MARYLAND OFFSHORE WIND PROJECT

Navigation Safety Risk Assessment

US Wind Inc.

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Contact person:	Matthew Filippelli	Tel: 617 620 7001
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Prepared by:

N Rouxel

Noe Rouxel
Senior Engineer

Tim Fowler
Senior Principal Consultant

Ian Evans
Geospatial Specialist

Katherine Diaz
Offshore Wind Analyst

Verified by:

Cheryl L Stahl

Cheryl Stahl
Senior Principal Consultant

Approved by:

Jake Frye
Acting Director, Offshore Wind North America

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Abbreviation	Meaning
ADLS	Aircraft Detection and Lighting System
AIS	Automatic Identification System
ALARP	As low as reasonably practicable
AMSA	Australian Maritime Safety Agency
ATB	Articulated Tug Barge
ATBA	Area To Be Avoided
ATON	Aids to Navigation
AWO	American Waterways Operators
BOEM	U.S. Bureau of Ocean Energy Management
CBPARS	Chesapeake Bay PARS
CEC	Commission of the European Communities
CFR	Code of Federal Regulations
CIOSS	Cooperative Institute for Oceanographic Satellite Studies, Oregon State University
COGOW	Climatology of Global TBD Winds
COLREGs	International Regulations for Preventing Collisions at Sea
COP	Construction and Operations Plan
CPA	Closest Point of Approach
CTV	Crew transfer vessel(s)
DOE	U.S. Department of Energy
DSC	Digital Selective Calling
DWT	Dead Weight Tonnage
ECA	Emission Control Area
ECDIS	Electronic Chart Display and Information System
ENC	Electronic navigation chart
FAA	Federal Aviation Administration
FR	Federal Register
FSA	Formal Safety Assessment
GC	Gain Control
GPS	Global Positioning System
HF	High Frequency
HFR	High Frequency Radar
HLV	Heavy lift vessel
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
IOOS	NOAA Integrated Ocean Observing System
LOA	Length Overall
MARCO	Mid-Atlantic Ocean Data Portal
MARCS	Marine Accident Risk Calculation System
MARIPARS	Areas Offshore of Massachusetts and Rhode Island Port Access Route Study
MA/RI WEA	Massachusetts/Rhode Island Wind Energy Area
MARPOL	International Convention for the Prevention of Pollution from Ships
MCA	UK Maritime & Coastguard Agency
MEP	Marine Environment Protection/Response
MHHW	Mean Higher High Water
MISLE	Marine Information for Safety and Law Enforcement system
MLLW	Mean Lower Low Water
MSL	Mean sea level

Abbreviation	Meaning
NBDC	National Data Buoy Center
NGDC	National Geophysical Data Center
NJPARS	Vessel Traffic Analysis for Port Access Route Study: Seacoast of New Jersey including the offshore approaches to the Delaware Bay, Delaware
NMFS	National Marine Fisheries Service
NOAA	U.S. National Oceanic and Atmospheric Administration
NROC	Northeast Regional Ocean Council
NOWRDC	National Offshore Wind Research & Development Consortium
NSRA	Navigation Safety Risk Assessment
NVIC	Navigation and Vessel Inspection Circular
O&M	Operations and Maintenance
OCS	Outer Continental Shelf
OREIs	Offshore Renewable Energy Installations
OSS	Offshore substation(s)
PARS	Port Access Route Study
PATON	Private Aids to Navigation
PAWSA	Ports and Waterways Safety Assessment
PPU	Portable Pilotage Unit
RODEO	BOEM Realtime Opportunity for Development Environmental Observations
ROV	Remotely Operated Vehicle
RRO	Risk Reduction Options
SAR	Search and Rescue
SAROPS	Search and Rescue Optimal Planning System
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
TEU	Twenty-foot equivalent unit
TSS	Traffic Separation Scheme
U.S.	United States
UHF	Ultra-High Frequency
UK	United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
USCG	U.S. Coast Guard
VHF	Very High Frequency
VMS	Vessel Monitoring System
VTIS	Vessel Traffic Information System
VTR	Vessel Trip Report
WEA	Wind Energy Area(s)
WTG	Wind Turbine Generator
WTRIM	Wind Turbine-Radar Interference Mitigation

List of units

Unit	Meaning
dB	decibels
dB(A)	A-weighted decibels
ft	Feet
ft/s	feet per second
GHz	gigahertz or 10^9 Hertz
Hz	Hertz
hp	horsepower
kg	kilograms
km	kilometers
km^2	square kilometers
kt	knots
lb	pound
m	meters
m^2	square meters
mi	miles
MJ	megajoules
MW	megawatts
NM	nautical miles
m/s	meters per second
s	seconds

EXECUTIVE SUMMARY

This document presents the Navigation Safety Risk Assessment (NSRA) for the Maryland Offshore Wind Project (the Project) in the commercial Lease for Renewable Energy Development on the Outer Continental Shelf (OCS-A 0521).

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

This assessment covers the following elements, as specified in NVIC 01-19:

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

In this report, DNV does not offer its opinion or make a determination whether the Project poses acceptable or unacceptable navigation safety risk; rather, the NSRA is intended to provide data, information, and relevant context for the USCG to make that determination within the remit of NVIC 01-19.

Key findings for each element are listed in Section 17 of this report.

Figure ES-1 shows the Project and NSRA study boundaries. The layouts used to assess risk from all potential structure locations has a minimum of 1.0 NM (1.9 km) between structures in a north-south direction and 0.76 NM (1.4 km) between structures in an east-west direction.[1]

The study assessed conservative "maximum risk" parameters as relevant to each hazard (listed in Section 1.1). The risk evaluated in this NSRA represents the maximum risk for any design within the parameters.

Marine risk modeling using Marine Accident Risk Calculation System (MARCS) software was performed to estimate the increase in the number of marine accidents that may result from the Project. This study attempts to balance the need to accurately estimate risk with the uncertainty accompanying the data and assumptions and aims to assure that any error is on the side of overestimating the risk.

The marine accidents that were modeled in this risk assessment are:

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

[1] Excepting the meteorological tower, which is aligned east-west but not north-south.

The risk increase most relevant to the Project lies within the Lease Area and is due to the potential for a vessel to strike a Project structure (allision risk). In line with accident causation theory, the great majority of maritime allision accidents are minor in nature. Similarly, most of the allision accidents predicted by the modeling are expected to be minor in nature.

One year of Automatic Identification System (AIS) data provided the main marine traffic input to the model. Additional vessel transits were added to account for both current and future traffic not represented in AIS, such as commercial fishing[2] (hereinafter "fishing"). The estimation of and routes assigned to additional traffic are presented following the discussion of each vessel type's traffic pattern in Section 2.1.1. There is a high degree of uncertainty in the fishing and pleasure traffic estimates, so the study's goal was to use high but realistic estimates.

Three potential layouts were compared to assess the risk of a deep draft vessel powered allision with a Project structure. The summary results of the layout sensitivity analysis for Cargo/Carrier and Tanker vessels per-structure allision frequency are shown in Table ES-1. The layout containing 119 structures has a deep draft vessel allision recurrence of less than 1 allision every 100 years. US Wind has identified this as the preferred Project layout, which has no structures within 1 NM (1.9 km) of the adjacent Traffic Separation Scheme (TSS). The distances from the TSS assume implementation of the TSS extension as proposed in the draft Port Access Route Study: Seacoast of New Jersey including the offshore approaches to the Delaware Bay, Delaware (NJPARS) (USCG, 2021a). The draft has since been issued as a final report, but the specifics concerning the location of the extension were intentionally removed from the final report to facilitate alignment of multiple studies' outputs in future rulemaking by USCG Headquarters.

The modeling shows that the benefit of removing a single structure decreases as more structures are removed from the layout. Therefore, an optimized selection process for structures should consider structures that have the greatest frequency of allision rather than a specified distance from a given route.

Table ES-1 Modeled Sensitivity of Cargo/Carrier/Tanker Allision Frequency for the Project (allisions/year; years/allision)

Allision type	126 Structures	119 Structures (none within 1 NM of the TSS)	98 Structures (none within 2 NM of the TSS)
Drift	0.0086 allisions/year (1 allision every 117 years)	0.0080 allisions/year (1 allision in 125 years)	0.0063 allisions/year (1 allision in 158 years)
Powered	0.0023 allisions/year (1 allision in 437 years)	0.0016 allisions/year (1 allision in 611 years)	0.0004 allisions/year (1 allision in 2,445 years)
Total allision frequency per structure per year	**0.0108 allisions/year (1 allision in 92 years)**	**0.0096 allisions/year (1 allision in 104 years)**	**0.0068 allisions/year (1 allision in 148 years)**

Based on the modeling conducted for this assessment, the modeled risk increase from the Project is 0.68 accidents per year for the preferred layout with 119 structures. The reader should note that the increase in accident frequency represents all accidents, which includes accidents with small and zero consequence such as bumping into a Project structure while drifting. Marine accidents involving Pleasure vessels represent 78% of the increase (Table ES-1). The modeling indicates that a powered allision scenario wherein an errant deep draft ship under power deviates from its route into the Lease Area is

[2] Commercial fishing vessels are AIS type "fishing" and related types. In this NSRA, all references to fishing activity and fishing vessels are to commercial fishing vessels except where specifically indicated as recreational fishing.

not a likely event. This potential event has a recurrence interval of less than 2 in 1,000 years for Cargo/Carrier and Tanker vessels.

Table ES-2 Modeled Change in Accident Frequencies per Vessel Type from the Project

Vessel type	Increase in frequency of any accident (number per year)	Percentage of total increase in accident frequency
Cargo/Carrier & Tanker	0.013	2.0%
Cruise/Ferry	<0.0005*	<0.05%*
Fishing	0.028	4.1%
Other	0.007	1.0%
Passenger	0.090	13.3%
Pleasure	0.527	77.7%
Tug-ATB	0.004	0.7%
Tug-Towline	0.009	1.3%
Total	**0.675**	**100.0%**

* Grey cells indicate frequencies with a recurrence of less than 5 in 10,000 years.

The MARCS results provide a view of the risk from the revised traffic flow after all the leases in the MARCS Study Area are built out, disregarding the proposed routing measures. If all vessel types were to utilize their relevant recommended routes, the risk would be less than is indicated by the modeling results. The main takeaways from the modeling effort are:

- Collision risk increases (mainly due to the assumed increase in traffic generated by the Project), but from a small baseline level to the predicted future collision risk total of 0.04/year, or 1 accident every 25 years.
- Allision risk increases. This is an inevitable consequence of developing offshore wind energy to reduce greenhouse gas emissions. About 92% of this allision frequency is due to smaller ships navigating within the Lease Area. The consequence of these allisions is likely to be low for both the vessel and the structure. The frequency of higher consequence allisions (powered allision of ships with LOA > 100 m) is 0.00192 per year, or 1 allision in 520 years, which is 20 times the design lifetime of the Project.
- Grounding risk increases mainly due to the assumed/predicted traffic increase due to the Project. The developer does not have much influence over these risks. In addition, the risk model has not been optimized to focus on these grounding risks. The developer has influence over the risk of its own vessel groundings, which may be mitigated by crew selection and training (reduced human error probabilities) and transit rules (e.g., no transits during poor visibility or strong wind).

This is a conservative and reasonable maximum estimate of the additional risk that could result from the presence of the Project, assuming the additional transits added to AIS adequately represent the actual traffic. If the number of transits were half of the number in the model, one would expect the risk would reduce significantly.

Additional risk mitigation measures whose benefits were not quantified in the model may be employed by the Project, including use of AIS technology within the Lease Area. Project lighting, sound signals, and marking of structures are generally described in Section 14 and will be subject to a separate review/permitting process.

The Project's effects on radar, positioning, and communications are discussed in Section 10, noting that some issues are complex and are the subject of ongoing research efforts.

The USCG's search and rescue (SAR) processes will not meet their original intents should offshore wind developments be constructed in this region. Sections 8 and 12 summarize key information concerning current SAR activity and potential Project impacts to SAR missions.

An evaluation was conducted of the costs versus the benefits of additional risk reduction measures followed by an as low as reasonably practicable (ALARP) assessment of the disproportionately costly measures. Given the Project's plans and the adoption of the additional risk controls measures recommended on the basis of the ALARP review process, the Project meets the ALARP principles.

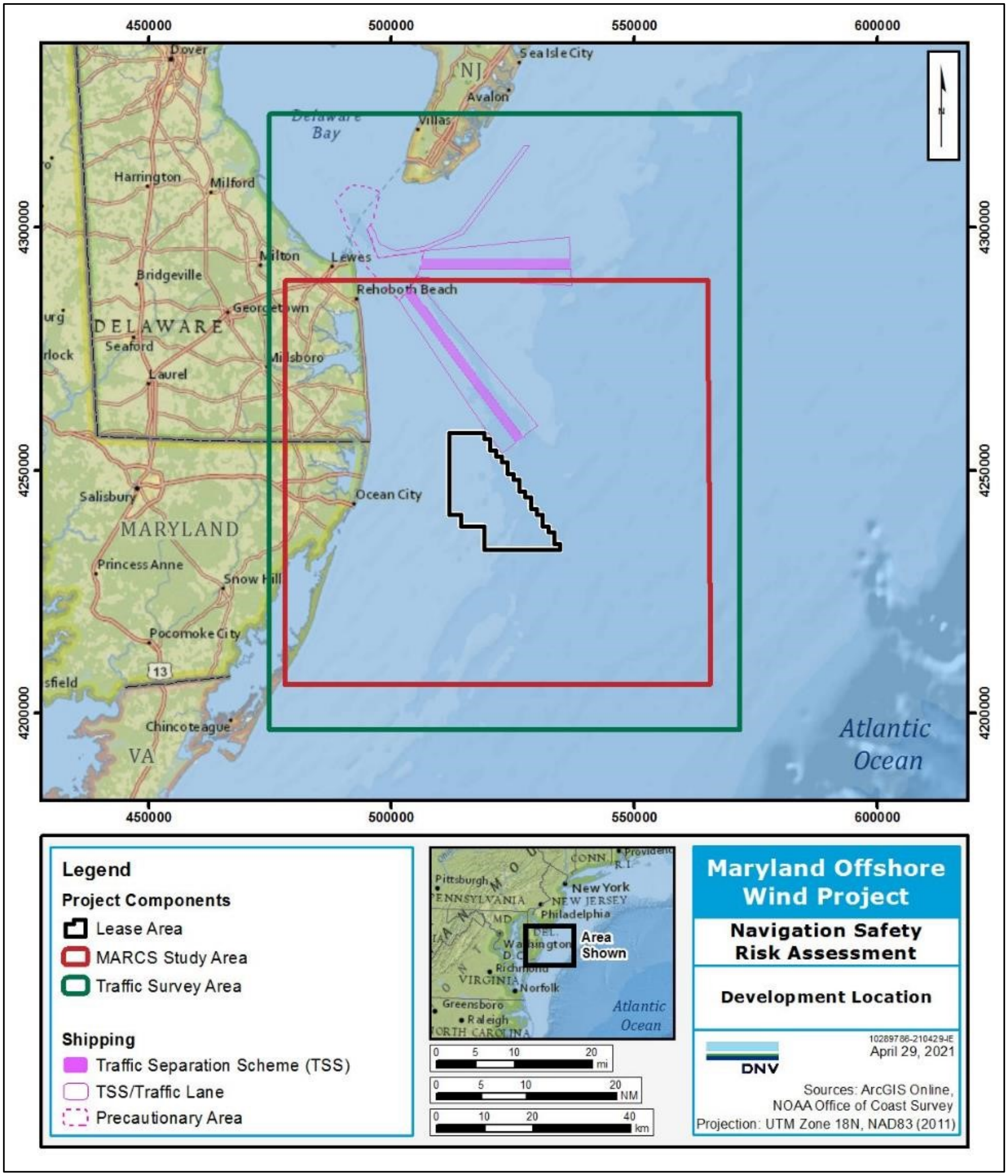


Figure ES-1 Project Location and NSRA Study Boundaries

1 INTRODUCTION AND PROJECT DESCRIPTION

DNV Energy USA Inc. (DNV) conducted this independent Navigation Safety Risk Assessment (NSRA) of the Maryland Offshore Wind Project (the Project). Offshore structures associated with the Project will be located within the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf OCS-A 0490 (the Lease Area).

This NSRA was conducted in line with the guidance provided in United States Coast Guard (USCG) *Navigation and Vessel Inspection Circular No. 01-19* (NVIC 01-19) (USCG, 2019a). This report, prepared by DNV, presents the results of the risk assessment.

1.1 Project components

This NSRA assessed risks from wind turbine generators (WTG), offshore substations (OSS), a meteorological (Met) tower, array cables, and export cable. Several alternatives are being considered for the number, and sizes, of offshore structures. Foundation types being considered for the Project include monopiles and jackets.

To facilitate comprehensive and resilient analyses of the Project, this NSRA is based on maximum risk parameters for each analysis herein, such that the NSRA will continue to be applicable as long as changes to the Project are within the parameters listed in Table 1-1. For the OSS, designs that result in vessel hazards that are the same size or smaller than the evaluated topsides' dimensions also fit in this risk envelope.

Table 1-1 Parameters Defining the NSRA Maximum Risk Envelope (US Wind, 2022)

Project-related parameter	Values evaluated in this NSRA	Parts of NSRA that used this parameter
Number of offshore structure locations (WTG + OSS + Met tower)	126 / 119 / 98	Considered in all parts of the NSRA
Number of evaluated WTG locations	121 / 114 / 93	Considered in all parts of the NSRA
Number of evaluated OSS locations	4	Considered in all parts of the NSRA
Number of evaluated Met tower locations	1	Considered in all parts of the NSRA
Maximum WTG foundation dimensions at mean sea level (MSL)	Monopile maximum diameter: 12 meters (m) (39 feet [ft])	Visual obstruction Collision, allision, grounding risk modeling
Minimum WTG air gap from Mean Higher High Water (MHHW)	Maximum 34.7 m (114 ft)	Vessel clearances
Maximum WTG blade tip height from Mean Lower Low Water (MLLW)	Maximum 286 m (938 ft)	Emergency response
Maximum nacelle height from MLLW	Maximum 166 m (545 ft)	Emergency response

Project-related parameter	Values evaluated in this NSRA	Parts of NSRA that used this parameter
Maximum OSS foundation dimensions	Monopile diameter: 8.0 m (26.2 ft) Jacket footprint: 45 m x 45 m (168 ft x 168 ft)	Visual obstruction
Maximum OSS platform footprint	OSS at locations F05 and J09 40 m x 80 m (131 ft x 262 ft) OSS at locations B05 and M11 30 m x 42.5 m (98 ft x 139 ft)	OSS hazard footprint for collision, allision, grounding risk modeling (circumscribed diameters are 92 m and 52 m)
Minimum OSS air gap from MHHW based on maximum size of OSS with a jacket foundation	21.6 m (70.9 ft) Footprint of the hazard posed by the OSS (topsides plus jacket): 45 m x 80 m (148 ft x 262 ft)	Vessel clearances Allision risk modeling
Maximum Met tower foundation dimensions from MSL	Jacket footprint: 15 m x 15 m x 21 m (50 ft x 50 ft x 71 ft)	Visual obstruction Collision, allision, grounding risk modeling (circumscribed diameter is 21 m)
Minimum Met tower air gap from MHHW	20.0 m (65.6 ft)	

In addition to the offshore structures listed in Table 1-1, the remaining offshore Project components will be buried and/or covered and comprise:

- Inter-array cables within the Lease Area connecting the WTGs to the OSSs
- An offshore export cable to convey power from the OSSs to shore
- A Met tower within the Lease Area.

The evaluated locations of the structures and cable route options are presented in Section 1.2.

1.2 Site location and installation coordinates

The geographic limits of the NSRA were defined in consultation with the USCG, are shown in Figure 1-1, and are defined as:

- The Project Lease Area (Lease OCS-A-0490) (black outline).
- An area larger than the Lease Area was considered in the risk modeling of the Project using the Marine Accident Risk Calculation System (MARCS) software. This area is termed the MARCS Study Area (red outline). It was selected to optimize the relevance of the model results to effects from the Project. The MARCS Study Area was selected to encompass offshore waters at least 12 nautical miles (NM) (22 kilometers [km]) from the Lease Area in any direction. It was also extended north to include the Southeast Approach Traffic Separation Scheme (TSS)[3] and extended southeast to include traffic transiting east around the Lease Area, potentially entering or departing the TSS.
- An area even larger than the MARCS Study Area was considered for the Traffic Survey Area (green outline). The Traffic Survey Area was selected to encompass offshore waters at least 20 NM (37 km) from the Lease Area in any direction and extended northward to include the traffic entering and exiting Delaware Bay.

[3] The TSS boundaries shown in all maps were downloaded from Marine Cadastre. The files were originally created from electronic navigation chart (ENC) files published by the Office of Coast Survey (NOAA). It should be noted that the western boundary of the south-eastbound traffic lane extends 1.5 NM further south than the corresponding line defined in *33 CFR [Code of Federal Regulations] 167.172(c)*.

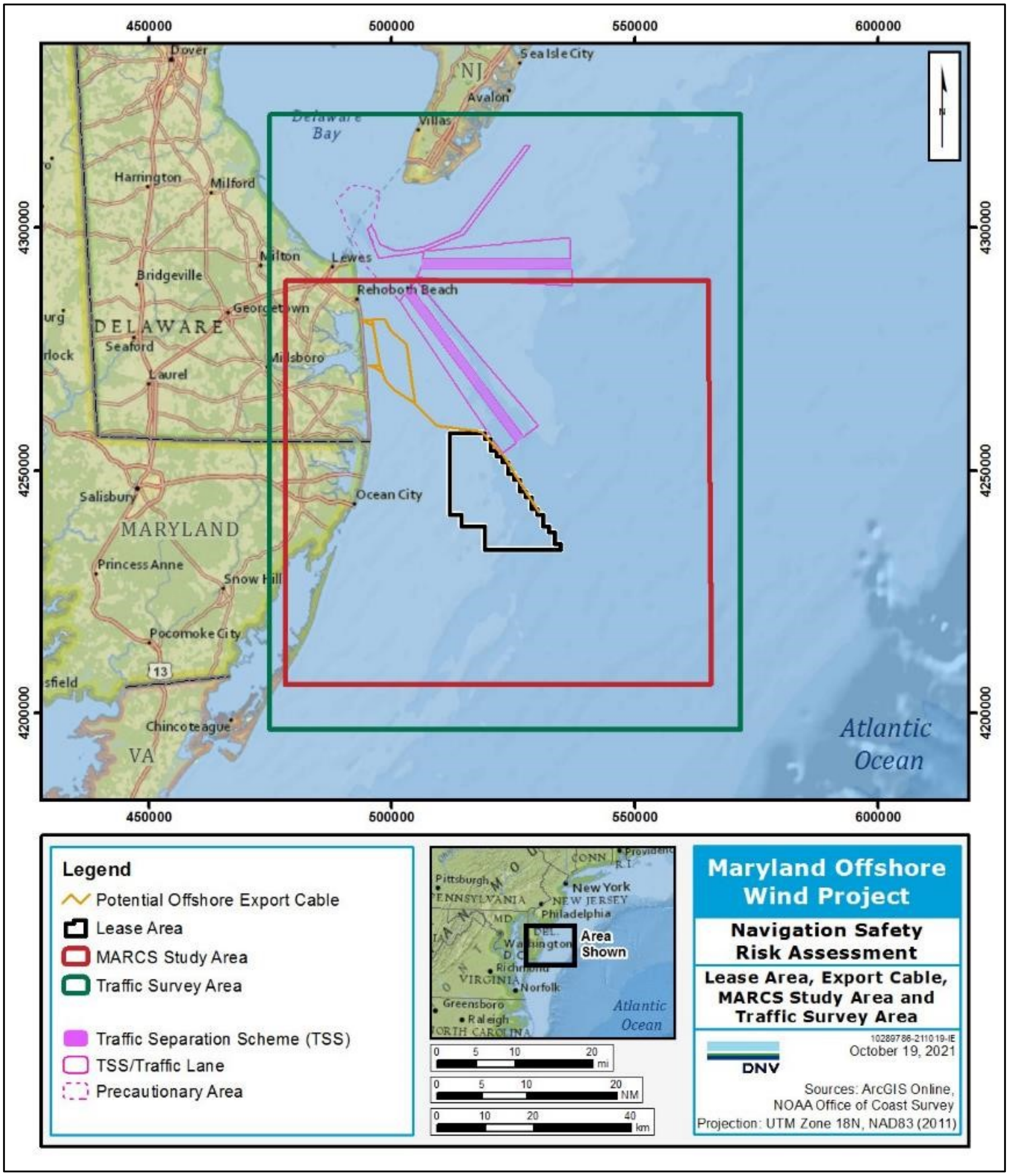


Figure 1-1 NSRA Lease Area, MARCS Study Area, and Traffic Survey Area

Figure 1-2 through Figure 1-4 show the layouts of offshore structures evaluated in this NSRA. The structure numbering scheme used in this report is not indicative of the final marking scheme to be implemented by the Project. The preferred layout proposed by US Wind is the layout with no structures within 1 NM of the Delaware Bay Southeastern Approach TSS, which contains 119 structures. The distance between offshore structures is 1.0 NM (1.9 km) north-south by 0.76 NM (1.4 km) east-west (US Wind, 2022). The only structure that does not align with the grid pattern on both axes is the Met tower, which is 0.47 NM from the nearest structure. The risk of an allision with this structure is presented in Section 11.2.2.

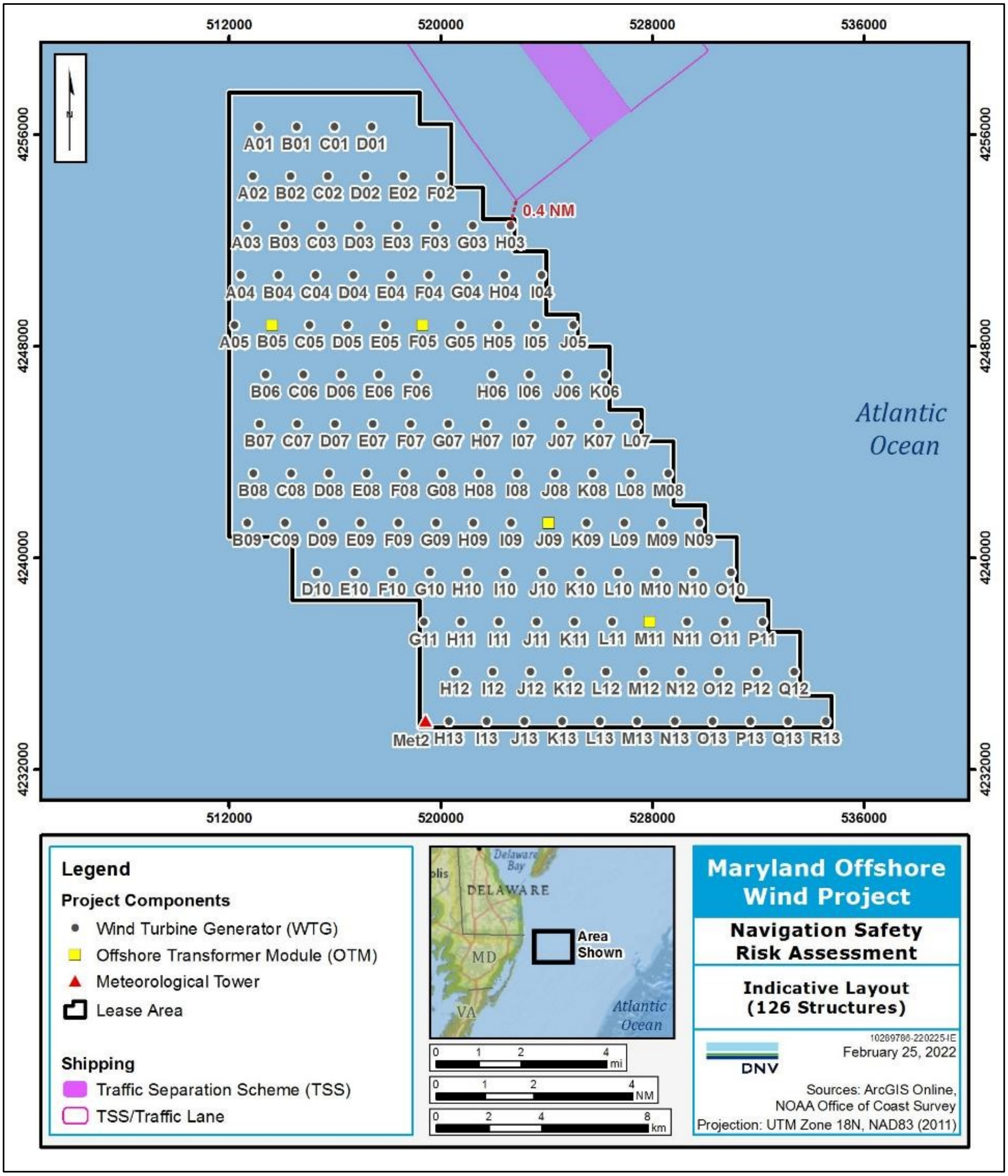


Figure 1-2 Indicative Maximum Layout of 126 Structures Evaluated in the NSRA (US Wind, 2022)[4]

[4] The structure numbering scheme used in this report is not indicative of the final marking scheme to be implemented by the Project.

