management Plan for Prince William Sound which involved a multi-million-dollar investment program.

The risk assessment project had an unstated but important subsidiary objective. Since the *Exxon Valdez* accident an atmosphere of distrust and confrontation had arisen between the major stakeholders in Prince William Sound. One result of this was that it was nearly impossible to gain consensus regarding how to modify the marine oil transportation system to reduce risk levels; each party favored a different approach. Each of these stakeholder groups was represented on the Risk Assessment Steering Committee. The process of managing the risk assessment, which entailed being actively involved in data gathering and validation, as well as examining risk assessment methods and results, improved mutual understanding of different group's positions, promoted co-operation and, to some extent, trust. The contract team, headed by DNV, facilitated this process by providing clear explanations of the technical field of risk assessment with tact and without bias.

The Prince William Sound Risk Assessment Project had a total budget of about $2MM comprising $1MM for DNV's contributions with the remainder shared by the two sub-contracting organizations. The project was completed at the start of 1997 at which time a full, public domain report was issued.

D.6.3 Selected model development projects

Safety of Shipping in Coastal Waters (SAFECO II), 1998-1999

The Safety of Shipping in Coastal Waters (SAFECO II) project was performed for the Transport Directorate (DGVII) of the European Union under the Fourth Framework programme by a consortium of 10 European organisations with complimentary maritime expertise and was managed by DNV.

The objectives of SAFECO II were:

- To assess the marine risk reduction potential of risk reduction measures based around the theme of improved ship-to-ship and ship-to-shore communication (measures explicitly evaluated were: ship transponders; standard maritime communication phrases; and an expert system providing advice on collision avoidance maneuvers);
- To develop improved ship accident consequence models, in terms of lives lost, bunker and crude oil outflow and financial impacts;
- To demonstrate the application of marine risk assessment methods in two case study areas (the North Sea and Rotterdam Port Approach) by performing a cost-benefit analysis of possible risk reduction measures.

The overall objective of the SAFECO programme was to develop marine risk assessment methods such that they form a solid basis for marine transport regulation. This aim was achieved by SAFECO II.

Safety of Shipping in Coastal Waters (SAFECO), 1997-1998

The SAFECO project was performed for the Transport Directorate (DGVII) of the European Union under the Fourth Framework programme. The objective of SAFECO was to improve the safety of shipping in coastal waters. The project aimed to establish robust methodologies capable of delivering secure risk assessment parameters to quantitative risk assessment tools. The ultimate aim of SAFECO was to use risk assessment results as the basis for marine transport regulation.

The project was performed by a consortium of 10 organizations headed and managed by DNV. Each project partner was an expert in one or more factors crucial to safe navigation (e.g. training of mariners, reliability of machinery, strength of ship hulls etc.) and developed a program of research to quantify the effect of these different factors on safety levels. However, in order to compare the relative effect of each factor, it was necessary to draw the results of each research program into a comprehensive marine risk model. DNV built an interface to each of the project partner research programs to allow the inter-comparison of the effects of each factor investigated by the project partners. This enabled the determination of those factors which had the greatest influence on the overall risk levels.

The SAFECO I project concluded with an evaluation of 8 risk reduction measures via 3 case studies (English Channel, North Sea and Rotterdam Port Approach).

D.6.4 Additional documents in the public domain

The following is a selection of papers and reports that are in the public domain:

- OVERVIEW OF PRINCE WILLIAM SOUND RISK ASSESSMENT PROJECT. Presented at, “Marine Risk Assessment - A better way to manage your business”, Institute of Marine Engineers, London, 7-8 May 1997
- SAFECO I Summary Report. DNV Report 98-2038
- SAFECO II Summary Report. DNV Report 99-2032
- Modelling Ship Transportation Risk, Risk Analysis, Vol 20, No. 2, 2000, pages 225-244
- Aleutian Islands Risk Assessment, Project Overview https://www.slideserve.com/aristotle-farley/aleutian-islands-risk-assessment-project-overview-powerpoint-ppt-presentation

APPENDIX E OCEAN WIND FARM MARINE ACCIDENT MODELING

E.1 Introduction

This appendix documents evaluation of the frequency and description of (1) collision between vessels, (2) allision with structures, and (3) grounding because of the establishment of a structure:

- Likely frequency of collision (vessel to vessel)
- Likely location of collision
- Likely type of collision
- Likely vessel type involved in collision
- Likely frequency of allision (vessel to structure)
- Likely location of allision
- Likely vessel type involved in allision
- Likely frequency of grounding
- Likely location of grounding
- Likely vessel type involved in grounding

The consequences of the modeled events are described in the main report.

The MARCS model is a set of risk parameters and calculation tools that have been developed to quantify marine risk. MARCS calculates the frequency of accidents due to the following navigation hazards:

- Collision between two ships underway
- Powered grounding, where a ship grounds due to human error (steering and propulsion not impaired)
- Drift grounding, where a ship strikes the grounding line due to mechanical failure (steering and/ or propulsion failed)
- Powered allision, where a ship strikes a man-made structure (e.g., WTG) due to human error (steering and propulsion not impaired)
- Drift allision, where a ship strikes a man-made structure (e.g., WTG) due to mechanical failure (steering and/ or propulsion failed)

The frequency of each accident type is calculated for each grid cell for each accident type and each ship type.

MARCS was used to calculate the frequency of collision, grounding, and allision for each cell defined by a grid covering the Study Area. The model provides the average annual frequency of occurrence for each accident type in each grid cell. These results are reported in this appendix. A detailed description of the collision, grounding (drift and powered), and allision (drift and powered) models is included in APPENDIX D.

Four cases are reported here:

1. The Base Case (or Case 0). This includes the un-modified shipping traffic as transiting the area today prior to the installation of the wind turbines.
2. The Base Case Plus (or Case 1). This includes the un-modified shipping traffic as transiting the area today prior to the installation of the wind turbines. In addition, the wind turbine locations are also included in Case 1 to provide an estimate of the extra risk introduced by the presence of the wind farm, in the absence of any modification to the traffic pattern.
3. The Future Case (or Case 2). This is similar to Case 1, but includes additional traffic caused by the presence of the wind farm and includes modified traffic routes, assuming some ships will navigate around the wind farm once it is installed.
4. The Future Case with Tows (or Case 3). This is similar to Case 2, but 50% of the coastal tugs are modeled as tug-with-tows.

The differences in risk between these four cases provide an estimate of the changed risk introduced by the construction of the wind farm.

E.2 Model inputs

E.2.1 Study area

This is a quantitative assessment of collision, allision, and grounding in the modeled Marine Traffic Study Area (Study Area) during operation of Ocean Wind Farm (the Project). The Study Area utilized in the MARCS modeling of the Project is shown in Figure E-1. Note the distinctions between the Project Area, Lease Area, and Study Area.

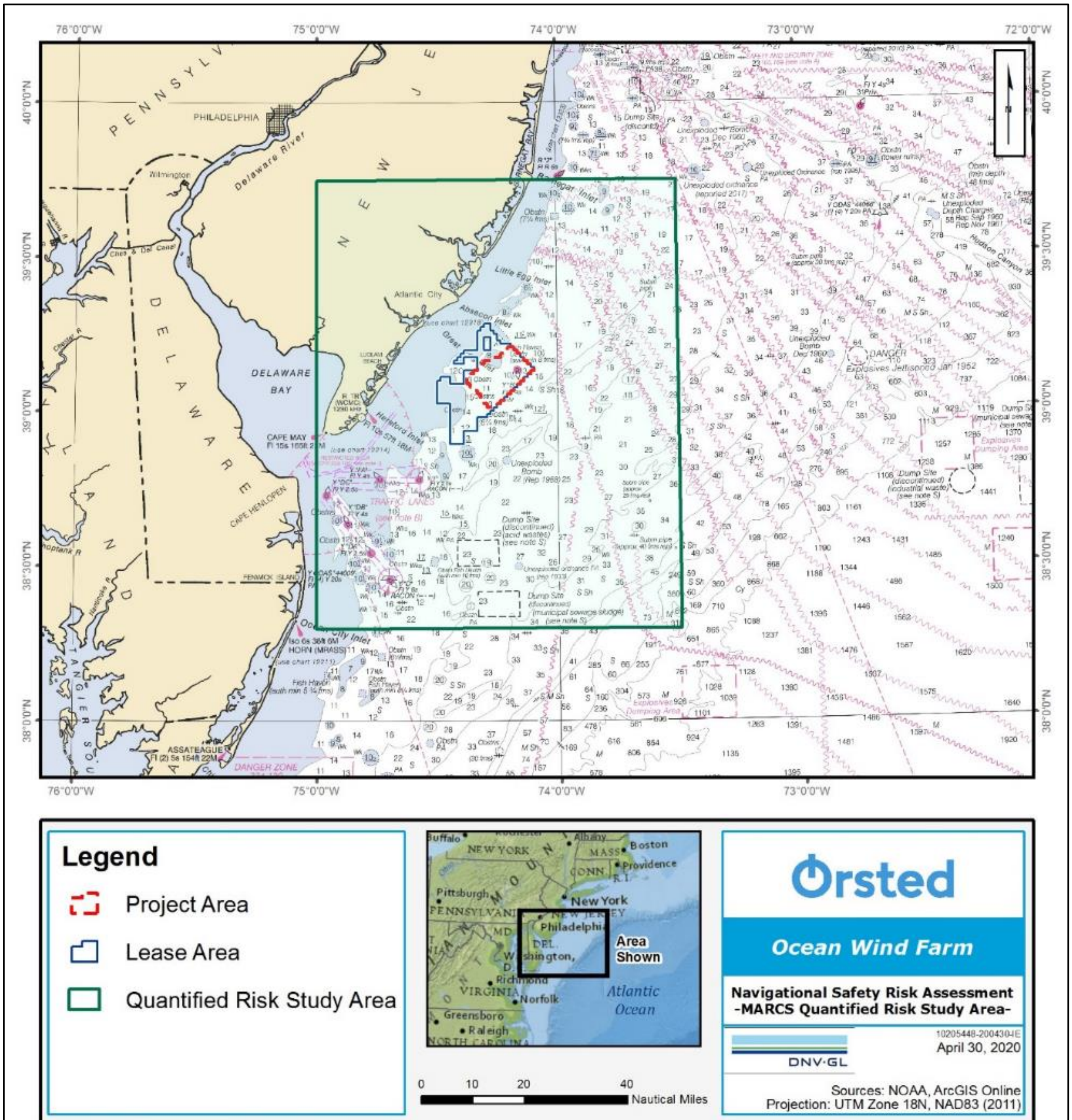


Figure E-1 Quantified risk Study Area

Accident frequency results are presented below for each sub-area as defined in Figure E-2.

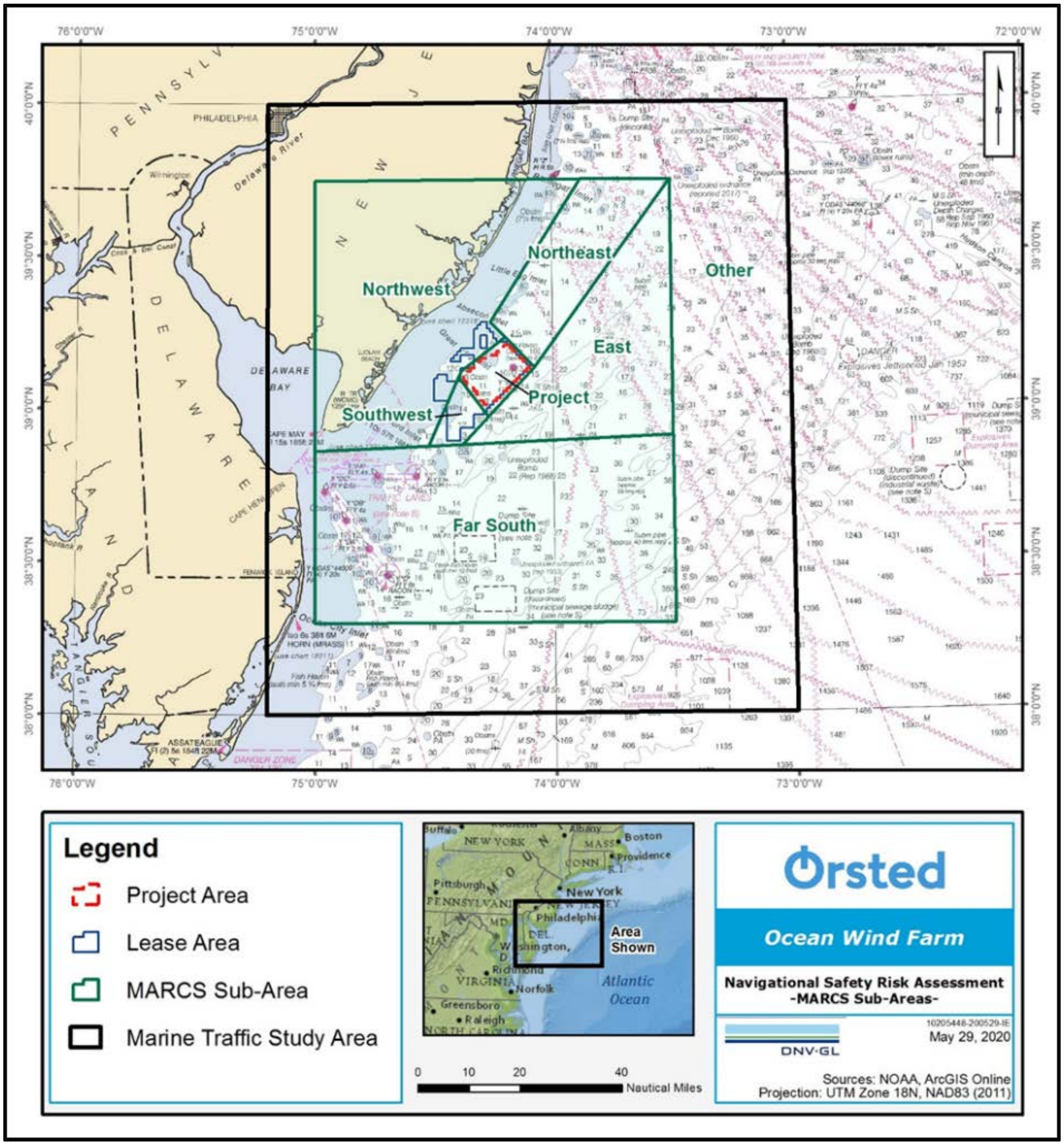


Figure E-2 Definition of sub-areas within the Study Area

E.2.2 Wind Farm

The Project is modeled as 102 Project structures, consisting of 99 WTGs and 3 sub-station structures. The Project structures are separated by a minimum distance of 0.8 NM. Each WTG has a diameter of 10 m at and near sea level (i.e., the collision cross section is 10 m) and each sub-station has a collision cross-section of 113 m (the diagonal of a 79 m by 79 m square).