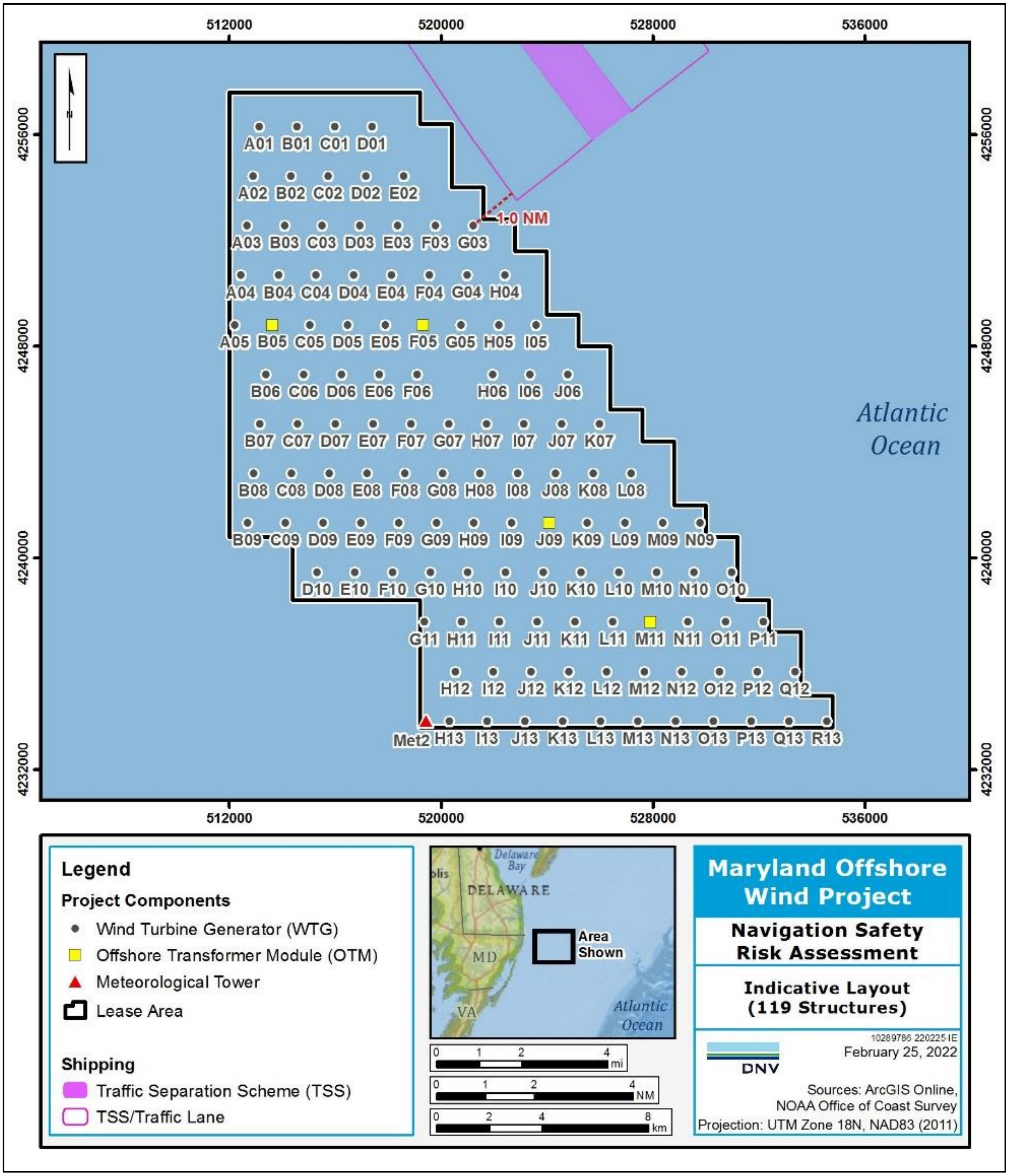


Figure 1-3 Indicative Maximum Layout of 119 Structures Evaluated in the NSRA (US Wind, 2022)[4]

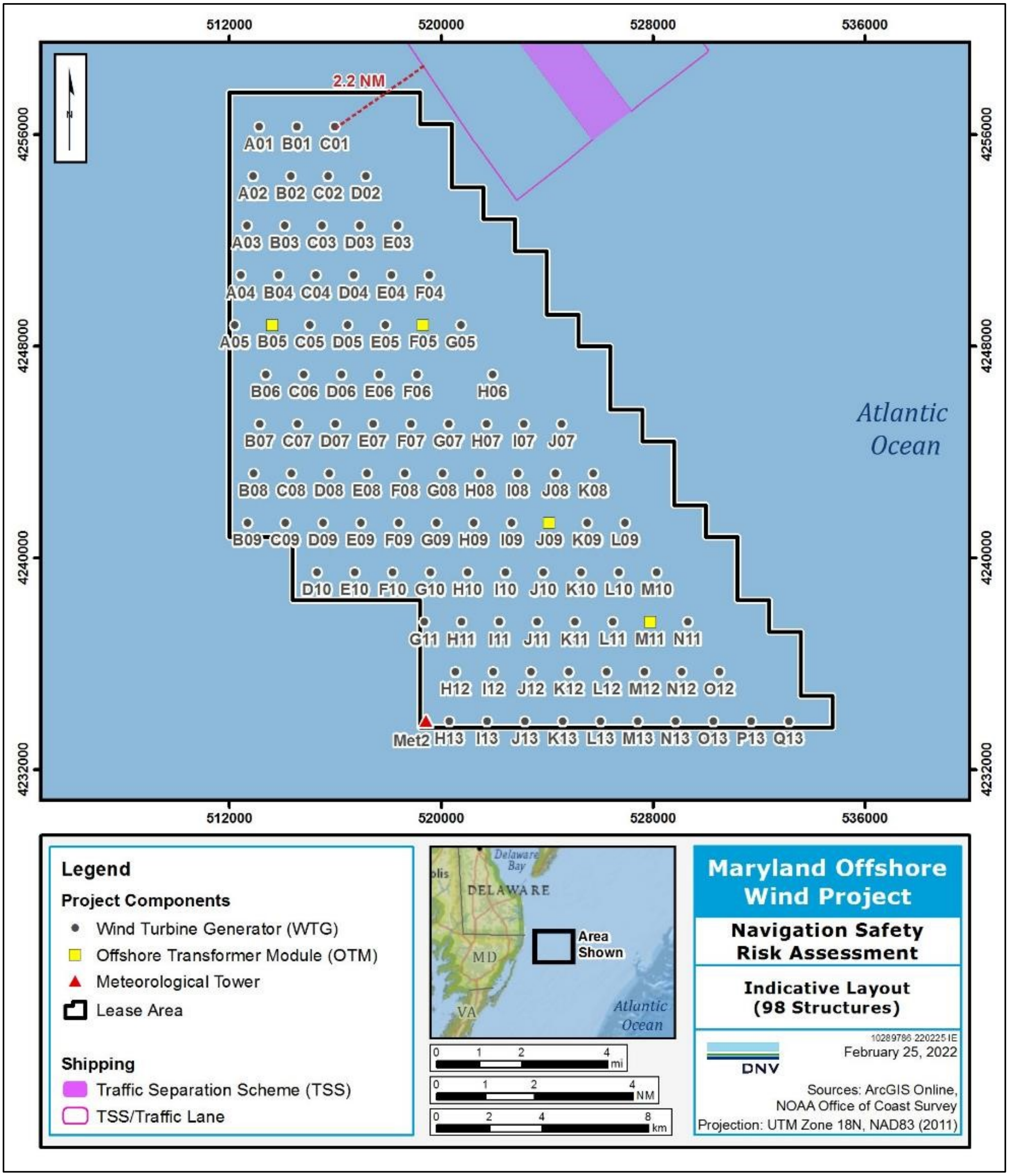


Figure 1-4 Indicative Maximum Layout of 98 Structures Evaluated in the NSRA (US Wind, 2022)[4]

2 TRAFFIC SURVEY

The traffic survey describes the marine traffic within the Traffic Survey Area. Traffic patterns were identified using the following inputs:

- National Automatic Identification System (AIS) data for 2019 were identified as the most recent representative data for this NSRA based on consultations with the USCG. The maps in Appendix A are based on this data set. The following vessels in the Traffic Survey Area are required to carry AIS class A or class B equipment:[5]
  - Deep draft vessels (i.e., cargo vessels, carriers, tankers, large passenger vessels, most commercial ships on international voyages, public vessels, and military vessels/submarines, with a few exceptions)
  - Commercial self-propelled vessels of 19.8 m (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 8.2 m (27 ft) or more in length and more than 600 horsepower (hp)
  - Passenger vessels certificated to carry 150 or more passengers
- Relative commercial fishing density from Vessel Monitoring System (VMS) data from the National Marine Fisheries Service (NMFS). VMS data are collected for selected vessels by National Oceanic and Atmospheric Administration (NOAA) NMFS via type-approved transmitters that automatically transmit a vessel's position for relay to NMFS. This NSRA primarily uses 2019 VMS data processed by the USCG in support of the Vessel Traffic Analysis for Port Access Route Study: Seacoast of New Jersey including the offshore approaches to the Delaware Bay, Delaware (NJPARS) (USCG, 2022a), supported by 2015/2016 VMS data (NROC and RPS, 2018) for geographic areas not covered by the 2019 data set.
- Relative use of commercial fishing gear from combined permit / Vessel Trip Report (VTR) data. VTR data are collated from vessel reports provided to NOAA's Northeast Fisheries Science Center by a subset of fishing vessels (NOAA, 2016).
- The images and summaries provided in the NJPARS vessel traffic analysis (USCG, 2022a).
- Ongoing dialogue with recreational boating, fishing, towing industry organizations, and other stakeholders. See Appendices B and C and the Construction and Operations Plan (COP) Appendix II-F1. See also Appendix II-L2, the Fisheries Communications Plan, for details.

Per NVIC 01-19, the following aspects of marine traffic in the Traffic Survey Area are described in the traffic survey:

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

The proposed Traffic Survey Area for the NSRA was presented to the USCG during a dialogue on 15 April 2021, early in the NSRA process. The Traffic Survey Area (Figure 2-1) encompasses the Lease Area and offshore waters for more than

[5] 33 Code of Federal Regulations (CFR) 164.46 and the International Convention for the Safety of Life At Sea (SOLAS) (International Maritime Organization [IMO], 1974).

20 NM (37 km) in any direction. The 2019 AIS data were deemed the most appropriate for purposes of the NSRA versus 2020 or 2021 data because of effects from COVID-19 on shipping volumes and patterns.

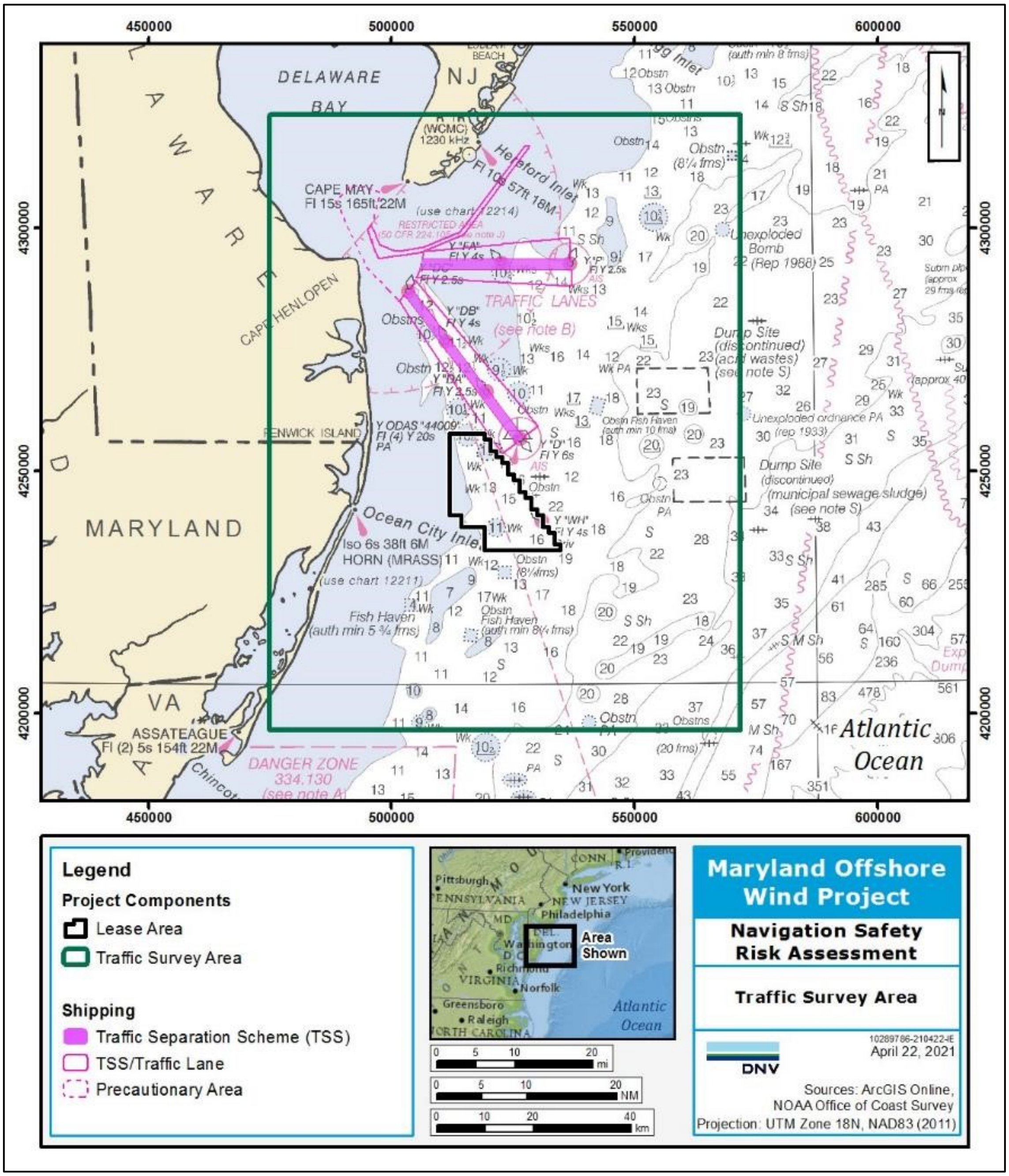


Figure 2-1 Traffic Survey Area

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

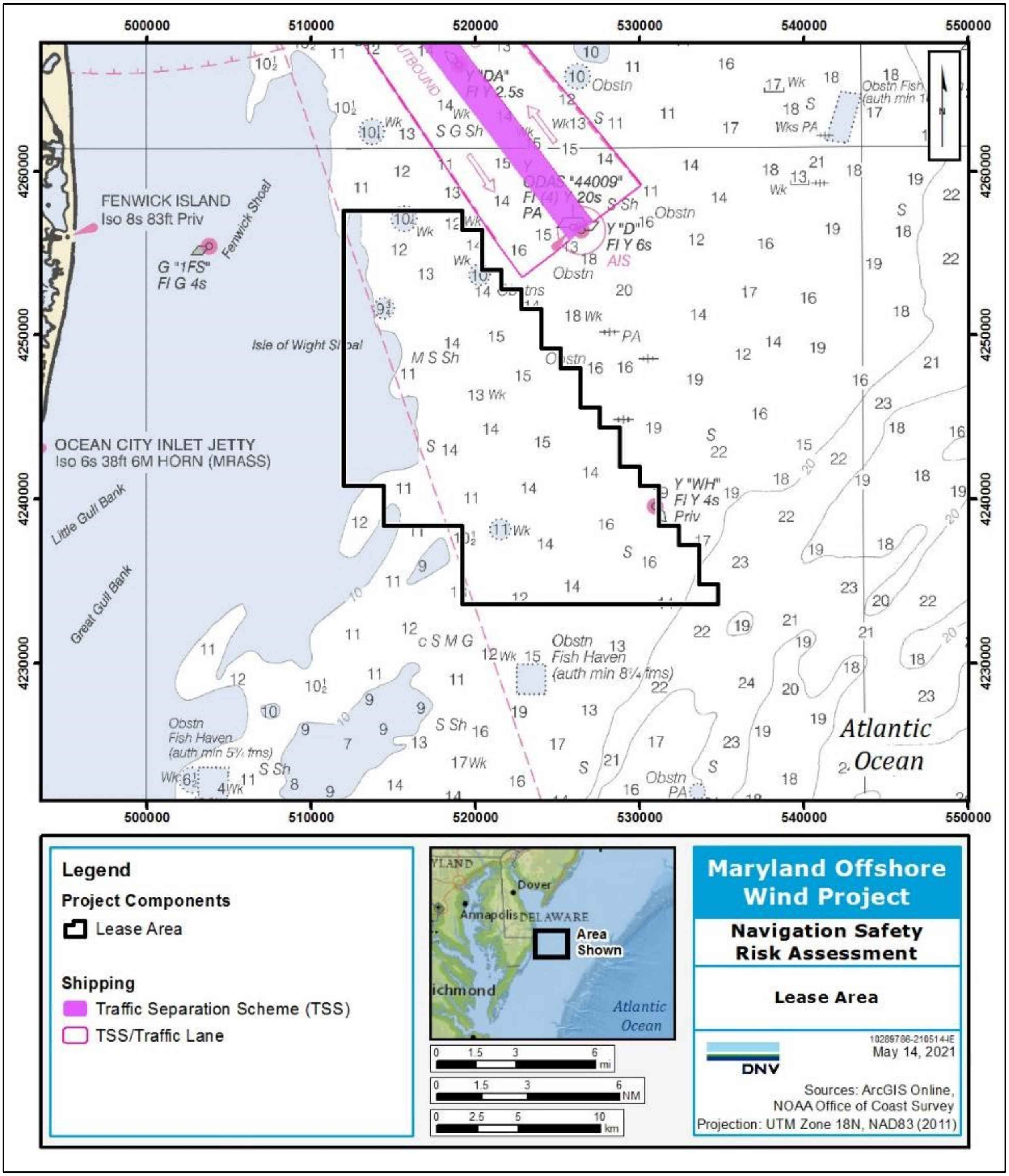


Figure 2-2 Navigation Chart in the Vicinity of the Lease Area

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 January 2019 through 31 December 2019. The data were spatially analyzed based on timestamp and proximity to create vessel tracks. Each vessel track represents a one-way 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 (USCG, 2021i). As a result, the data set 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 in the region 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 under U.S. law. In particular, foreign vessels not destined for, or departing from, a location under U.S. jurisdiction (including innocent passage and international straits), and some self-propelled vessels less than 1,600 gross tons are not required to carry AIS under U.S. law. However, international law (International Maritime Organization [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 USCG 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: (A)Certain dangerous cargo as defined in subpart C of part 160 of this chapter, or (B) Flammable or combustible liquid cargo in bulk that is listed in 46 CFR 30.25-1, Table 30.25-1.*
>
> *Use of a USCG 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: (A) 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 (B) 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.

To generalize, the great majority of vessels in the Traffic Survey Area carry AIS class A or class B equipment except fishing and pleasure vessels (includes recreational craft):

- Deep draft vessels, which are commonly defined as vessels 1600 gross tons and greater engaged in commercial trade (tankers, large passenger vessels, and most commercial ships on international voyages)
- Commercial self-propelled vessels of 65 ft (equivalent to 20 m) or more in length, regardless of service
- Self-propelled vessels moving certain dangerous cargoes, flammable or combustible liquids in bulk
- U.S. flag towing vessels pushing, pulling, or hauling a barge that is carrying oil or hazardous material in bulk
- U.S. flag towing vessels of 26 ft (equivalent to 7.92 m) or more in length
- Passenger vessels certificated to carry 150 or more passengers

Overview of Vessel Tracks

Figure 2-3 presents the AIS tracks for vessels transmitting AIS signals in the Traffic Survey Area in 2019.[6] Although the Traffic Survey Area includes some inland waterways, the discussions in this report focus on offshore vessel traffic.

In the following views, vessel tracks are shown with transparency to allow differentiation of overlaps. The traffic separation zones are illustrated as pink rectangles as on a nautical chart. Additional views of the AIS data, such as track density plots, are available in Appendix A.

[6] National terrestrial AIS data for the period 1 January 2019 through 31 December 2019 (NOAA, 2020a)

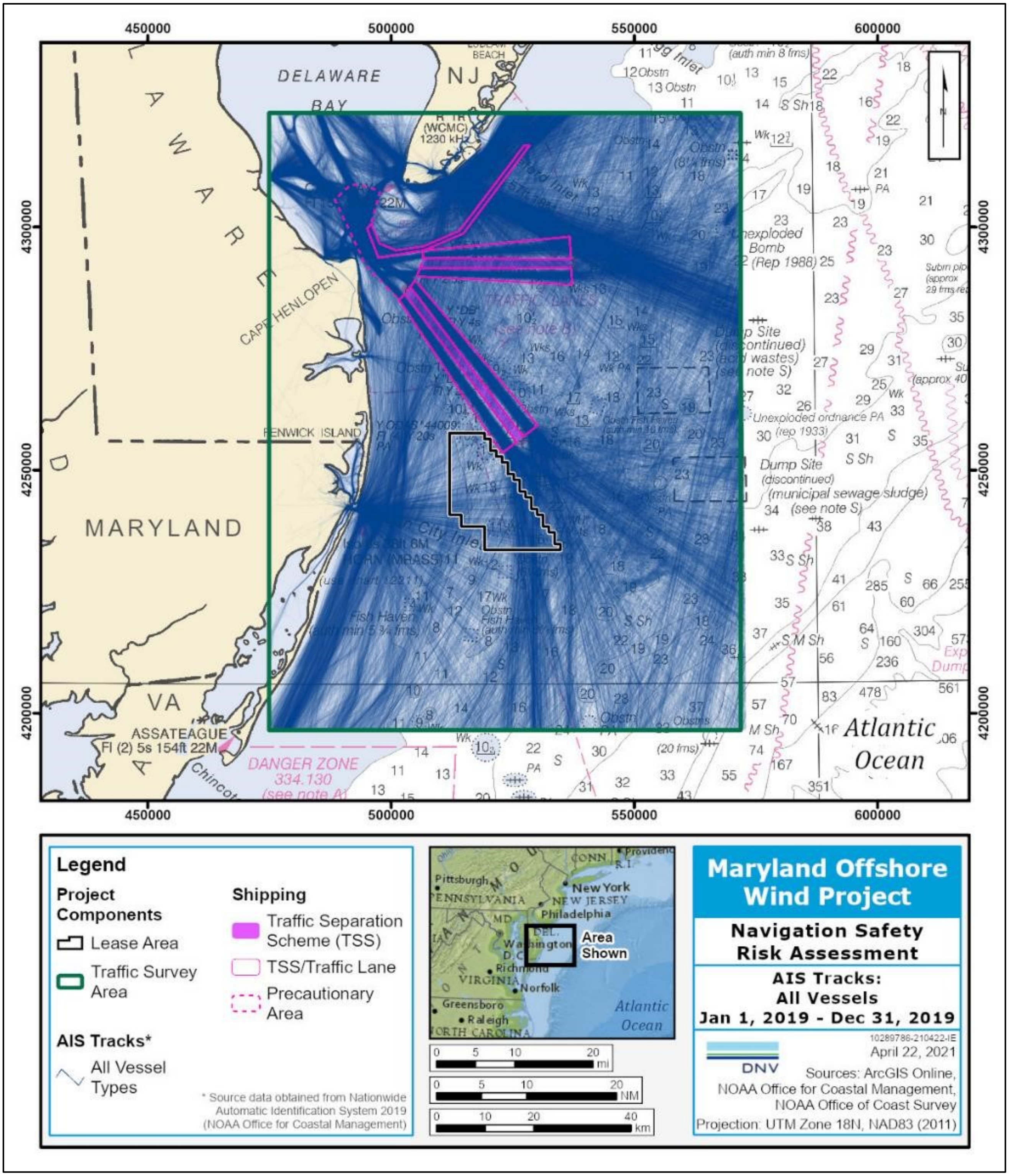


Figure 2-3 AIS Tracks in the Traffic Survey Area[6]

A closer view of the Lease Area in Figure 2-4 reveals the primary traffic patterns within the Lease Area. Three main patterns of tracks crossing the Lease Area can be observed in this view:

- The vessels exiting the outbound lane and entering the inbound lane of the Delaware Bay Southeastern Approach TSS pass through the eastern part of the Lease Area in a north-south direction.
- The tracks of vessels transiting from or to the Ocean City inlet form a fan-like pattern originating in Ocean City and crossing the Lease Area predominantly in an east-west direction.
- Tracks of vessels transiting along the coast without entering the Delaware Bay TSS pass through the Lease Area in a northeast-southwest direction.

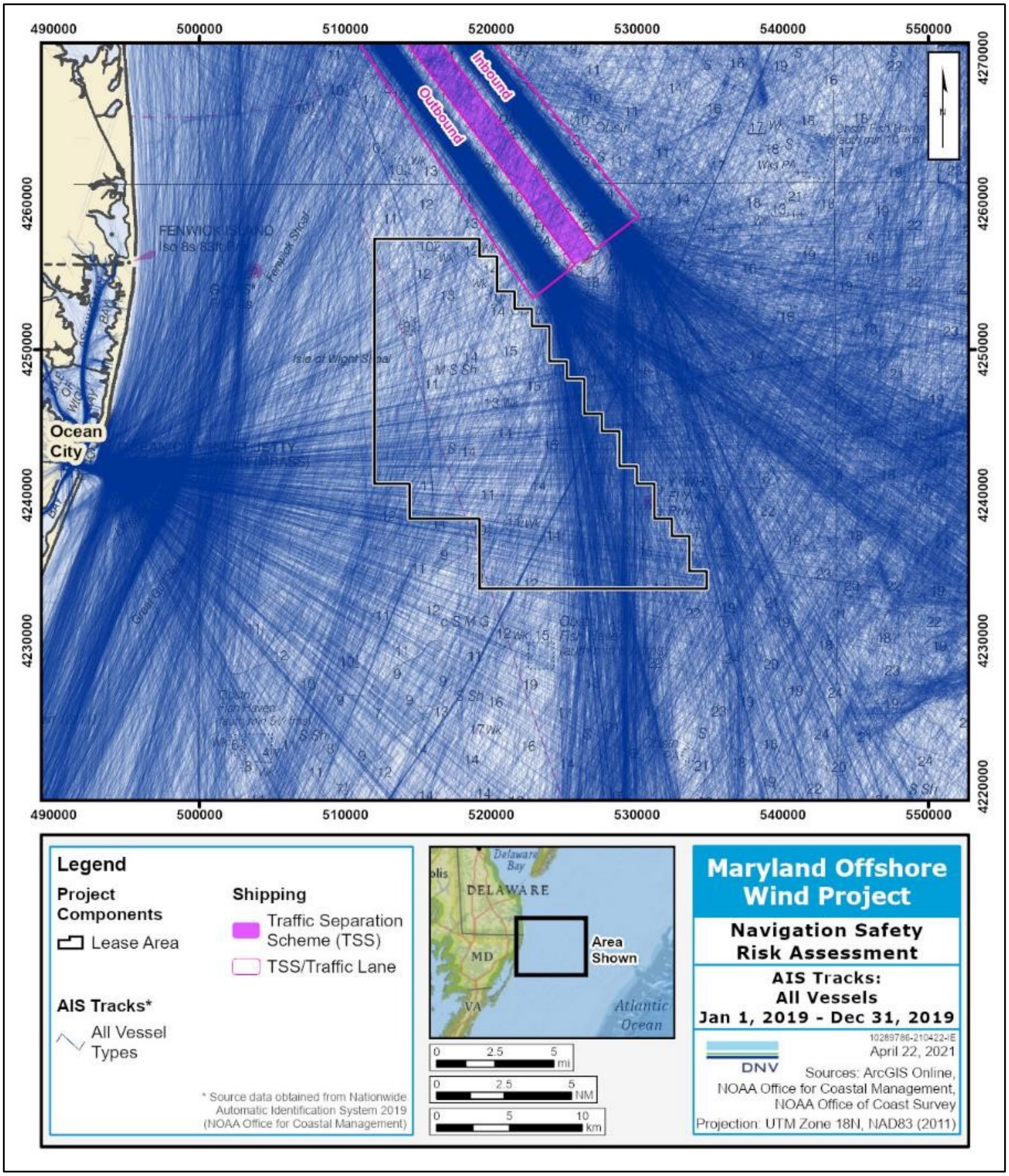


Figure 2-4 AIS Tracks in the Lease Area[6]

AIS data contain detailed vessel type information. The AIS vessel types were grouped as shown in Table 2-1 for purposes of the NSRA. Note that several vessel types including dredgers, military vessels, and pilot vessels are grouped with "Other" vessels. This was done to facilitate discussions of traffic routes and align with a framework that fits with the modeling conducted to estimate collision, allision, and grounding frequency.

Table 2-1 Groupings of AIS Vessel Types for the NSRA[6]

NSRA Vessel Type	Vessel Code in Raw AIS Data[3]	Vessel Type in Raw AIS Data[3]	Length in Raw AIS Data[3]	Number of Tracks
Cargo/Tanker	70	Cargo; all ships of this type	Any length	6,752
	71	Cargo; hazardous category A	Any length	162
	72	Cargo; hazardous category B	Any length	48
	74	Cargo; hazardous category D	Any length	2
	79	Cargo; no additional information	Any length	177
	80	Tanker; all ships of this type	Any length	2,452
	81	Tanker; hazardous category A	Any length	8
	82	Tanker; hazardous category B	Any length	3
	83	Tanker; hazardous category C	Any length	2
	84	Tanker; hazardous category D	Any length	49
	89	Tanker; no additional information	Any length	23
Cruise Ships and Large Ferries	60	Passenger; all ships of this type	≥ 75 m	1,028
Fishing	30	Fishing	Any length	10,370
Other	0	Not available or no ship; default	Any length	21
	12	Reserved for future use	Any length	20
	33	Dredging or underwater operations	Any length	8
	34	Diving operations	Any length	7
	35	Military operations	Any length	10
	38	Reserved	Any length	3
	39	Reserved	Any length	2
	47	High speed craft; reserved for future use	Any length	2
	50	Pilot Vessel	Any length	16
	51	Search and Rescue (SAR) vessel	Any length	68
	53	Port tender	Any length	15
	90	Other type; all ships of this type	Any length	3,163
	97	Other type; reserved for future use	Any length	6
	99	Other type; no additional information	Any length	29
	107	Reserved for regional use	Any length	1
	"Null" (blank)	"Null" (blank)	Any length	4,289
Passenger	60	Passenger; all ships of this type	< 75 m or Unknown	3,605
Pleasure	36	Sailing	Any length	1,688
	37	Pleasure craft	Any length	10,306
Tug	31	Towing	Any length	4,934
	32	Towing: length exceeds 200 m or breadth exceeds 25 m	Any length	25
	52	Tug	Any length	23

The distribution of AIS-based tracks among the vessel types in the Traffic Survey Area is shown in Figure 2-5.

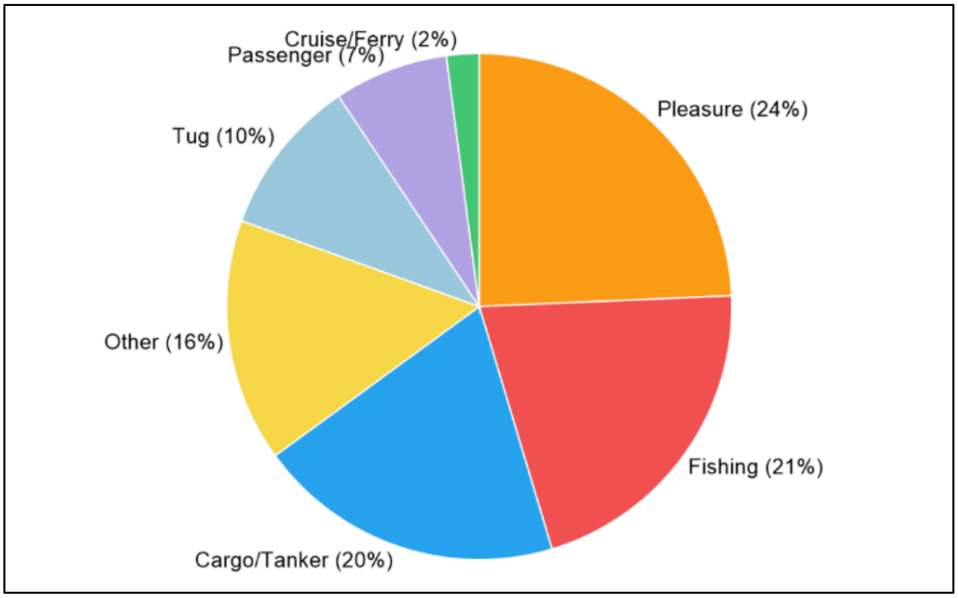


Figure 2-5 Distribution of Vessel Tracks in the Traffic Survey Area[6]

In the immediate vicinity of the Lease Area, and within the Lease Area itself, a larger proportion of the traffic is composed of deep draft vessels and a smaller proportion of the traffic is fishing vessels (Figure 2-7).

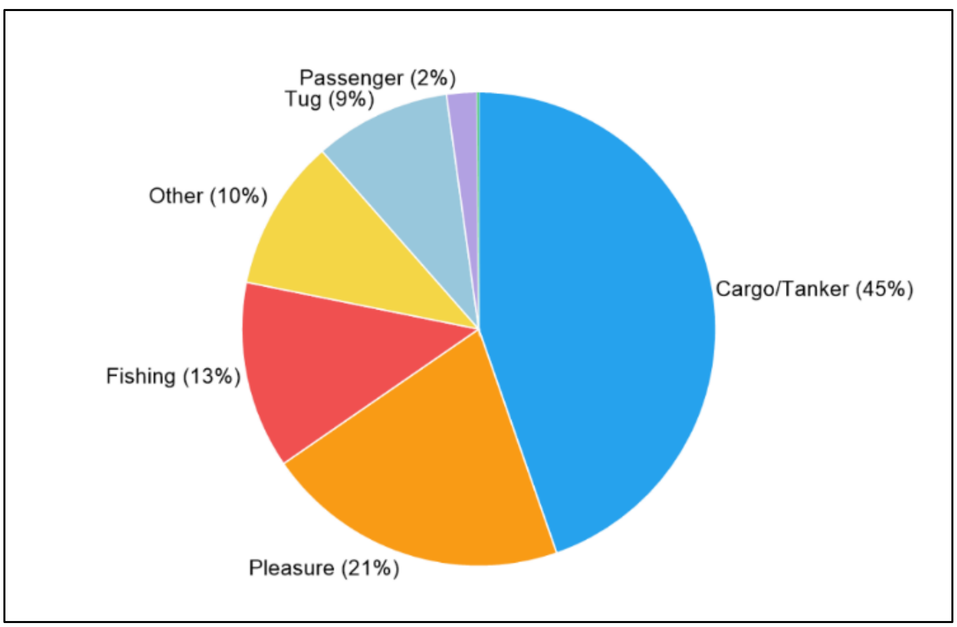


Figure 2-6 Distribution of Vessel Tracks within 4.3 NM (8 km) of the Lease Area[6]

2.1.1 Traffic patterns

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

- Cargo/Carrier and Tanker vessels (Section 2.1.1.1)
- Fishing vessels (Section 2.1.1.2)
- Cruise ships and Ferries (Section 2.1.1.3)
- Passenger vessels (Section 2.1.1.4)
- Pleasure and recreational vessels (Section 2.1.1.5)
- Tugs (Section 2.1.1.6)
- Other vessels (Section 2.1.1.7)

2.1.1.1 Cargo/Carrier and Tanker traffic

Cargo/Carrier and Tanker vessels transit the main shipping routes following the designated TSS: the Delaware Bay Eastern and Southeastern Approach TSS. Most of these vessels in the vicinity of the Lease Area pass predominantly to the north of the Lease Area. However, the traffic exiting the outbound lane of the TSS and heading south, and the traffic coming from the south and entering the inbound lane of the TSS, pass though the Lease Area. At the TSS terminus, the vessel tracks spread out, forming a fan-like pattern. The traffic coming to/from the Eastern Approach TSS does not pass in the vicinity of the Lease Area.

Figure 2-7 presents the tracks for Cargo/Carrier and Tanker vessels.

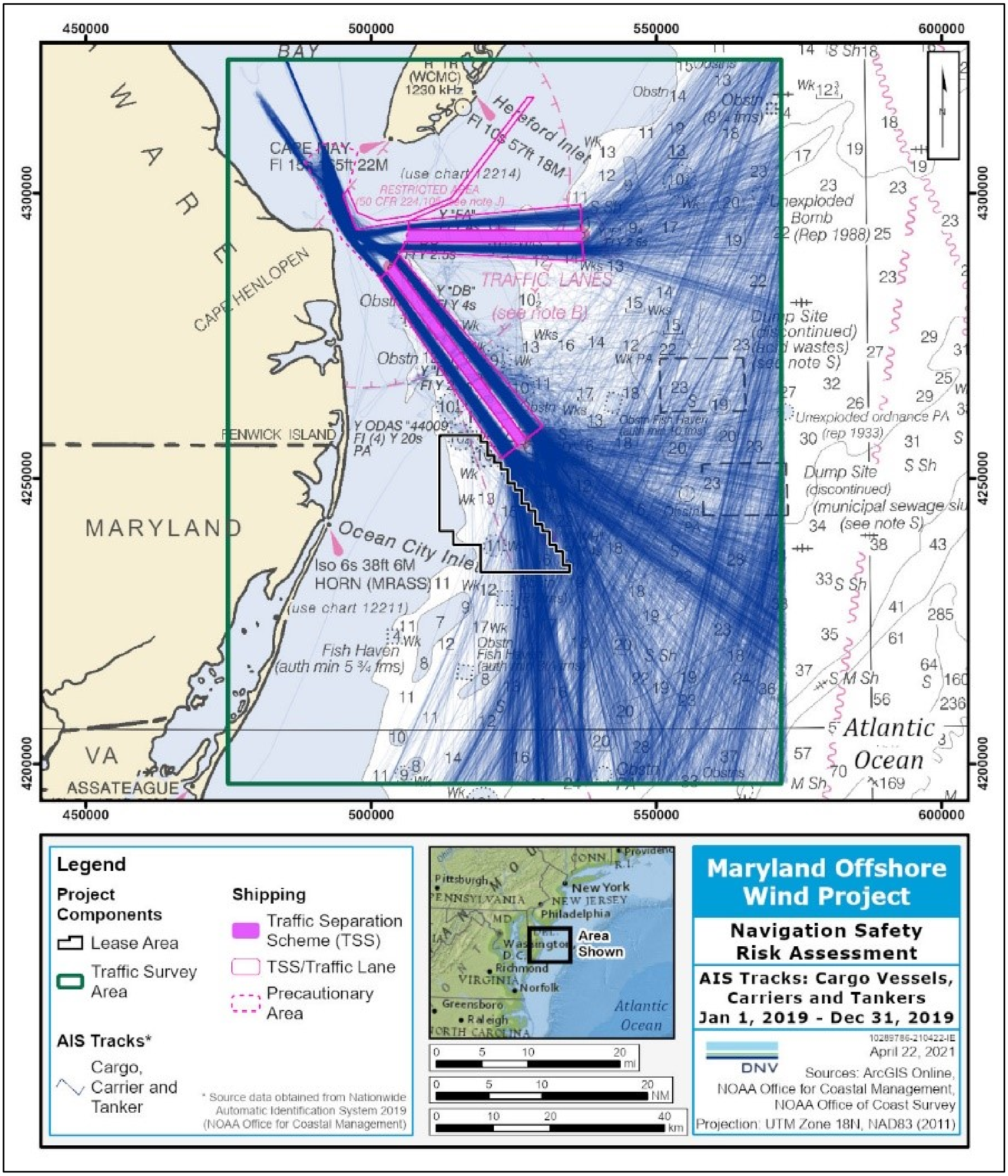


Figure 2-7 AIS Tracks for Cargo/Carriers and Tankers[6]

A review of the Cargo/Carrier and Tanker AIS tracks in the vicinity of the Project (Figure 2-8) shows that tracks pass through the Lease Area predominantly in its eastern part and aligned in a north-south direction.

Moored vessels weathervaning around their anchors produce tracks with small diameter circular patterns. Several of the Cargo/Carrier and Tanker tracks show that the vessels were moored along the southwest border of the Delaware Bay Southeastern Approach TSS, 2 to 4 NM (4 to 7 km) from the southern boundary of the outbound lane. Some of those mooring locations are within the northern part of the Lease Area and are visible as small light blue circles, for instance, south of the 10-fathom wreck near the TSS terminus. Analysis of anchorage activity is provided in Section 2.2.3.2.

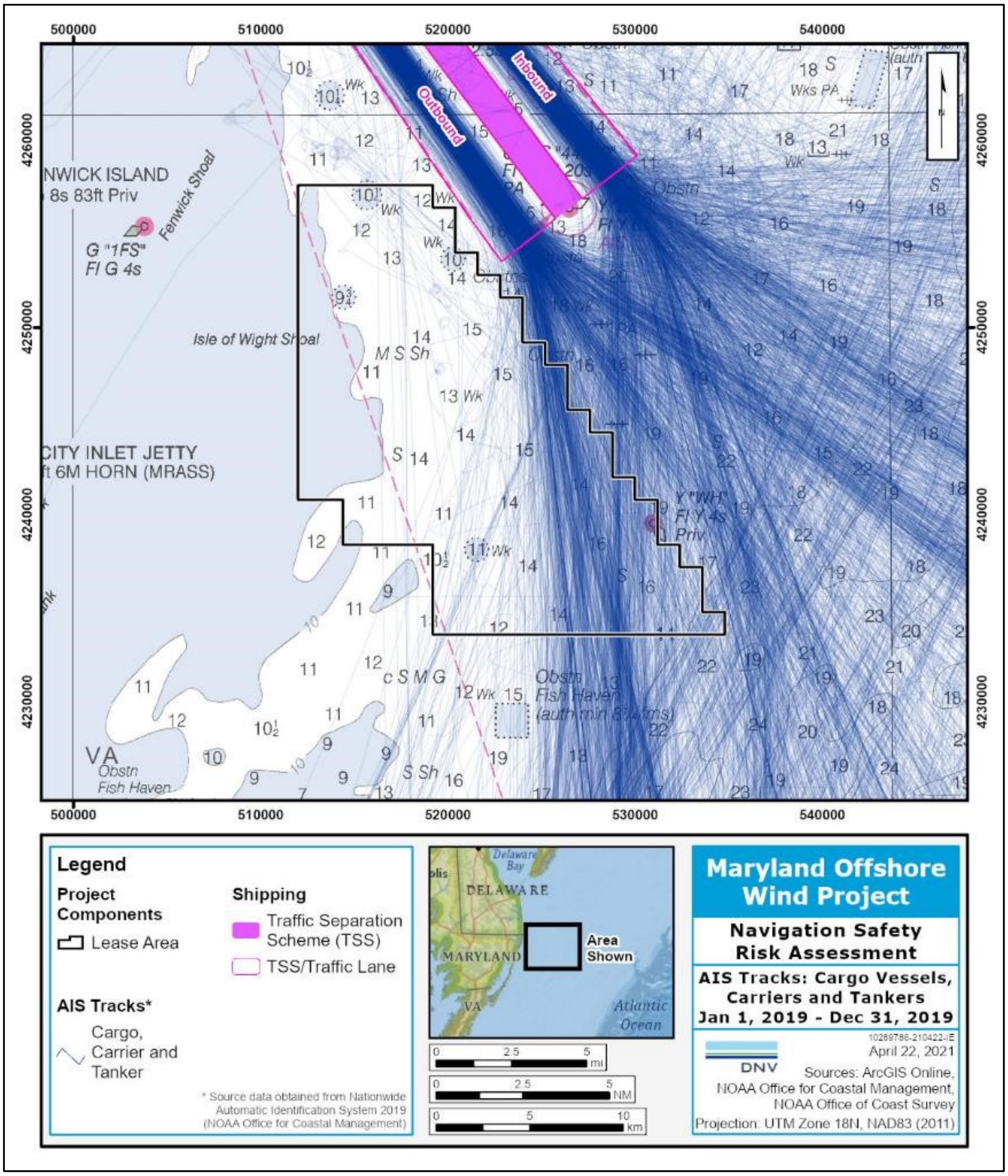


Figure 2-8 AIS Tracks for Cargo/Carriers and Tankers – Lease Area[6]

2.1.1.2 Commercial Fishing vessel traffic

Figure 2-9 presents the AIS tracks for commercial Fishing vessels in the Traffic Survey Area and Lease Area. The Fishing vessel tracks captured in the AIS data show the highest number of tracks between Cape May and fishing grounds east/northeast of the Traffic Survey Area. The AIS tracks also show significant traffic adjacent to the Maryland coast (west of the Lease Area) and between Ocean City inlet and fishing grounds east of the Lease Area.

Fishing vessel tracks in the vicinity of the Lease Area show fan-like patterns originating at fishing ports. For example, most tracks passing through the Lease Area that originate from Ocean City are generally oriented east-west. Relative to vessels originating from Ocean City, there are fewer vessels coming from Cape May that cross the Lease Area.

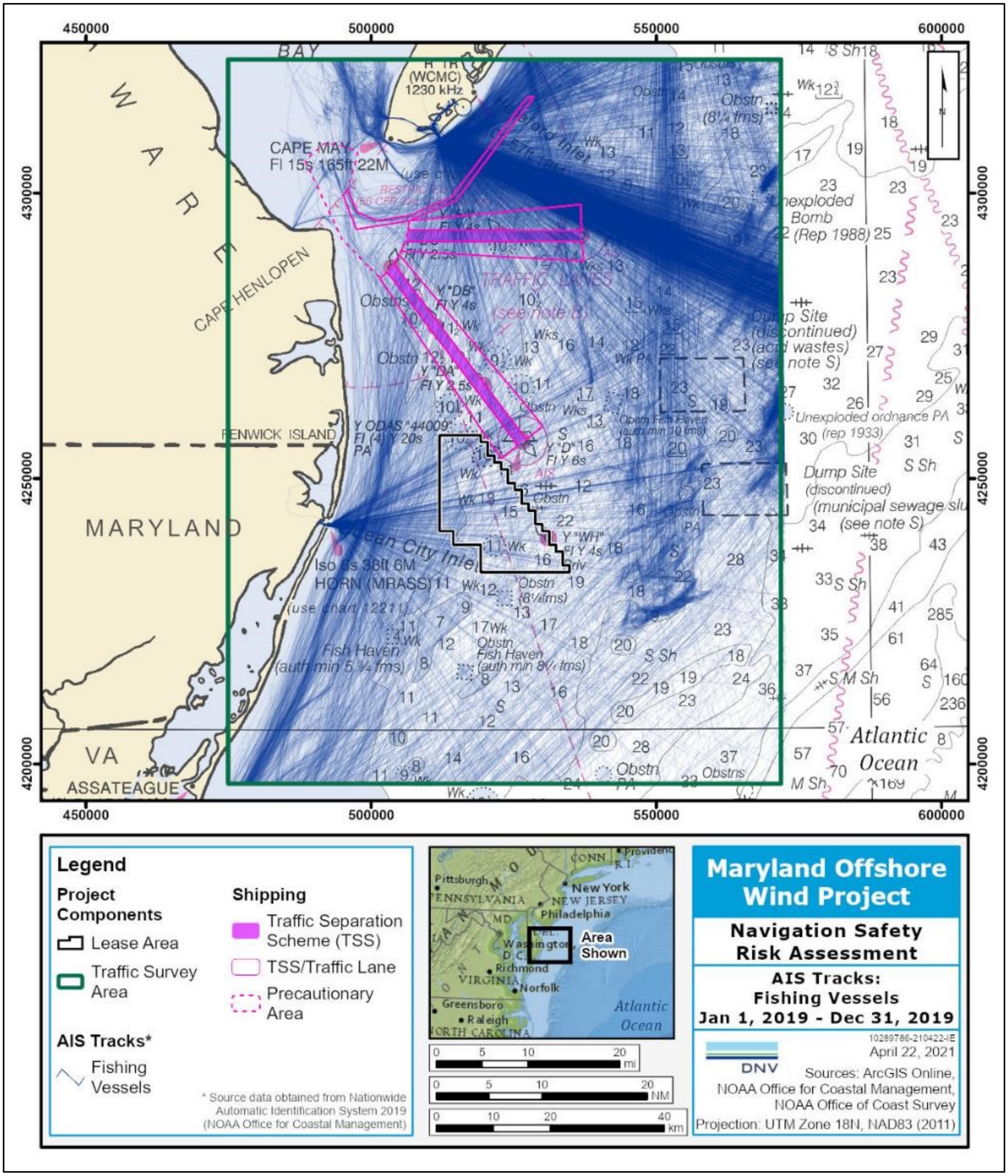


Figure 2-9 AIS Tracks for Fishing Vessels[6]

Fishing vessel activity is generally recognized as not fully captured in AIS data. A significant portion of 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 NJPARS report (USCG, 2022a), this study assumes that fishing vessels are underrepresented in the AIS data. Therefore, for the purposes of risk modeling, a reasonable maximum number of transits of non-AIS fishing vessels were estimated and added to the models that were built to estimate collision, allision, and grounding risk from the Project. The transits are summarized in Table 2-2 at the end of this Section (2.1.1.2).

Commercial Fishing vessel density

Fishing vessels generally do not travel within prescribed vessel routes like vessels in commercial trade. The fishing locations, and hence vessel routes, are closely guarded. The locations of fish populations change over time, and therefore, the level of fishing activity at a given location varies over time as well. Section 17 of COP Volume II discusses fishing activity in the existing environment.

For this NSRA, fishing activity is qualitatively evaluated in two ways:

- Fishing activity by catch – VMS data that indicate which types of fish were caught in the Traffic Survey Area. VMS data are collected by NOAA NMFS via type-approved transmitters that automatically transmit a vessel's position for relay to NMFS. Not all fishing vessels transmit VMS.
- Fishing activity by year – Combined permit / VTR data are evaluated that indicate where specific fishing gear was used in the Traffic Survey Area. 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 transits 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 Lease Area.

The USCG NJPARS Traffic Summary (USCG, 2022a) and the Chesapeake Bay PARS (CBPARS) Traffic Summary (USCG, 2021b) present fishing activity based on VMS data. To supplement the PARS data, VMS data (NROC and RPS, 2018) are used to evaluate fishing activity in the southern part of the Traffic Survey Area. The most recent year available to the public covers the period from 2015 to 2016. 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.

Fishing activity by catch (VMS data)

This section summarizes fishing activity based on VMS data. The two sets of VMS data, for the northern and southern portions of the Traffic Survey Area are reported using different categories:

Fishing vessel density in 2019 (USCG, 2021a), used in the northern portion of the Traffic Survey Area:

- Bottom Trawl
- Dredge
- Scallops
- Squid, Mackerel, Butterfish
- Surfclam and ocean quahog
- Declare out of Fishery
- No Gear or Not Applicable

Fishing vessel density while fishing at less than 5 knots (kt) for 2015-2016 (VMS) (NROC and RPS, 2018), used in the southern portion of the Traffic Survey Area:

- Herring
- Monkfish
- Multispecies
- Pelagics
- Scallops
- Squid
- Surfclam and ocean quahog

Figure 2-10 provides views of fishing activity in the northern portion of the Traffic Survey Area based on VMS data provided by USCG as part of the NJPARS Traffic Survey (USCG, 2022a) for the year 2019. The color scale in the figure is based on relative values rather than absolute values. An area defined as “High” indicates higher than average fishing activity compared within the boundaries of the NJPARS Traffic Study (approximately from Neptune City to Ocean City).

The below figures indicate that most of the significant fishing activity occurs outside the Lease Area. The main fishing grounds appear to be 10 to 50 NM (18 to 93 km) east of the Lease Area along the edge of the continental shelf. However, there are a significant number of fishing tracks between Ocean City and those fishing grounds which pass through the Lease Area. This traffic crosses the Lease Area predominantly in an east-west direction and has a comparatively “high” to “very high” density.

The most obvious Fishing vessel traffic patterns (previous Figure 2-9) from Cape May and Ocean City to fishing grounds are consistent with the VMS data patterns shown in Figure 2-10.

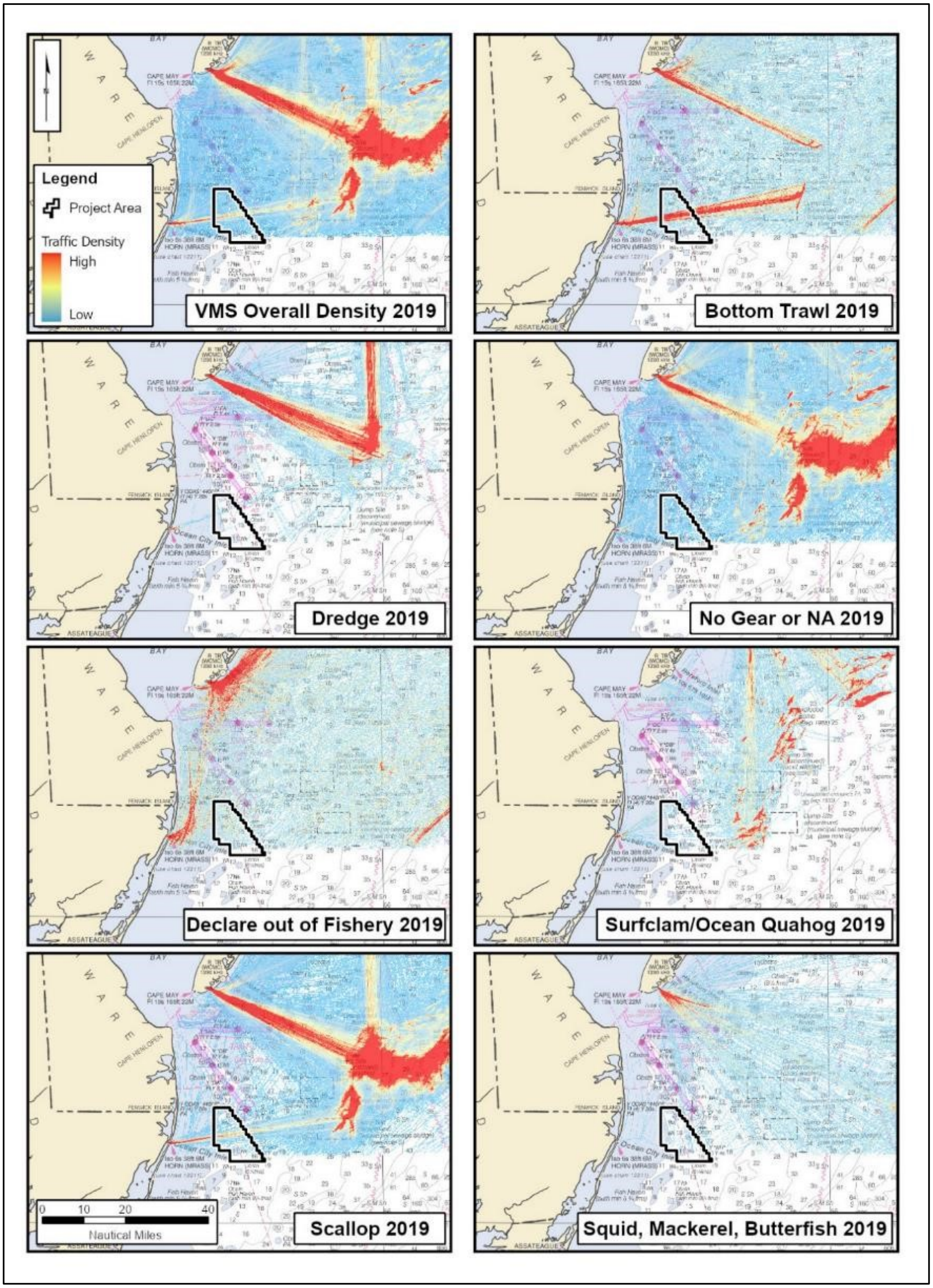


Figure 2-10 Commercial Fishing Vessel Density in 2019 (USCG, 2021a)

Figure 2-11 provides views of fishing activity in the Traffic Survey Area based on VMS data provided by NMFS in 2015 and 2016. Only the Fishing vessel activity at reduced speeds (below 4 or 5 kt) is displayed in the figures to capture the vessels actively fishing as opposed to the vessels in transit. As with Figure 2-10, the color scales in Figure 2-11 show relative values. 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).

Despite some small variations in the fishing grounds locations, the patterns observed in the VMS data from 2015 to 2016 are generally consistent with the VMS data from 2019 in Figure 2-10 and corroborate that a comparatively low level of fishing activity is occurring within the Lease Area.

The closest fishing activity to the Lease Area was surfclam/ocean quahog, approximately 5 NM (9 km) to the east. The linear pattern recorded for scallop Fishing vessels between Ocean City and the fishing grounds, and passing through the Lease Area, most likely represents vessels transiting at less than 5 kt rather than actual fishing activity (Sea Risk Solutions, 2001).

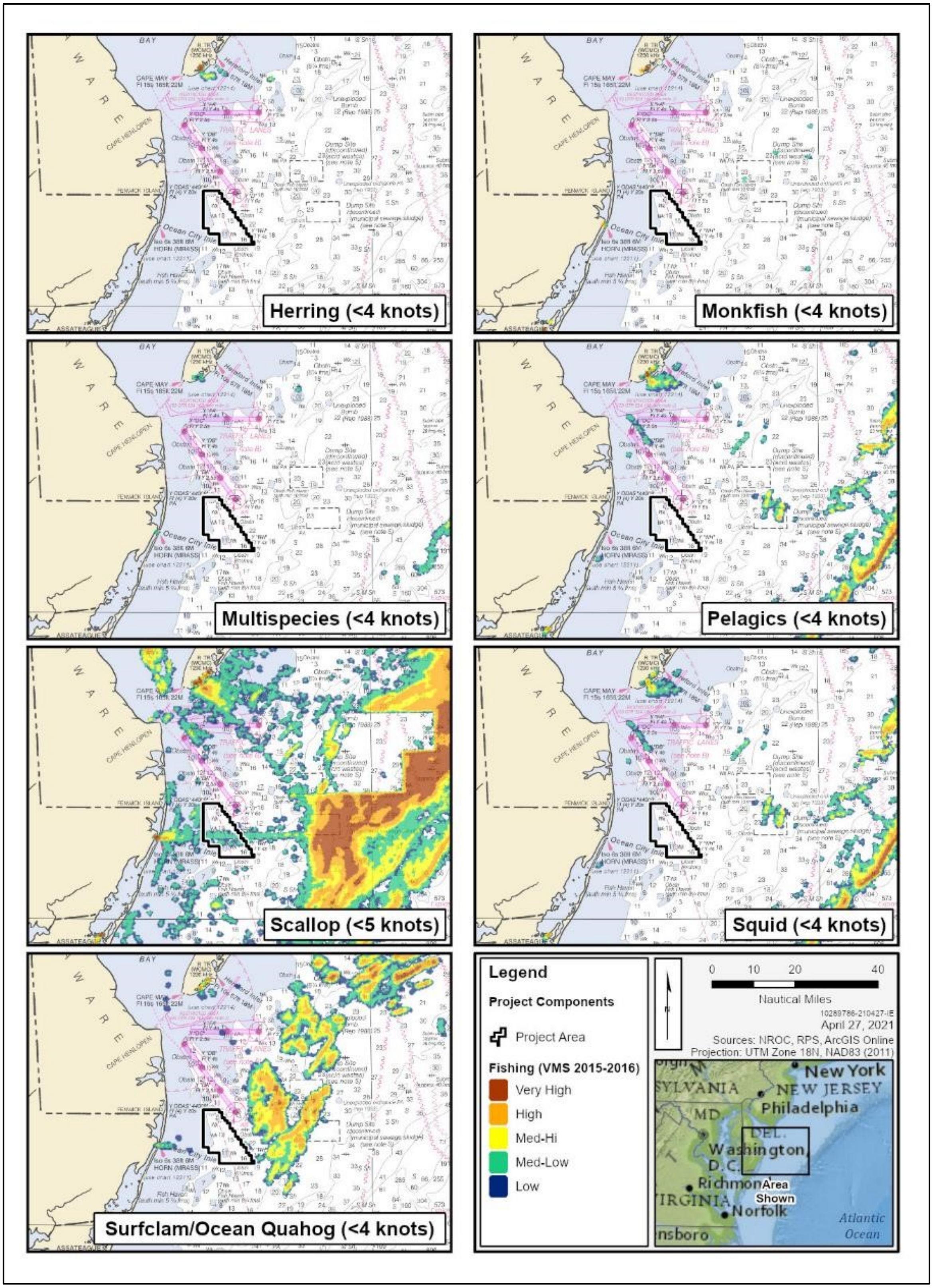


Figure 2-11 Commercial Fishing Vessel Density at less than 5 kt - 2015-2016 (VMS) (NROC and RPS, 2018)

The polar histograms of VMS activity shown in Figure 2-12 and Figure 2-13 represent the courses of fishing vessels passing through the Lease Area between January and August 2019 (BOEM, 2021a). The courses of vessels passing through the Lease Area correlate well with the AIS and VMS tracks:

- The fishing vessels predominantly crossed the Lease Area in an east-west direction, between Ocean City and the eastern fishing grounds. The vessels transiting from Ocean City were almost exclusively identified as fishing for scallops or surfclam/ocean quahog.
- A significant portion of the fishing vessels passed through the Lease Area in a 30º-210º direction aligned with the coastline. These vessels were predominantly identified as “Declared Out of Fisheries” in the VMS data.
- A smaller portion of the fishing vessels sailed through the Lease Area in a north-south direction, which is the alignment to transit from and to Cape May.
- Approximately four times as many vessels transited faster than 5 kt in the Lease Area than transited at slower speeds. The overwhelming majority of the slower vessels were heading west, in the direction of Ocean City, which is consistent with laden transit back to port at reduced speed.

Figure 2-12 VMS Activity by Course in the Lease Area – Jan to Aug 2019 (BOEM, 2021a) (1 of 2)

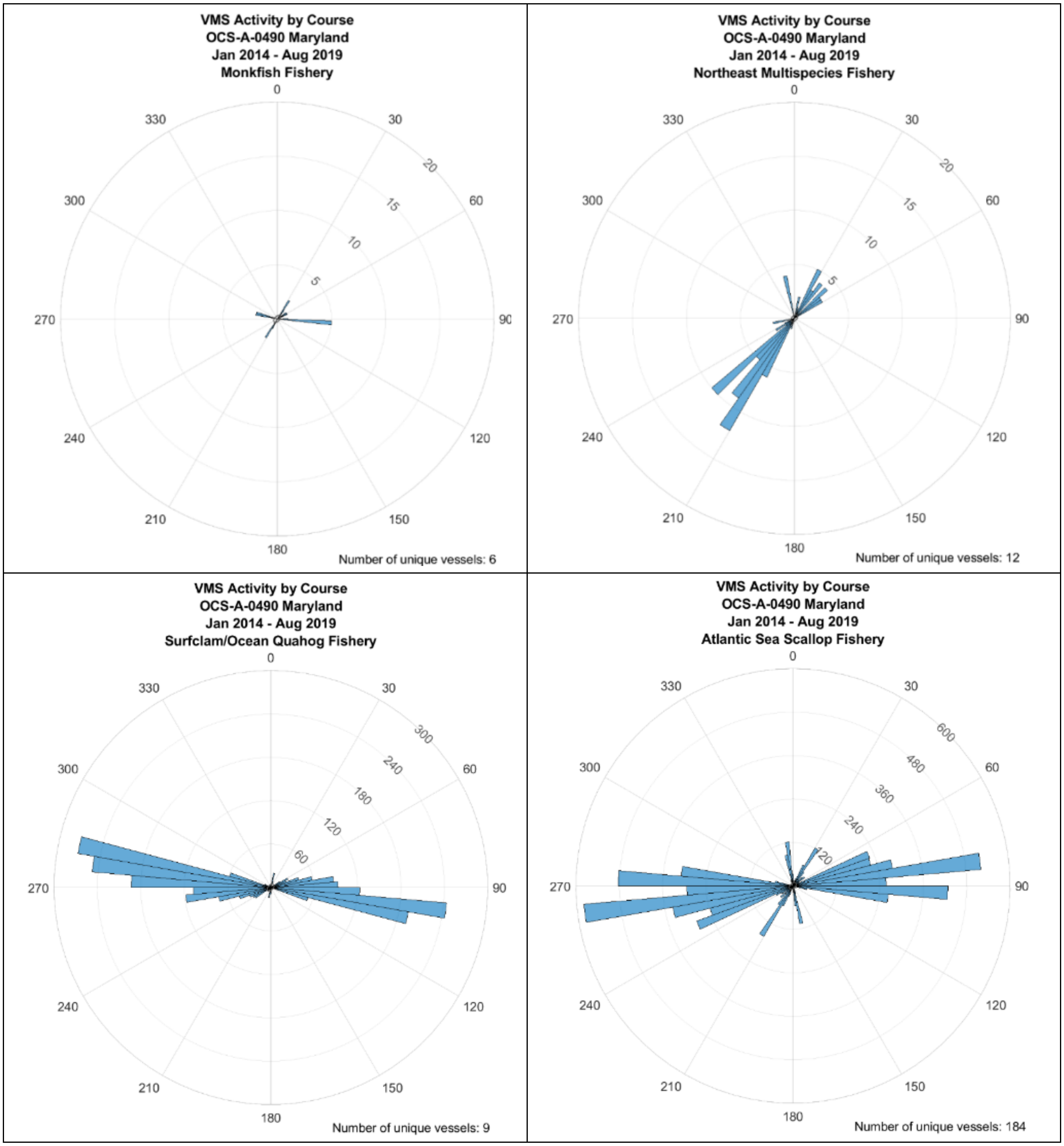


Figure 2-13 VMS Activity by Course in the Lease Area – Jan to Aug 2019 (BOEM, 2021a) (2 of 2)

Fishing activity by gear (VTR data)

The major commercial fishing ports closest to the Lease Area are Ocean City and Cape May.

The most recent available data were obtained for fishing gear use in the Traffic Survey Area, these data represent the period 2011 through 2015 and are provided by Communities at Sea (NOAA, 2016). Figure 2-14 shows activity level by fishing gear type. These data show comparatively low level of activity of all fishing gear in the Lease Area. Generally, the locations of the main fishing grounds visible on the VTR data are consistent with those visible on the VMS data, 5 to 50 NM (18 to 93 km) east of the Lease Area. Only the pots and traps VTR records show a comparatively medium level of activity at the eastern boundary of the Lease Area, which is not clearly visible in the VMS data. Gillnet fishing occurs in the Lease Area, at a level that is defined as “Less” than other areas in the mid-Atlantic, indicating that the Lease Area is not a major destination for gillnet fishing, although it does occur.

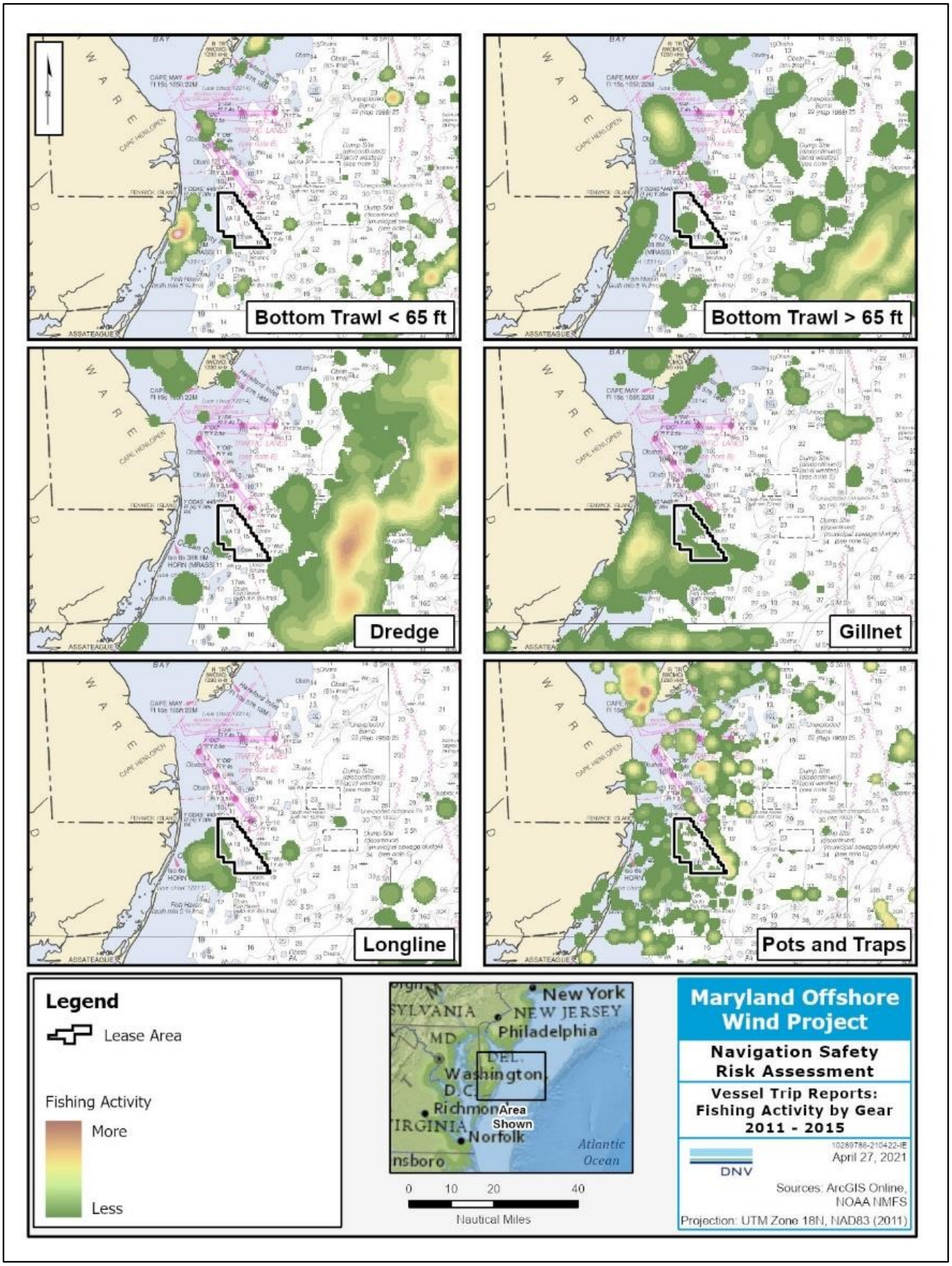


Figure 2-14 Fishing Activity by Gear Types, 2011 – 2015 (NOAA, 2016)

Traffic added to AIS for the purpose of risk modeling

The collision, allision, and grounding risk from the Project was estimated by modeling a Base Case without the Project and a Future Case assuming all Project structures are constructed. For the purposes of modeling collision, allision, and grounding risk described in Section 11, additional Fishing vessel transits were estimated and added to the AIS traffic (Table 2-2).