E.2.3 Metocean inputs

The metocean inputs utilized in MARCS are consistent with the weather outlined in Section 7 of the main report and are described below.

Wind

MARCS uses the wind speed and direction as a modeling input. Table E-1 shows the wind data described in Section 7.1 of the main report, formatted for MARCS: eight directions (north, northeast, east, southeast, south, southwest, west, and northwest) and four speed categories (calm, fresh, gale, and storm). The probabilities presented below are based on adjusted data from the Climatology of Global Ocean Winds (COGOW website, 2020).

Table E-1 Annual wind direction and wind speed probabilities

Wind Speed in knots	N	NE	E	SE	S	SW	W	NW	Total
< 20 (calm)	0.0806	0.1093	0.0640	0.0524	0.1080	0.1948	0.1373	0.1286	0.8749
20 – 30 (fresh)	0.0117	0.0241	0.0027	0.0011	0.0003	0.0043	0.0328	0.0461	0.1232
30 – 45 (gale)	0.0003	0.0008	0.0000	0.0000	0.0000	0.0003	0.0000	0.0005	0.0019
> 45 (storm)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0925	0.1343	0.0667	0.0534	0.1082	0.1994	0.1701	0.1753	1.0000

Visibility

The Journal of Navigation's information regarding marine traffic studies[7] defines poor visibility as beginning at 2.2 NM (4.0 km).[8] Visibility was therefore assessed as either poor, less than 2 NM (3.7 km), or good, greater than 2 NM. Table E-2 presents the visibility data used in the MARCS model.

[7] G.R.G. Lewison, "The Estimation of Collision Risk for Marine Traffic in UK Waters," Journal of Navigation, September 1980.
[8] National Oceanic and Atmospheric Administration, National Centers for Environmental Information, Block Island State Airport, RI, U.S. (WBAN:94793), Visibility data for Start date: 2010-09-01, End date: 2019-08-31. Website: https://www.ncdc.noaa.gov/cdo-web/datatools/lcd. Accessed 9 September 2019.

Table E-2 Visibility

Visibility in NM	Frequency	Modeled visibility
< 1	2.7%	Bad visibility = 5.6% of an average year
1 – 2*	2.9%	
2 – 3	2.5%	Good visibility = 94.4% of an average year
3 – 4	2.1%	
4 – 5	1.8%	
5 - 6	1.9%	
6 - 7	4.2%	
7 - 8	2.7%	
10+	5.9%	
Total	**100.0%**	

* Visibility was not measured at 2.2 NM

Sea state

A designation of “open water” in MARCS allows a higher power transfer from the wind to the waves than “semi-sheltered” or “sheltered” waters, leading to higher wave heights (also called higher sea state). This allows for the wind speed in the area to have a greater effect on sea state, with higher winds resulting in rougher seas. The entire Study Area was modeled as an “open water” area because the MARCS Project Area is located about 13 NM (24 km) from the nearest shoreline close to Atlantic City and is directly open to the Atlantic Ocean.

Shoreline

Figure E-3 illustrates the shoreline used in MARCS. The defined shoreline identifies possible grounding locations for the model.

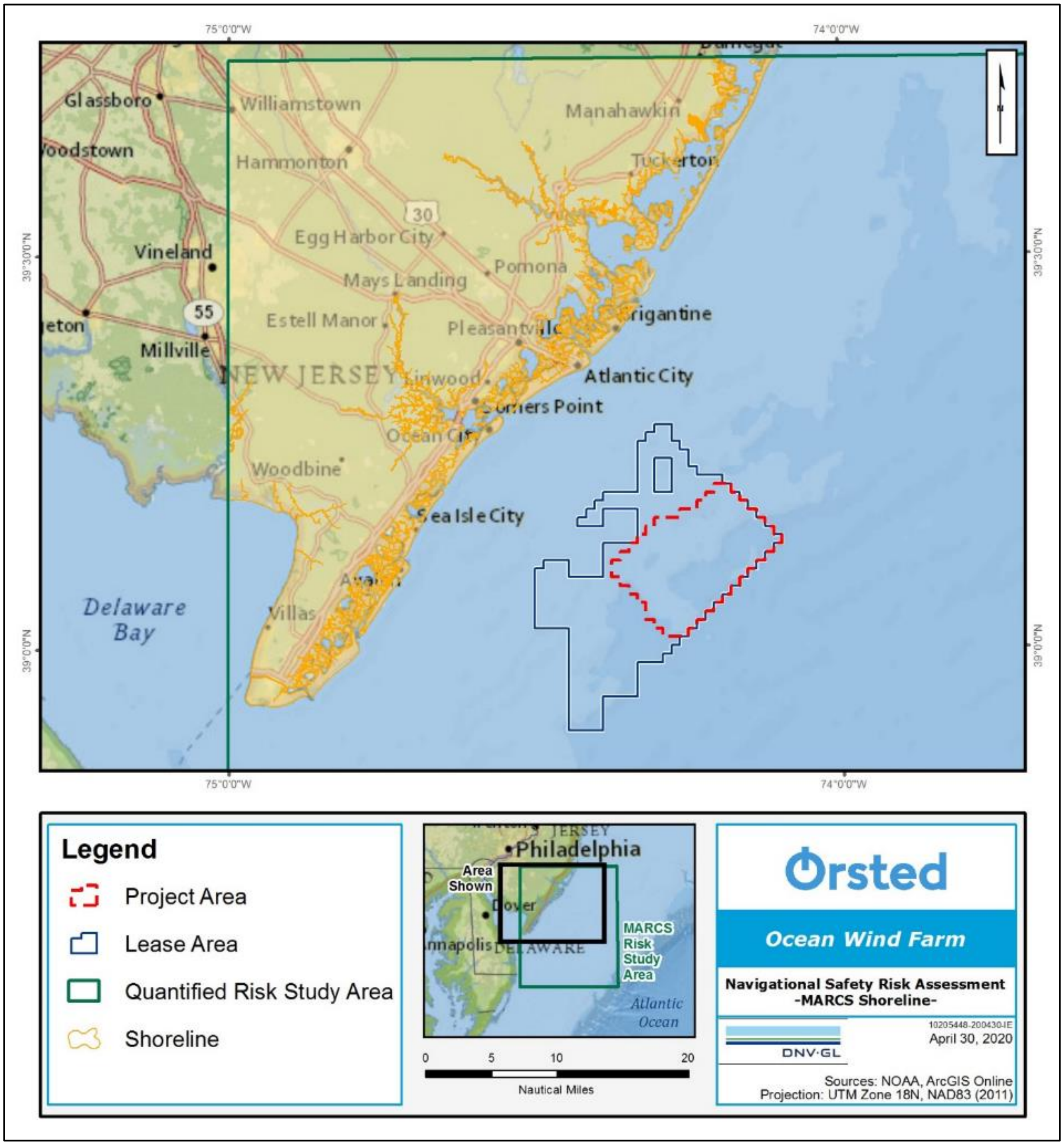


Figure E-3 Shoreline utilized in MARCS

Tidal current

The average tidal current in the vicinity of the Project is about 0.5 kt (0.25 m/s) (see previous Figure 6-2). The tidal current was not added to the MARCS algorithm as it creates unnecessary model complexity in estimating the effects of a minor semidiurnal current. MARCS estimates the distance a ship could drift given a constant wind vector and is not time-dependent. Conservatism is already built into MARCS from the assumption that strong winds, if present, do not decrease while a ship is adrift. Incorporating tidal currents into the MARCS model does not provide a more accurate risk result. Based on a preliminary model run, inclusion of tidal current into MARCS may provide an unrealistically conservative result regarding allision risk and a non-conservative (more than offsetting) reduction in grounding risk.

E.2.4 Traffic data

Traffic data was derived by analysis of 2.7 million lines of Automatic Identification System (AIS) data for the time period between 1 March 2019 and 29 February 2020 for the MARCS Study Area. MARCS uses a statistical representation of aggregated ship tracks (Appendix D) and up to eight distinct traffic types. The traffic types selected for this analysis are shown in Table E-3. Also shown are the average vessel speeds derived from the AIS data for each vessel type for each sub-area shown in Figure E-3.

Table E-3 Traffic types used for MARCS analysis

			Average Speed (knots)			
Id	Traffic type name	Draft	Wind Farm Sub-Area	The VTS Sub-Area	Coastal Sub-Area	Remainder of the Study Area
1	Cargo/Carrier	Deep draft	12.29	8.92	13.07	11.30
2	Cruise Ships and Large Ferries	Deep draft	18.51	10.33	14.73	10.65
3	Fishing	Shallow draft	6.99	6.48	6.92	6.63
4	Other/Undefined	Shallow draft	2.72	7.73	2.81	3.04
5	Pleasure	Shallow draft	6.50	6.73	6.41	6.53
6	Tanker/Tanker - Oil	Deep draft	11.71	8.78	11.76	9.79
7	Tug	Shallow draft	7.23	6.88	6.82	6.93
8	Tug with Towline	Shallow draft	8.22	7.88	8.01	8.00

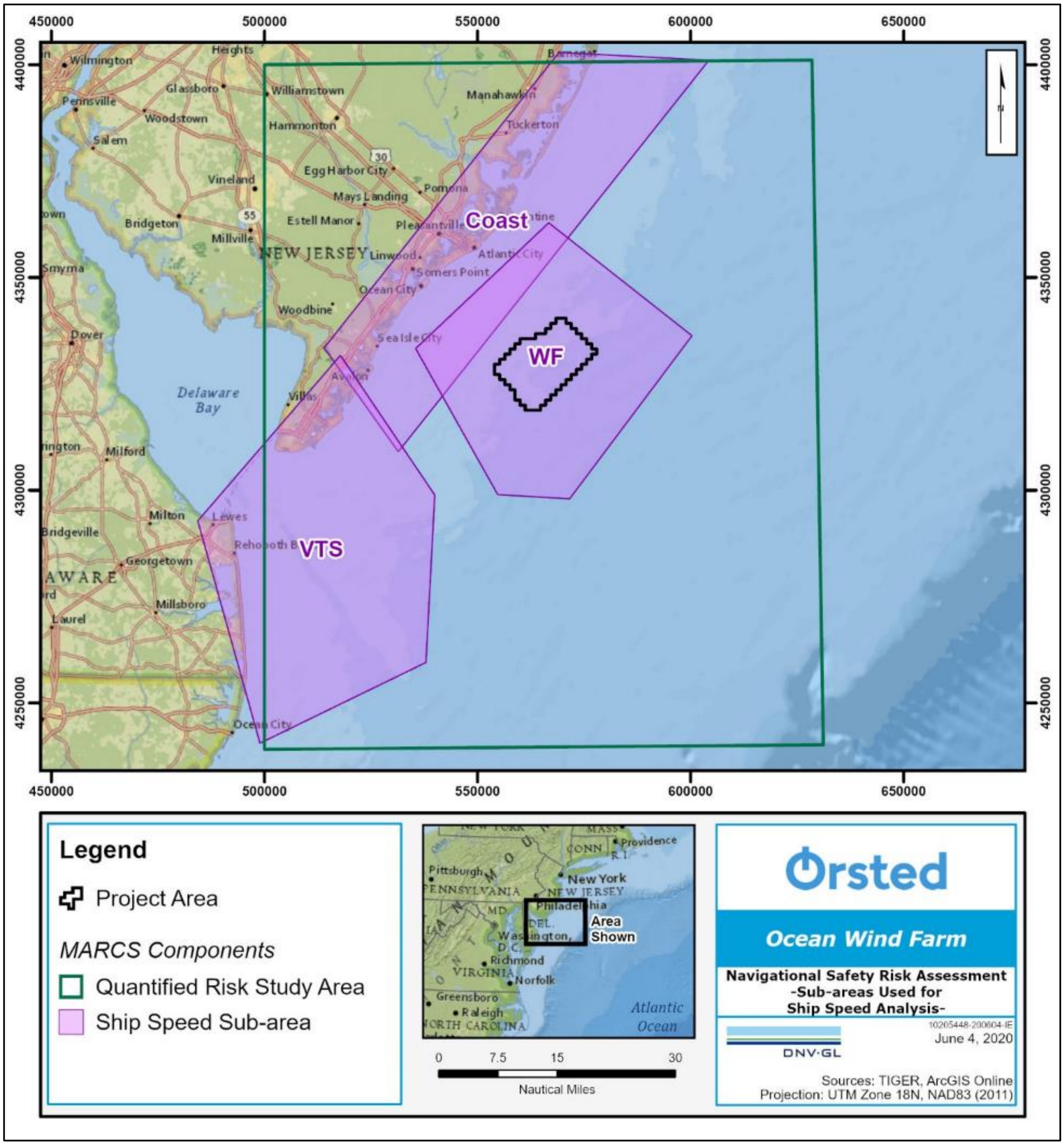


Figure E-4 Definition of the Sub-Areas used for the Ship Speed Analysis

The AIS dataset was analyzed in the following stages:

- Dirty (e.g., obvious data entry errors) or missing data were corrected or removed.
- Each AIS ship type was mapped to the most appropriate ship type category in Table E-3.

- Each AIS ship size was mapped to a MARCS ship size category for that ship type. Where no ship size data were available in the AIS data, the average ship size for that ship type category was assigned.
- Ship position reports were used to derive shipping density plots for each ship type and for all ships.
- A ship route structure was derived from the shipping density plots.
- Ship tracks were derived by linking successive ship position reports separated by a short time interval and a small distance for a specified ship.
- The ship tracks were allocated to the ship routes to derive the annual frequency of movement of each ship type and ship size along each route.

E.2.5 Traffic data adjustments

The traffic data derived from AIS data analysis were adjusted to correctly represent the data required for the three calculation cases. Three types of adjustments have been made:

1. The addition of traffic that is not correctly captured in the AIS data
2. The addition of traffic that is projected to be generated by the presence of the wind farm
3. The modification of traffic routes for some ship types due to the construction of the wind farm

Each is described here.

Additional traffic added to all the cases (Base Case, Base Case Plus, and Future Case)

The adjustments to pleasure vessels (including recreational boating) and to commercial fishing transits not in the AIS data were implemented into the MARCS model for all cases.

The AIS dataset is a reliable resource for capturing the main traffic patterns and vessels equipped with AIS transmitters. However, not all vessels are required to have AIS on board per Coast Guard regulations. To achieve the most realistic results for the Study Area, special care was placed on estimated recreational and commercial fishing vessel traffic in the vicinity of the Project that may not have been captured in the AIS dataset. This was done as described below.

For commercial fishing, an analysis of fishing ship lengths for commercial fishing vessels registered in New Jersey was performed.

Key assumptions are:

- All of the longer commercial fishing vessels are represented in the AIS dataset on departure from or approach to port, and the shorter vessels are assumed to not be represented in the data at all.
- The number of transits per year to/through the Project Area taken by an average fishing vessel *longer* than 65 feet is the same as the number of transits per year taken by an average fishing vessel *shorter* than 65 feet. Regardless of vessel size, the number of transits per vessel is assumed to be the same.

The results of this analysis showed an additional 344 commercial fishing vessel trips (344 inbound transits and 344 outbound transits per year) allocated equally between two new routes, as shown in Figure E-5.

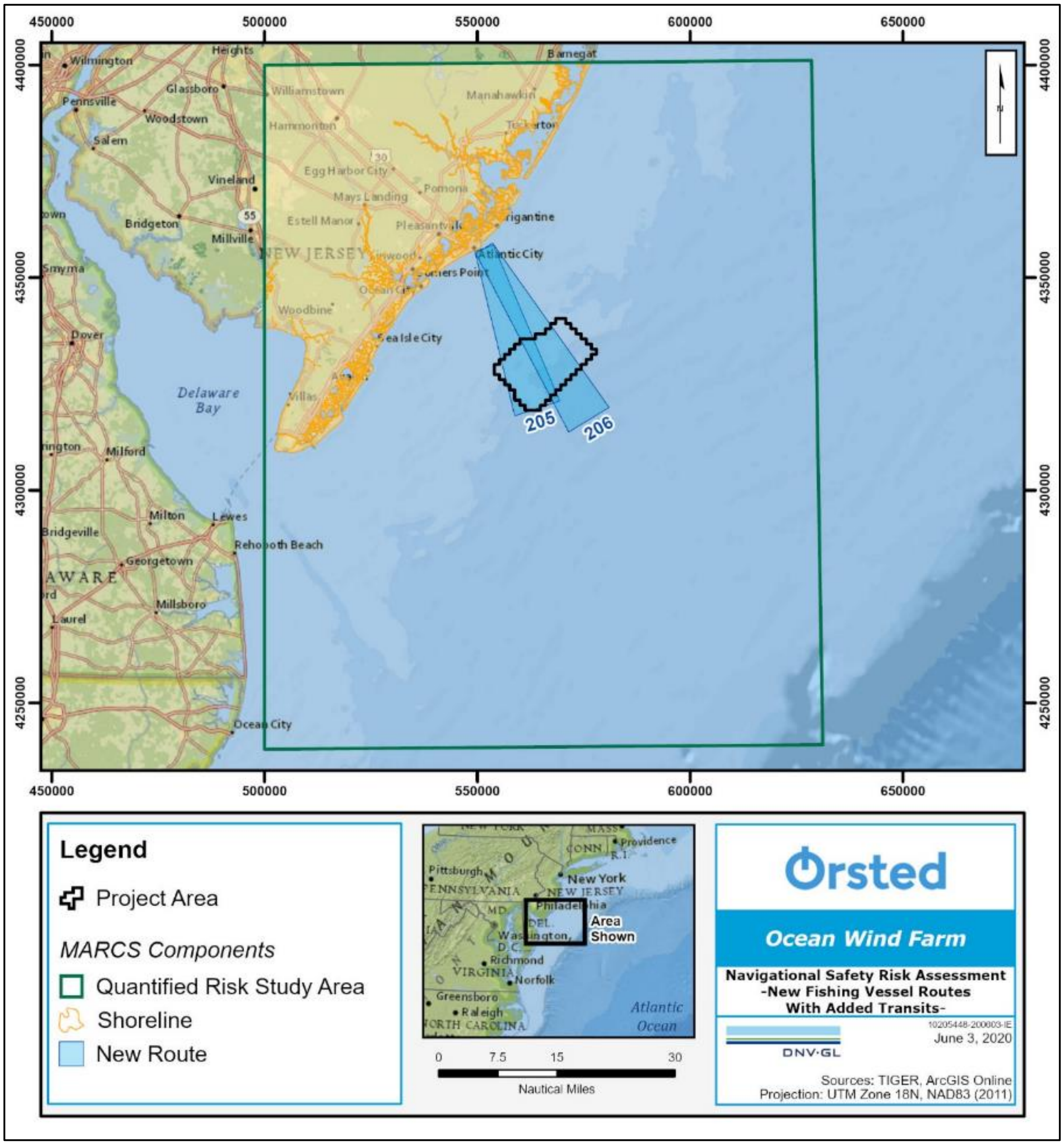


Figure E-5 New fishing vessel routes that had transits added to them

Additional traffic added to the Future Case

The adjustments described in this section are to the Future Case (Case 2) MARCS model with the Project.

It is anticipated that there will be public interest in the Project that could potentially lead to pleasure tours of the wind farm and a potential increase of recreational traffic (including recreational fishing). It is difficult to estimate a precise number of vessels per year that will be added to local traffic patterns. The following was assumed:

- Additional pleasure ships for sightseeing/recreational fishing. Ten trips a day for half of the year was assumed taking the four route segments shown in Figure E-6. While fishing vessels might transit to the Project from any location, this route, starting off Lewes and Rehoboth Beach, Delaware, was selected as a conservative (higher risk) modeling option. Factors considered when selecting the route(s) were: (1) requires significant distance to be transiting within the Study Area and (2) transits across the highest density traffic in the Study Area. The alternative of allocating a fraction of the vessels to each of the ports was considered but not selected because it adds to model complexity without significantly increasing realism, and vessels from ports closer to the Project would contribute less risk in the model that those further away.
- Additional sight-seeing pleasure ships. One hundred trips per year was assumed taking the same four route segments shown in Figure E-6.

These are conservatively high estimates for the first operational year of the Project. It is anticipated that as time passes, there will be less traffic due to wind farm tours, and the increase in vessels may diminish. This study aims to present the conservative case with the most possible traffic, as opposed to an average traffic scheme over a longer period. This additional traffic in the Future Case is included in the pleasure vessel category.

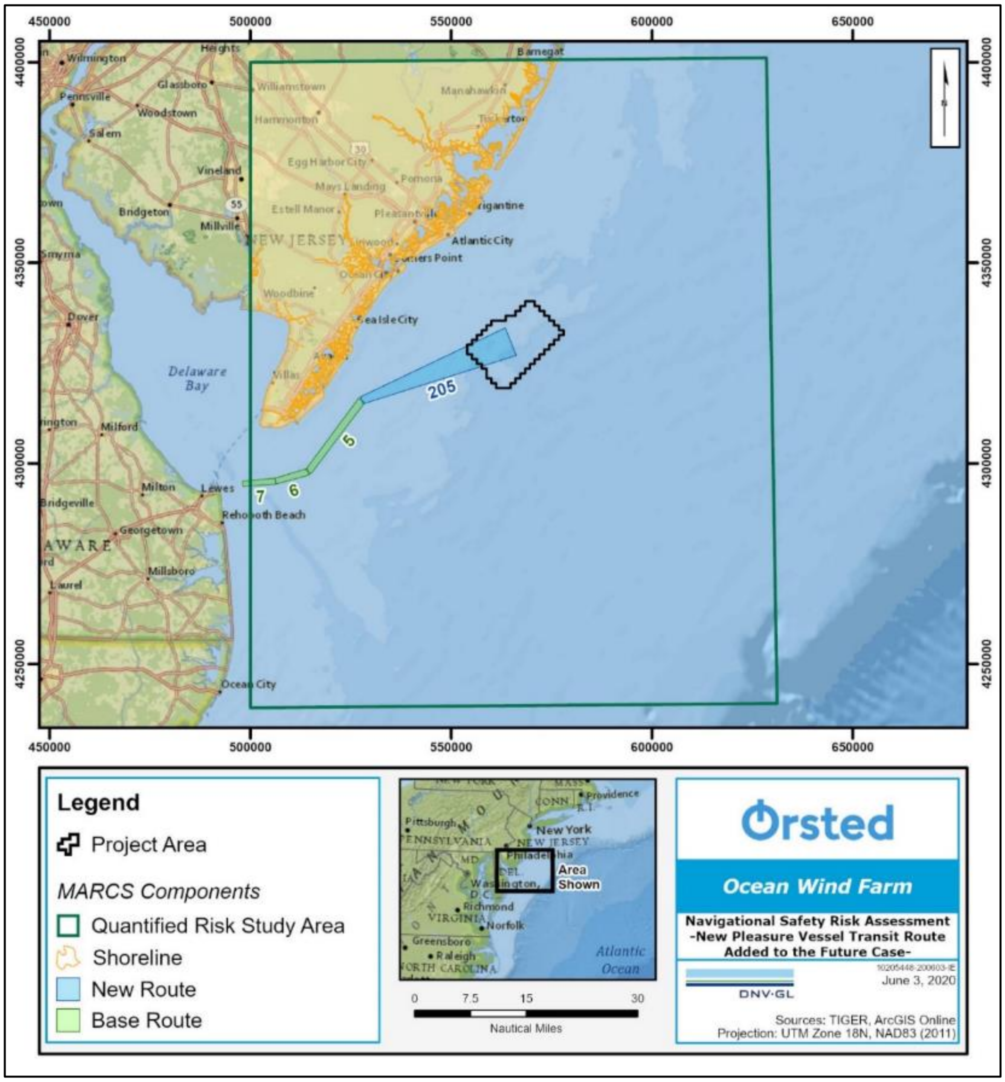


Figure E-6 New pleasure vessel transit route added to the Future Case

Modification of traffic routes in the Future Case

Currently, some shipping routes traverse the area where the wind farm is to be constructed. Many ships will choose not to navigate through the wind farm. At this time, the extent to which they will adjust their course is a matter of speculation. DNV GL developed alternative routes for vessels to avoid the Project Area and to minimize the additional navigation while taking into account the existing TSSs using the following principles:

- Deep draft ships are routed to the east of the Project Area and the adjacent wind farm lease area to the northeast.
- Tugs and tug-with-tows are routed to the west of the Project Area and the adjacent wind farm lease area.
- Fishing, other, and pleasure ship types all continue to use the same routes in the Future Case as they do in the Base Case.

Figure E-7 shows an example of how this modification was performed for one of the routes that needed modification.

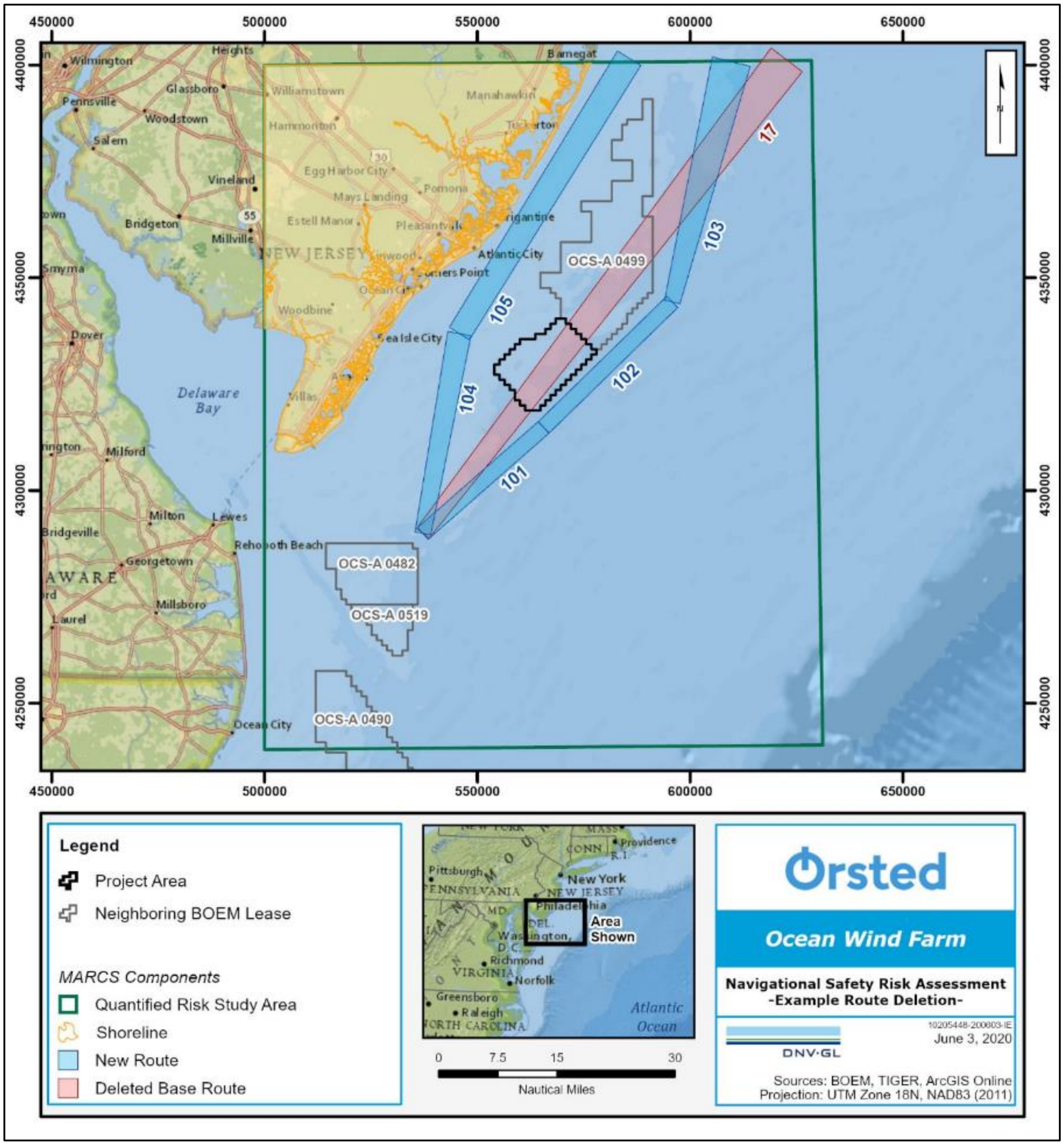


Figure E-7 Example of how one route was modified (red route was deleted; blue routes were added)

Consistent with the above principles, the deep draft ships were re-allocated to Routes 101, 102 and 103 while tugs and tug-with-tows were re-allocated to Routes 104 and 105.