Table 2-2 Commercial Fishing Vessel Transits Added to the AIS Tracks for Risk Modeling

Vessel type and activity	Adjusted number of tracks per year	Routes	Model case
Commercial fishing vessels – transiting to and transiting through the Lease Area	Increase the number of tracks in AIS data by 50% to account for vessel transits not indicated in the data. Reason: Fishing vessels may not transmit AIS or their signals may not be received because they are lower priority AIS-B signals.	All Fishing vessel routes in the MARCS Study Area.	Base Case and Future Case

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 in the AIS data and had reported lengths greater than 75 m (246 ft). Figure 2-15 shows that Cruise Ships and Large Ferries primarily followed established routes in Delaware Bay between Cape May, New Jersey and Lewes, Delaware, 30 NM (56 km) north of the Lease Area. Additional tracks of this vessel type follow a northeast-southwest direction parallel to the coast. The majority of this traffic passed 25 NM (46 km) east of the Lease Area and only a very few tracks were recorded through or close to the Lease Area. Cruise ships do not typically call on Delaware Bay ports. [7]

[7] The only Cruise ship in 2019 AIS data was the Anthem of the Seas, which transited the Traffic Survey Area in January 2019.

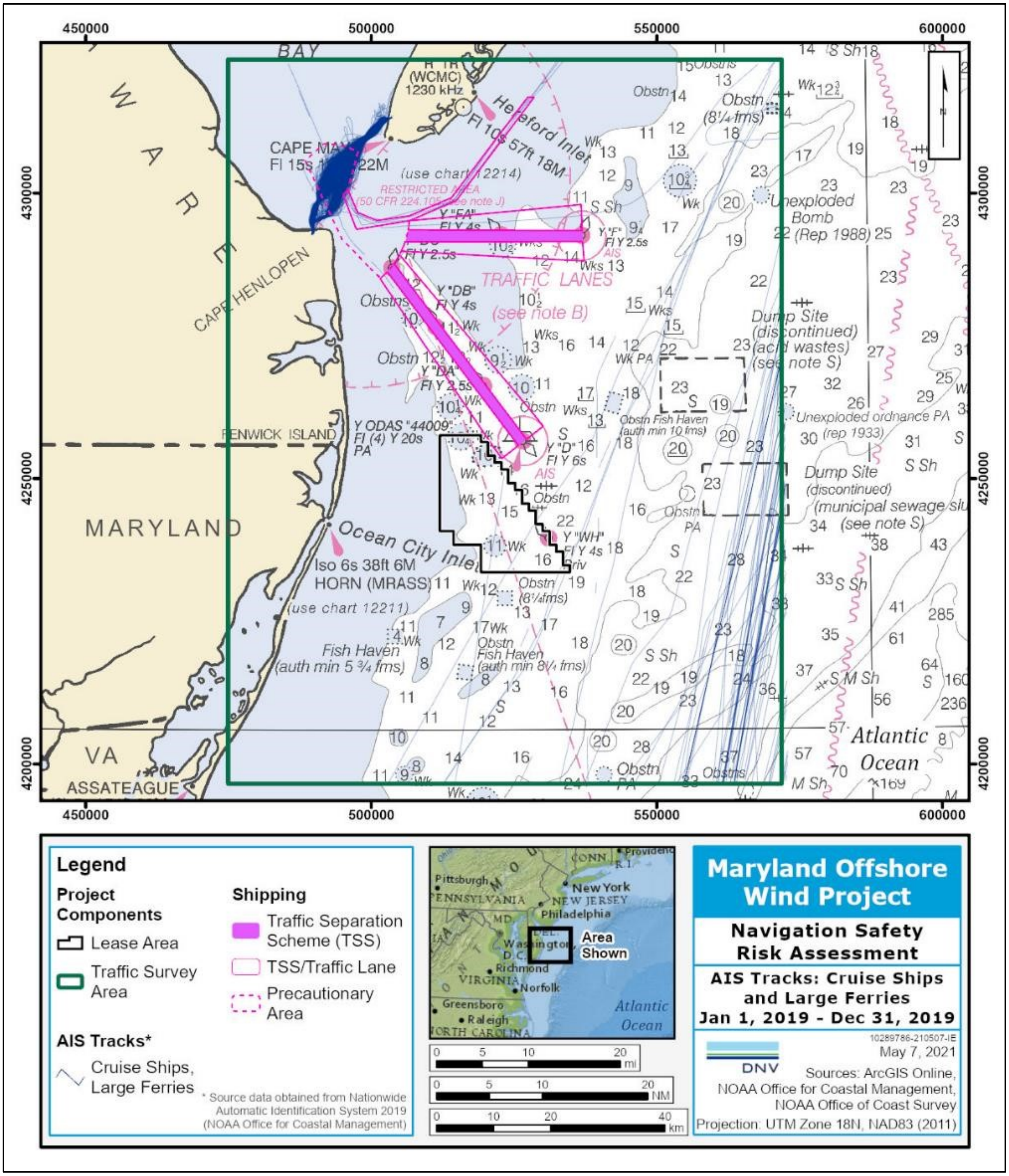


Figure 2-15 AIS Tracks for Cruise Ships and Large Ferries[6]

2.1.1.4 Passenger vessel traffic

For this NSRA, vessels were designated as the type “Passenger” if they were indicated as passenger type in the AIS data and had reported lengths less than 75 m (243 ft). Figure 2-16 shows that most of the Passenger vessels navigate near shore, in the vicinity of the Delaware Bay inlet, particularly to and from Mispillion River Lewes, and Cape May. Some Passenger vessels transit further offshore, forming fan-like patterns from Delaware Bay, Cape May, and Ocean City inlets. Most of the Passenger vessels passing through the Lease Area were transiting from or to Ocean City in the southern part of the Lease Area in an east-west direction.

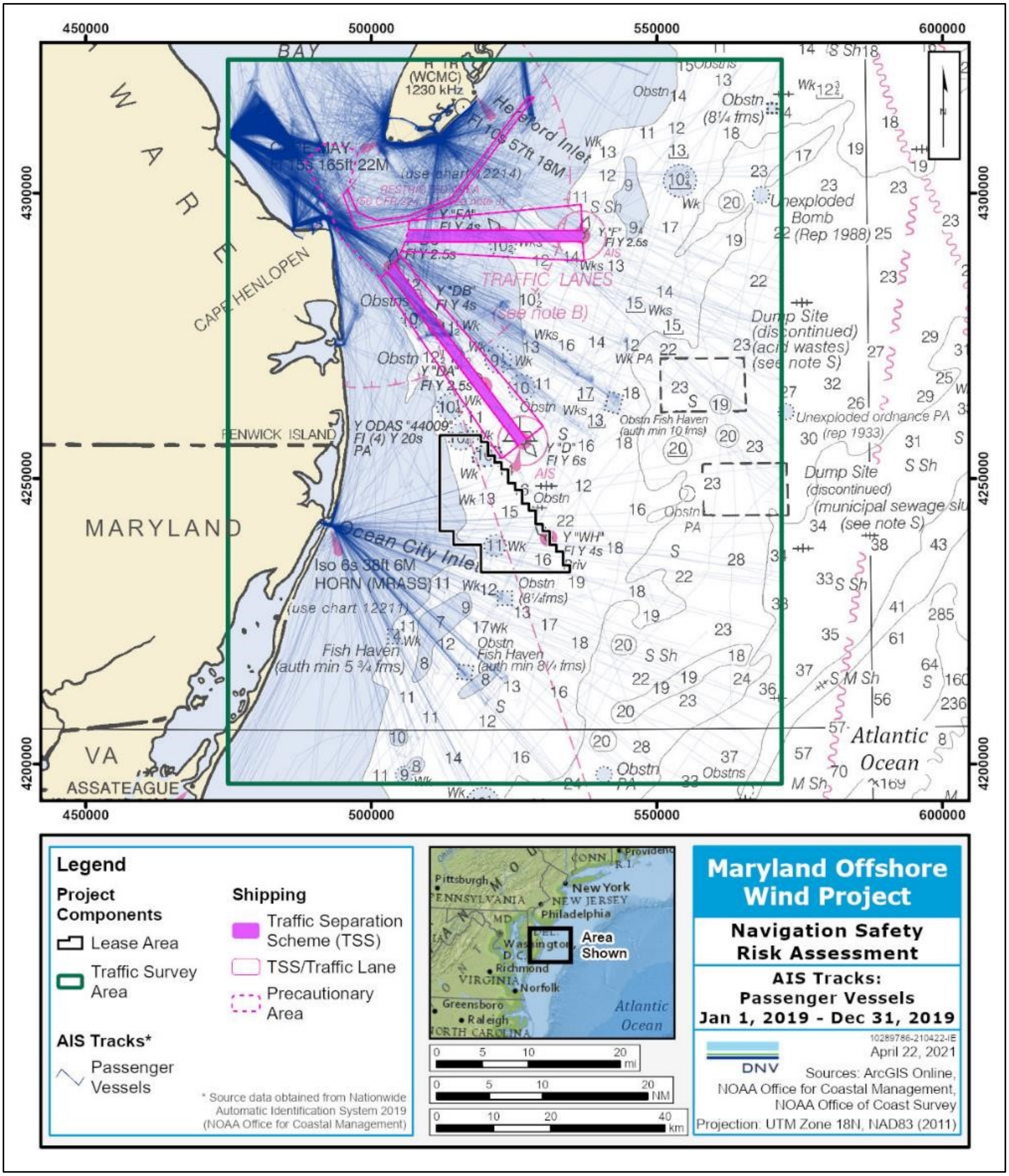


Figure 2-16 AIS Tracks for Passenger Vessels[6]

Traffic added to AIS for the purpose of risk modeling

The collision, allision, and grounding risk from the Project was estimated by modeling a Base Case without the Project and a Future Case assuming all Project structures are constructed. For the purposes of modeling collision, allision, and grounding risk described in Section 11, additional Passenger vessel transits were estimated and added to the AIS traffic (Table 2-4).

Table 2-3 Passenger Vessel Transits Added to the AIS Tracks for Risk Modeling

Vessel type and activity	Number of transits per year	Routes	Model case
Crew Transfer Vessel (CTV) transits supporting Project operation	1200 transits (600 each direction) Based on the following estimated average: • 2 round trips per day	Ocean City – Lease Area	Future Case

2.1.1.5 Pleasure / Recreational vessel traffic

Figure 2-17 shows Pleasure vessels AIS track densities in the Traffic Survey Area. The Recreational vessels traffic predominantly occurs along the coast east of the Lease Area.

The tracks also form fan-like patterns from Cape May and Ocean City inlets. The tracks passing through the Lease Area generally have a northeast-southwest or east-west directionality.

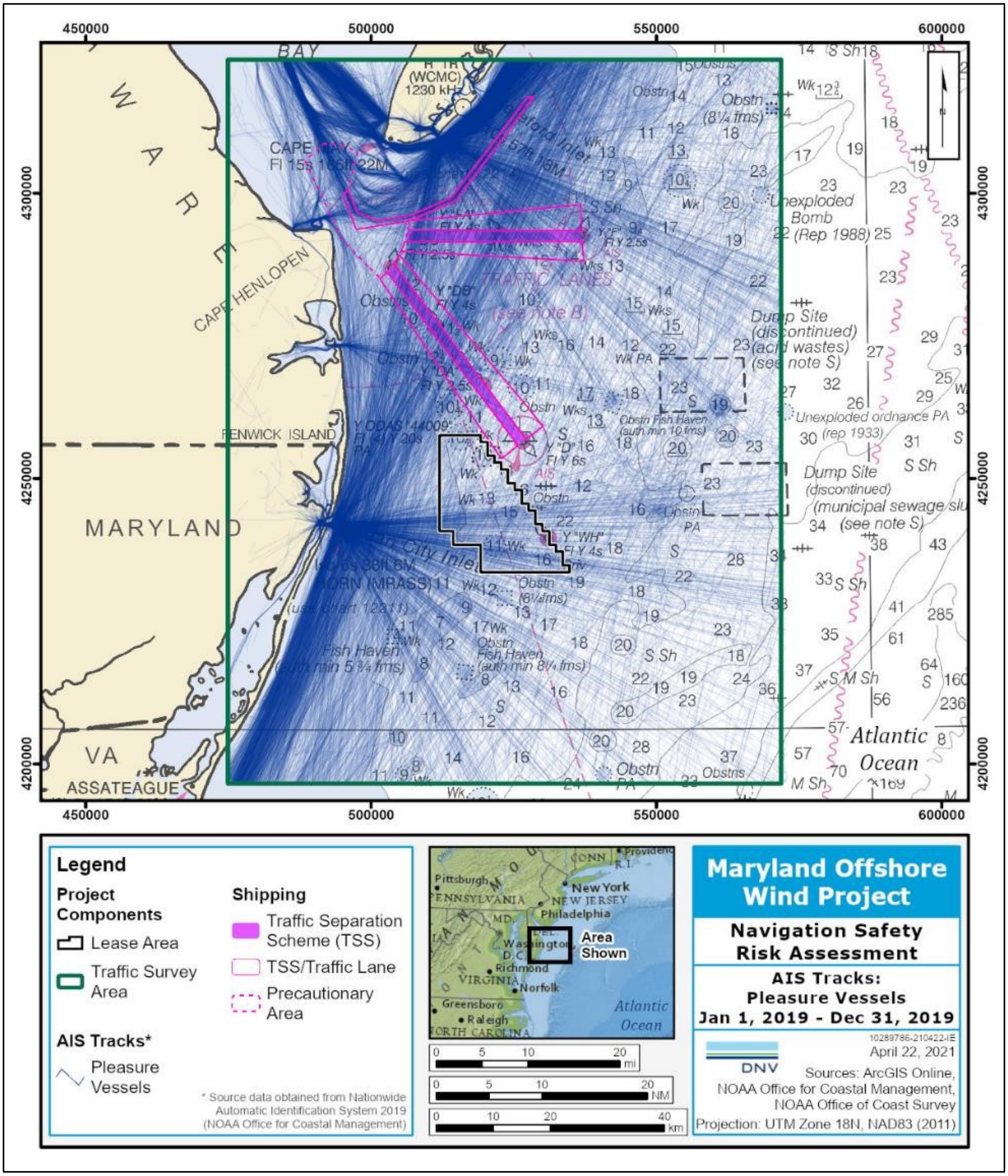


Figure 2-17 AIS Tracks for Pleasure/Recreational Vessels[6]

Traffic added to AIS for the purpose of risk modeling

The collision, allision, and grounding risk from the Project was estimated by modeling a Base Case without the Project and a Future Case assuming all Project structures are constructed. For the purposes of modeling collision, allision, and grounding risk described in Section 11, additional Pleasure vessel transits were estimated and added to the AIS traffic (Table 2-4). The below estimates were developed together with Sea Risk Solutions, which has been in close communication with the local fishing communities.

The following estimates were inputs to the below values:

- $^{2}/_{3}$ of all new fishing traffic in the MARCS Study Area would originate from Ocean City, Maryland
- $^{1}/_{6}$ of all new fishing traffic in the MARCS Study Area would originate from Indian River Inlet, Delaware; $^{1}/_{2}$ of this traffic is assumed to transit to offshore wind leases other than US Wind's lease.
- $^{1}/_{6}$ of all new fishing traffic in the MARCS Study Area would originate from Cape Lewes, Delaware; $^{1}/_{2}$ of this traffic is assumed to transit to offshore wind leases other than US Wind's lease.

Table 2-4 Pleasure Vessel Transits Added to the AIS Tracks for Risk Modeling

Vessel Type and Activity	Additional Number of Transits per Year	Routes	Model Case
Pleasure vessel transits for current/ongoing recreational fishing	2,440 transits (1,220 each direction) Based on the following estimated averages: 2 round trips per day – December to March 3 round trips per day – April & September to November 5 round trips per day May through August	Ocean City – Lease Area	Base Case and Future Case
Pleasure vessel transits for new recreational fishing, charters, and/or tours after Project construction	3,644 transits (1,822 each direction) 424 transits (212 each direction) Based on the following estimated averages: 12.5 round trips per day – May to September 7 round trips per day – April, October, November 1 round trip per day – June to September	Ocean City – Lease Area Indian River Inlet – Lease Area	Future Case

2.1.1.6 Tug traffic

For this NSRA, vessels were designated as the type "Tug" if they were indicated as tug in the AIS data.

The Tug category includes different towing configurations: towing lines, tugs towing alongside or from the stern, and Articulated Tug Barges (ATB). The different towing configurations are not accurately distinguishable in the AIS data as some of the vessels are able to be used in more than one configuration, and the vast majority of AIS data points were self-identified under the same AIS code 31 (“Towing”). The three primary configurations used in the Traffic Survey Area are:

- Hawser – In a hawser tow configuration, the Tug is pulling a barge or another vessel with a towing line between the bow of the towed package to the stern of the Tug placed in front. The length of the towline can exceed 200 m (722 ft) and the set has poor maneuverability. This configuration is mostly implemented in open waters such as the lower Delaware Bay and outside the Bay, along the coast.
- Alongside or astern – Tugs towing barges (referred to as Tug-Tow) from the stern or alongside are connected with tight head and/or stern lines. This configuration allows excellent maneuverability but limits the towing speed. This configuration is predominantly used in protected waterways and ports and is therefore very unlikely to transit in the vicinity of the Lease Area.
- Articulated – ATBs consist of a barge and a special tug that is positioned in a notch in the stern of the barge, forming a rigid unit which enables the tug to propel and maneuver the barge. This configuration provides both good maneuverability and transit speed and is used both in congested and open water. The Delaware Pilot Association, contacted by DNV, estimates that the proportion of tugs outside the Delaware Bay is made up of approximately 60% ATBs and 40% hawser line configuration.

Figure 2-18 shows that Tug traffic consistently used the two-way traffic lane from the Delaware Bay that ends northeast of Hereford Inlet. Near the end of this lane, the traffic splits as it moves up the coast.

However, only a portion of the tugs transiting from or to Delaware Bay inlet from to the south used the Delaware Bay Southeastern Approach TSS. A significant portion of these tugs accessed the Delaware Bay inlet via the coast from the south, avoiding the TSS. Analysis of marine traffic by the USCG shows that an average of approximately 5 tugs per day use this route (USCG, 2021a).

A large proportion of Tug tracks recorded in the Traffic Survey Area were transiting in a northeast-southwest direction along the coast without entering the Delaware Bay. These tugs did not consistently follow determined routes, but seem to follow unofficial lanes, approximately 4 and 12 NM (7 and 22 km) from the coast.

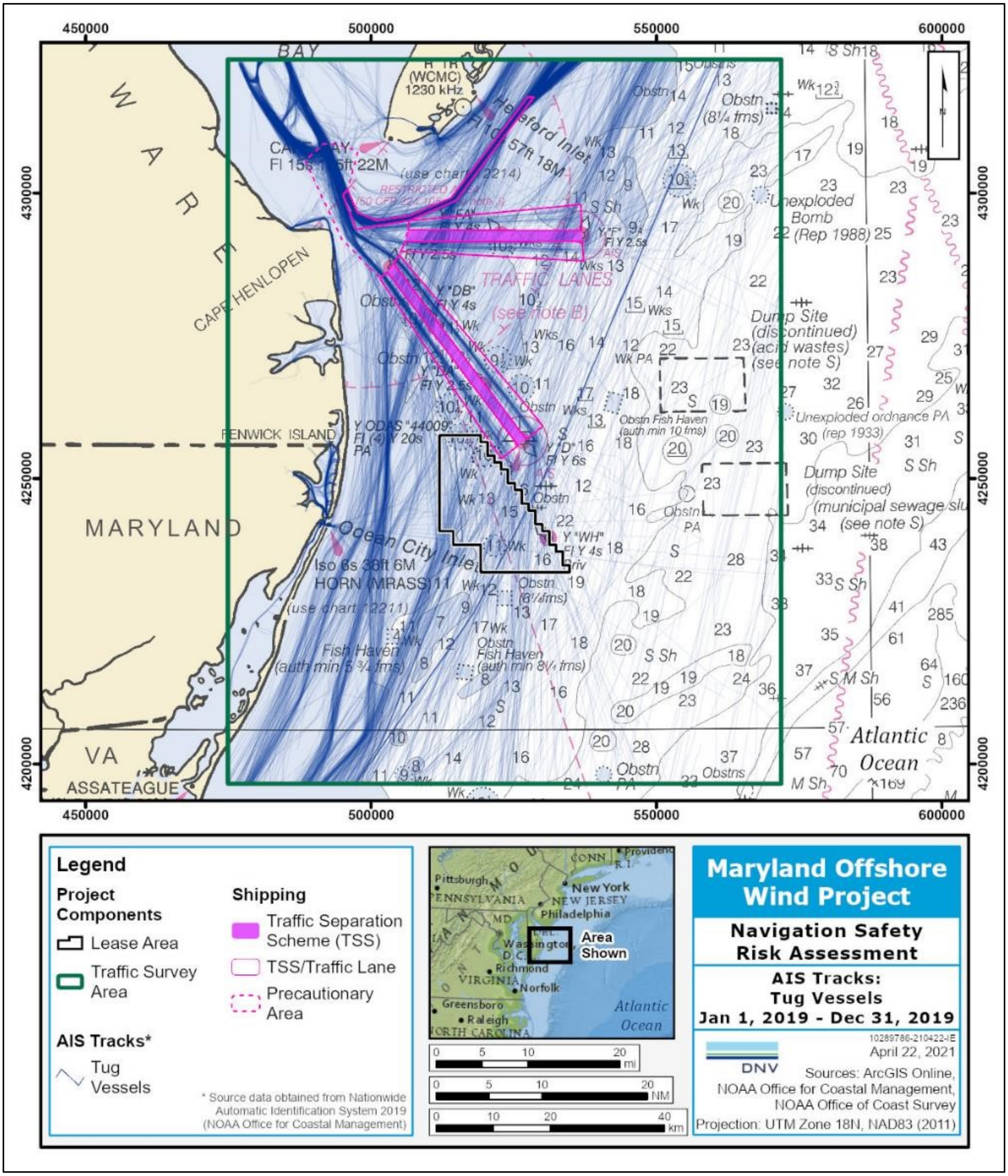


Figure 2-18 AIS Tracks for Tugs[6]

Figure 2-19 shows that Tugs transiting along the coast predominantly cross the Lease Area with a northeast-southwest directionality, while tugs entering and exiting the Southeastern Approach TSS cross the Lease Area with a north-south directionality.

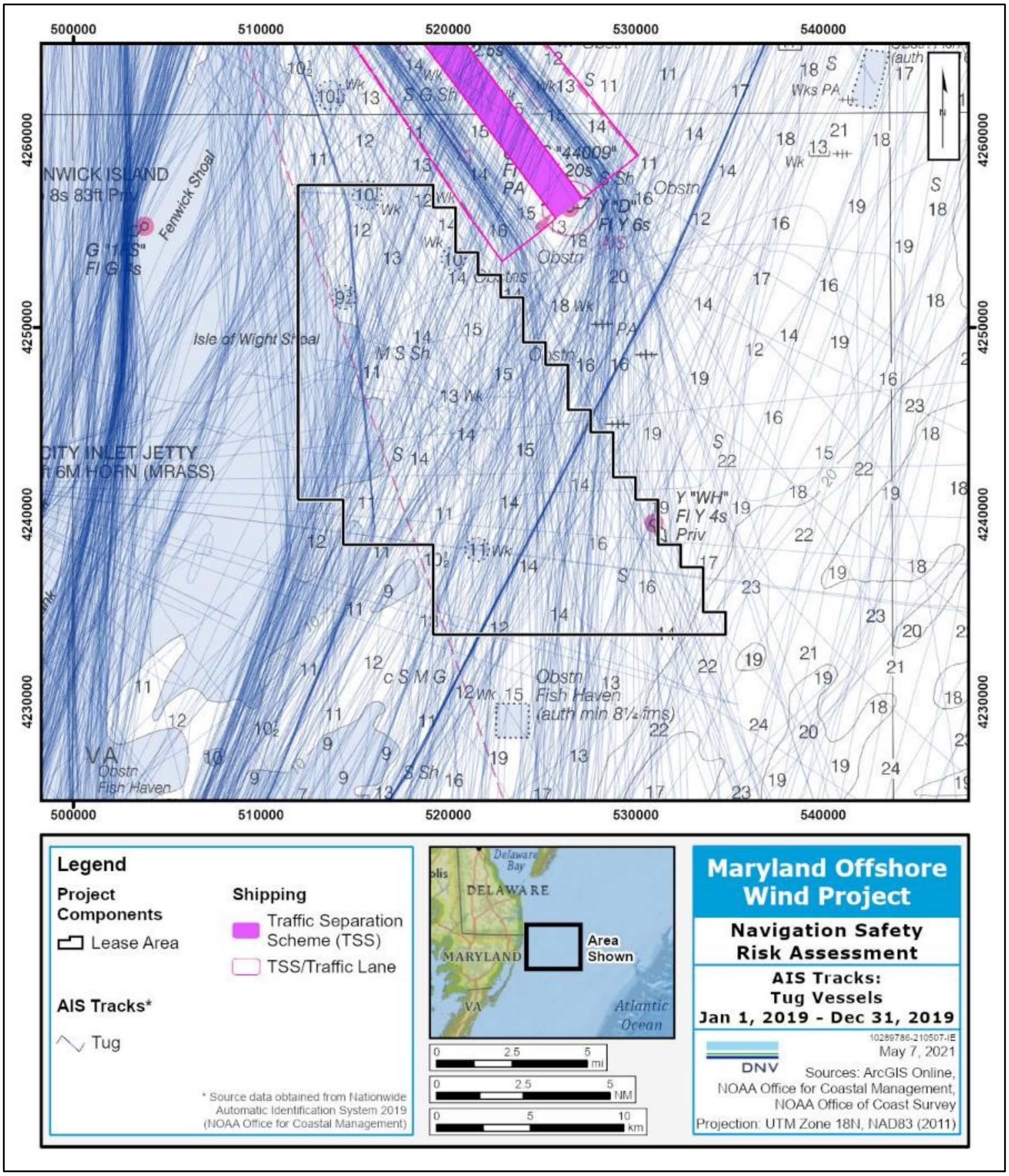


Figure 2-19 AIS Tracks for Tugs – Lease Area[6]

2.1.1.7 Other vessel traffic

AIS tracks for the Other vessel type is presented in Figure 2-20. When a vessel type is not selected in AIS by the operator, the vessel is included in this category. A complete list of AIS types that comprise the Other category is provided in Table 2-1.

A high density of AIS tracks was recorded near Cape May and Rehoboth Beach, 20 NM (37 km) north of the Lease Area. Vessels classified as Other also used the two-way traffic lane from the Delaware Bay that ends northeast of Hereford Inlet.

The rest of the traffic categorized as Other did not follow obvious patterns in the Traffic Survey Area or in the Lease Area.

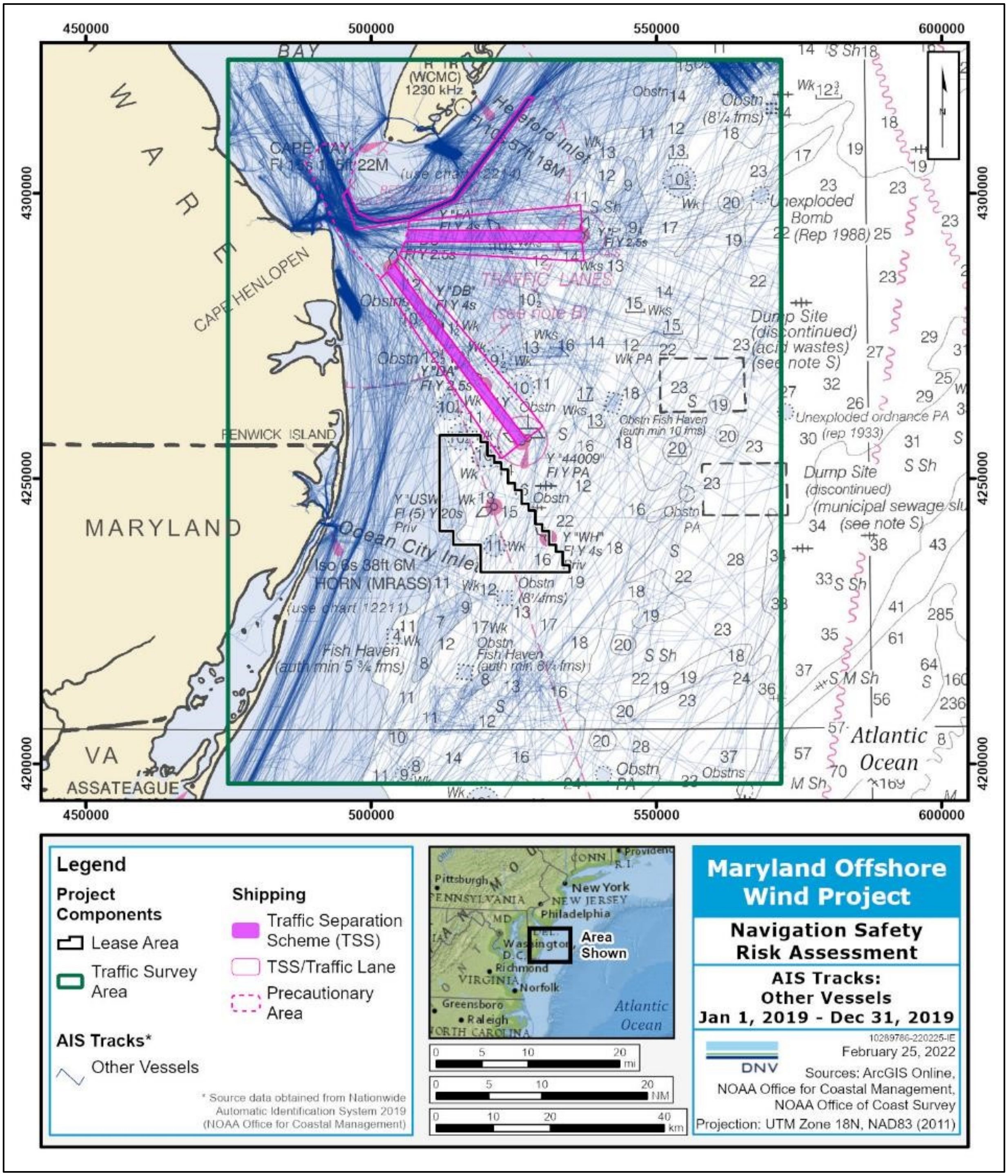


Figure 2-20 AIS Tracks for Vessel Type Other[6]

2.1.2 Traffic density

Figure 2-21 presents track densities for all AIS traffic in the Traffic Survey Area. Track density maps for each vessel type are provided in Appendix A.

The track density shows an intense activity in the TSS as well as in the vicinity of Cape May, Delaware Bay, and Ocean City inlets. Because the terminus of the Delaware Bay Southeastern Approach TSS is just northeast of the Lease Area, a higher level of traffic density is observed in the eastern part of the Lease Area. The traffic in the western part of the Lease Area is significantly less dense, with less than 20 tracks per 100 x 100 m grid cell.

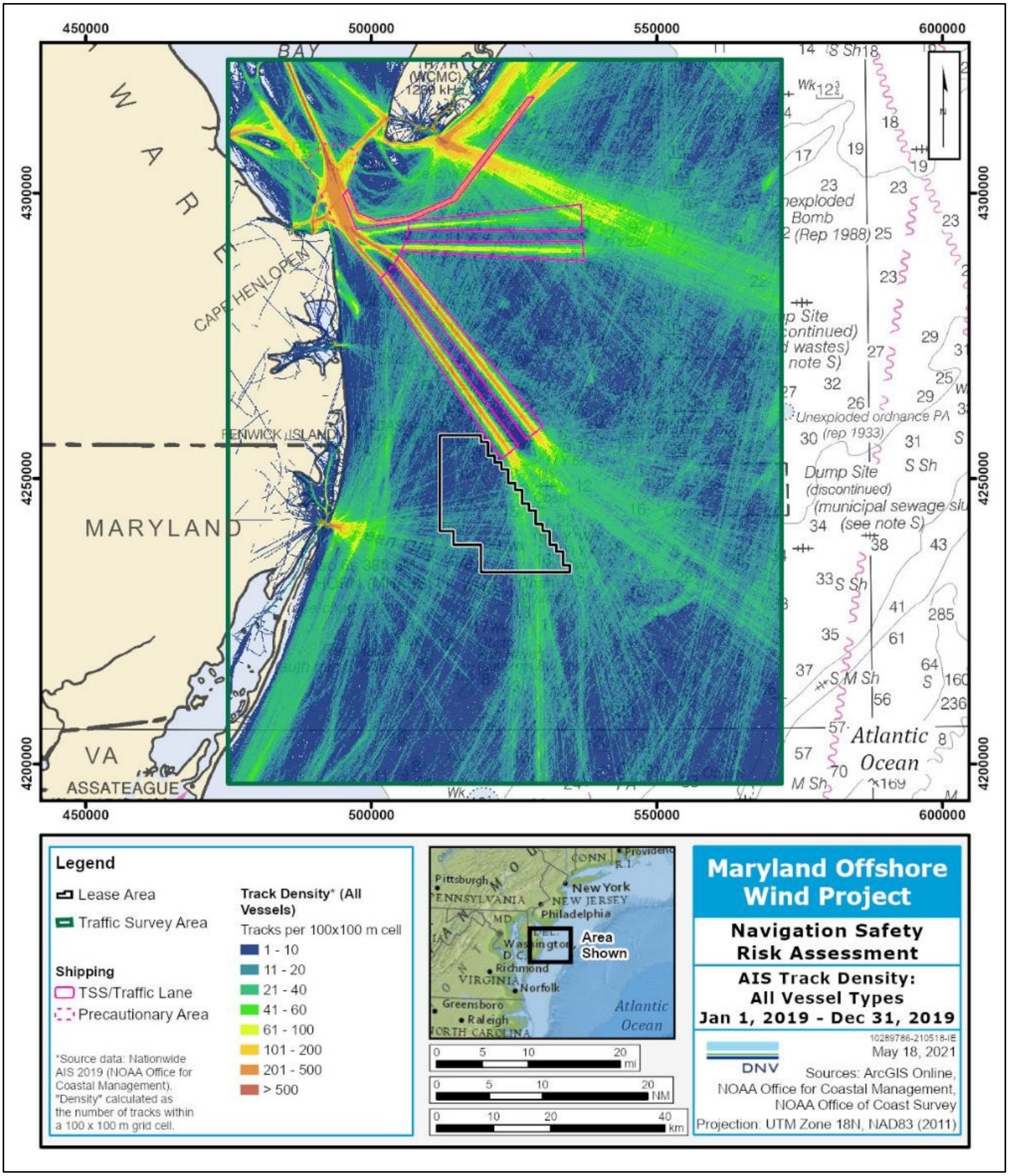


Figure 2-21 AIS Track Density[6]

2.1.3 Traffic statistics

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

Table 2-5 lists the number of tracks and number of unique vessels in the Traffic Survey Area and in the vicinity of the Lease Area.

As expected for deep draft vessels in international trade, the data indicate that each Cargo/Carrier or Tanker vessel transits this region relatively infrequently; there was an average of 7 tracks per unique vessel in 2019. The pattern for Pleasure vessels in the Traffic Survey Area is similar, with an average of 5 tracks per unique vessel. At the opposite end of the spectrum, Passenger vessels and Cruise/Ferry vessels tend to transit the same routes often, averaging 46 and 38 tracks per unique vessel in 2019 respectively. Tugs fall in between, with an average of 20 tracks per unique vessel.

In the immediate vicinity of the Lease Area, the average number of tracks per vessel for all of the vessel types is within a narrow range: 1.8 to 6.4 tracks per vessel. This indicates that a large proportion of vessels that transit near the Project do so only a few times per year.

Table 2-5 Number of Tracks and Vessels in the Traffic Survey Area[6]

NSRA Vessel Type	Traffic Survey Area		In the Vicinity of the Lease Area*	
	Number of Tracks	Number of Unique Vessels	Number of Tracks	Number of Unique Vessels
Cargo/Carrier/Tanker	9,678	1,413	3,702	895
Cruise/Ferry	1,028	27	9	5
Fishing	10,370	418	1,059	193
Other	7,660	594	857	289
Passenger	3,605	77	172	27
Pleasure	11,994	2,515	1,718	762
Tug	4,982	247	771	134
Total	**49,317**	**5,291**	**8,288**	**2,305**

* defined, for consistency, as within 4.3 NM (8 km) of the Lease Area

2.1.3.1 Track counts

Figure 2-22 shows the transects defined for this NSRA. The transect locations were selected to evaluate traffic composition for the major traffic routes within the Traffic Survey Area. The number of vessel tracks crossing each transect provides insight into the amount and types of marine traffic among the routes indicated by the 2019 AIS data.[6]

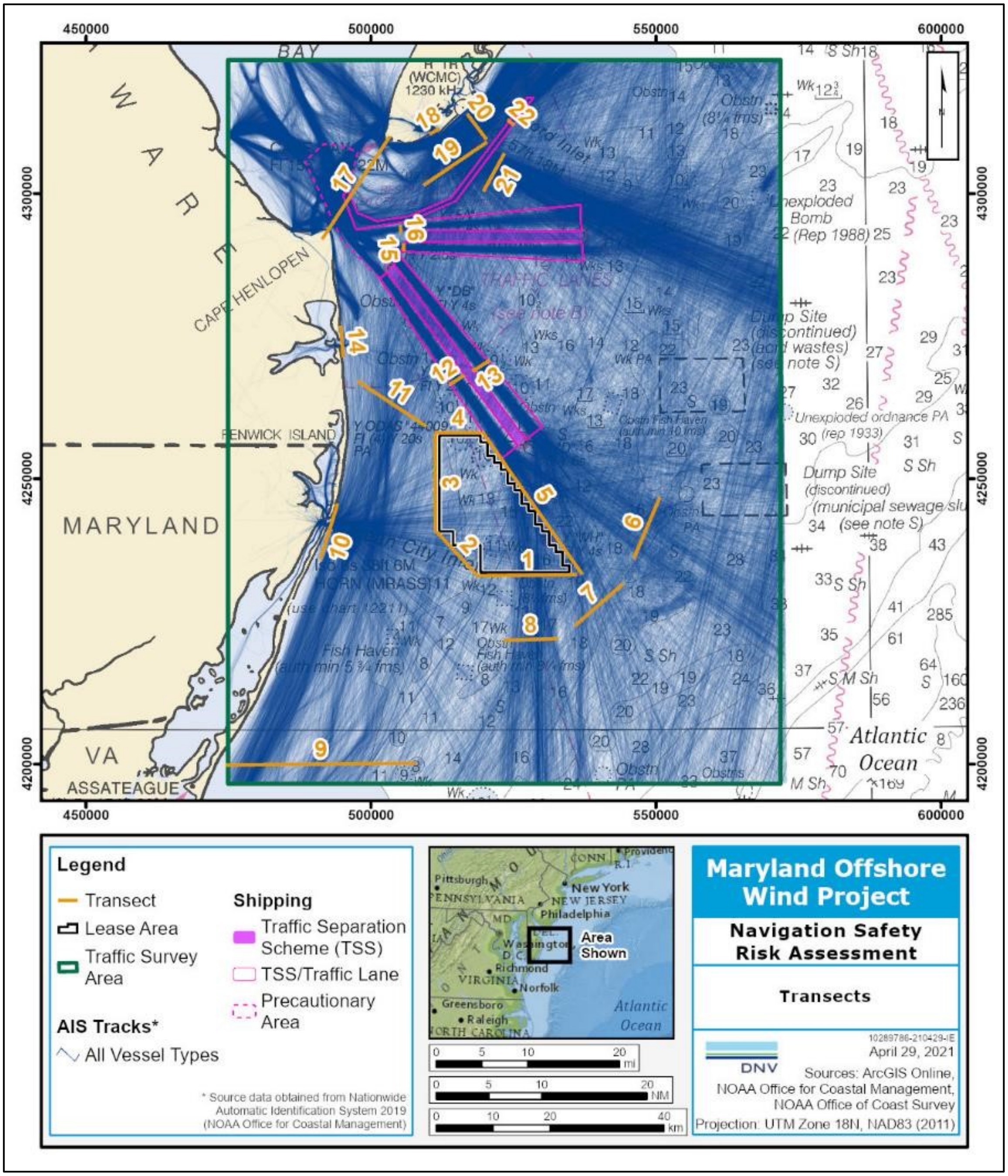


Figure 2-22 Transects Used for Statistical Analysis of Traffic[6]

Figure 2-23 presents the counts of AIS tracks for the transects in the southern portion of the Traffic Survey Area based on the 2019 AIS data.[6] Transects 12 and 13 show that the number of tracks in the Delaware Bay Southeastern Approach TSS average slightly more than five tracks per day, with the majority being Cargo/Carrier and Tanker vessel types.

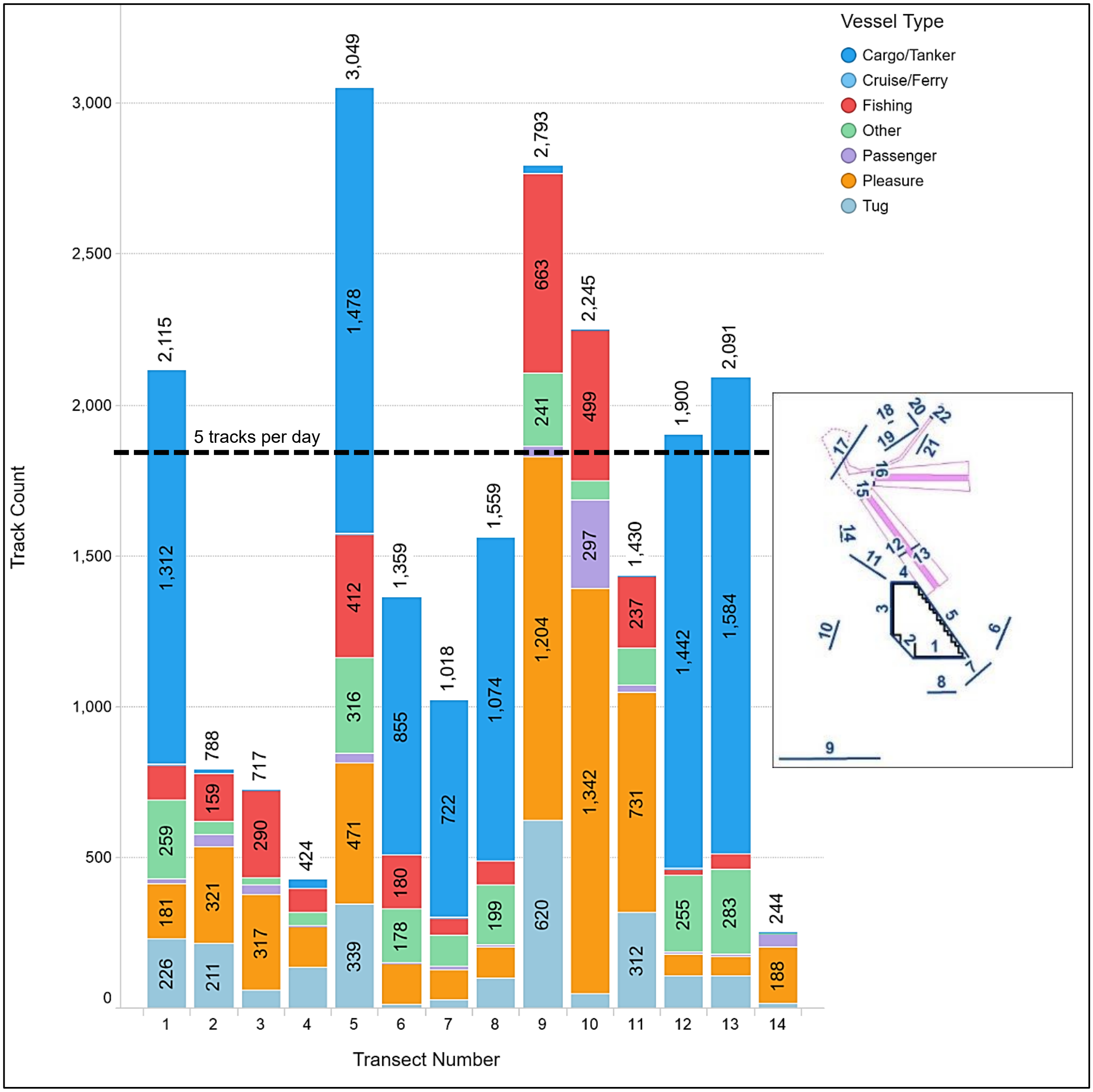
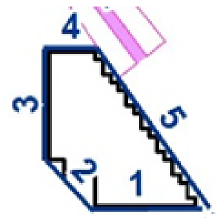


Figure 2-23 Annual Number of Vessel Tracks for the Southern Traffic Survey Area – Transects 1 to 14[6]

The Lease Area is bounded to the south by transect 1, to the west by transects 2 and 3, and to the northeast by transect 5. Table 2-6 lists the number of tracks that crossed each transect in 2019 [6]. For a given vessel track that crosses into the Lease Area, it will be counted in two different transects, one on entering the Lease Area and another on exiting the Lease Area.



Most of the tracks that enter the Lease Area are Cargo/Tanker vessels. Many of the Cargo/Tanker vessels that cross transect number 1 also transit the TSS. This corroborates the observations in Section 2.1.1, Traffic patterns, notably:

- Cargo/Tanker vessels transit predominantly between transects 5 and 1 (north-south)
- Fishing vessels transit predominantly between transects 3, 2 and 5 (east-west)

Table 2-6 Track Counts – Transects Circumscribing the Lease Area

Transect Number	Cargo/Tanker	Cruise/Ferry	Fishing	Other	Passenger	Pleasure	Tug	Total
1	1,312	4	114	259	19	181	226	**2,115**
2	14	0	159	44	39	321	211	**788**
3	0	0	290	22	31	317	57	**717**
4	31	0	81	41	5	134	132	**424**
5	1,478	3	412	316	30	471	339	**3,049**

Figure 2-24 presents the AIS track counts for the transects in the northern portion of the Traffic Survey Area based on the 2019 AIS data.[6] The entrance to Delaware Bay, transect 17, has the highest number of tracks, with an average of 24.5 per day.

Traffic in the Delaware Bay Eastern Approach TSS is represented in transects 15 and 16, with an average of 1 to 2 tracks per day.

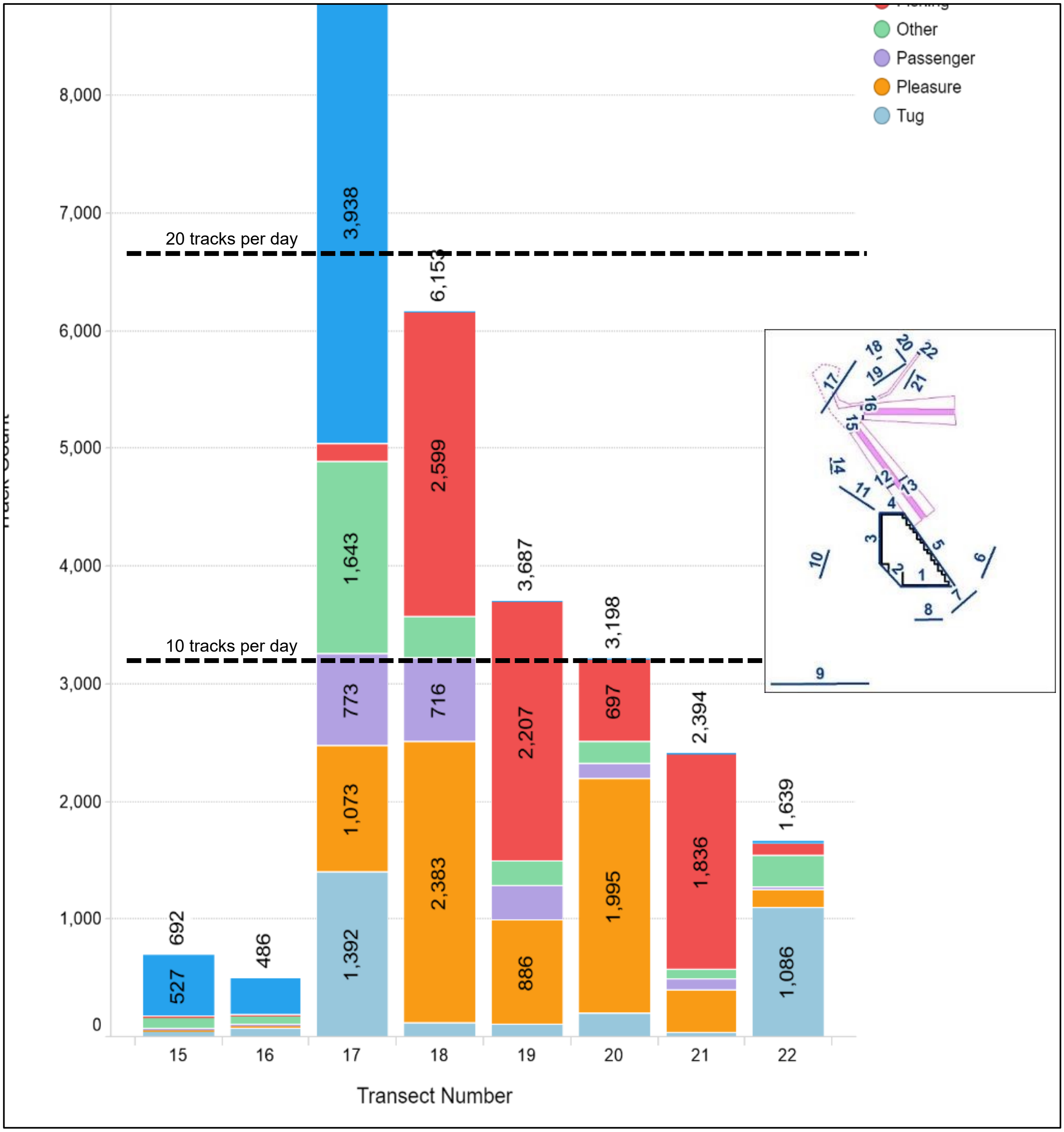


Figure 2-24 Annual Number of Vessel Tracks for the Northern Traffic Survey Area – Transects 15 to 22[6]

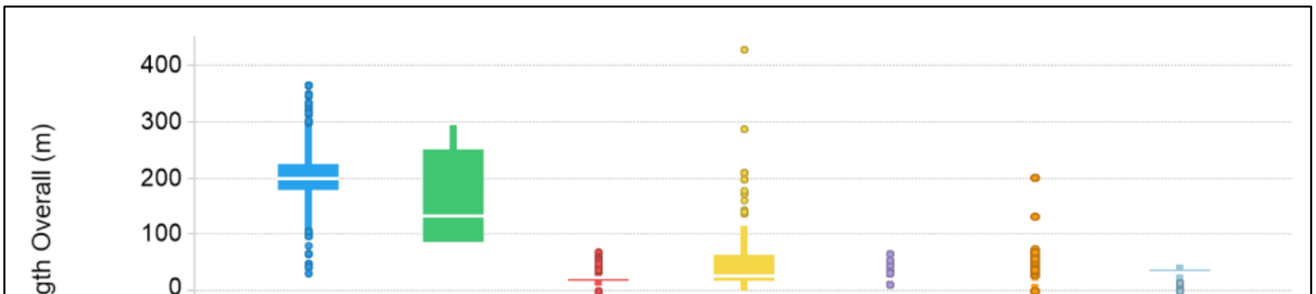
2.1.3.2 Vessel size

Vessel sizes were evaluated within the Traffic Survey Area and within a more limited area within 5 statute miles (4.3 NM, 8 km) of the Lease Area. 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 structures would be suitable to assess vessel sizes based on past offshore wind modeling results in Atlantic waters. The primary uses of the vessel size data and statistics in this assessment include:

- A general sense of the range of vessel sizes in the Traffic Survey Area and in the vicinity of the Lease Area.
- Length Overall (LOA) and beam are used in the powered and drift allision models, respectively.

Size distributions for LOA, beam, and draft for vessels in the Traffic Survey Area are provided in Figure 2-25 through Figure 2-27 based on data as reported in the AIS data.[6,] The figures are box-and-whisker plots of vessel tracks: a white line indicates the median (the middle value in the data); the bottom of the solid box indicates the first quartile (the middle of the bottom half of the data); and the top of the solid rectangle is the third quartile (the middle of the top half of the data). Dots indicate all other points outside the box.

Vessel size statistics presented in this section are based on inputs entered by each AIS system user. For Cargo/Carrier and Tanker vessels, the average LOA is 218 m (715 ft), the average beam is 32 m (105 ft), and the average draft is 11 m (36 ft).



	Cargo/Tanker	Cruise/Ferry	Fishing	Other	Passenger	Pleasure	Tug
Count	13,028	26	10,423	1,174	2,396	9,993	5,224
Median	199	133	23	26	21	14	33
Avg	203	163	22	43	22	15	32

Figure 2-25 Vessel LOA Track Counts in the Traffic Survey Area[6]

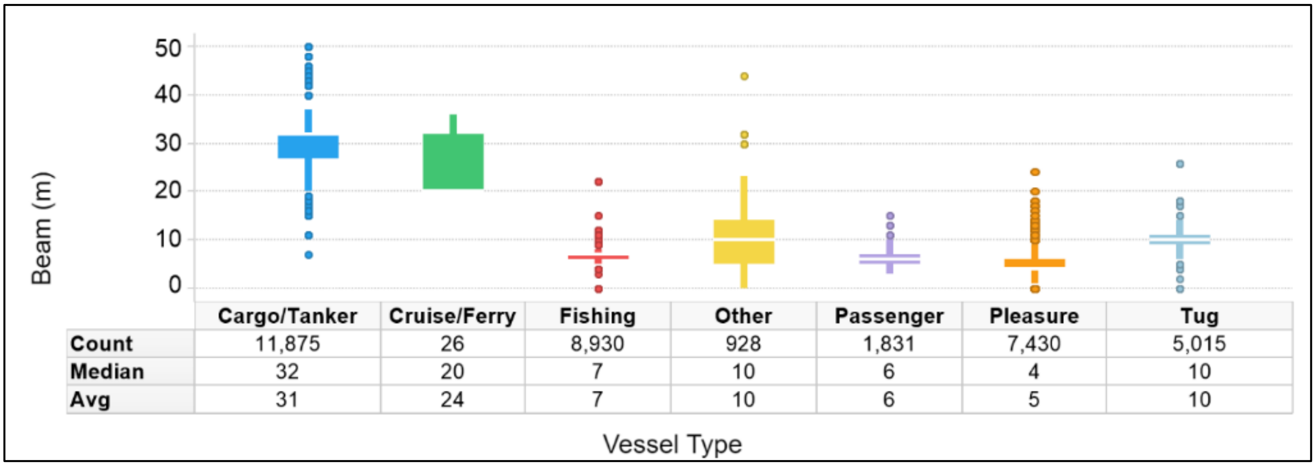


Figure 2-26 Vessel Beam Track Counts in the Traffic Survey Area[6]

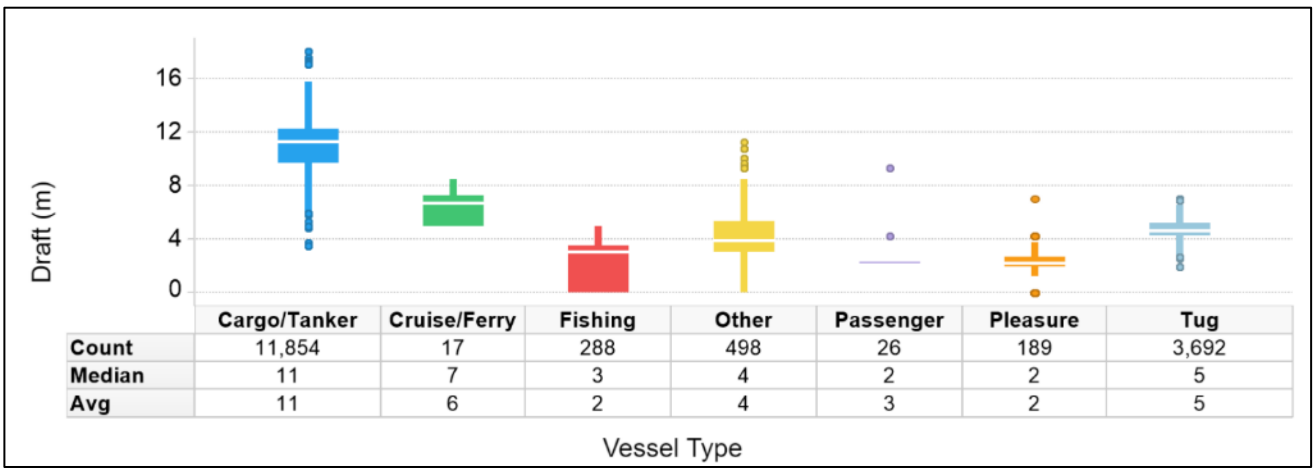
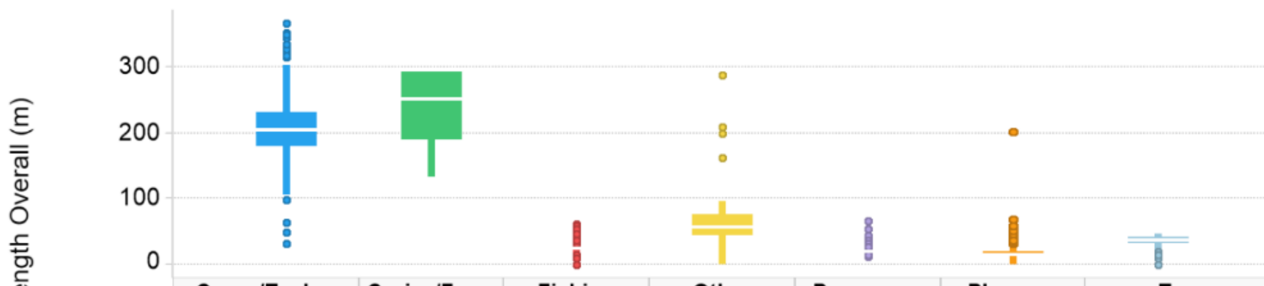


Figure 2-27 Vessel Draft Track Counts in the Traffic Survey Area[6]

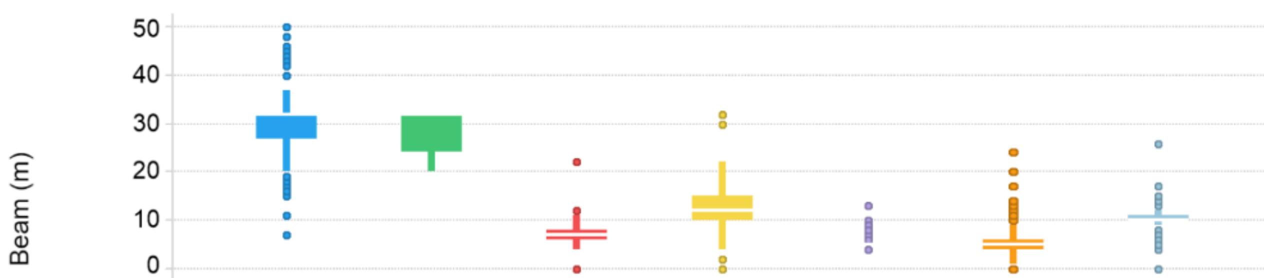
To analyze vessel sizes in the vicinity of the Lease Area, any AIS-based tracks coming within 5 statute miles (4.2 NM, 8 km) of the Lease Area were identified as “near” the Lease Area, and their sizes are presented in Figure 2-28 through Figure 2-30. Comparing the larger Traffic Survey Area to tracks passing within 5 statute miles of the Lease Area, the size distributions for six of the seven vessel types are very similar. The exception is the vessel type Cruise/Ferry. On average, these vessels are larger near the Lease Area. This is due to the large cruise ships in the Southeastern Approach TSS and the relatively smaller Cape May-Lewes Ferry that crosses the entrance to Delaware Bay.



	Cargo/Tanker	Cruise/Ferry	Fishing	Other	Passenger	Pleasure	Tug
Count	79,706	198	23,034	2,948	2,420	30,602	16,918
Median	204	252	24	57	19	15	37
Avg	208	237	23	64	21	16	35

Vessel Type

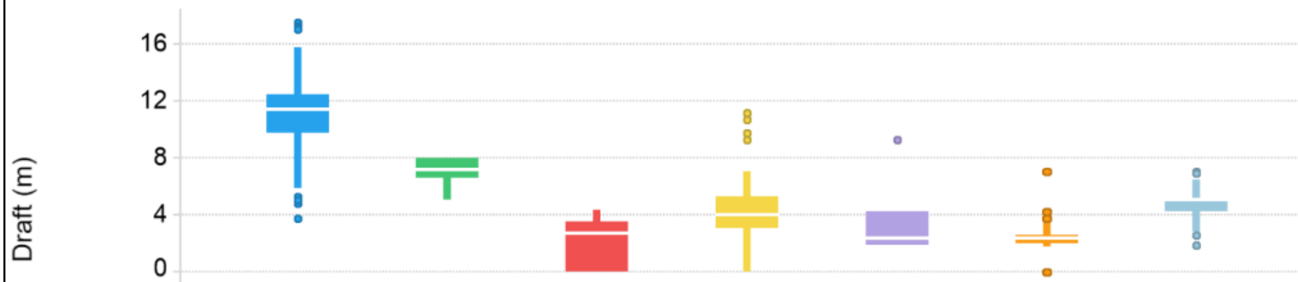
Figure 2-28 Vessel LOA Track Counts Near the Lease Area[6]



	Cargo/Tanker	Cruise/Ferry	Fishing	Other	Passenger	Pleasure	Tug
Count	71,346	198	22,242	2,684	2,266	23,496	16,500
Median	32	32	7	12	5	5	10
Avg	31	28	7	12	5	5	10

Vessel Type

Figure 2-29 Vessel Beam Track Counts Near the Lease Area[6]



	Cargo/Tanker	Cruise/Ferry	Fishing	Other	Passenger	Pleasure	Tug
Count	71,170	198	902	2,024	154	946	14,212
Median	11	7	3	4	2	2	5
Avg	11	7	2	5	3	2	5

Figure 2-30 Vessel Draft Track Counts Near the Lease Area[6]

2.1.3.3 Vessel speed

This section characterizes vessel speeds in the Traffic Survey Area. Figure 2-31 presents speeds reported in the AIS data. The highest speeds are observed close to the coasts, especially around Lewes, Cape May, and the Delaware coast, primarily Pleasure and Passenger vessels.

In the vicinity of the Lease Area, high vessel speeds are also observed in the outbound lane of the Delaware Bay Southeastern Approach TSS, north of the Lease Area and through the eastern part of the Lease Area, consisting primarily of Cargo/Carrier and Tanker vessels, at an average speed between 12 and 15 kt. The Fishing vessels transiting from Ocean City and the fishing grounds through the Lease Area have an average speed between 9 and 15 kt. Figure 2-32 through Figure 2-38 provide seasonal views of vessel speed.

At certain times of the year, vessels 65 ft (19.8 m) or longer must travel at 10 kt or less within designated Seasonal Management Areas (50 CFR 224.105) to reduce the threat of vessel collisions with endangered North Atlantic right whales. A Seasonal Management Area has been established outside the entrance to Delaware Bay. The effect of this restriction is notable in Figure 2-32 through Figure 2-38, which indicate reduced speeds by applicable vessels during winter, spring, and fall in the western portions of the TSS.