E.2.6 Modification of tug traffic to represent tug-with-tows (Case 3)

In DNV GL's previous marine risk studies in North America (e.g., Prince William Sound, the Aleutians, Vancouver, and Prince Rupert), tugs (whether towing or not) were represented as small ships. This assumption was made because of the difficulty of identifying if a tug is actually towing (the AIS data flag is manually entered and is thus relatively uncertain) and also because the focus of these studies was not the tugs. For the Project, the tug traffic is one of the key concerns and was addressed as follows.

For consistency with previous studies, for Cases 0 to 2 the tugs were represented as small ships consistent with DNV GL's previous studies. These results provide a base line risk level for the tug traffic.

For Case 3, it was decided to re-assign 50% of the tug traffic on coastal routes (see Figure E-8 and Figure E-9) to the ship type tug-with-tow. The average length and breadth of this ship type was assumed to be 0.5 NM (927 m) and 0.25 NM (463 m), respectively, consistent with ACPARS, which states, "In general…the swept path for towing a large 600-700' barge astern with 2,000' wire could easily be up to a ½ NM or more under typical adverse crosswind and crosscurrent conditions." The results for Case 3 provide an upper limit of the risk to, and due to, tug-with-tows. It is not presently possible for MARCS to estimate where a towed barge might be relative to its tow and the effect of this on risk levels.

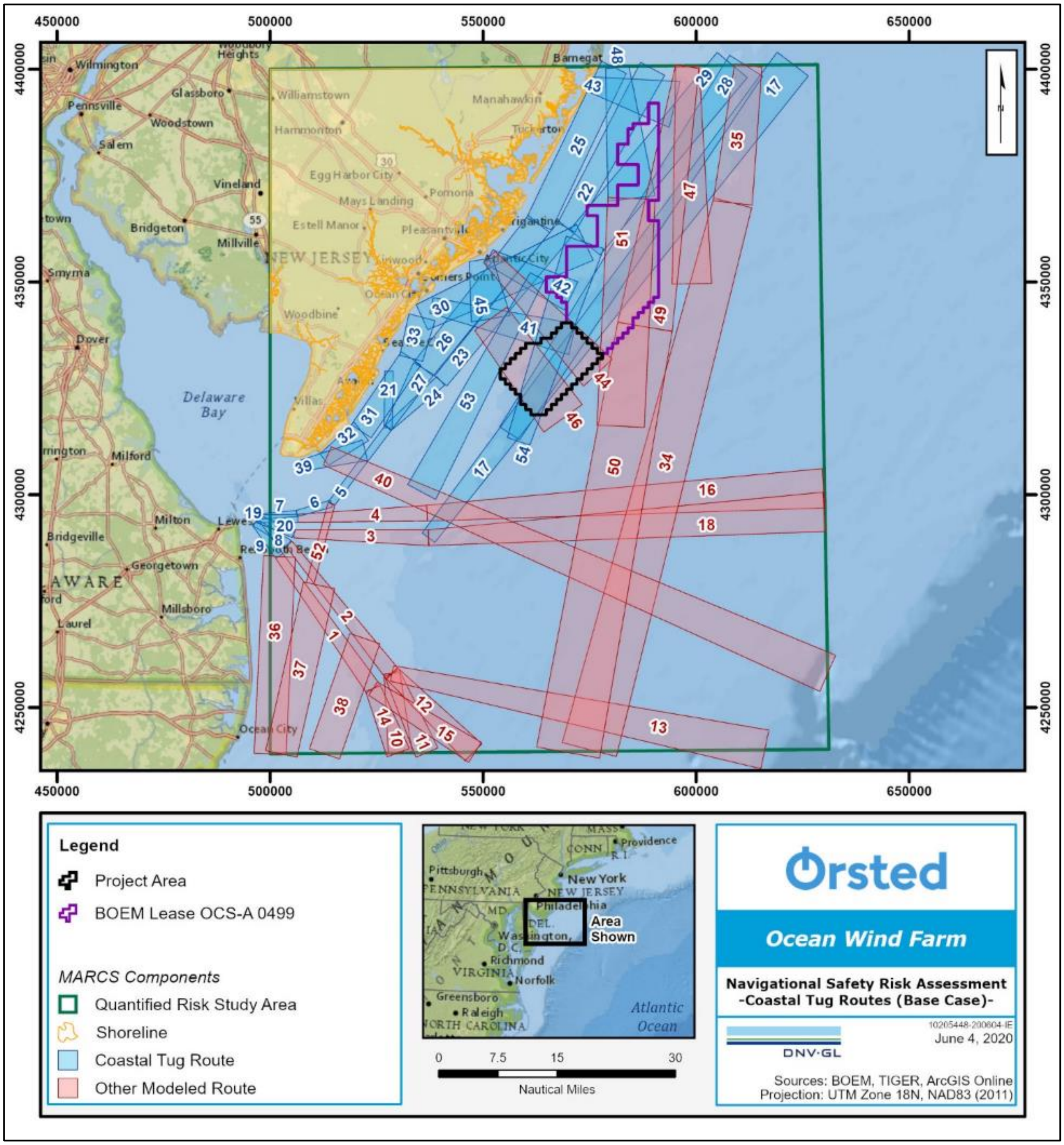


Figure E-8 Definition of coastal routes (shown in blue) for the Base Case

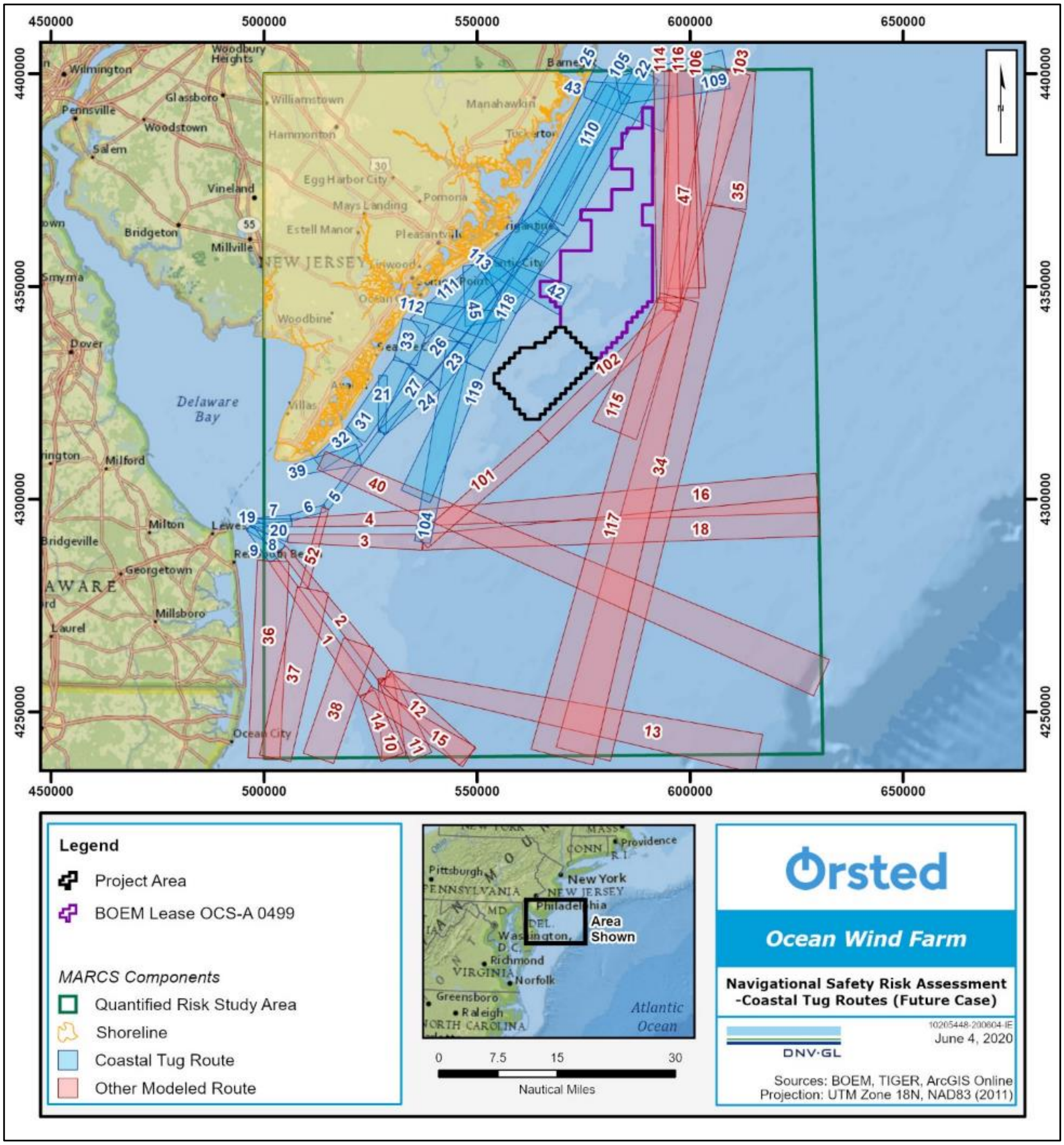


Figure E-9 Definition of coastal routes (blue) for the Future Case

E.2.7 Operational inputs

The MARCS model can apply different risk reduction options to a specific type of traffic and/or to a specified area. For the Project, the risk controls applied do not depend on the location of ships within the Study Area. The risk controls applied to vessels transiting are described in Table E-4. This table show which risk controls are applied based on vessel types.

Table E-4 Risk controls applied in MARCS modeling for the Study Area

	Deep Draft Vessels	All Other Vessels
Differential global positioning systems	Yes	Yes
Conventional aids to navigation	Yes	Yes
Electronic chart display and information system	Yes	Yes
Port State Control	Yes	-
Vessel traffic services	-	-
Pilotage	-	-
Portable pilotage unit	-	-
Underkeel clearance management	-	-

Note, if a risk control is not applied to all ships of the specified type then it is applied to no ships of that ship type. This is a conservative assumption that tends to over-estimate the calculated risks.

E.2.8 Drift Allision

In the MARCS Drift Grounding and Drift Allision accident models (see Appendix D), a drifting ship can recover control (stop drifting) by one of three mechanisms:

- Self-repair. The crew are able to repair the ship and it resumes normal navigation.
- Anchoring. If the sea bottom and water depth in the vicinity of the drifting ship meets defined criteria then the ship may stop drifting by deploying the anchors.
- Tug control. If a suitable tug is available, the tug may take control of the drifting ship.

In DNV GL's early studies of navigation risk for possible US wind farm developments, the only save mechanism included in the results was self-repair. This is a conservative assumption (tending to calculate a higher accident frequency).

In this study, it was agreed to include the anchoring save mechanism in addition to self-repair. The entire Project Area was judged to have a soft sea bottom type (good anchor holding power) and to have a suitable depth to allow anchoring and to prevent drift allision. The anchoring response time was assumed to be 5 minutes for all wind speed conditions. Anchoring was only allowed for ship types 1 to 6 inclusive (tugs and tug-with-tows are assumed to not deploy their anchors). Tug saves are not included, so the drift allision results are still conservative.

Areas of the coastline where anchors might be used to prevent drift grounding have not been included in the model for this NSRA.

E.3 Collision, allision, and grounding frequency results

In line with NVIC 01-19, this assessment compares the risk before the Project is built, and after it is operational:

- A Base Case (Case 0) was modeled for the current conditions in the Study Area. The results from the Base Case consist of collision, powered grounding, and drift grounding accident frequencies alone since this case is an estimate of the risk levels today prior to the construction of the wind farm.
- A Base Case Plus (Case 1) was modeled for the current conditions in the Study Area plus the proposed wind farm. This provides a hypothetical estimate of the risk after construction of the wind farm but without any modifications to the traffic pattern. The Base Case Plus estimates the frequency of a collision, grounding, and allision with Project structures.
- A Future Case with the Project (Case 2). This estimates the anticipated future conditions of the Study Area assuming all tugs are represented as small ships. The Future Case incorporates the Project structures, traffic redistribution due to the Project, and any anticipated increases in traffic due to the Project. The Future Case estimates the frequency of a collision, grounding, and allision with Project structures.
- A Future Case with the Project and with towing tugs (Case 3). This estimates the anticipated future conditions of the Study Area assuming 50% of tugs on coastal routes west of the Project Area are towing a barge. All towing tugs are assigned a breadth of 463m and a length of 927m. The Future Case incorporates the Project structures, traffic redistribution due to the Project, and any anticipated increases in traffic due to the Project. The Future Case estimates the frequency of a collision, grounding, and allision with Project structures.

Table E-5 summarizes these cases.

Table E-5 Summary of modeled cases

Case	Considerations
Base Case (Case 0)	- AIS data - Traffic adjustments to fishing vessels not in the AIS data
Base Case Plus (Case 1)	- AIS data - Traffic adjustments to fishing vessels not in the AIS data - Implementation of the Project structures
Future Case with the Project (Case 2)	- AIS data - Traffic adjustments to fishing and pleasure vessels not in the AIS data - Traffic adjustments to tour passenger vessel traffic - Re-distribution of traffic lanes for ship types Cargo, Passenger, Tankers, and Tugs - Implementation of Project structures
Future Case with the Project and with tug-with-tows (Case 3)	- AIS data - Traffic adjustments to fishing and pleasure vessels not in the AIS data - Traffic adjustments to tour passenger vessel traffic - Re-distribution of traffic lanes for ship types cargo, passenger, tankers and tugs - Implementation of Project structures - 50% of coastal tug traffic assigned a breadth of 463m and a length of 927m to represent the combined tug and barge

Cases 0, 1, 2 and 3 are modeled in MARCS. The MARCS model is detailed further in APPENDIX D to this NSRA. It has been utilized globally by DNV GL to determine the navigation risk of more than 20 wind farms.

All results are reported for the Project Area, the Study Area, and the other defined sub-areas.

E.3.1 Base Case (Case 0)

The Base Case results define the baseline average annual frequencies of marine accidents. The Base Case utilized AIS data from 1 March 2019 through 29 February 2020 plus additional transits for commercial fishing vessels.

Table E-6 presents the Base Case accident frequencies for each ship type and for each accident type for the Project Area. Cells shaded grey denote frequencies less than 1 in 10,000 per year (in this table and all subsequent similar tables). Note that these frequencies are for all accidents irrespective of whether the accident has significant consequences.

Table E-6 Case 0 accident frequencies (per year) without the wind farm in the Project Area[9]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0004	0.0000	0.0000	0.0000	0.0000	0.0004

Table E-6 shows the Base Case accident frequencies in the Project Area for allision and grounding are zero (no wind turbines and no grounding locations in the Base Case Project Area). Table E-6 also shows the accident frequency for ship type tug-with-tow is zero. This is because all tugs in the Base Case are not towing. Collision frequency is low (0.0004/year, or 4 accidents in 10,000 years) because there is very little ship traffic in the Project Area.

Table E-7 presents the Base Case accident frequencies for each ship type and for each accident type for the Study Area. In Table E-7, the majority of the accident frequency is due to grounding accidents (1.26/year out of 1.28/year). This is partly as expected for navigation close to shore, but also partly because the model input data has not been fully reconciled to estimate grounding risk (which is not the primary focus of this study).

Table E-8 through Table E-13 show the Base Case accident frequency results for the remaining sub-areas (shown in previous Figure E-2).

[9] Note the number of significant figures quoted in this Table, and in similar Tables, is only to facilitate comparison of results. Up to two significant figures are reasonable to evaluate considering uncertainties in the modeling.

Table E-7 Case 0 accident frequencies (per year) without the wind farm in the Study Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0025	0.0036	0.0103	0.0000	0.0000	0.0164
Passenger	0.0000	0.0007	0.0006	0.0000	0.0000	0.0013
Fishing	0.0042	0.1336	0.0989	0.0000	0.0000	0.2367
Other	0.0028	0.0827	0.0865	0.0000	0.0000	0.1720
Pleasure	0.0075	0.4186	0.2222	0.0000	0.0000	0.6483
Tankers	0.0007	0.0036	0.0040	0.0000	0.0000	0.0083
Tug	0.0034	0.1073	0.0863	0.0000	0.0000	0.1970
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0211	0.7501	0.5088	0.0000	0.0000	1.2800

Table E-8 Case 0 accident frequencies (per year) without the wind farm in the Northwest

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0001	0.0036	0.0103	0.0000	0.0000	0.0140
Passenger	0.0000	0.0007	0.0006	0.0000	0.0000	0.0013
Fishing	0.0035	0.1336	0.0989	0.0000	0.0000	0.2360
Other	0.0023	0.0827	0.0865	0.0000	0.0000	0.1715
Pleasure	0.0064	0.4186	0.2222	0.0000	0.0000	0.6472
Tankers	0.0001	0.0036	0.0040	0.0000	0.0000	0.0077
Tug	0.0029	0.1073	0.0863	0.0000	0.0000	0.1965
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0153	0.7501	0.5088	0.0000	0.0000	1.2742

Table E-9 Case 0 accident frequencies (per year) without the wind farm in the Northeast

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0007	0.0000	0.0000	0.0000	0.0000	0.0007
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003
Other	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
Pleasure	0.0005	0.0000	0.0000	0.0000	0.0000	0.0005
Tankers	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Tug	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0020	0.0000	0.0000	0.0000	0.0000	0.0020

Table E-10 Case 0 accident frequencies (per year) without the wind farm in the Southwest

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table E-11 Case 0 accident frequencies (per year) without the wind farm in the East

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001

Table E-12 Case 0 accident frequencies (per year) without the wind farm in the Far South

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0016	0.0000	0.0000	0.0000	0.0000	0.0016
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003
Other	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003
Pleasure	0.0004	0.0000	0.0000	0.0000	0.0000	0.0004
Tankers	0.0005	0.0000	0.0000	0.0000	0.0000	0.0005
Tug	0.0004	0.0000	0.0000	0.0000	0.0000	0.0004
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0035	0.0000	0.0000	0.0000	0.0000	0.0035

Table E-13 Case 0 accident frequencies (per year) without the wind farm in the Other sub-area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

E.3.2 Base Case Plus the Project (Case 1)

The Case 1 results show the average annual frequencies of marine accidents using unmodified Base Case traffic data plus including the Project structures. This case is used to verify the modeling.

Table E-14 shows the results for the Project Area, Table E-15 shows the results for the Study Area, and Table E-16 through E-21 show the results for each remaining sub-area. (Sub-areas are shown in previous Figure E-2).

The results for Case 1 are compared with the other case results and discussed in Section E.4.

Table E-14 Case 1 accident frequencies (per year) with the wind farm in the Project Area

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0001	0.0000	0.0000	0.0213	0.0040	0.0254
Passenger	0.0000	0.0000	0.0000	0.0003	0.0000	0.0003
Fishing	0.0002	0.0000	0.0000	0.0150	0.0036	0.0188
Other	0.0000	0.0000	0.0000	0.0025	0.0022	0.0047
Pleasure	0.0001	0.0000	0.0000	0.0091	0.0020	0.0112
Tankers	0.0000	0.0000	0.0000	0.0039	0.0008	0.0047
Tug	0.0000	0.0000	0.0000	0.0020	0.0093	0.0113
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0004	0.0000	0.0000	0.0541	0.0219	0.0764

Table E-15 Case 1 accident frequencies (per year) with the wind farm in the Study Area

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0025	0.0036	0.0103	0.0213	0.0040	0.0417
Passenger	0.0000	0.0007	0.0006	0.0003	0.0000	0.0016
Fishing	0.0042	0.1336	0.0989	0.0150	0.0036	0.2553
Other	0.0028	0.0827	0.0865	0.0025	0.0022	0.1767
Pleasure	0.0075	0.4186	0.2222	0.0091	0.0020	0.6594
Tankers	0.0007	0.0036	0.0040	0.0039	0.0008	0.0130
Tug	0.0034	0.1073	0.0863	0.0020	0.0093	0.2083
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0211	0.7501	0.5088	0.0541	0.0219	1.3560

Table E-16 Case 1 accident frequencies (per year) with the wind farm in the Northwest

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0001	0.0036	0.0103	0.0000	0.0000	0.0140
Passenger	0.0000	0.0007	0.0006	0.0000	0.0000	0.0013
Fishing	0.0035	0.1336	0.0989	0.0000	0.0000	0.2360
Other	0.0023	0.0827	0.0865	0.0000	0.0000	0.1715
Pleasure	0.0064	0.4186	0.2222	0.0000	0.0000	0.6472
Tankers	0.0001	0.0036	0.0040	0.0000	0.0000	0.0077
Tug	0.0029	0.1073	0.0863	0.0000	0.0000	0.1965
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0153	0.7501	0.5088	0.0000	0.0000	1.2742

Table E-17 Case 1 accident frequencies (per year) with the wind farm in the Northeast

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0007	0.0000	0.0000	0.0000	0.0000	0.0007
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003
Other	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
Pleasure	0.0005	0.0000	0.0000	0.0000	0.0000	0.0005
Tankers	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Tug	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0020	0.0000	0.0000	0.0000	0.0000	0.0020

Table E-18 Case 1 accident frequencies (per year) with the wind farm in the Southwest

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table E-19 Case 1 accident frequencies (per year) with the wind farm in the East

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001

Table E-20 Case 1 accident frequencies (per year) with the wind farm in the Far South

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0016	0.0000	0.0000	0.0000	0.0000	0.0016
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003
Other	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003
Pleasure	0.0004	0.0000	0.0000	0.0000	0.0000	0.0004
Tankers	0.0005	0.0000	0.0000	0.0000	0.0000	0.0005
Tug	0.0004	0.0000	0.0000	0.0000	0.0000	0.0004
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0035	0.0000	0.0000	0.0000	0.0000	0.0035

Table E-21 Case 0 accident frequencies (per year) without the wind farm in the Other sub-area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

E.3.3 Future Case with the Project (Case 2)

The Case 2 results show the average annual frequencies of marine accidents using modified Base Case traffic data including the Project structures.

Table E-22 presents the Future Case accident frequencies for each ship type and for each accident type in the Project Area. Table E-23 presents the corresponding results for the Study Area and Table E-24 through Table E-29 present the results for the remaining sub-areas. (Sub-areas are shown in previous Figure E-2).

The results for Case 2 are compared with the other case results and discussed in Section E.4 below.

Table E-22 Case 2 accident frequencies (per year) with the wind farm in the Project Area

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0004	0.0002	0.0006
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0004	0.0000	0.0000	0.0150	0.0036	0.0190
Other	0.0001	0.0000	0.0000	0.0025	0.0022	0.0048
Pleasure	0.0019	0.0000	0.0000	0.0479	0.0052	0.0550
Tankers	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
Tug	0.0000	0.0000	0.0000	0.0000	0.0073	0.0073
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0024	0.0000	0.0000	0.0659	0.0185	0.0868

Table E-23 Case 2 accident frequencies (per year) with the wind farm in the Study Area

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0028	0.0155	0.0124	0.0004	0.0002	0.0313
Passenger	0.0000	0.0014	0.0007	0.0000	0.0000	0.0021
Fishing	0.0058	0.1336	0.0989	0.0150	0.0036	0.2569
Other	0.0036	0.0827	0.0865	0.0025	0.0022	0.1775
Pleasure	0.0292	0.4930	0.3383	0.0479	0.0052	0.9136
Tankers	0.0008	0.0054	0.0044	0.0001	0.0000	0.0107
Tug	0.0059	0.1668	0.1111	0.0000	0.0073	0.2911
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0481	0.8984	0.6523	0.0659	0.0185	1.6832

Table E-24 Case 2 accident frequencies (per year) with the wind farm in the Northwest

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0004	0.0155	0.0124	0.0000	0.0000	0.0283
Passenger	0.0000	0.0014	0.0007	0.0000	0.0000	0.0021
Fishing	0.0046	0.1336	0.0989	0.0000	0.0000	0.2371
Other	0.0029	0.0827	0.0865	0.0000	0.0000	0.1721
Pleasure	0.0189	0.4929	0.3384	0.0000	0.0000	0.8502
Tankers	0.0001	0.0054	0.0044	0.0000	0.0000	0.0099
Tug	0.0049	0.1668	0.1111	0.0000	0.0000	0.2828
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0318	0.8983	0.6524	0.0000	0.0000	1.5825

Table E-25 Case 2 accident frequencies (per year) with the wind farm in the Northeast

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0005	0.0000	0.0000	0.0000	0.0000	0.0005
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
Other	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Pleasure	0.0004	0.0000	0.0000	0.0000	0.0000	0.0004
Tankers	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Tug	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0014	0.0000	0.0000	0.0000	0.0000	0.0014

Table E-26 Case 2 accident frequencies (per year) with the wind farm in the Southwest

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003

Table E-27 Case 2 accident frequencies (per year) with the wind farm in the East

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002

Table E-28 Case 2 accident frequencies (per year) with the wind farm in the Far South

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0017	0.0000	0.0000	0.0000	0.0000	0.0017
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0006	0.0000	0.0000	0.0000	0.0000	0.0006
Other	0.0005	0.0000	0.0000	0.0000	0.0000	0.0005
Pleasure	0.0076	0.0000	0.0000	0.0000	0.0000	0.0076
Tankers	0.0006	0.0000	0.0000	0.0000	0.0000	0.0006
Tug	0.0010	0.0000	0.0000	0.0000	0.0000	0.0010
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0120	0.0000	0.0000	0.0000	0.0000	0.0120

Table E-29 Case 2 accident frequencies (per year) without the wind farm in the Other sub-area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

E.3.1 Future Case with the Project and tug-with-tows (Case 3)

The Case 3 results show the average annual frequencies of marine accidents using modified Base Case traffic data, including the Project structures and assuming 50% of coastal tug traffic has tows attached.

Table E-30 presents the Case 3 accident frequencies for each ship type and for each accident type in the Project Area. Table E-31 presents the corresponding results for the Study Area and Table E-32 through Table E-37 present the results for the remaining sub-areas. (Sub-areas are shown in previous Figure E-2).

The results for Case 3 are compared with the other case results and discussed in Section E.4 below.

Table E-30 Case 3 accident frequencies (per year) with the wind farm in the Project Area

Future Case with Tows	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0004	0.0002	0.0006
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Future Case with Tows	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Fishing	0.0004	0.0000	0.0000	0.0150	0.0036	0.0190
Other	0.0001	0.0000	0.0000	0.0025	0.0022	0.0048
Pleasure	0.0019	0.0000	0.0000	0.0479	0.0052	0.0550
Tankers	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
Tug	0.0000	0.0000	0.0000	0.0000	0.0037	0.0037
Tug-with-tow	0.0000	0.0000	0.0000	0.0001	0.0249	0.0250
Total	0.0024	0.0000	0.0000	0.0660	0.0398	0.1082

Table E-31 Case 3 accident frequencies (per year) with the wind farm in the Study Area

Future Case with Tows	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0028	0.0155	0.0124	0.0004	0.0002	0.0313
Passenger	0.0000	0.0014	0.0007	0.0000	0.0000	0.0021
Fishing	0.0058	0.1336	0.0989	0.0150	0.0036	0.2569
Other	0.0036	0.0827	0.0865	0.0025	0.0022	0.1775
Pleasure	0.0292	0.4930	0.3383	0.0479	0.0052	0.9136
Tankers	0.0008	0.0054	0.0044	0.0001	0.0000	0.0107
Tug	0.0029	0.0837	0.0558	0.0000	0.0037	0.1461
Tug-with-tow	0.0026	0.0754	0.0472	0.0001	0.0249	0.1502
Total	0.0477	0.8907	0.6442	0.0660	0.0398	1.6884

Table E-32 Case 3 accident frequencies (per year) with the wind farm in the Northwest

Future Case with Tows	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0004	0.0155	0.0124	0.0000	0.0000	0.0283
Passenger	0.0000	0.0014	0.0007	0.0000	0.0000	0.0021
Fishing	0.0046	0.1336	0.0989	0.0000	0.0000	0.2371
Other	0.0029	0.0827	0.0865	0.0000	0.0000	0.1721
Pleasure	0.0189	0.4929	0.3384	0.0000	0.0000	0.8502
Tankers	0.0001	0.0054	0.0044	0.0000	0.0000	0.0099
Tug	0.0024	0.0837	0.0559	0.0000	0.0000	0.1420
Tug-with-tow	0.0022	0.0754	0.0472	0.0000	0.0000	0.1248
Total	0.0315	0.8906	0.6444	0.0000	0.0000	1.5665

Table E-33 Case 3 accident frequencies (per year) with the wind farm in the Northeast

Future Case with Tows	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0005	0.0000	0.0000	0.0000	0.0000	0.0005
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
Other	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Pleasure	0.0004	0.0000	0.0000	0.0000	0.0000	0.0004
Tankers	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0013	0.0000	0.0000	0.0000	0.0000	0.0013

Table E-34 Case 3 accident frequencies (per year) with the wind farm in the Southwest

Future Case with Tows	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0003	0.0000	0.0000	0.0000	0.0000	0.0003

Table E-35 Case 3 accident frequencies (per year) with the wind farm in the East

Future Case with Tows	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0002	0.0000	0.0000	0.0000	0.0000	0.0002

Table E-36 Case 3 accident frequencies (per year) with the wind farm in the Far South

Future Case with Tows	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0017	0.0000	0.0000	0.0000	0.0000	0.0017
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0006	0.0000	0.0000	0.0000	0.0000	0.0006
Other	0.0005	0.0000	0.0000	0.0000	0.0000	0.0005
Pleasure	0.0076	0.0000	0.0000	0.0000	0.0000	0.0076
Tankers	0.0006	0.0000	0.0000	0.0000	0.0000	0.0006
Tug	0.0006	0.0000	0.0000	0.0000	0.0000	0.0006
Tug-with-tow	0.0004	0.0000	0.0000	0.0000	0.0000	0.0004
Total	0.0120	0.0000	0.0000	0.0000	0.0000	0.0120

Table E-37 Case 3 accident frequencies (per year) without the wind farm in the Other sub-area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tankers	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug-with-tow	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

E.4 Model verification

Several checks and cross-checks were conducted to assure the model is self-consistent, and provides valid, credible results.