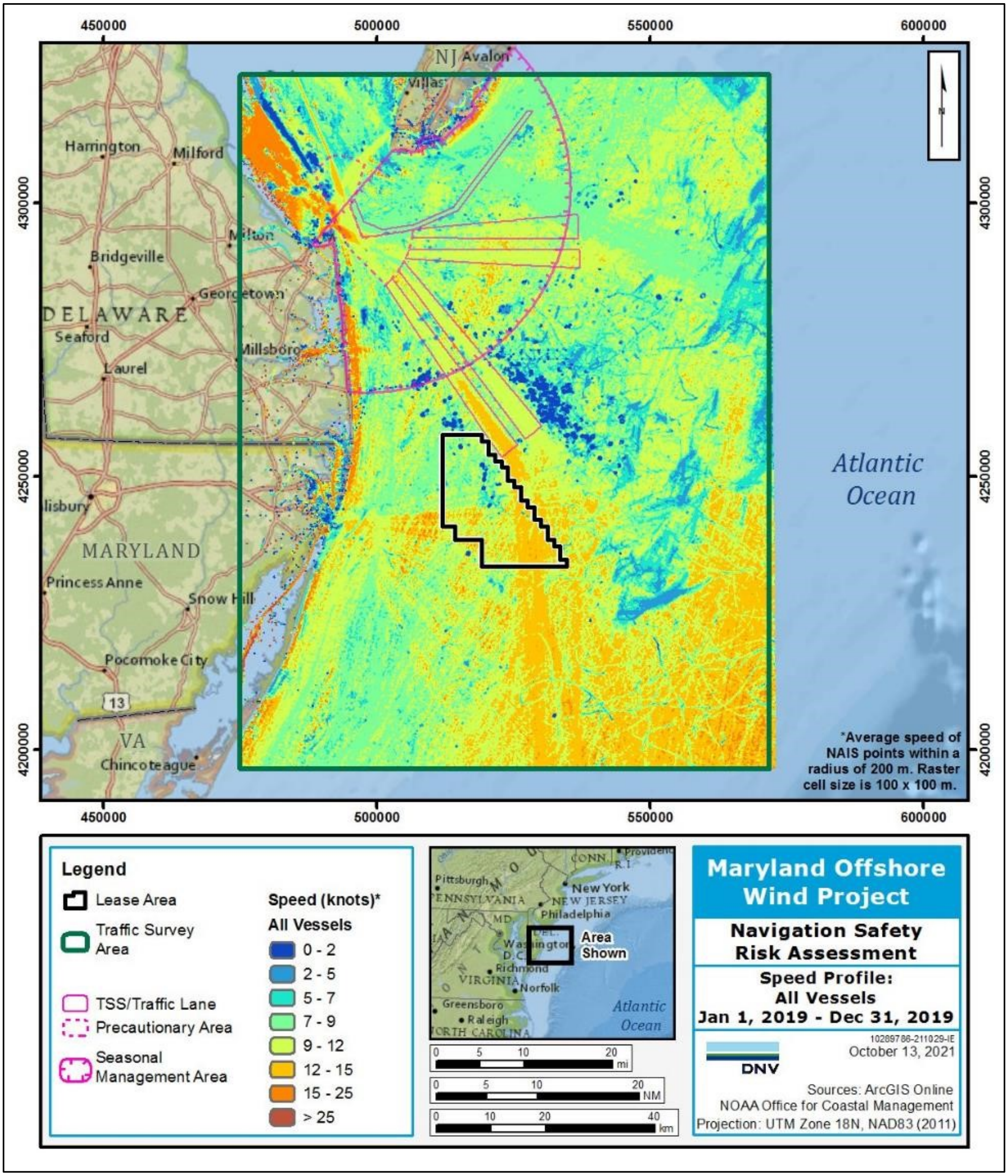


Figure 2-31 Speed of All Vessel Types in 2019[6, 8]

[8] Based on reported Speed over Ground as reported in the raw AIS data (NOAA, 2020a)

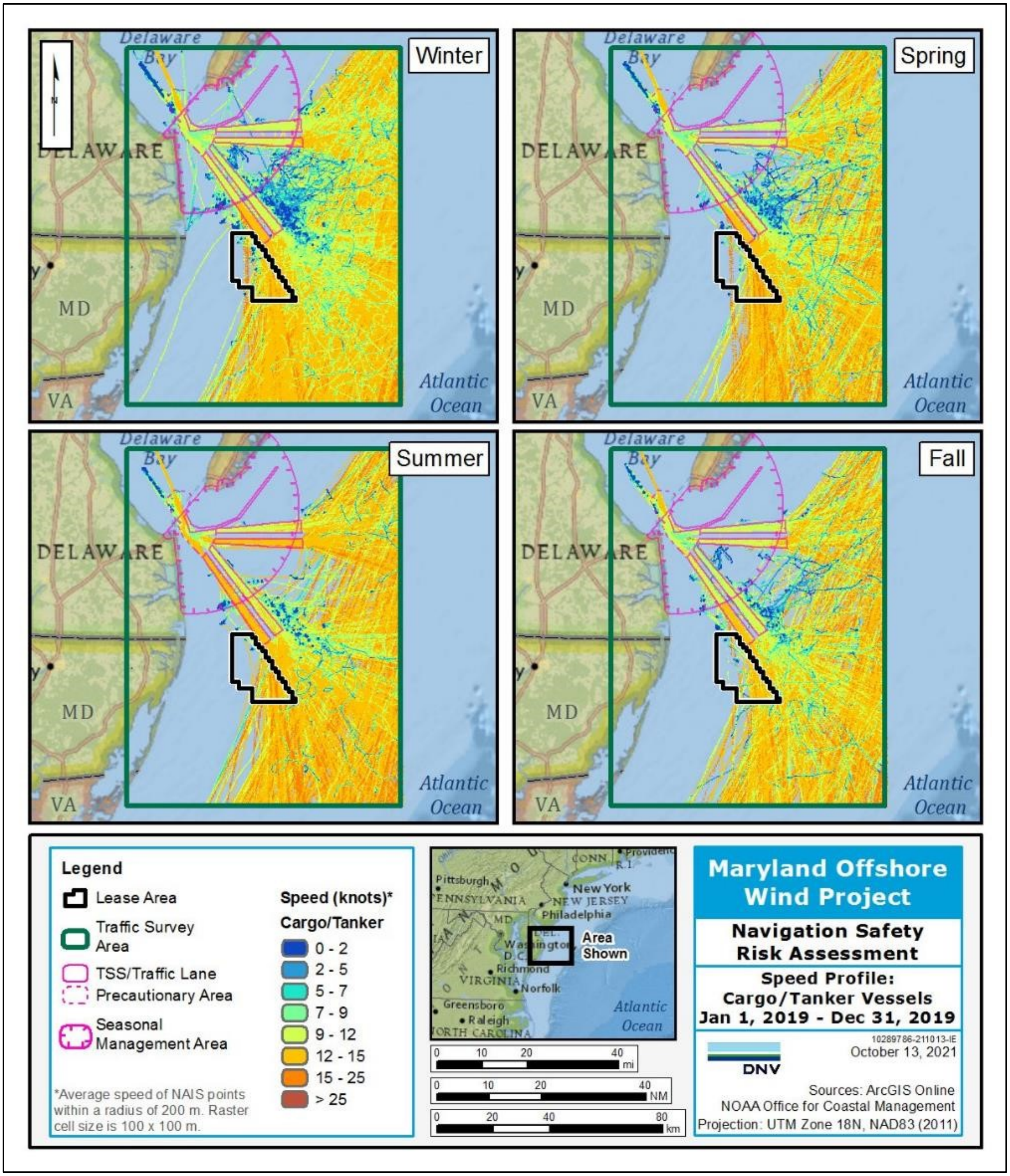


Figure 2-32 Speed of Cargo/Carriers and Tankers per Season[6, 8]

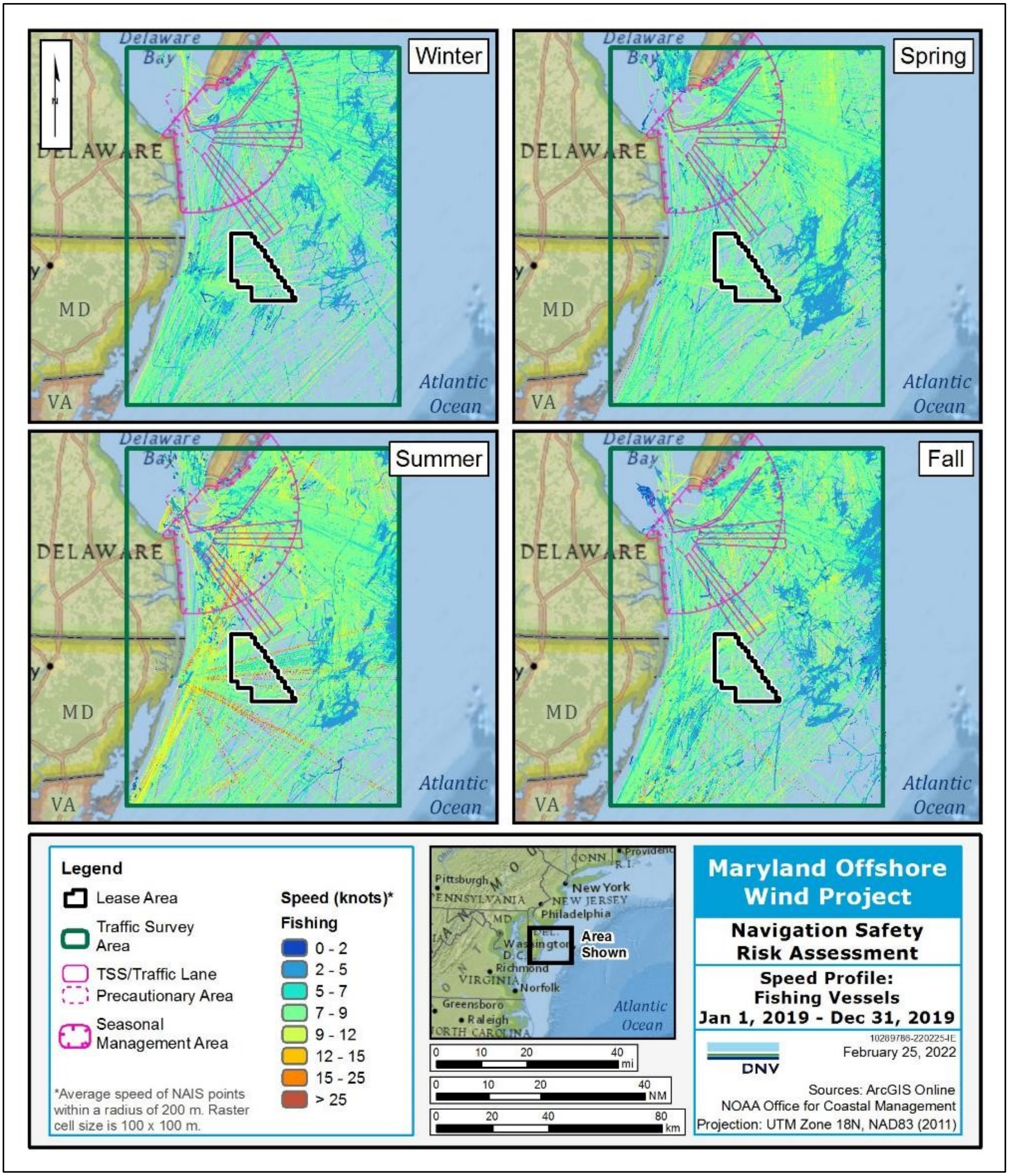


Figure 2-33 Speed of Fishing Vessels per Season[6, 8]

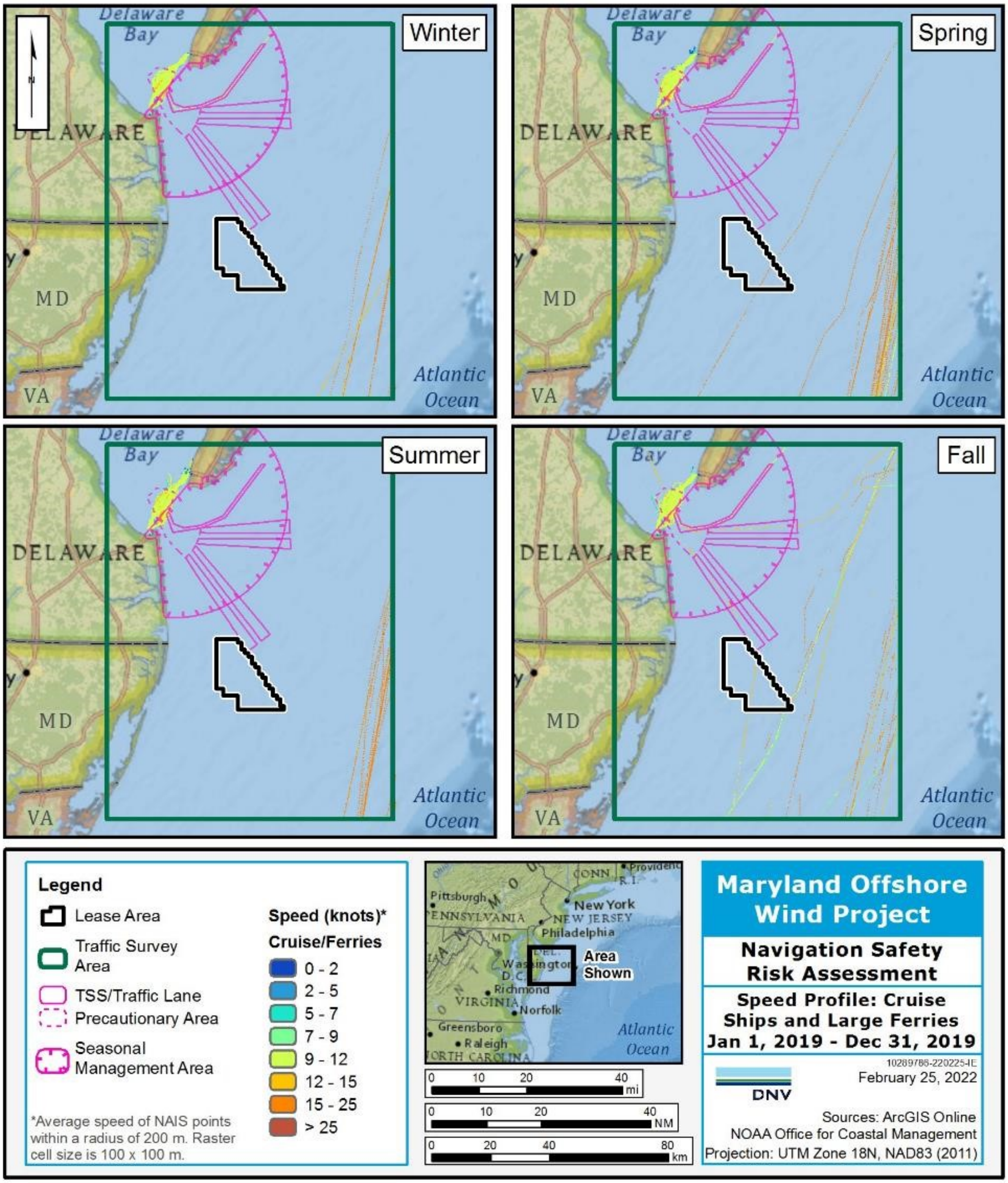


Figure 2-34 Speed of Cruise Ships and Large Ferries per season[6, 8]

DNV

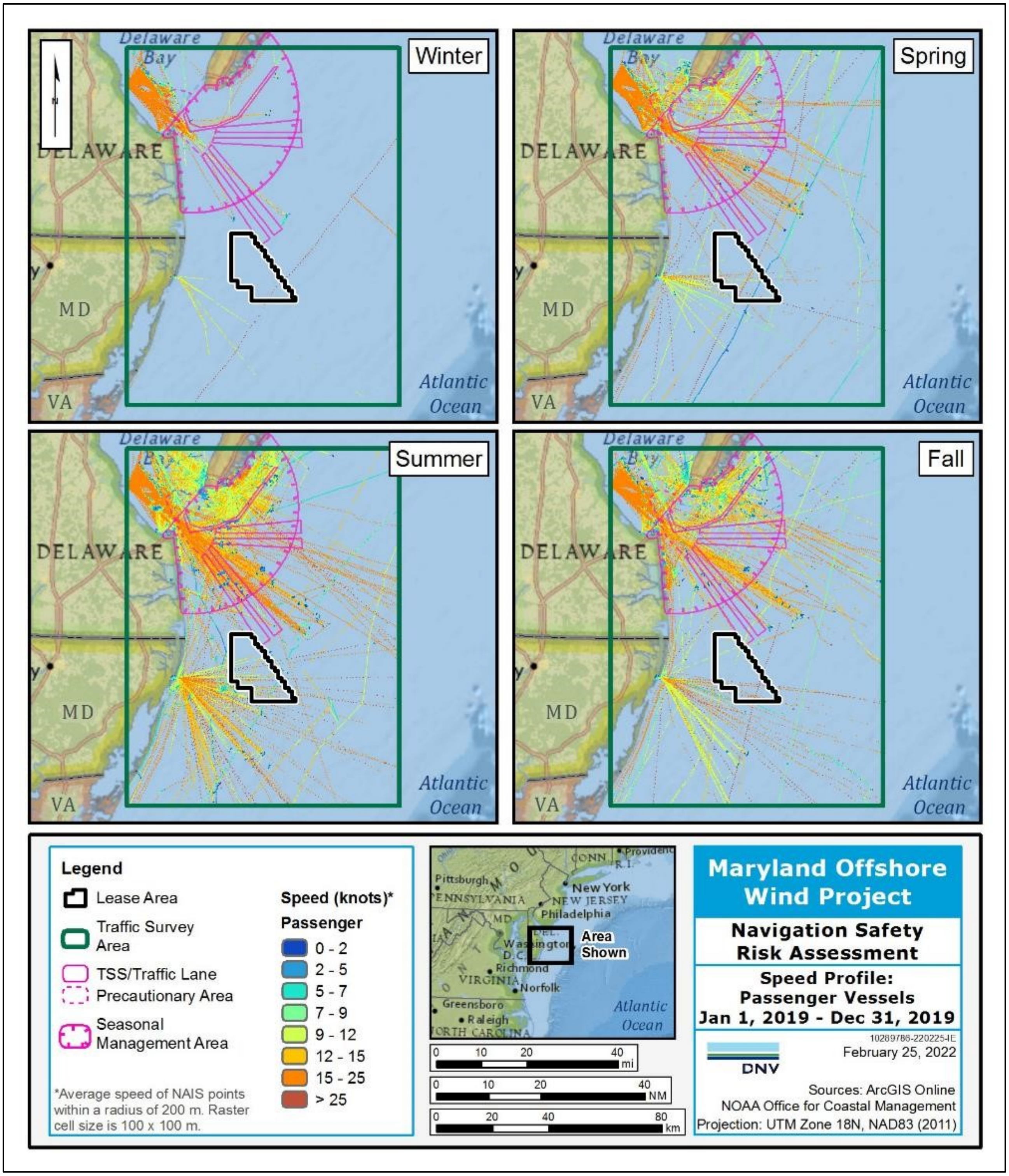


Figure 2-35 Speed of Passenger Vessels per Season[6, 8]

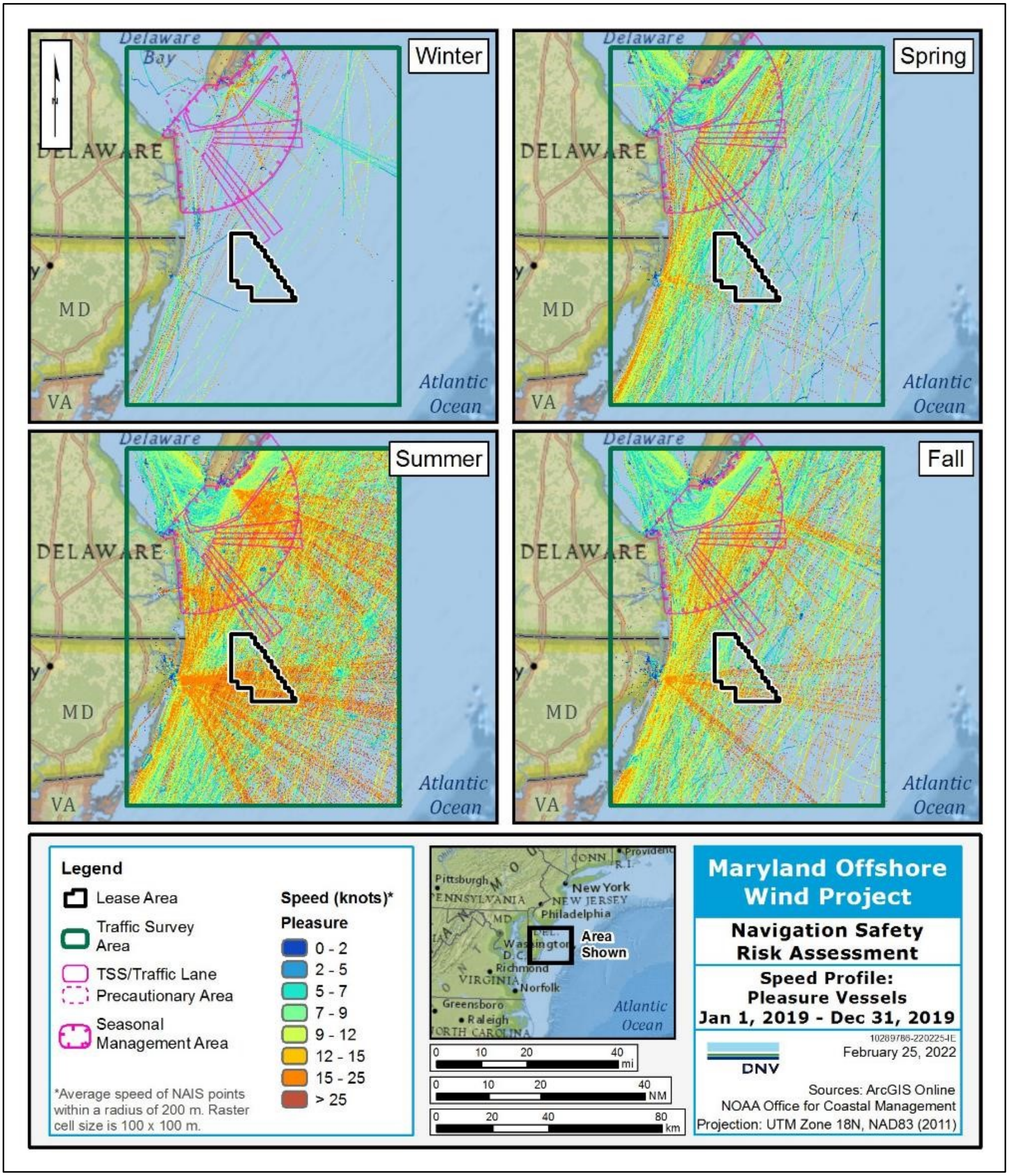


Figure 2-36 Speed of Pleasure Vessels per Season[6, 8]

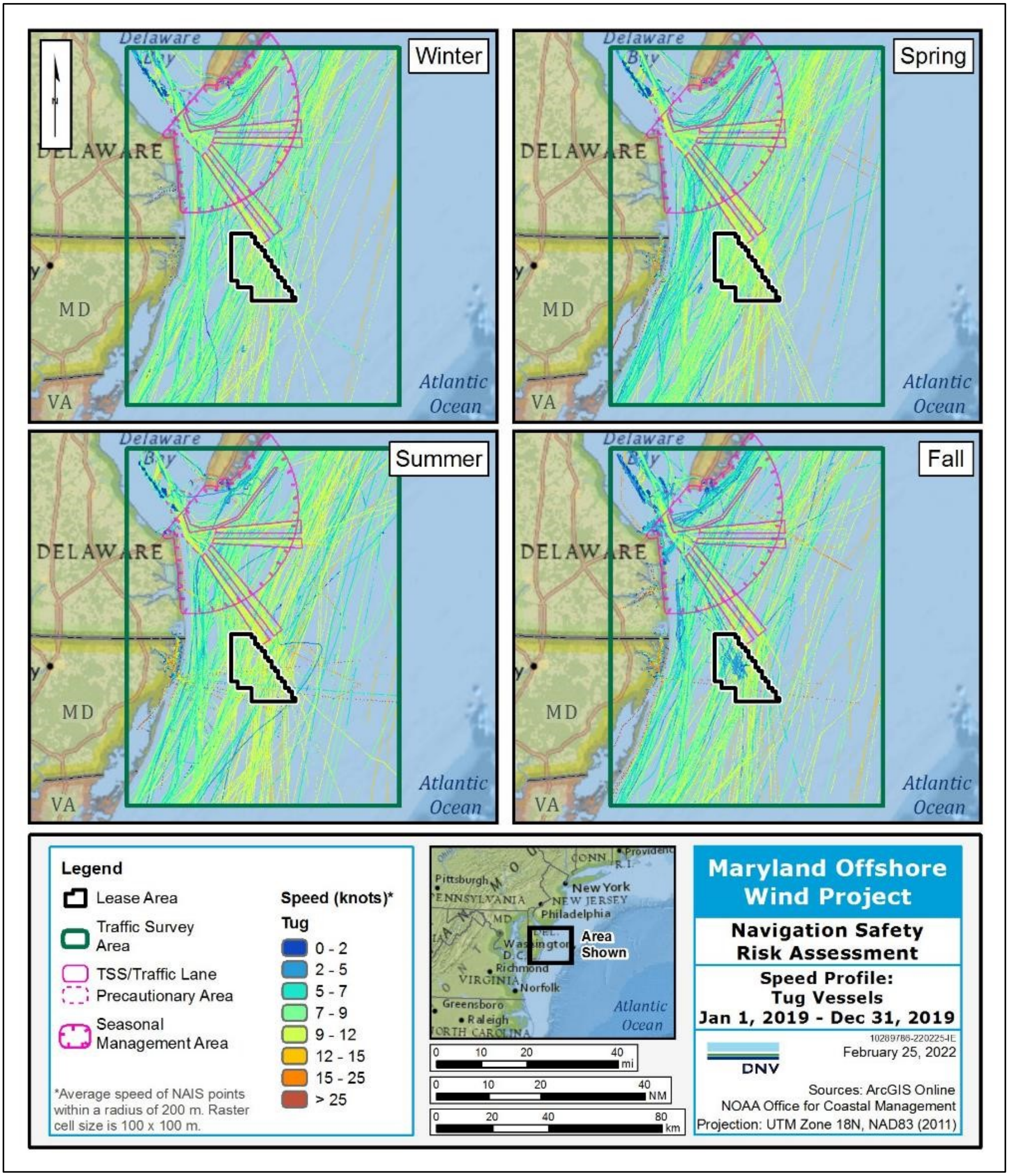


Figure 2-37 Speed of Tug Vessels per Season[6, 8]

Slow moving tugs are apparent in the AIS data for the fall of 2019. Two vessels are the primary contributors to this effect, the LA Elite and the A.J. McAllister. These were not associated with Project survey activity (US Wind, 2022). The reason for the vessels' activity is unclear based on the available data.

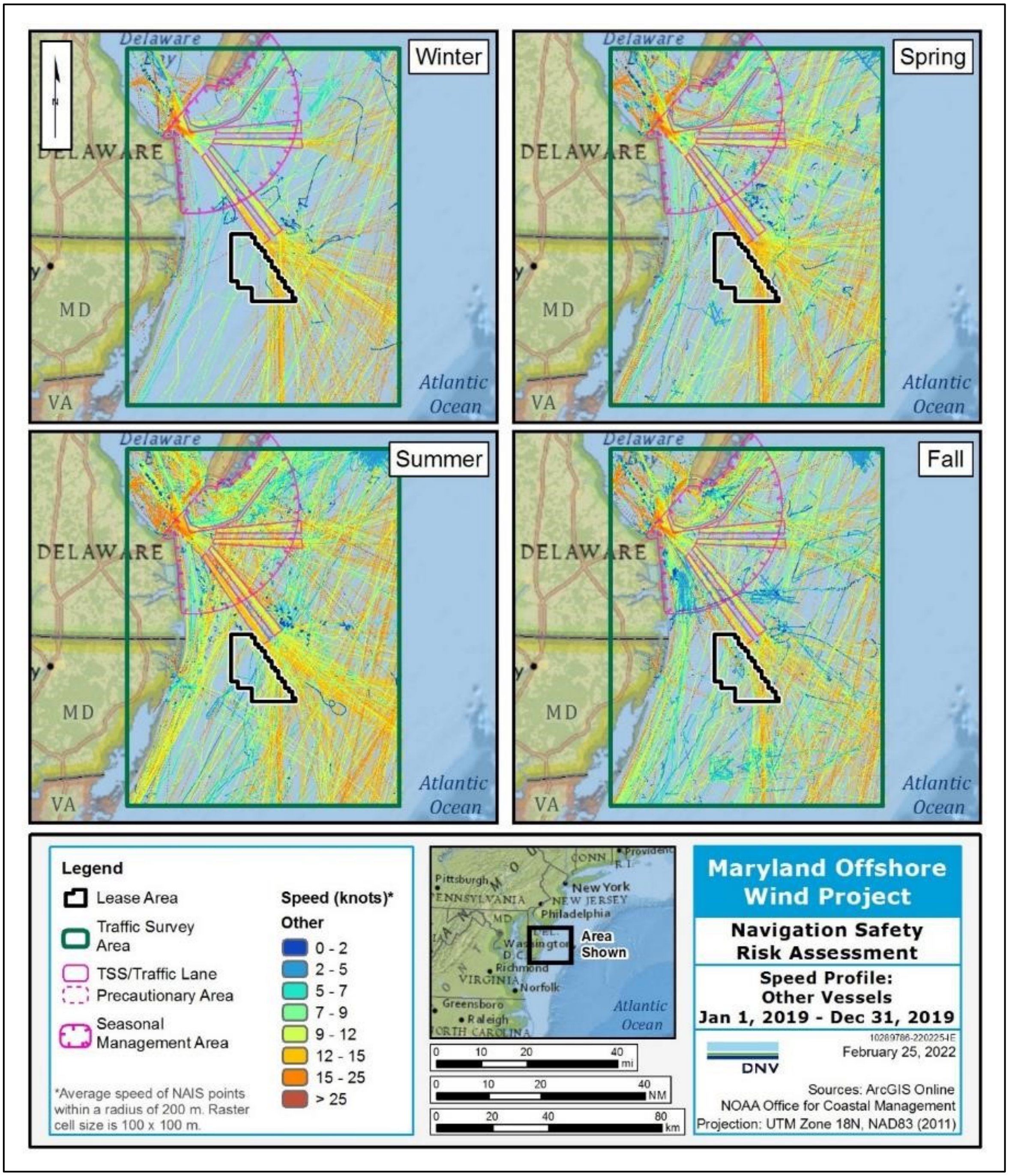


Figure 2-38 Speed of Other Vessels Within the Traffic Survey Area[6, 8]

2.1.4 Types of cargo

The South Jersey Port Corporation (2021), the Philaport (Philadelphia Regional Port Authority, 2021), the Port of Wilmington, Delaware (2021), and the Port Authority of New York and New Jersey (2021) sites and data were accessed to identify the main categories of goods transiting in the Traffic Survey Area.

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

- Cars/vehicles
- Crude oil
- Chemicals (including hazardous materials categories A through D)
- Containerized cargo
- Dry bulk (cocoa beans, sand, gravels, salt, sulfur, etc.)
- Fresh fruit
- Fruit juice
- Livestock
- Oil products
- Steel products
- Wood products

The 2018 Delaware River Ports and Waterways Safety Assessment (PAWSA) report summarized that, “Philadelphia has the largest refinery capacity on the U.S. East Coast, is the 5th largest U.S. port complex, and is the largest fruit and juice concentrate import center in the U.S. In calendar year 2017, the port saw an increase of 18% in overall container throughput with 972,412 containers being handled. Container throughput is trending upward and is expected to exceed 1 million TEU [Twenty-foot equivalent units] in the year 2019.” (USCG, 2018a).

2.2 Location of the Project in relation to other uses

This section describes the proximity of the Project to navigation-related aspects identified in NVIC 01-19. Figure 2-39 shows the navigation chart and Figure 2-40 shows the evaluated potential export cable routes. Analysis of hazards related to the export cable is provided in Section 3.1 and Section 4.