The difference between Case 1 and Case 0 provides an estimate of the maximum risk increase that could result from the presence of the Project wind farm if none of the traffic varied their routes because of the Project.

The difference between Case 2 and Case 1 provides an estimate of how risk is mitigated when some traffic types are re-routed around the wind farm footprint.

The difference between Case 3 and Case 2 provides an estimate of the effect on accident frequency of tugs attached to long line tows.

E.4.1 Comparing Case 1 to Case 0

The Base Case (Case 0) is without the Project structures and without modification of the traffic data. The Base Case Plus (Case 1) is the same as the Base Case but includes the Project structures. Comparing the two cases for the Study Area shows that the total accident frequency increases by 0.076 accidents per year when the Project structures are present and without modification of the traffic data. It also shows that the collision and grounding accident frequency is exactly unchanged. This is because the only difference between Case 0 and Case 1 is the addition of the project turbines in Case 1.

The turbine allision accident frequencies in Case 1 are 0.054 and 0.022 for powered and drift allision respectively. The sum of the allision frequencies represents the difference in the total accident frequency between Case 1 and Case 0. Approximately 71% of the total allision frequency is due to powered allision.

Other comparisons that were made to assure model quality were miles travelled per vessel type and ratio of accident frequencies per vessel type and per accident type.

E.4.2 Comparing Case 2 to Case 1

The Future Case (Case 2) includes the Project structures and the modified traffic data. The Base Case Plus (Case 1) is the same as the Future Case but without the modifications to the traffic data.

The ratios of accident frequencies by ship type for the Future Case (Case 2) and the Base Case Plus (Case 1) were calculated for the study area. The main differences were:

- Powered allision is reduced for Cargo, Passenger, Tanker and Tugs. This is because these ship types are re-routed around the wind farm in the Future Case.
- Powered allision for Pleasure ships is increased. This is because of the additional pleasure tour and recreational fishing ships included in the Future Case (Case 2).
- Powered grounding is increased for Cargo ships. This is because the cargo ships are re-routed around the northern limit of the project and lease areas. The new route defined aligns against the coastline. This risk could be mitigated by forcing the ships to turn south further out to sea.
- Collision frequency increases because there is 23% more ship-miles in the Study Area in the Future Case.

E.4.3 Comparing Case 3 to Case 2

The Future Case with tows (Case 3) is the same as the Future Case (Case 2) except that 50% of the coastal tug traffic is assigned to long line towing as described above. The effect is to reduce the allision accident frequency for tugs and to increase the allision frequency for tugs with tows.

The powered allision frequency for tug and tug-with tow increases from 0.0000/year for Case 2 to 0.0001/year for Case 3. These very low frequencies result from the fact that both ship types are re-routed around the Project in the Future Cases.

The drift allision frequency for tug and tug-with-tow increases from 0.0073/year for Case 2 to 0.0286/year for Case 3 (nearly a factor of 4 from a relatively low base frequency). This is as expected because the tug-with-tow traffic is assigned a ship length of 0.5 NM and this significantly increases the collision cross-section of this drifting composite ship.

E.5 Results and discussion

E.5.1 Project risk difference: comparing Case 2 to Case 0

The Future Case (Case 2) includes the Project structures and the modified traffic data. The Base Case (Case 0) is without the Project structures and without the modifications to the traffic data.

Table E-38 shows the predicted effect of the Project on accident frequency, that is, the difference between Case 2 and Case 0 for the Project sub-area. Differences in frequency less than 0.001 per year are highlighted in gray.

Table E-38 Case 2 minus Case 0 accident frequencies (per year) in the Project Area

Future Case minus Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.000	0.000	0.000	0.000	0.000	0.001
Passenger	0.000	0.000	0.000	0.000	0.000	0.000
Fishing	0.000	0.000	0.000	0.015	0.004	0.019
Other	0.000	0.000	0.000	0.003	0.002	0.005
Pleasure	0.002	0.000	0.000	0.048	0.005	0.055
Tankers	0.000	0.000	0.000	0.000	0.000	0.000
Tug	0.000	0.000	0.000	0.000	0.007	0.007
Tug-with-tow	0.000	0.000	0.000	0.000	0.000	0.000
Total	0.002	0.000	0.000	0.066	0.019	0.086

Table E-34 shows that the main difference is the powered and drift allision frequency. All the powered allision frequency (0.066/year) is attributed to those ship types not re-routed around the Project (fishing, other and, pleasure). Pleasure ships dominate (73%) the total powered allision frequency. This is partly because of the increase in pleasure ships assumed in the Future Case.

Drift allision and, to a lesser extent, collision frequencies are increased because there are 23% more ship-miles in the assumed Future Case.

E.5.2 Tug sensitivity analysis: comparing Case 3 to Case 0

The Future Case with Tows (Case 3) includes the Project structures and the modified traffic data. The Base Case (Case 0) is without the Project structures and without the modifications to the traffic data.

Table E-39 shows the predicted effect of the Project on accident frequency, that is, the difference between Case 3 and Case 0 for the Project sub-area. Differences in frequency less than 0.001 per year are highlighted in gray.

Table E-39 Case 3 minus Case 0 accident frequencies (per year) in the Project Area

Future Case with Tows minus Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.000	0.000	0.000	0.000	0.000	0.001
Passenger	0.000	0.000	0.000	0.000	0.000	0.000
Fishing	0.000	0.000	0.000	0.015	0.004	0.019
Other	0.000	0.000	0.000	0.003	0.002	0.005
Pleasure	0.002	0.000	0.000	0.048	0.005	0.055
Tankers	0.000	0.000	0.000	0.000	0.000	0.000
Tug	0.000	0.000	0.000	0.000	0.004	0.004
Tug-with-tow	0.000	0.000	0.000	0.000	0.025	0.025
Total	0.002	0.000	0.000	0.066	0.040	0.108

Table E-39 is mostly similar to Table E-38. The main difference is in the drift allision results, which are higher by a factor of 2.2. This is as expected because the "tug with tow" traffic is assigned a ship length of 0.5 NM and this significantly increases the collision cross section of this drifting composite ship.

E.5.3 Discussion of the sub-area results

The sub-area accident frequency differences between Case 0 and Case 2 are presented in Table E-40 through Table E-44 and discussed below. These are conservative estimates of the risk increase from the Project.

Table E-40 Case 2 minus Case 0 Accident frequencies (per year) in the Northwest

Future Case minus Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.000	0.012	0.002	0.000	0.000	0.014
Passenger	0.000	0.001	0.000	0.000	0.000	0.001
Fishing	0.001	0.000	0.000	0.000	0.000	0.001
Other	0.001	0.000	0.000	0.000	0.000	0.001
Pleasure	0.013	0.074	0.116	0.000	0.000	0.203
Tankers	0.000	0.002	0.000	0.000	0.000	0.002
Tug	0.002	0.060	0.025	0.000	0.000	0.086
Tug-with-tow	0.000	0.000	0.000	0.000	0.000	0.000
Total	0.017	0.148	0.144	0.000	0.000	0.308

Table E-41 Case 2 minus Case 0 accident frequencies (per year) in the Northeast

Future Case minus Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.000	0.000	0.000	0.000	0.000	0.000
Passenger	0.000	0.000	0.000	0.000	0.000	0.000
Fishing	0.000	0.000	0.000	0.000	0.000	0.000
Other	0.000	0.000	0.000	0.000	0.000	0.000
Pleasure	0.000	0.000	0.000	0.000	0.000	0.000
Tankers	0.000	0.000	0.000	0.000	0.000	0.000
Tug	0.000	0.000	0.000	0.000	0.000	0.000
Tug-with-tow	0.000	0.000	0.000	0.000	0.000	0.000
Total	-0.001	0.000	0.000	0.000	0.000	-0.001

Table E-42 Case 2 minus Case 0 accident frequencies (per year) in the Southwest

Future Case minus Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.000	0.000	0.000	0.000	0.000	0.000
Passenger	0.000	0.000	0.000	0.000	0.000	0.000
Fishing	0.000	0.000	0.000	0.000	0.000	0.000
Other	0.000	0.000	0.000	0.000	0.000	0.000
Pleasure	0.000	0.000	0.000	0.000	0.000	0.000
Tankers	0.000	0.000	0.000	0.000	0.000	0.000
Tug	0.000	0.000	0.000	0.000	0.000	0.000
Tug-with-tow	0.000	0.000	0.000	0.000	0.000	0.000
Total	0.000	0.000	0.000	0.000	0.000	0.000

Table E-43 Case 2 minus Case 0 accident frequencies (per year) in the East

Future Case minus Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.000	0.000	0.000	0.000	0.000	0.000
Passenger	0.000	0.000	0.000	0.000	0.000	0.000
Fishing	0.000	0.000	0.000	0.000	0.000	0.000
Other	0.000	0.000	0.000	0.000	0.000	0.000
Pleasure	0.000	0.000	0.000	0.000	0.000	0.000
Tankers	0.000	0.000	0.000	0.000	0.000	0.000
Tug	0.000	0.000	0.000	0.000	0.000	0.000
Tug-with-tow	0.000	0.000	0.000	0.000	0.000	0.000
Total	0.000	0.000	0.000	0.000	0.000	0.000

Table E-44 Case 2 minus Case 0 accident frequencies (per year) in the Far South

Future Case minus Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo	0.000	0.000	0.000	0.000	0.000	0.000
Passenger	0.000	0.000	0.000	0.000	0.000	0.000
Fishing	0.000	0.000	0.000	0.000	0.000	0.000
Other	0.000	0.000	0.000	0.000	0.000	0.000
Pleasure	0.007	0.000	0.000	0.000	0.000	0.007
Tankers	0.000	0.000	0.000	0.000	0.000	0.000
Tug	0.001	0.000	0.000	0.000	0.000	0.001
Tug-with-tow	0.000	0.000	0.000	0.000	0.000	0.000
Total	0.009	0.000	0.000	0.000	0.000	0.009

In general, the differences in accident frequencies observed reflect the differences in the amount of shipping traffic of each ship type in each sub-area.

The largest change in accident frequency due to the Project occurs in the Northwest sub-area. This is because some traffic is re-routed to the coastal zone from the Project area in the Future Case. The increase in accident frequency is 0.31/year and is mainly due to increased grounding risk.

The changes in accident frequency for the remaining sub-areas are judged to be insignificant.

E.6 Summary

The MARCS model calculates accident frequencies for the Base Case (Case 0), for Base Case Plus (addition of the Project to the Base Case) (Case 1), for the Future Case with the addition of the Project (and additional vessel traffic caused by the presence of the wind farm and assumes modified traffic routes) and for the Future Case with Tows. The difference between Case 3 and Case 0 is our best estimate of the increase in accident frequency caused by the presence of the Project.

Per NVIC 01-19 recommendations, this NSRA addresses the difference in collision and grounding due to the implementation of the Project, in addition to the risk of allision with Project structures. In this assessment, the difference in accident frequency between Case 3 and Case 0 is 0.41 accidents per year across the entire Study Area (an increase of 32%). This is our best estimate of the extra risk that results from the presence of the Project.

The quantified risk assessment of the navigation risk for the Project concludes that there is a small risk increase due to the Project. This modeling included a maximum estimate of the number of commercial fishing vessels, recreational fishing, and pleasure vessels that will transit to and through the Project, as the current number of transits is not available in the public domain.

APPENDIX F CHECKLIST FOR NSRA DEVELOPMENT AND REVIEW

Enclosure (6) to NVIC 01-19 contains the below checklist for review and development of an NSRA. This appendix provides the checklist that was completed during development of this NSRA.