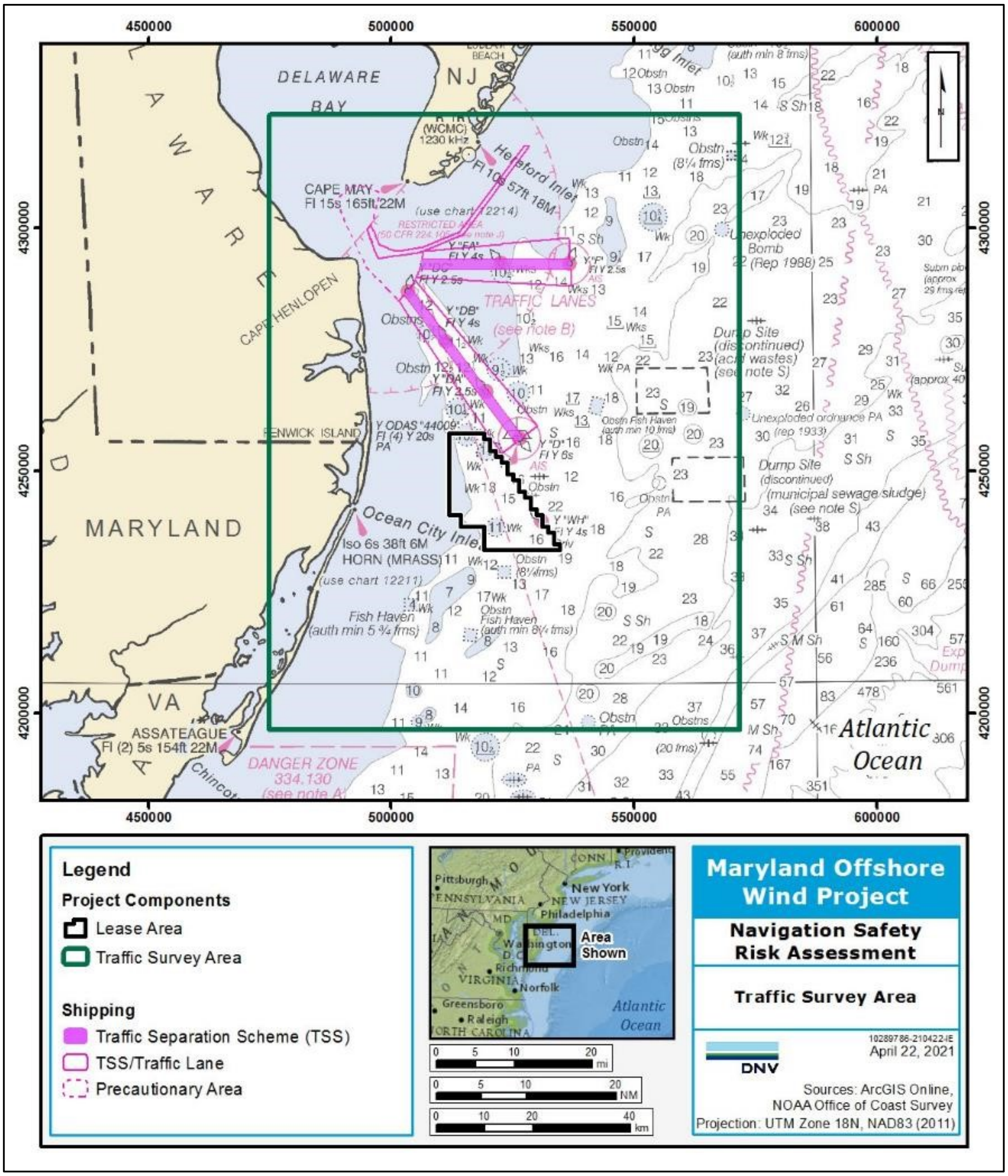


Figure 2-39 Navigation Chart

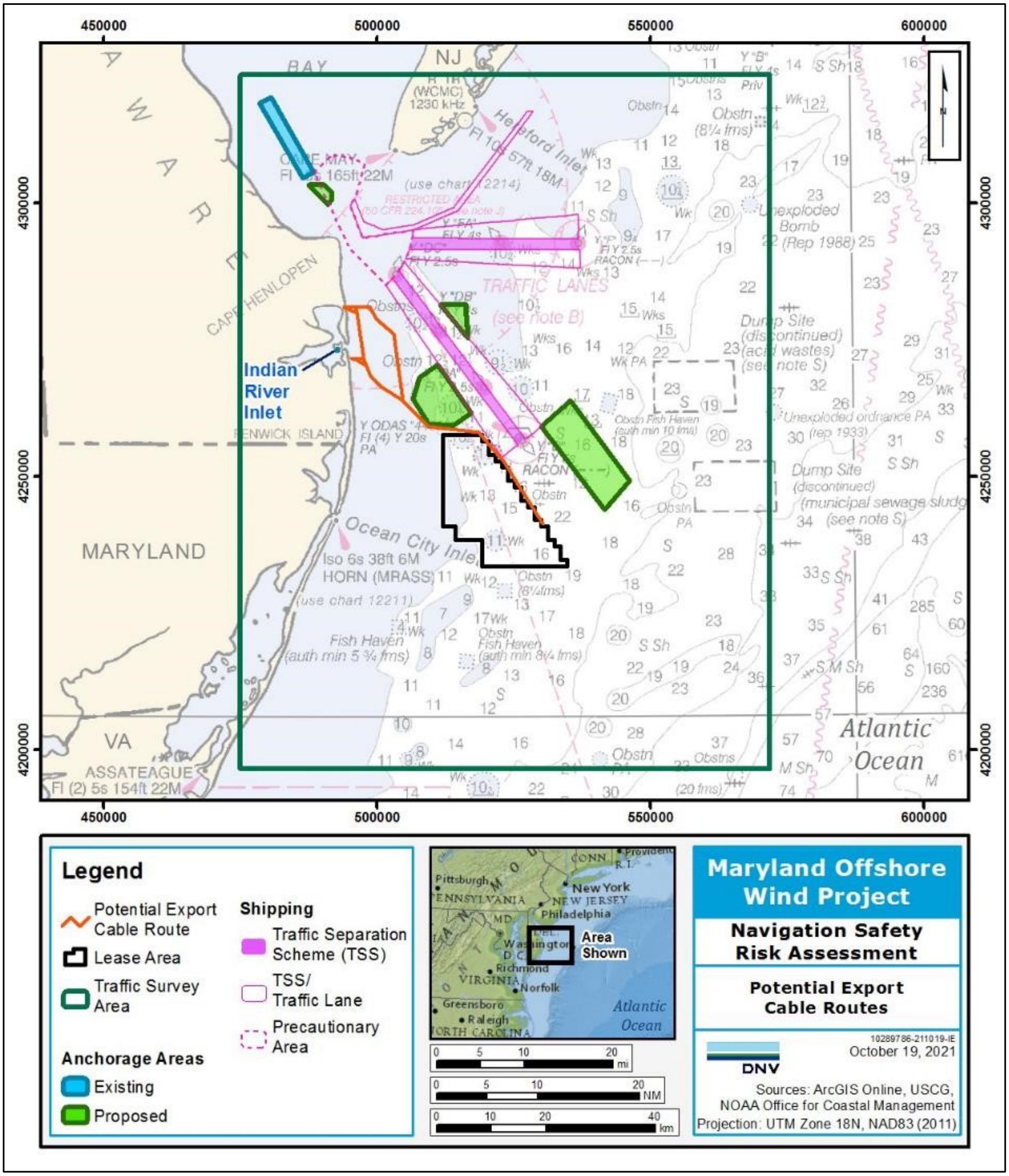


Figure 2-40 Potential Export Cable Routes (US Wind, 2022)

Aligning with NVIC 01-19, fishing grounds and routes used by Fishing vessels are described in previous Section 2.1.1.2. Locations of other uses and relation to Project effects on risk are described in the following sections:

- Section 2.2.1 Non-transit uses
  - Recreational fishing
  - Day cruising of leisure craft (pleasure and passenger)
  - Sailing and racing courses
  - Wildlife viewing transits
  - Aggregate mining
- Section 2.2.2 Transit uses
  - Routes used by coastal or deep-draft vessels, ferry routes
  - Transit routes used by fishing vessels
  - Shipping routes
- Section 2.2.3 Transit-related safety measures
  - Routing measures, precautionary areas, separation zones, TSS
  - Anchorage grounds
  - Safe havens
  - Port approaches
  - Pilot boarding or landing areas
  - Anchoring in the Lease Area
- Section 2.2.4 Other aspects
  - Within the jurisdiction of a port or navigation authority
  - Offshore firing/bombing ranges or areas used for military purposes
  - Existing or proposed offshore renewable energy facility, gas platform, or marine aggregate mining
  - Existing or proposed structure developments or existing designated offshore disposal areas
  - Aids to navigation (ATON) and/or Vessel Traffic Services

2.2.1 Non-transit uses

2.2.1.1 Fishing

NMFS has provided commercial fisheries landings data specific to each lease area in the Atlantic Outer Continental Shelf by combining VTRs and dealer reports into modeled fishing intensity raster data sets (NOAA, NMFS, and GARFO, 2020). For the years 2008 through 2018, data for the Lease Area indicate that the gear types of pots and gillnets represent 95% of the commercial fishing landings in the Lease Area represented by this data set.

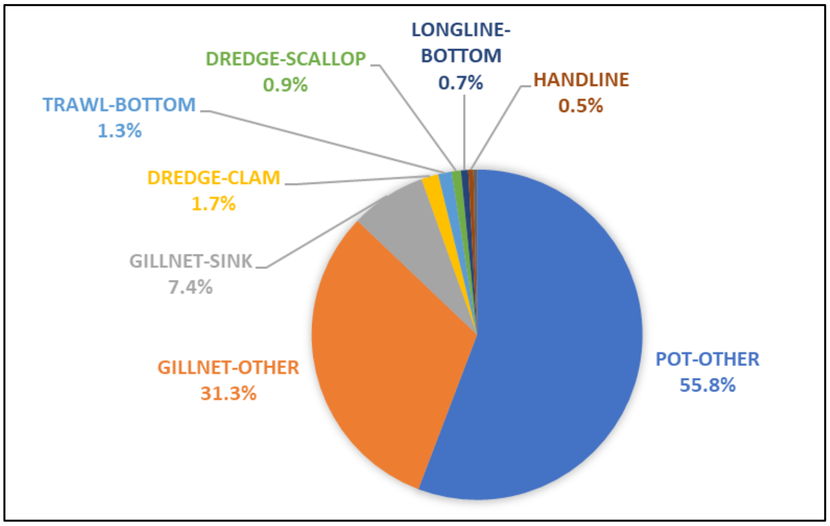


Figure 2-41 Representative Types of Fishing in the Lease Area (NEFMC, 2019)

2.2.1.2 Day cruising of leisure craft and other recreational activities

Commercial day trips and tours are common from Ocean City and other ports in the area. Commercial day cruises in the Lease Area include sightseeing cruises and sunrise/sunset cruises.

Section 2.1.1.3 describes the routes taken by Passenger vessels, such as cruise ships and ferries. The Project may attract day trips from Ocean City. Additional transits were added to the Future Case risk model to account for this possibility (see Section 2.1.1.3).

Recreational boating is popular in this area, with most of the activity located inshore or closer to shore than the Lease Area. Recreational boating routes mapped by participants in the 2012 Northeast Recreational Boater Survey are shown in Figure 2-42.

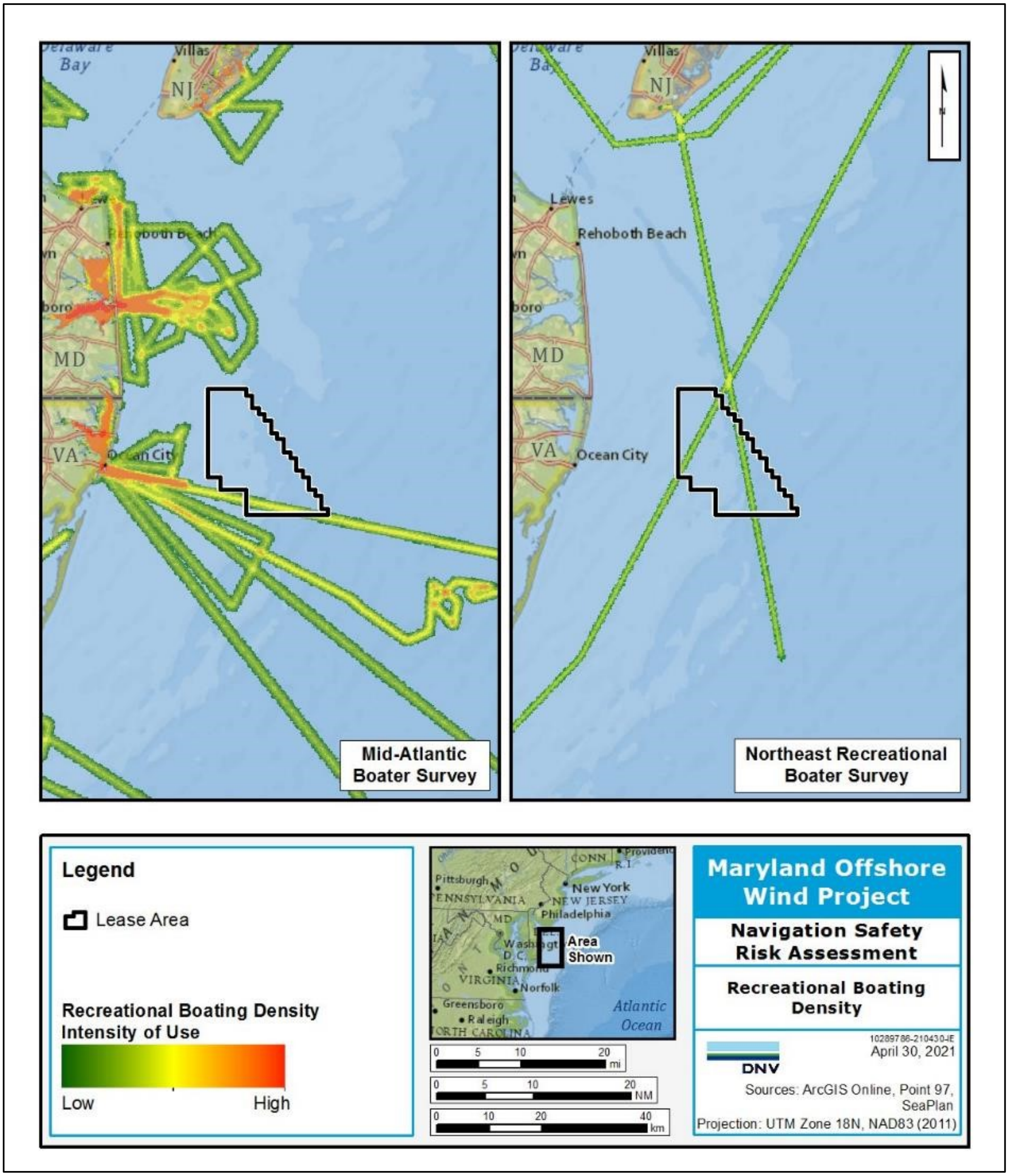


Figure 2-42 Recreational Boating Activities and Routes (Point 97 et al., 2014; SeaPlan, 2013)

2.2.1.3 Sailing and racing courses

Figure 2-43 illustrates typical routes of distance sailing races, some of which have historically transited through the Lease Area (SeaPlan and NROC, 2015). The routes shown in the figure are from the Annapolis to Newport Race, a 475-mile biennial race in June hosted by the Annapolis Yacht Club and the Newport Yachting Center. Future races will most likely route around the Lease Area because these events are held in open water by the designers of the events.

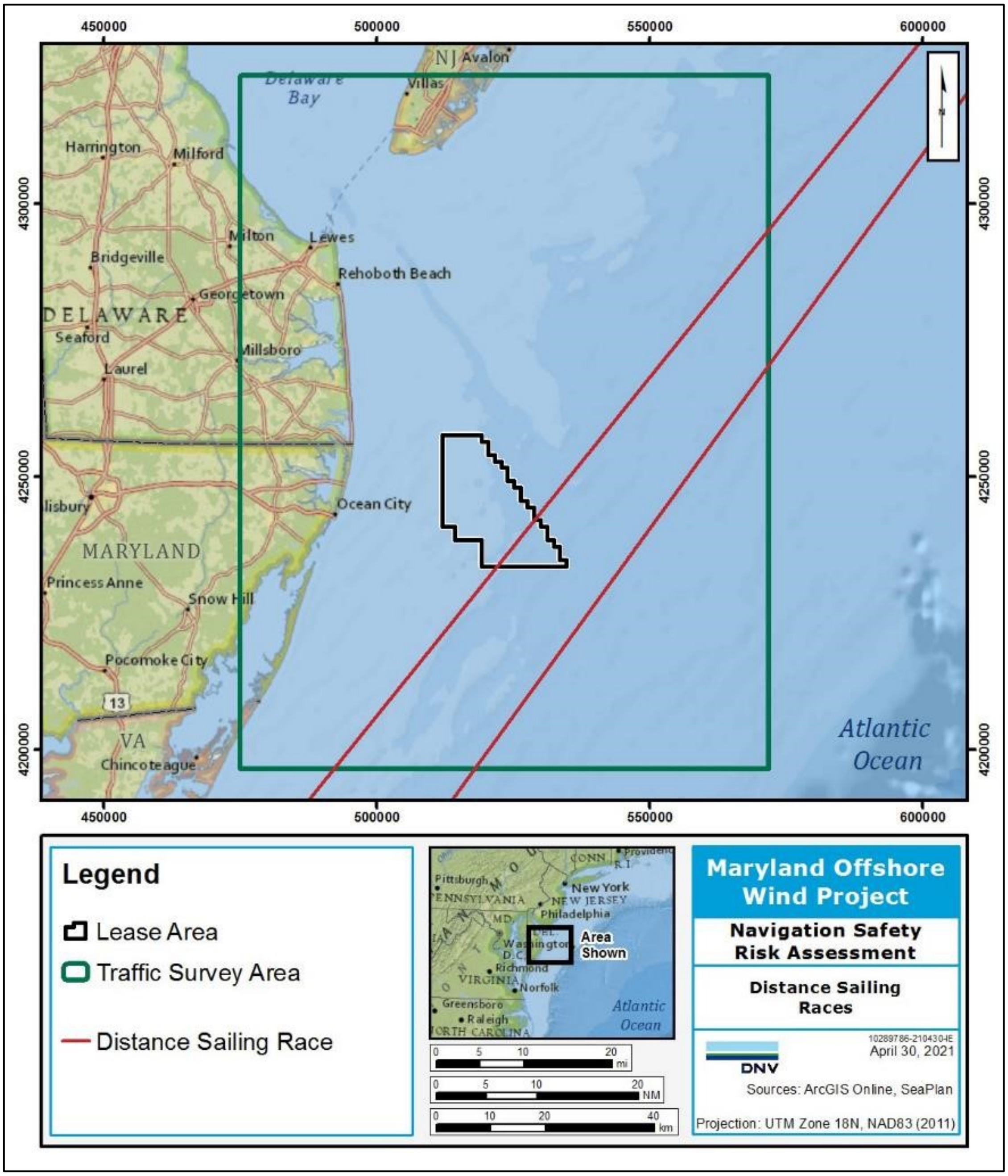


Figure 2-43 Distance Sailing Races (SeaPlan & NROC, 2015)

2.2.1.4 Wildlife viewing

Figure 2-44 illustrates the offshore wildlife viewing areas in the Traffic Survey Area (Mid-Atlantic Ocean Data Portal [MARCO] et al., 2012), including wildlife and sightseeing. Vessels transiting to offshore wildlife viewing areas could take routes to or through the Lease Area. Section 2.1.1.5 discusses the potential for additional recreational vessel traffic to the Project Area for uses such as wildlife viewing. Offshore wildlife of potential viewing interest in the mid-Atlantic includes birds, dolphins, turtles, whales, and fish (Biodiversity Research Institute, 2015).

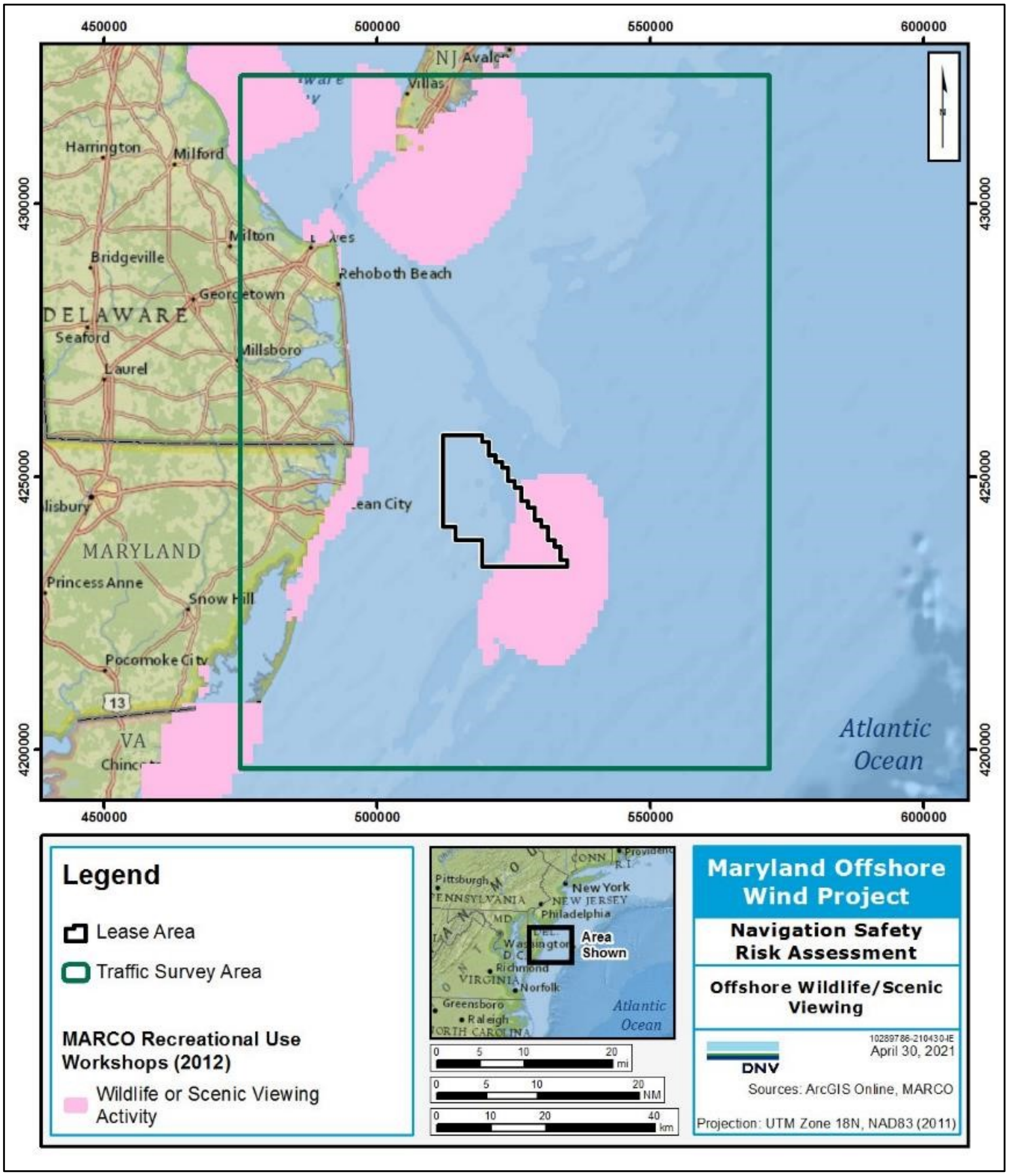
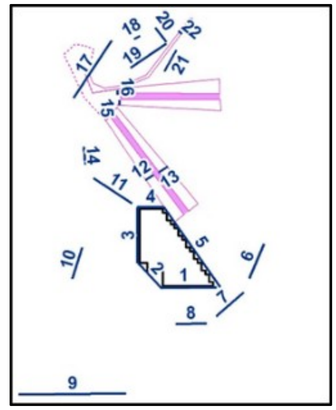


Figure 2-44 Offshore Wildlife Viewing Areas (MARCO et al., 2012)

2.2.2 Transit uses

Risk modeling was conducted to understand the change in risk from the Project's influence on transit uses. The results and conclusions are presented in Section 11.1.

2.2.2.1 Coastal, deep draft, and ferry routes



The routes taken by coastal vessels (Tugs), deep draft vessels (Cargo/Carrier and Tanker, and Cruise/Ferry types), and ferries (Cruise/Ferry) are described in Section 2.1.1.1.

The influence of Project structures on the risk experienced by these vessels is limited to those with tracks passing through or near the Lease Area. The number of tracks of these vessel types that passed through the Lease Area in 2019 were:

- Cargo/Carrier and Tanker – 1,362
- Cruise/Ferry – 4
- Tug – 557

The number of tracks of these vessel types that passed near the Lease Area[9] in 2019 were:

- Cargo/Carrier and Tanker – 3,702
- Cruise/Ferry – 9
- Tug – 771

The design of the risk modeling for the Future Case, after the Project is constructed, was that any routes that crossed or came within 1 NM of the Lease Area were re-assigned to routes around the Project. All other routes remained as they were in the Base Case before the Project is constructed.

2.2.2.2 Transit routes used by Fishing vessels

A summary of the available information about transit routes used by Fishing vessels is presented in Section 2.1.1.2.

This study identified areas of relatively high fishing traffic density in the Traffic Survey Area, and some medium-high scallop fishing activity in the Project Area compared within the region (see previous Figure 2-10 and Figure 2-11). In 2019, 1,059 fishing tracks crossed the Lease Area when transiting from Ocean City to fishing grounds to the east [6].

It is possible, and considered likely, that Fishing vessels will not modify the overall direction of their route because of the presence of Project structures.

2.2.2.3 Shipping routes

The vicinity of the Lease Area is traversed by international and coastwise shipping routes. The outbound lane of the Delaware Bay Southeastern Approach TSS, located immediately north of the Lease Area, has an average of 5 (1900/365)

[9] "Near" is defined as within 4.3 NM (8 km) of the Lease Area, for consistency in this study and with other studies

transits per day. Deep draft vessels in international trade use this and other routes in the Traffic Survey Area, described in Section 2.1.1.1. Coastwise traffic is primarily Tugs, either ATBs or towlines, whose routes are described in Section 2.1.1.6.

The NJPARS process considered additional routing measures that would provide for safe routes around the Project and other lease areas (USCG, 2022a). The recommended measures are shown in Figure 2-45. If implemented, nearly all of the towline coastal shipping traffic would route to the west of the Lease Area, as needed, to avoid higher sea states, and the ATB coastal traffic headed to or from the Ports of New York / New Jersey would route to the east of the Lease Area.

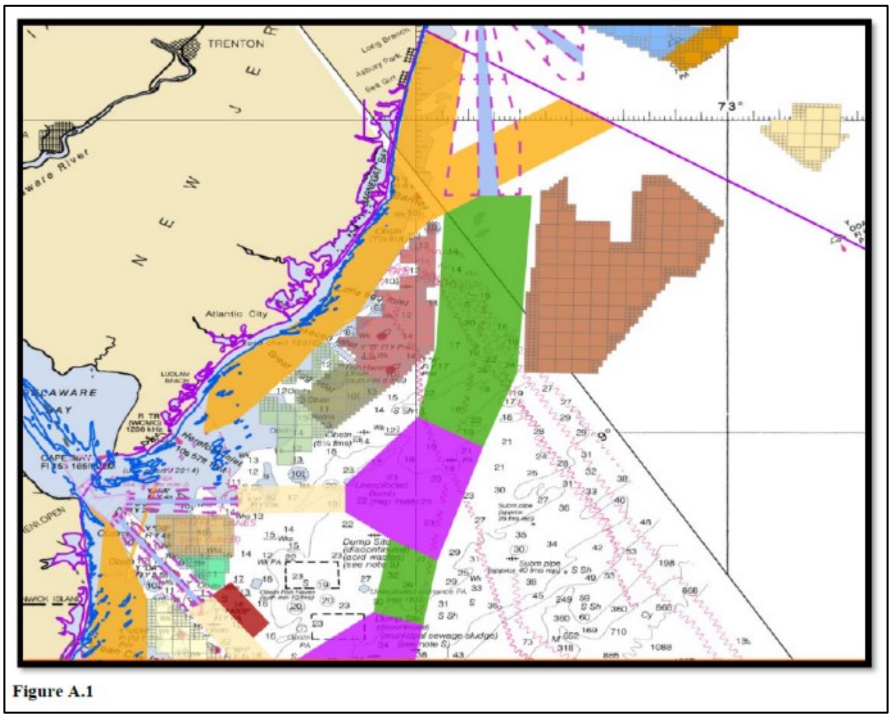


Figure 2-45 NJPARS Recommended Routing Measures and Anchorage Area (taken from USCG, 2022a)

Project structures pose a potential hazard to vessels in shipping routes that intend to transit a safe route around the Lease Area but depart the intended route because of human error or an onboard failure. This hazard is quantified in the frequency modeling presented in Section 11.1 and Appendix E. The modeling shows that extending the TSS as recommended in the final NJPARS would reduce accident frequency from the Project (Section 11.2.8). The changes in traffic patterns were modeled with the assumption that existing safety measures would be adjusted to direct traffic in a similar manner as it is directed today, for instance, moving the buoy that marks the entrance of the Southeastern Approach TSS.

2.2.3 Transit-related safety measures

2.2.3.1 Routing measures, precautionary areas, and separation zones

This section provides a review of proposed distances from routing measures, precautionary areas, and TSS.

The Marine Planning Guidelines in NVIC 01-19 Enclosure 3 are based on general risk principles; their primary intent is to inform marine spatial plans. Site-specific risk assessments, like this one, estimate the incremental risk increase related to a project and can identify ways to reduce either the consequences or likelihood of the risk. Risk-informed decisions benefit from Project-specific analysis in an NSRA to support decision making.

The existing TSS evaluated in this NSRA are codified in 33 CFR Subpart B and have also been adopted by the IMO. The sizes of lane widths and separation zones for each TSS are determined case by case. As shown in previous Figure 2-45, the current proposed routing measures extend the TSS along the northeast boundary of the Lease Area and beyond it by more than 5 NM (9.3 km).

A comparison of the recommended navigation safe distances for planning in the Marine Planning Guidelines and Project location are provided in Table 2-7.

Table 2-7 Marine Planning Guidelines

Marine Planning Guideline	Project characteristic
2 NM from the parallel outer or seaward boundary of a traffic lane.	For the 126-structure layout in previous Figure 1-2, the Project structure closest to the TSS is H03, 0.5 NM (0.9 km) from the parallel outer boundary of the Delaware Bay Southeastern Approach TSS, which does not conform to the guideline. The H03 structure is 0.4 NM (0.7 km) from the recommended TSS extension. For the 119-structure layout in previous Figure 1-3, the Project structure closest to the recommended TSS extension is N09, 1.0 NM (1.9 km) from the parallel outer boundary, which does not conform to the guideline. For the 98-structure layout in previous Figure 1-4, the Project structure closest to the recommended TSS extension is Q13, 2.0 NM (3.7 km) from the parallel outer boundary, which conforms to the guideline. Analysis of the risk resulting from departure from the guidelines is presented in Section 3.1 and Section 11/Appendix E.
5 NM from the entry/exit (terminations) of a TSS.	The current terminus of the Delaware Bay Southeastern Approach TSS is 0.5 NM (0.9 km) from the closest Project structure (H03), which does not conform to the guideline. The terminus from the recommended extension of the Delaware Bay Southeastern Approach TSS is a minimum of 5.6 NM (10 km) from the closest Project structure (R13) in any Project layout, which conforms to the guideline.

NVIC 01-19 lists site-specific considerations for potential contributions to risk. These were reviewed, and the following aspects are accounted for in the risk model to the extent they are applicable (see Appendix E and Section 11):

- High-density traffic areas
- Obstructions/hazards on the opposite side of a route
- Weather/sea-state conditions. Effects on risk from weather and sea state are discussed in greater detail in Sections 6 and 7
- Mixing of vessel types
- Complex vessel interactions

The width of the TSS lane adjacent to the Lease Area appears to be sufficient for the current level of traffic given the current lane width of approximately 2 NM (3.7 km) and an average of 5.2 vessels per day transiting the outbound lane of the Delaware Southeastern Approach. The NJPARS reviewed the need for changes to the TSS and other existing routing measures and the potential need for additional measures.

Large distances along a route is listed as a consideration in NVIC 01-19. It was accounted for in the model generically as part of the underlying fault trees in the model. The underlying assumption is that the MARCS Study Area is sufficiently represented by global averages for human errors in critical situations aboard ship. Human fatigue is a risk factor that can lead to an increased frequency of human error-caused accidents. Fatigue can be an issue for seafarers on long voyages, or on voyages with many ports of call along the seaboard. There is likely significant variation in fatigue levels among the vessel types; however, taken on the whole, the risk controls and traffic in the MARCS Study Area are expected to be at least as good as other coastal waters around the globe in DNV's expert judgment.

NVIC 01-19 also provides a list of potential risk mitigation measures, which are incorporated in the comprehensive list of identified measures in Section 11.3.

2.2.3.2 Anchorages and safe havens

Figure 2-46 shows the designated anchorages in the Traffic Survey Area. The closest existing anchorage is the Indian River Bay Anchorage Area, located 13 NM (23 km) from the Lease Area, and is too far to be influenced by routing changes associated with the Project.

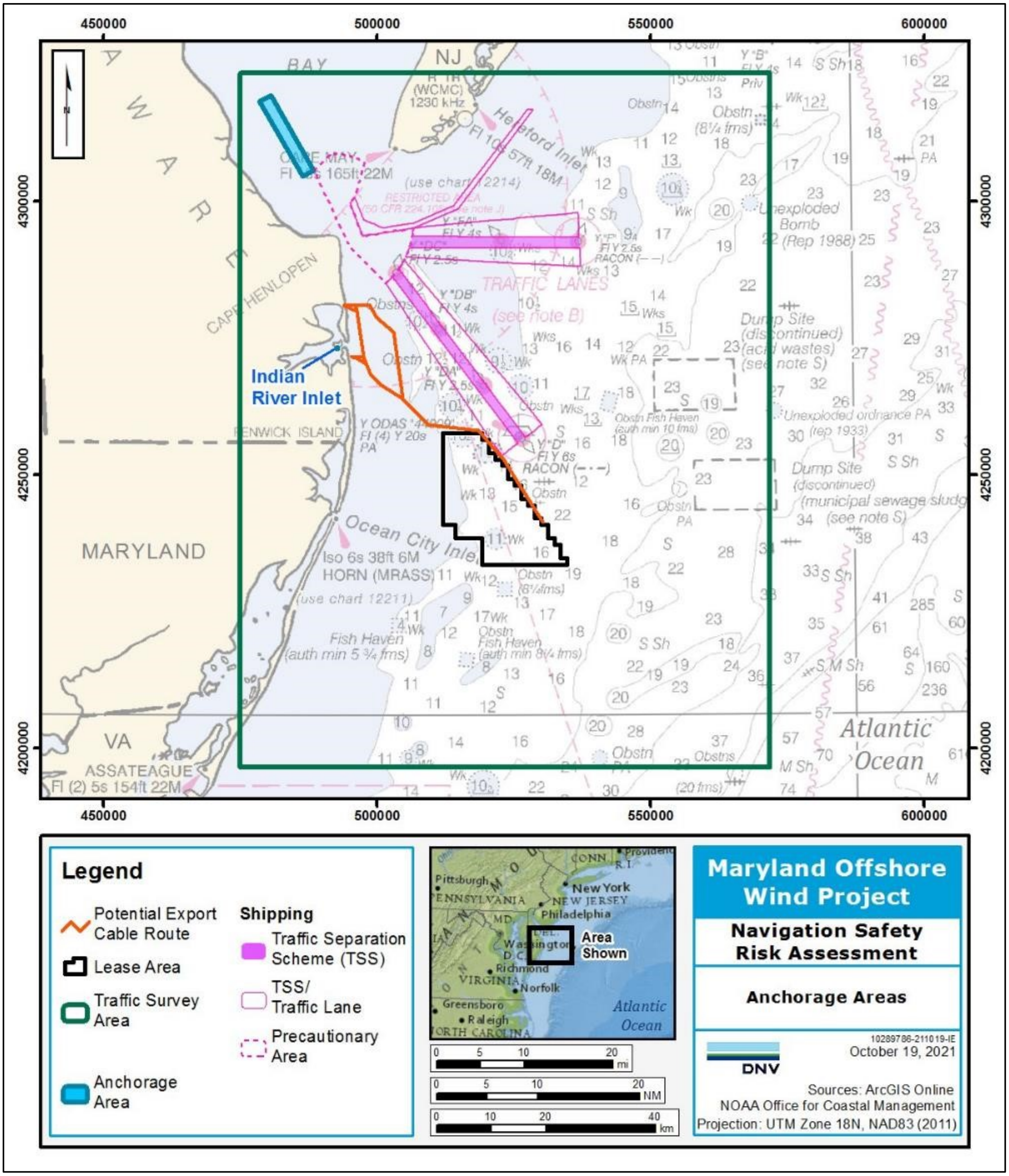


Figure 2-46 Anchorage Areas (NOAA, 2017)

Figure 2-47 shows vessels presumed to be “at anchor,” which are transiting at less than 1 kt. Most of the vessels at anchor in the vicinity of the Lease Area are deep draft vessels.