ISSUE	Covered in the NSRA?	COMMENTS
1. SITE AND INSTALLATION COORDINATES		
Has the developer ensured that coordinates and subsequent variations of site perimeters and individual structures are made available, upon request, to interested parties at all, relevant project stages?	Yes, for current project stage	See Section 1.3 and Appendix G
Has the coordinate data been supplied as authoritative Geographical Information System (GIS) data, preferably in Environmental Systems Research Institute (ESRI) format? Metadata should facilitate the identification of the data creator, its date and purpose, and the geodetic datum used. For mariners' use, appropriate data should also be provided with latitude and longitude coordinates in WGS84 datum.	Yes	See Appendix G
2. TRAFFIC SURVEY		
Was the traffic survey conducted within 12 months of the NSRA?	Yes	See Section 2
Does the survey include all vessel types?	Yes	See Section 2 See details per vessel type in Section 2.1
Is the time period of the survey at least 28 days duration?	Yes	See Section 2
Does the survey include consultation with recreational vessel organizations?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include consultation with fishing vessel organizations?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include consultation with pilot organizations?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include consultation with commercial vessel organizations?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include consultation with port authorities?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include proposed structure location relative to areas used by any type of vessel?	Yes	See Section 2.2.2.
Does the survey include numbers, types, sizes and other characteristics of vessels presently using such areas?	Yes	See Section 2.1.3

ISSUE	**Covered in the NSRA?**	**COMMENTS**
Does the survey include types of cargo carried by vessels presently using such areas?	Yes	See Section 2.1.4
Does the survey identify non-transit uses of the areas (for example, fishing, day cruising of leisure craft, racing, marine regattas and parades, aggregate mining)?	Yes	See Section 2.2.1
Does the survey include whether these areas contain transit routes used by coastal or deep-draft vessels, ferry routes, and fishing vessel routes?	Yes	See Section 2.2.2.1 and Section 2.2.2.2 (refers to Section 2.1.1.2)
Does the survey include alignment and proximity of the site relative to adjacent shipping routes	Yes	See Section 2.2.2.3
Does the survey include whether the nearby area contains prescribed or recommended routing measures or precautionary areas?	Yes	See Section 2.2.2.4
Does the survey include whether the site lies on or near a prescribed or conventionally accepted separation zone between two opposing routes or traffic separation scheme?	Yes	See Section 2.2.2.4
Does the survey include the proximity of the site to anchorage grounds or areas, safe haven, port approaches, and pilot boarding or landing areas?	Yes	See Section 2.2.2.5
Does the survey include the feasibility of allowing vessels to anchor within the vicinity of the structure field?	Yes	See Section 2.2.2.5
Does the survey include the proximity of the site to existing fishing grounds, or to routes used by fishing vessels to such grounds?	Yes	See Section 2.2.3 (refers to Section 2.1.1.2)
Does the survey include whether the site lies within the limits of jurisdiction of a port and/or navigation authority?	Yes	See Section 2.2.3
Does the survey include the proximity of the site to offshore firing/bombing ranges and areas used for any marine or airborne military purposes?	Yes	See Section 2.2.3
Does the survey include the proximity of the site to existing or proposed offshore OREI/gas platform or marine aggregate mining?	Yes	See Section 2.2.3
Does the survey include the proximity of the site to existing or proposed structure developments?	Yes	See Section 2.2.3
Does the survey include the proximity of the site relative to any designated areas for the disposal of dredging material or ocean disposal site?	Yes	See Section 2.2.3
Does the survey include the proximity of the site to aids to navigation and/or Vessel Traffic Services (VTS) in or adjacent to the area and any impact thereon?	Yes	See Section 2.2.3

ISSUE	Covered in the NSRA?	COMMENTS
Does the survey include a researched opinion using computer simulation techniques with respect to the displacement of traffic, mixing of vessel types that were previously segregated; changes in traffic density and resultant change in vessels encounters; and, in particular, the creation of 'choke points' in areas of high traffic density?	Yes	See Section 2.3 and Appendix E
Does the survey include whether the site lies in or near areas that will be affected by variations in traffic patterns as a result of changes to vessel emission requirements?	Yes	See Section 2.4
Does the survey include seasonal variations in traffic?	Yes	See Section 2.5
3. OFFSHORE ABOVE WATER STRUCTURES		
Does the NSRA denote whether any features of the offshore above water structure, including auxiliary platforms outside the main generator site and cabling to the shore, could pose any type of difficulty or danger to vessels underway, performing normal operations, or anchoring? Such dangers would include clearances of wind turbine blades above the sea surface, the burial depth of cabling, and lateral movement of floating wind turbines.	Yes	See Section 3 and Section 4
Does the NSRA denote whether minimum safe (air) clearances between sea level conditions at Mean Higher High Water (MHHW) and wind turbine rotors are suitable for the vessels types identified in the traffic survey? Depths, clearances, and similar features of other structure types which might affect navigation safety and other Coast Guard missions should be determined on a case by case basis.	Yes	See Section 3.2
Does the NSRA denote whether any feature of the installation could impede emergency rescue services, including the use of lifeboats, helicopters and emergency towing vessels (ETVs)?	Yes	See Section 3.3
Does the NSRA denote how rotor blade rotation and power transmission, etc., will be controlled by the designated services when this is required in an emergency?	Yes	See Section 3.3
Does the NSRA denote whether any noise or vibrations generated by a structure above and below the water column would impact navigation safety or affect other Coast Guard missions?	Yes	See Section 3.4
Does the NSRA denote the ability of a structure to withstand collision damage by vessels without toppling for a range of vessel types, speeds, and sizes?	Yes	See Section 3.5

<table>
<tr><th>ISSUE</th><th>Covered in the NSRA?</th><th>COMMENTS</th></tr>
<tr><td colspan="3">4. OFFSHORE UNDER WATER STRUCTURES</td></tr>
<tr><td>Does the NSRA denote whether minimum safe clearance over underwater devices has been determined for the deepest draft of vessels that could transit the area?</td><td>Yes</td><td>See Section 4</td></tr>
<tr><td>Has the developer demonstrated an evidence-based, case- by-case approach which will include dynamic draft modeling in relation to charted water depth to ascertain the safe clearance over a device?</td><td>NA</td><td>Not applicable.
See Section 4</td></tr>
<tr><td>To establish a minimum clearance depth over devices, has the developer identified from the traffic survey the deepest draft of observed traffic?
This will then require modeling to assess impacts of all external dynamic influences giving a calculated figure for dynamic draft. A 30% factor of safety for under keel clearance (UKC) should then be applied to the dynamic draft, giving an overall calculated safe clearance depth to be used in calculations.</td><td>NA</td><td>Not applicable.
See Section 4</td></tr>
<tr><td colspan="3">5. ASSESSMENT OF ACCESS TO AND NAVIGATION WITHIN, OR CLOSE TO, A STRUCTURE. Has the developer determined the extent to which navigation would be feasible within the structure site itself by assessing whether:</td></tr>
<tr><td>Navigation within the site would be safe?
• By all vessels or
• By specified vessel types, operations and/or sizes?
• In all directions or areas; or
• In specified directions or areas?
• In specified tidal, weather or other conditions; and
• At any time, day or night?</td><td>Yes</td><td>See Section 5 for information to support Coast Guard’s evaluation.</td></tr>
<tr><td>Navigation in and/or near the site should be
• Prohibited by specified vessel types, operations and/or sizes;
• Prohibited in respect to specific activities;
• Prohibited in all areas or directions;
• Prohibited in specified areas or directions;
• Prohibited in specified tidal or weather conditions;
• Prohibited during certain times of the day or night; or
• Recommended to be avoided?</td><td>Yes</td><td>See Section 5 for information to support Coast Guard’s evaluation</td></tr>
<tr><td>Does the NSRA contain enough information for the Coast Guard to determine whether or not exclusion from the site could cause navigation, safety, or transiting problems for vessels operating in the area?</td><td>Yes</td><td>See Section 5 and supporting information in Section 2.3, Section 3.1, and Section 11</td></tr>
</table>

ISSUE	Covered in the NSRA?	COMMENTS
6. THE EFFECT OF TIDES, TIDAL STREAMS, AND CURRENTS. Does the NSRA contain enough information for the Coast Guard to determine whether or not:		
Current maritime traffic flows and operations in the general area are affected by the depth of water in which the proposed structure is situated at various states of the tide, that is, whether the installation could pose problems at high water which do not exist at low water conditions, and vice versa?	Yes	See Section 6
Current maritime traffic flows and operations in the general area are affected by existing currents in the area in which the proposed structure is situated?	Yes	See Section 6 introductory material and Section 6.2
The set and rate of the tidal stream, at any state of the tide, would have a significant effect on vessels in the area of the structure site?	Yes	See Section 6 introduction and Section 6.2
Current directions/velocities might aggravate or mitigate the likelihood of allision with the structure?	Yes	See Section 6.2
The maximum rate tidal stream runs parallel to the major axis of the proposed site layout, and, if so, its effect?	Yes	See Section 6.2
The set is across the major axis of the layout at any time, and, if so, at what rate?	Yes	See Section 6.2
In general, whether engine failure or other circumstance could cause vessels to be set into danger by the tidal stream or currents?	Yes	See Section 6.2 and Section 11 for risk results
Structures themselves could cause changes in the set and rate of the tidal stream or direction and rate of the currents?	Yes	See Section 6.2
Structures in the tidal stream could produce siltation, deposition of sediment or scouring, any other suction or discharge aspects, which could affect navigable water depths in the structure area or adjacent to the area?	Yes	See Section 6.2 and relevant sections of the COP
Structures would cause danger and/or severely affect the air column, water column, seabed and sub-seabed in the general vicinity of the structure?	Yes	See Section 6.2 and relevant sections of the COP
7. WEATHER. Does the NSRA contain a sufficient analysis of expected weather conditions, water depths and sea states that might aggravate or mitigate the likelihood of allision with the structure, so that Coast Guard can properly assess the applicant's determinations of whether:		
The site, in all weather conditions, could present difficulties or dangers to vessels, which might pass in close proximity to the structure?	Yes	See Section 7 and Section 11 risk results
The structures could create problems in the area for vessels under sail, such as wind masking, turbulence, or sheer?	Yes	See Section 7.2

ISSUE	Covered in the NSRA?	COMMENTS
In general, taking into account the prevailing winds for the area, whether engine failure or other circumstances could cause vessels to drift into danger, particularly if in conjunction with a tidal set such as referred above?	Yes	See Section 7 and Section 11 risk results
Depending on the location of the structure and the presence of cold weather, sea ice and/or icing of the structure may cause problems? A thorough analysis of how the presence of the structure would mitigate or exacerbate icing?	Yes	See Section 7.4
An analysis of the ability for structures to withstand anticipated ice flows should be conducted by the applicant?	Yes	See Section 7.4
An analysis of the likelihood that ice may form on the structure, especially those types that have rotating blades such as a Wind Turbine Generator (WTG), should be conducted by the applicant, and should include an analysis of the ability of the structure to withstand anticipated ice accumulation on the structures, and potential for ice to be thrown from the blades, and the likely consequences of that happening and possible actions to mitigate that occurrence?	Yes	See Section 7.4
8. CONFIGURATION AND COLLISION AVOIDANCE		
The Coast Guard will provide Search and Rescue (SAR) services in and around OREIs in US waters. Layout designs should allow for safe transit by SAR helicopters operating at low altitude in bad weather, and those vessels (including rescue craft) that decide to transit through them. Has the developer conducted additional site specific assessments, if necessary, to build on any previous assessments to assess the proposed locations of individual turbine devices, substations, platforms and any other structure within OREI such as a wind farm or tidal/wave array? Any assessment should include the potential impacts the site may have on navigation and SAR activities. Liaison with the USCG is encouraged as early as possible following this assessment which should aim to show that risks to vessels and/or SAR helicopters are minimized and include proposed mitigation measures.	Yes	See Section 8 and Section 10
Each OREI layout design will be assessed on a case-by-case basis.	Yes	See Section 8

ISSUE	Covered in the NSRA?	COMMENTS
Risk assessments should build on any earlier work conducted as part of the NSRA and the mitigations identified as part of that process. Where possible, an original assessment should be referenced to confirm where information or the assessment remains the same or can be further refined due to the later stages of project development. Risk assessments should present information to enable the USCG to adequately understand how the risks associated with the proposed layout have been reduced to As Low As Reasonably Practicable (ALARP).	Yes	See Section 8 and Section 11
In order to minimize risks to surface vessels and/or SAR helicopters transiting through an OREI, structures (turbines, substations) should be aligned and in straight rows or columns. Multiple lines of orientation may provide alternative options for passage planning and for vessels and aircraft to counter the environmental effects on handling i.e. sea state, tides, currents, weather, visibility. Developers should plan for at least two lines of orientation unless they can demonstrate that fewer are acceptable.	Yes	See Section 1.3
Packed boundaries will be considered on a case-by-case basis as part of the risk assessment process. For opposite boundaries of adjacent sites due consideration should be given to the requirement for lines of orientation which allow a continuous passage of vessels and/or SAR helicopters through both sites. Where there are packed boundaries this will affect layout decisions for any possible future adjacent sites. The definition of 'adjacent' will be assessed on a case-by-case basis.	NA	Not applicable to the considered layout
9. VISUAL NAVIGATION. Does the NSRA contain an assessment of the extent to which:		
Structures could block or hinder the view of other vessels underway on any route?	Yes	See Section 9
Structures could block or hinder the view of the coastline or of any other navigational feature such as aids to navigation, landmarks, promontories?	Yes	See Section 9
Structures and locations could limit the ability of vessels to maneuver in order to avoid collisions?	Yes	See Section 9 and Section 11
10. COMMUNICATIONS, RADAR AND POSITIONING SYSTEMS. Does the NSRA provide researched opinion of a generic and, where appropriate, site specific nature concerning whether or not:		
Structures could produce interference such as shadowing, reflections or phase changes, with marine positioning, navigation, or communications, including Automatic Identification Systems (AIS), whether ship borne, ashore, or fitted to any of the proposed structures?	Yes	See Section 10

ISSUE	Covered in the NSRA?	COMMENTS
Structures could produce radar reflections, blind spots, shadow areas or other adverse effects in the following interrelationships: • Vessel to vessel; • Vessel to shore; • Vessel Traffic Service radar to vessel; • Radio Beacons (RACONS) to/from vessel; and • Aircraft and Air Traffic Control?	Yes	See Section 10
Structures, in general, would comply with current recommendations concerning electromagnetic interference?	Yes	See Section 10
Structures might produce acoustic noise or noise absorption or reflections which could mask or interfere with prescribed sound signals from other vessels or aids to navigation?	Yes	See Section 10.1 and Section 3.4
Structures, generators, and the seabed cabling within the site and onshore might produce electro-magnetic fields affecting compasses and other navigation systems?	Yes	See Section 10
The power and noise generated by structures above or below the water would create physical risks that would affect the health of vessel crews?	Yes	See Section 10
11. RISK OF COLLISION, ALLISION, OR GROUNDING. Does the NSRA, based on the data collected per paragraph 2 above, provide an evaluation that was conducted to determine the risk of collision between vessels, risk of allisions with structures, or grounding because of the establishment of a structure, including, but not limited to:		
• Likely frequency of collision (vessel to vessel); • Likely consequences of collision ("What if" analysis); • Likely location of collision; • Likely type of collision; • Likely vessel type involved in collision; • Likely frequency of allision (vessel to structure) • Likely consequences of allision ("What if" analysis); • Likely location of allision; • Likely vessel type involved in allision; • Likely frequency of grounding; • Likely consequences of grounding (" What if" analysis); • Likely location of grounding; and • Likely vessel type involved in grounding?	Yes	See Section 11

ISSUE	Covered in the NSRA?	COMMENTS
12. EMERGENCY RESPONSE CONSIDERATIONS. In order to determine the impact on Coast Guard and other emergency responder missions, has the developer conducted assessments on the Search and Rescue and the Marine Environmental Protection emergency response missions?		
Search and Rescue (SAR): • The Coast Guard will assist in gathering and providing the following information: The number of search and rescue cases the USCG has conducted in the proposed structure region over the last ten years. • The number of cases involving helicopter hoists. • The number of cases performed at night or in poor visibility/low ceiling • The number of cases involving aircraft (helicopter, fixed-wing) searches. • The number of cases performed by commercial salvors (for example, BOAT US, SEATOW, commercial tugs) responding to assist vessels in the proposed structure region over the last ten years. • Has the developer provided an estimate of the number of additional SAR cases projected due to allisions with the structures? • Will the structure enhance SAR such as by providing a place of refuge or easily identifiable markings to direct SAR units?	Yes	See Section 12 summarizing the available data and relevant model results
Marine Environmental Protection/Response: • How many marine environmental/pollution response cases has the USCG conducted in the • proposed structure region over the last ten years? • What type of pollution cases were they? • What type and how many assets responded? • How many additional pollution cases are projected due to allisions with the structures?	Yes	See Section 12 summarizing the available data and relevant model results
13. FACILITY CHARACTERISTICS. In addition to addressing the risk factors detailed above, does the developer's NSRA include a description of the following characteristics related to the proposed structure:		
Marine Navigational Marking?	Yes	See Section 13
How the overall site would be marked by day and by night, taking into account that there may be an ongoing requirement for marking on completion of decommissioning, depending on individual circumstances?	Yes	See Section 13
How individual structures on the perimeter of and within the site, both above and below the sea surface, would be marked by day and by night?	Yes	See Section 13

ISSUE	Covered in the NSRA?	COMMENTS
If the site would be marked by one or more Radar Beacons (RACONS) or, an Automatic Identification System (AIS) transceiver, or both and if so, the AIS data it would transmit?	Yes	Addressed to the extent practical at this project stage, see Section 13
If the site would be fitted with a sound signal, the characteristics of the sound signal, and where the signal or signals would be sited?	Yes	Addressed to the extent practical at this project stage, see Section 13
If the structure(s) are to be fitted with aviation marks, how would they be screened from mariners or potential confusion with other navigational marks and lights be resolved?	Yes	Addressed to the extent practical at this project stage, see Section 13
Whether the proposed site and/or its individual generators would comply in general with markings for such structures, as required by the Coast Guard?	Yes	See Section 13
Whether its plans to maintain its aids to navigation are such that the Coast Guard's availability standards are met at all times. Separate detailed guidance to meet any unique characteristics of a particular structure proposal should be addressed by the respective District Waterways Management Branch?	Yes	See Section 13
The procedures that need to be put in place to respond to and correct discrepancies to the aids to navigation, within the timeframes specified by the Coast Guard?	Yes	See Section 13
How the marking of the structure will impact existing Federal aids to navigation in the vicinity of the structure?	Yes	See Section 13
14. DESIGN REQUIREMENTS. Is the structure designed and constructed to satisfy the following recommended design requirements for emergency shut-down in the event of a search and rescue, pollution response, or salvage operation in or around a structure?		
All above surface structure individual structures should be marked with clearly visible unique identification characters (for example, alpha-numeric labels such as "Al," "B2."). The identification characters should each be illuminated by a low-intensity light visible from a vessel, or be coated with a phosphorescent material, thus enabling the structure to be detected at a suitable distance to avoid a collision with it. The size of the identification characters in combination with the lighting or phosphorescence should be such that, under normal conditions of visibility and all known tidal conditions, they are clearly readable by an observer, and at a distance of at least 150 yards from the structure. It is recommended that, if lighted, the lighting for this purpose be hooded or baffled so as to avoid unnecessary light pollution or confusion with navigation aids. (Precise dimensions to be determined by the height of lights and necessary range of visibility of the identification numbers).	Yes	See Section 14
All generators and transmission systems should be equipped with control mechanisms that can be operated from an operations center of the installation.	Yes	See Section 14

ISSUE	Covered in the NSRA?	COMMENTS
Throughout the design process, appropriate assessments and methods for safe shutdown should be established and agreed to through consultation with the Coast Guard and other emergency support services.	Yes	See Section 14
The control mechanisms should allow the operations center personnel to fix and maintain the position of the WTG blades, nacelles and other appropriate moving parts as determined by the applicable Coast Guard command center. Enclosed spaces such as nacelle hatches in which personnel are working should be capable of being opened from the outside. This would allow rescuers (for example, helicopter winch-man) to gain access if occupants are unable to assist or when sea-borne approach is not possible.	Yes	See Section 14
Access ladders, although designed for entry by trained personnel using specialized equipment and procedures for maintenance in calm weather, could conceivably be used in an emergency situation to provide refuge on the structure for distressed mariners. This scenario should therefore be considered when identifying the optimum position of such ladders and take into account the prevailing wind, wave, and tidal conditions.	Yes	See Section 14
15. OPERATIONAL REQUIREMENTS. Will the operations be continuously monitored by the facility's owners or operators, ostensibly in an operations center? Does the NSRA identify recommended minimum requirements for an operations center such as:		
The operations center should be manned 24 hours a day?	Yes	See Section 15
The operations center personnel should have a chart indicating the Global Positioning System (GPS) position and unique identification numbers of each of the structure?	Yes	See Sections 15 and 16
All applicable Coast Guard command centers (District and Sector) will be advised of the contact telephone number of the operations center?	Yes	See Section 15
All applicable Coast Guard command centers will have a chart indicating the position and unique identification number of each of the structures?	Yes	See Sections 15 and 16
16. OPERATIONAL PROCEDURES. Does the NSRA provide for the following operational procedures?		
Upon receiving a distress call or other emergency alert from a vessel that is concerned about a possible allision with a structure or is already close to or within the installation, the Coast Guard Search and Rescue Mission Coordinator (SMC) will establish the position of the vessel and the identification numbers of any structures visible to the vessel. The position of the vessel and identification numbers of the structures will be passed immediately to the operations center by the SMC.	NA	See Section 16

ISSUE	Covered in the NSRA?	COMMENTS
The operations center should immediately initiate the shut-down procedure for those structures as requested by the SMC, and maintain the structure in the appropriate shut-down position, again as requested by the SMC, until receiving notification from the SMC that it is safe to restart the structure.	Yes	See Sections 14, 15, and 16
Communication and shutdown procedures should be tested satisfactorily at least twice each year.	Yes	See Section 16
After an allision, the applicant should submit documentation that verifies the structural integrity of the structure.	Yes	See Section 16

APPENDIX G COORDINATES OF PROJECT OFFSHORE STRUCTURES

Table G-1 lists the locations of the offshore Project structures evaluated in this NSRA (Orsted, 2021).

Table G-1 Structure Coordinates

ID	NAD83 (2011) UTM Zone 18 (m)		NAD83(2011) (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
A02	569658.3445	4340200.382	39.20828258	-74.19318916
A03	570699.0277	4339140.710	39.19865071	-74.18124755
A04	571739.7109	4338081.038	39.18901764	-74.16930920
A05	572780.3941	4337021.365	39.17938336	-74.15737410
A06	573821.0772	4335961.693	39.16974788	-74.14544227
A07	574861.7604	4334902.021	39.16011120	-74.13351369
A08	575902.4436	4333842.349	39.15047331	-74.12158836
A09	576943.1268	4332782.676	39.14083423	-74.10966628
B09	575026.9181	4331147.704	39.12627021	-74.13201782
B08	574052.0869	4332263.563	39.13640768	-74.14317257
B07	573077.2557	4333379.423	39.14654411	-74.15433051
B06	572102.4245	4334495.282	39.15667949	-74.16549165
B05	571127.5933	4335611.141	39.16681382	-74.17665598
B04	570152.7621	4336727.001	39.17694709	-74.18782352
B02	568203.0997	4338958.719	39.19721047	-74.21016818
C02	566785.6624	4337749.315	39.18642357	-74.22670097
C03	567748.2201	4336622.984	39.17620057	-74.21566945
C04	568710.7778	4335496.652	39.16597654	-74.20464111
C05	569673.3355	4334370.321	39.15575148	-74.19361596
C06	570635.8933	4333243.989	39.14552539	-74.18259399
C07	571598.4510	4332117.658	39.13529828	-74.17157521
C08	572561.0087	4330991.327	39.12507014	-74.16055960
C09	573523.5664	4329864.995	39.11484097	-74.14954718
D09	572016.0293	4328578.715	39.10337719	-74.16711966
D10	572979.4065	4327453.083	39.09315487	-74.15610005
E10	571376.287	4326085.248	39.08096298	-74.17477959
F10	569967.4250	4324883.161	39.07024590	-74.19119035
G10	568558.5585	4323681.070	39.05952640	-74.20759621
H10	567149.7022	4322478.987	39.04880460	-74.22399700
I10	565740.8355	4321276.896	39.03808035	-74.24039297
J10	564331.9789	4320074.813	39.02735380	-74.25678387
D02	565272.3890	4336458.141	39.17490468	-74.24434601
D04	567199.1434	4334206.876	39.15447340	-74.22226542
D05	568162.5206	4333081.244	39.14425622	-74.21122991

ID	NAD83 (2011) UTM Zone 18 (m)		NAD83(2011) (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
D06	569125.8977	4331955.612	39.13403800	-74.20019758
D07	570089.2749	4330829.979	39.12381876	-74.18916843
D08	571052.6521	4329704.347	39.11359849	-74.17814246
E09	570414.6174	4327212.338	39.09119656	-74.18578017
E08	569452.9479	4328339.427	39.10142912	-74.19678393
E07	568491.2783	4329466.516	39.11166065	-74.20779086
E06	567529.6087	4330593.605	39.12189115	-74.21880097
E05	566567.9391	4331720.695	39.13212063	-74.22981426
E04	565606.2696	4332847.784	39.14234909	-74.24083072
E03	564644.6000	4333974.873	39.15257651	-74.25185037
E02	563682.9304	4335101.962	39.16280291	-74.26287320
F01	561312.3989	4335026.964	39.16229747	-74.29031677
F02	562274.0685	4333899.875	39.15207363	-74.27929001
F03	563235.7381	4332772.786	39.14184876	-74.26826642
F04	564197.4076	4331645.697	39.13162286	-74.25724602
F05	565159.0772	4330518.607	39.12139593	-74.24622880
F06	566120.7468	4329391.518	39.11116798	-74.23521476
F07	567082.4163	4328264.429	39.10093899	-74.22420390
F08	568044.0859	4327137.340	39.09070899	-74.21319621
F09	569005.7554	4326010.250	39.08047796	-74.20219170
G09	567596.8890	4324808.159	39.06975693	-74.21859831
G08	566635.2194	4325935.248	39.07998644	-74.22960358
G07	565673.5498	4327062.338	39.09021493	-74.24061203
G06	564711.8803	4328189.427	39.10044239	-74.25162365
G05	563750.2107	4329316.516	39.11066882	-74.26263844
G04	562788.5411	4330443.606	39.12089422	-74.27365641
G03	561826.8716	4331570.695	39.13111859	-74.28467756
G02	560865.2020	4332697.784	39.14134194	-74.29570189
G01	559903.5324	4333824.873	39.15156425	-74.30672940
H01	558494.6757	4332622.790	39.14082872	-74.32313694
H02	559456.3453	4331495.701	39.13060794	-74.31210868
H04	561379.6845	4329241.523	39.11016328	-74.29006171
H05	562341.3541	4328114.434	39.09993940	-74.27904299
H06	563303.0237	4326987.344	39.08971449	-74.26802745
H07	564264.6934	4325860.255	39.07948856	-74.25701508
H08	565226.3630	4324733.166	39.06926160	-74.24600589
H09	566188.0326	4323606.077	39.05903361	-74.23499986
I09	564779.1659	4322403.985	39.04830784	-74.25139658
I08	563817.4963	4323531.075	39.05853430	-74.26240335
I07	562855.8267	4324658.164	39.06875974	-74.27341330

ID	NAD83 (2011) UTM Zone 18 (m)		NAD83(2011) (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
I06	561894.1572	4325785.253	39.07898415	-74.28442641
I05	560932.4876	4326912.342	39.08920753	-74.29544270
I04	559970.8180	4328039.432	39.09942989	-74.30646216
I03	559009.1484	4329166.521	39.10965121	-74.31748480
I02	558047.4788	4330293.610	39.11987150	-74.32851062
I01	557085.8092	4331420.699	39.13009075	-74.33953962
J01	555676.9525	4330218.616	39.11935049	-74.35593721
J02	556638.6221	4329091.527	39.10913276	-74.34490748
J03	557600.2917	4327964.438	39.09891399	-74.33388092
J04	558561.9613	4326837.349	39.08869420	-74.32285754
J05	559523.6309	4325710.260	39.07847337	-74.31183733
J06	560485.3005	4324583.170	39.06825151	-74.30082030
J07	561446.9701	4323456.081	39.05802862	-74.28980644
J08	562408.6397	4322328.992	39.04780471	-74.27879575
J09	563370.3093	4321201.903	39.03757977	-74.26778823
K01	554268.0909	4329016.529	39.10860781	-74.37232989
K02	555229.7605	4327889.440	39.09839161	-74.36129942
K03	556191.4301	4326762.351	39.08817437	-74.35027213
K04	557153.0997	4325635.262	39.07795610	-74.33924801
K05	558114.7693	4324508.172	39.06773680	-74.32822706
K06	559076.4389	4323381.083	39.05751647	-74.31720929
K07	560038.1085	4322253.994	39.04729510	-74.30619469
K08	560999.7781	4321126.905	39.03707271	-74.29518325
K09	561961.4477	4319999.816	39.02684929	-74.28417499
K10	562923.1173	4318872.726	39.01662484	-74.27316988
Z02 (OSS)	566235.7662	4335332.508	39.16468956	-74.23330413
Z01 (OSS)	569177.9308	4337842.86	39.18707931	-74.19899425
Z11 (OSS)	560418.0149	4330368.612	39.12038612	-74.30108361

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