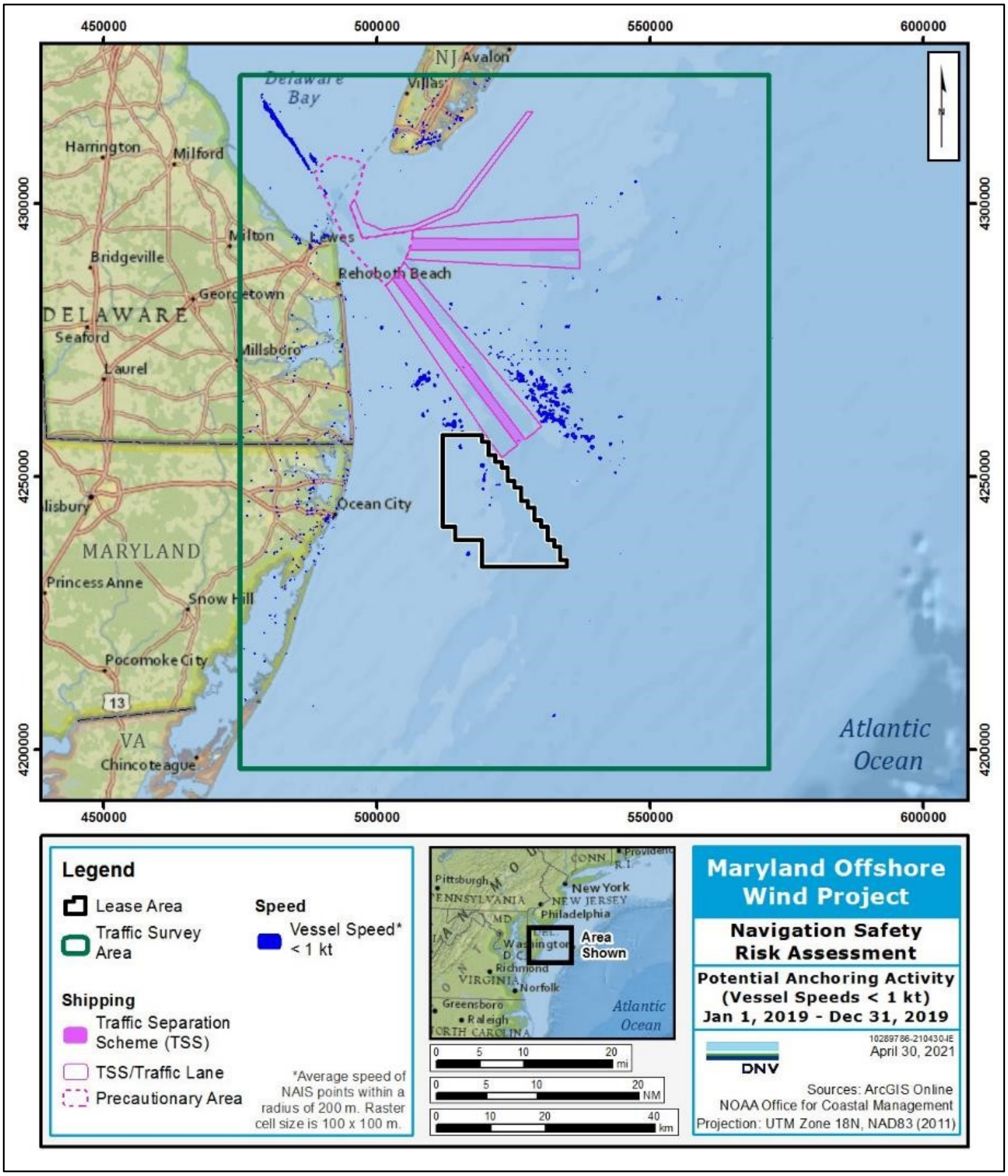


Figure 2-47 Anchoring Activity in the Vicinity of the Lease Area, Indicated by Speed < 1 kt[10]

[10] Based on speeds reported directly in the AIS data (NOAA, 2020a)

The USCG recognizes the need for additional identified anchorages outside Delaware Bay. On 9 March 2021, the USCG presented the traffic summary for the NJPARS at a meeting hosted by the Mariners Advisory Committee for the Bay & River Delaware and anchorage options were discussed (Figure 2-48) (MAC, 2021). Feedback received from participants on the three potential anchorages outside Delaware Bay was positive. Anchorages C and D were the subject of a proposed rulemaking on March 22, 2022 (87 FR 16126). The Fairway anchorage will be considered for incorporation in rulemaking that results from the ACPARS. The proposed inshore anchorage may be the subject of a separate rulemaking at a future date.

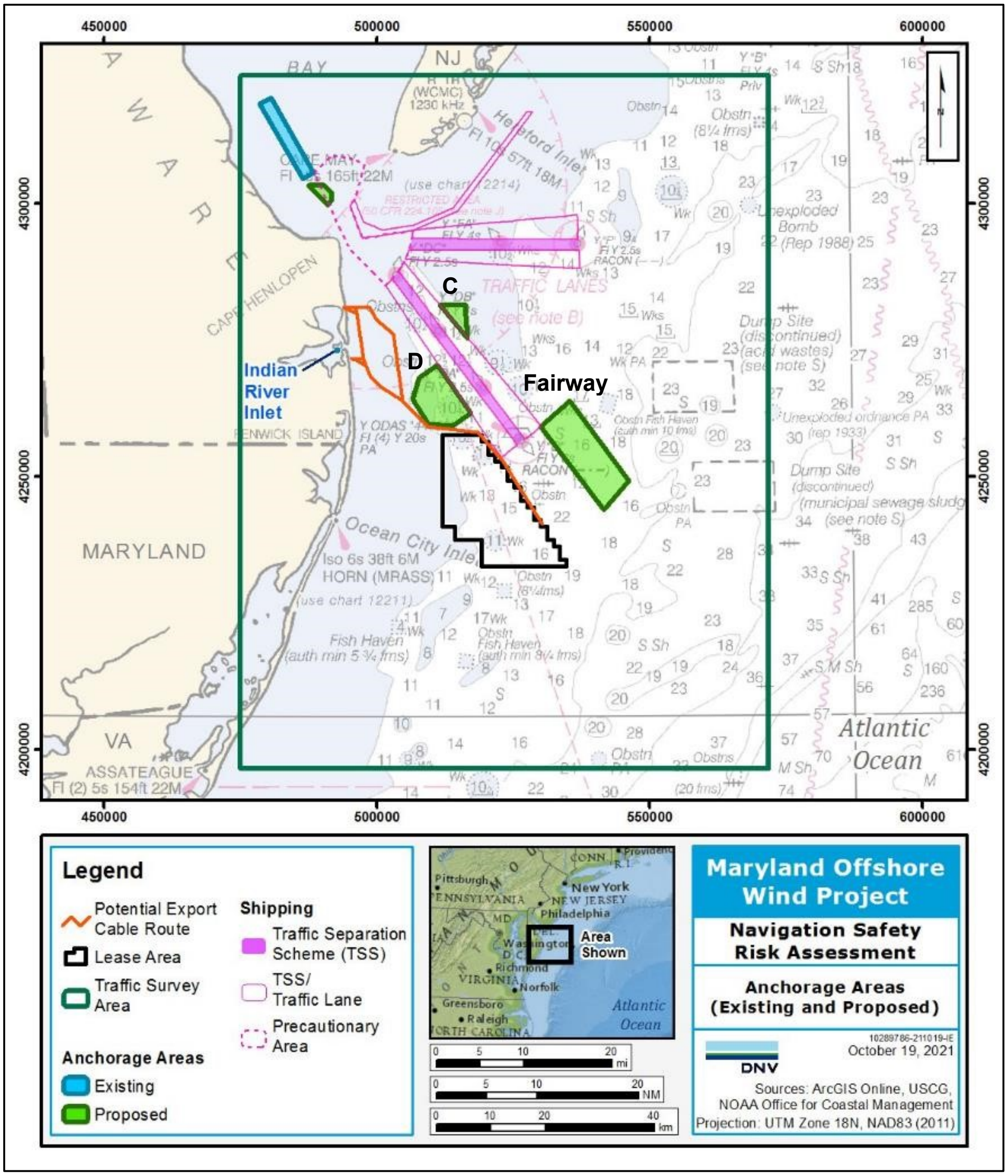


Figure 2-48 2021 Proposed Anchorage Areas as of March 2021 (USCG, 2021a)

There are no harbors of refuge for deep-draft vessels along this coast (NOAA, 2022). Waters just inside Delaware Bay are sheltered, and serve as a safe haven for vessels during conditions of adverse weather and seas. Given the alignment of the recommended fairways, the Lease Area is not anticipated to materially affect the ability of a vessel to transit to the Bay.

Concerning the potential for anchorage in an offshore wind development, based on conversations with members of the maritime industry, vessels in international trade would choose another course of action rather than anchor between structures within an offshore wind development.

2.2.3.3 Port approaches

The main deep draft ports in the vicinity of the Traffic Survey Area are along the Delaware River, which leads to the north of the Delaware Bay. To access those ports, the vessels pass through the Delaware Bay from the Delaware Bay inlet. The deep draft vessels approach the Delaware Bay inlet from the eastern TSS and the Southeastern TSS, north of the Lease Area and embark port pilots before the inlet. The other vessel types do not necessarily use the TSS to approach the inlet.

The other ports in the Traffic Survey Area are Cape May and Ocean City; however, those ports have shallow depths and accommodate primarily Recreational, Fishing, and Passenger vessels with LOA of less than 75 m.

The closest port from the Lease Area is Ocean City at 11 NM (20 km) to the west while the Delaware Bay inlet and Cape May are respectively at 24 and 29 NM (44 and 54 km) to the north. Due to these distances, the Project will not significantly impact the direct approach to these ports and inlets. However, the Southeastern TSS, which is currently ending north of the Lease Area, could be extended approximately 20 NM (37 km) further southeast to funnel the traffic around the Lease Area and prevent the deep draft traffic from transiting through the Lease Area, thus extending the total length of the TSS to approximately 39 NM (72 km).

2.2.3.4 Pilot boarding/landing areas

The Lease Area is 18 NM (33 km) from the pilot boarding areas (Figure 2-49), and because of the distance as well as the anticipated availability of anchorage areas, is not anticipated to have a material effect on pilot boarding.

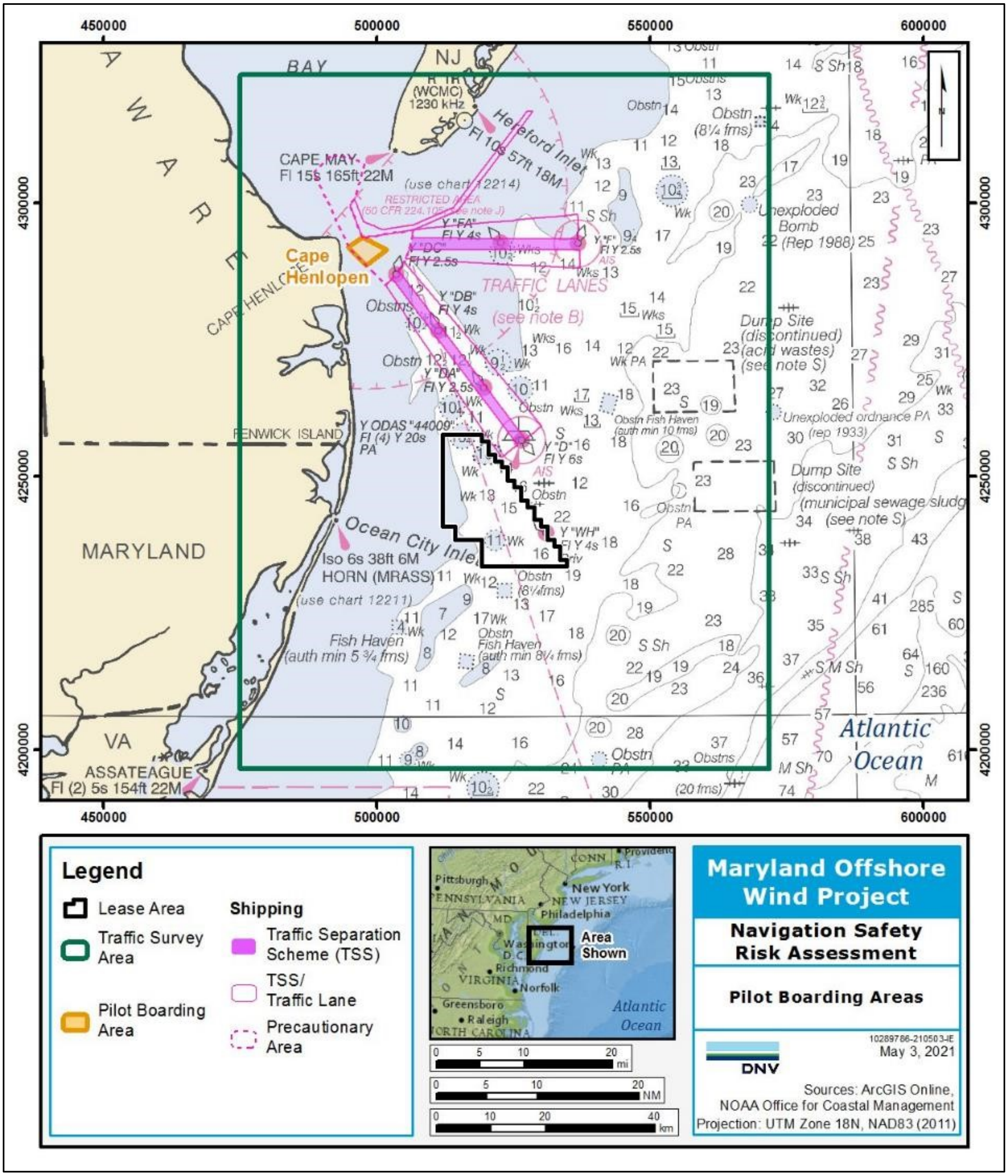


Figure 2-49 Pilot Boarding Area

2.2.3.5 Anchoring in an offshore wind development

Intentional anchorage of deep draft vessels in the Lease Area is not anticipated, as discussed in Section 2.2.3.2. In an emergency situation, the master/Watch Officer of the vessel will identify the safest course of action available at the time. Based on conversations with members of the maritime industry concerning emergency situations, vessels in international trade would choose another course of action rather than anchor between structures in an offshore wind development.

Emergency anchorage of a smaller vessel is not anticipated to snag a buried/covered inter-array cable in the Lease Area because burial depths will be based on the recommendations from a separate cable burial risk assessment and the cable location will be periodically monitored to verify that it remains at the required depth. An anchor of a small (shallow draft) vessel that snags a cable in the Lease Area has the potential to threaten vessel stability, endanger the crew, and damage the inter-array cable should an anchor penetrate the sea bed to the cable burial depth and penetrate cable protection. Standard industry practice is that anchoring in an offshore wind development is a potentially hazardous activity and should be undertaken only by Project-related vessels or in emergency situations. Cable risk is also discussed in Section 4.

2.2.4 Other aspects

This section identifies other aspects that could contribute to the risk posed by the Project:

- Section 2.2.4.1 Within the jurisdiction of a port of navigation authority
- Section 2.2.4.2 Military uses
- Section 2.2.4.3 Energy or mining uses
- Section 2.2.4.4 ATON and Vessel Traffic Services (VTS)
- Section 2.2.4.5 Structure developments and offshore disposal areas

2.2.4.1 Within the jurisdiction of a port or navigation authority

The Traffic Survey Area is within USCG Sectors Delaware Bay and Maryland/National Capital Region. No part of the Lease Area is under the jurisdiction of a port authority. Smaller port/harbor authorities exist in the region, harboring primarily recreational and fishing vessels.

State and federal agencies and port authorities, as relevant to the cable route, will be involved in the permitting process for the export cable.

2.2.4.2 Offshore firing/bombing ranges or areas used for military purposes

The Lease Area is within the Northern Virginia Capes Military Operations Area. The Lease Area is approximately 28 NM (52 km) from the nearest military firing/bombing range off Cape May, New Jersey.

2.2.4.3 Existing or proposed offshore renewable energy facility, gas platform, or marine aggregate mining

No existing gas platforms, marine mining, or renewable energy facilities are identified in the Traffic Survey Area (BOEM, 2020).

Proposed energy-related facilities in the Traffic Survey Area are shown in Figure 2-50. Section 11.4 discusses the potential cumulative effects from nearby proposed wind energy projects.

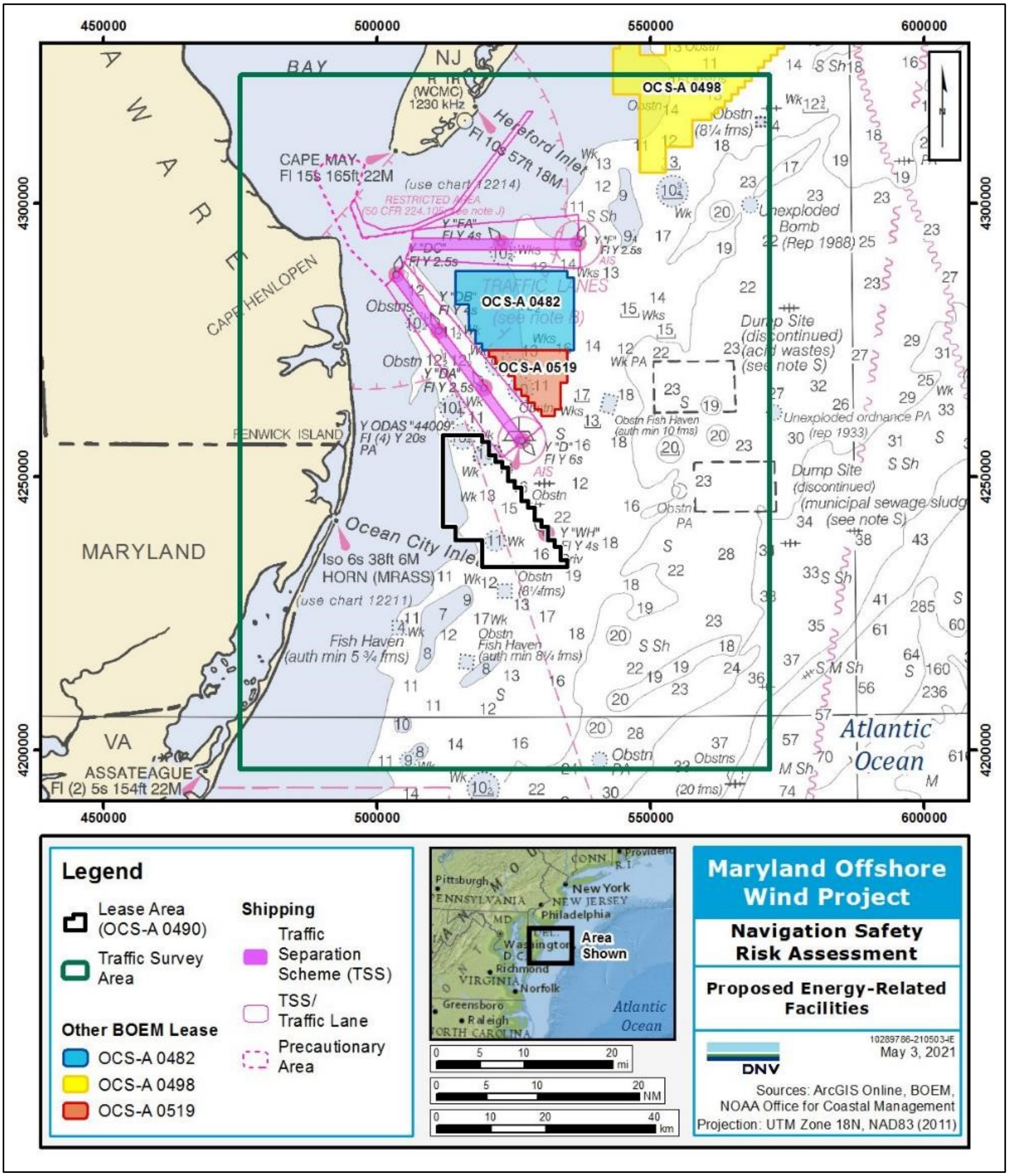


Figure 2-50 Proposed Energy-Related Facilities (BOEM, 2019a)

2.2.4.4 Aids to Navigation and Vessel Traffic Services

Federal ATON in the vicinity of the Lease Area are shown in Figure 2-51. The closest Federal ATON is Delaware Lighted Buoy D, which is 2.8 NM (5.2 km) from the Lease Area; two other buoys are nearby. No negative effects from the Project are anticipated on existing Federal ATON. Section 9 provides further discussion concerning Project effects on navigation safety and ATON. The lighting and marking of the structures may provide additional positive benefits to mariners on approach to or departure from the TSS. There is no VTS coverage in the Traffic Survey Area. The Maritime Exchange tracks cargo vessel movements within the Delaware Bay Captain of the Port zone.

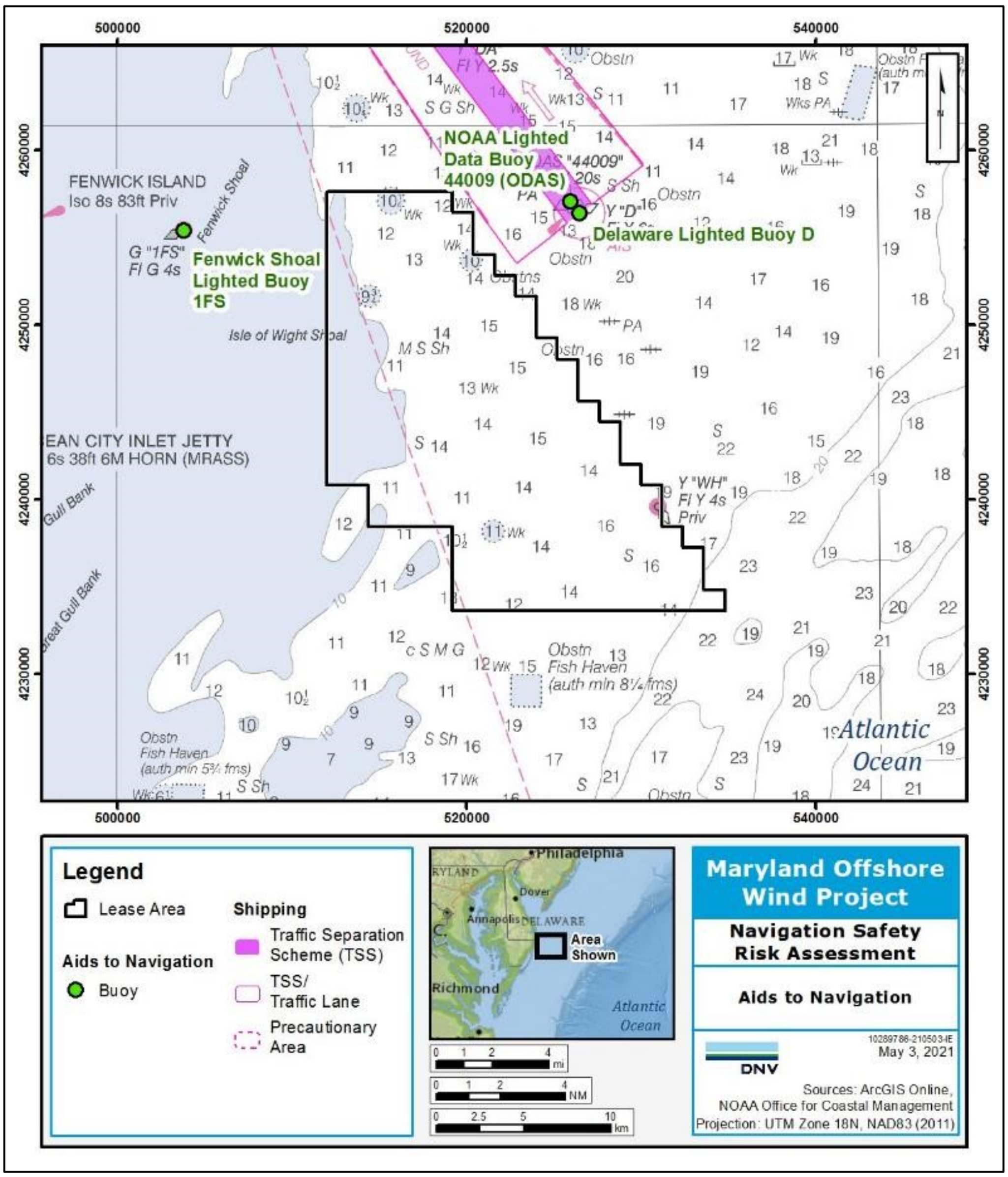


Figure 2-51 Aids to Navigation

2.2.4.5 Existing or proposed structure developments and existing designated offshore disposal areas

Except for the proposed developments mentioned in Section 2.2.4.3, no other existing or proposed structure developments are identified within the Traffic Survey Area.

There are 17 ocean disposal sites in the Traffic Survey Area (Figure 2-52). No effects from the Project are reasonably anticipated to the ocean disposal sites.

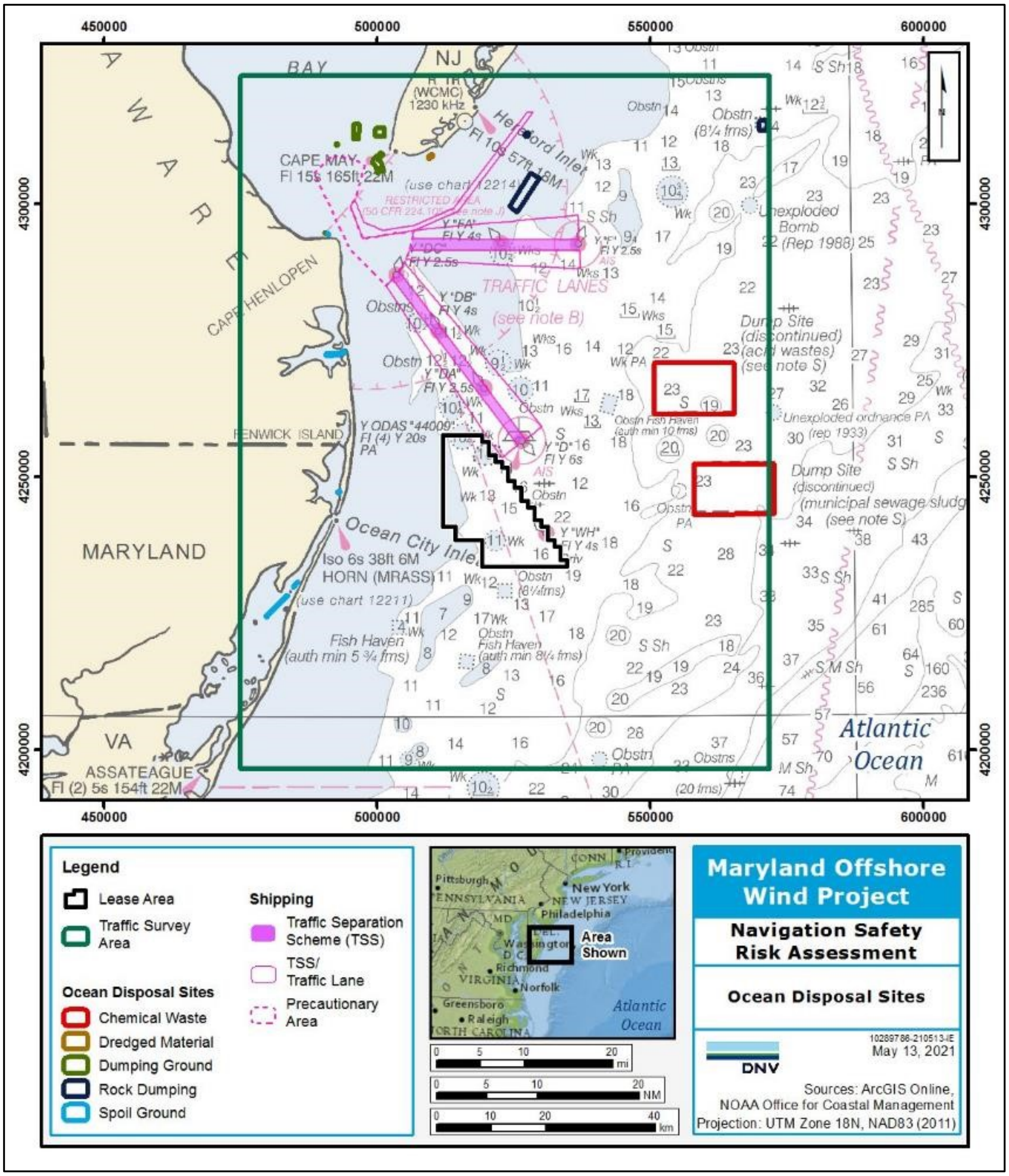


Figure 2-52 Ocean Disposal Sites (NOAA Office for Coastal Management, 2018)

2.3 Anticipated changes in traffic from the Project

Anticipated changes in traffic from the Project include new vessel transits and changes to existing traffic routes.

Section 11.4 discusses any estimated increase in distance sailed per vessel type.

2.3.1 Modification of traffic routes in the future

According to the 2019 AIS data, some deep draft vessels traverse the area where the Project structures are to be constructed. Many deep draft vessels (cargo, carriers, tankers, and cruise ships) as well as tug/service vessels are expected to choose not to navigate through a WEA based on input from industry organizations and mariners. At this time, the extent to which they will adjust their course is a matter of speculation.

For the purposes of modeling, alternative routes were developed for these vessels based on general principles of (1) avoiding a WEA by 1 NM (1.9 km), (2) minimizing the additional distance transited, and (3) accounting for existing routing measures.[11]

For the Future Case model, the following vessel types are assigned routes around the WEAs in the MARCS Study Area:

- Cargo/carriers and tankers
- Cruise ships (and Large Ferries, but no Ferries were affected)
- Tugs the alternative routes were assigned to deep draft ships (cargo, tanker, tanker oil, and passenger types) and tug/service vessels that used routes within 1 NM (1.9 km) of the Lease Area in the Base Case.

All other vessel types (Fishing, Other, and Pleasure) were modeled as continuing to navigate through the Lease Area in the Future Case. This is a conservative approach regarding any larger than average vessels in the Other category.

2.4 Effect of vessel emission requirements on traffic

The IMO specifies limits on vessel sulfur (SO_x) emissions in the defined Emission Control Areas (ECA) in North America and other locations (IMO, 1997). 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 vessels in international trade. Such vessels using fuel oil in an ECA must have a maximum of 0.50 % (mass basis) sulfur content in the fuel in use, or else be fitted with an approved equivalent means of compliance, such as a scrubber.

When Project construction begins, switchover to lower-sulfur fuel for inbound traffic should continue to occur outside the ECA boundary. The risk of loss of propulsion near the Project due to switchover at the 200 NM ECA boundary after the Project is constructed (also the border of the Exclusive Economic Zone) is below a level that is reasonably quantifiable in this Project risk model.

[11] A discussion of USCG recommended routing measures is in Section 11.4.

2.4.1 New traffic added to the Future Case

A Future Case model is built to estimate collision, allision, and grounding frequencies after the Project is constructed. It contains routes that differ from the Base Case (current situation) model to account for anticipated changes as a result of the Project and the existing Wind Energy Area (WEA) leases in the MARCS Study Area.

The following traffic that may increase in the future because of the Project was added to the Future Case model:

1. Additional non-Project traffic that might be generated by the presence of the Project. There could be public interest and structures attracting fish to the Lease Area, resulting in additional recreational fishing transits and/or pleasure tours of the Project. Discussions with recreational fishers have revealed interest in fishing within the Lease Area, once developed. Tours and pleasure vessel visits to Block Island Wind Farm, the only available analogue, are occurring (Smythe et. al., 2018). Although Block Island Wind Farm is much closer to local ports than the Project, the approach used in this assessment is to make a maximum realistic estimate of additional vessel transits to assess potential increases in navigation safety risk.
   The risk associated with this traffic is evaluated by adding it to the Future Case risk model described in Section 11 and Appendix E of this report.
   A hypothetical estimate was made of the number of vessels per year that will be added to existing local traffic patterns, as described in Section 2.1.1.5. The risk model built for this assessment includes a representation of the marine traffic in a Base Case, before the construction of the Project, and in a Future Case, after the Project is constructed. To represent the recreational traffic, 1,822 round-trips from Ocean City and 212 round trips from Indian River are added to the Future Case as Pleasure vessels.

2. Project-related traffic is another foreseeable change in marine traffic volume from the Project. Vessel transits to the Lease Area will occur related to construction, operations and maintenance, and inspections. During the Project's operational phase, which is modeled to estimate collision, allision, and grounding risk, an estimated 600 CTV round trips are anticipated to occur and are included in the Future Case model as Passenger vessels. Most of the time, these vessels will be holding station in the Lease Area, an aspect that is not included in a route-based model such as MARCS.

2.5 Seasonal variations in traffic

The AIS data set used in this assessment covers a time span of one year. Seasonal variations in traffic were analyzed per month for each vessel type. Figure 2-53 and Figure 2-54 show the number of vessel tracks per month per vessel type in the Traffic Survey Area.

The number of vessel tracks in the Traffic Survey Area is highest in the summer with a peak of approximately 6,000 tracks in June, July, and August. The low is in February with approximately 2,200 tracks. In 2019, Tug traffic was consistent across all months at an average of 438 per month.

The difference between winter and summer traffic was the greatest for Pleasure vessels, with a range of 8 to 2,154. Substantial seasonal differences are also evident in the data for Fishing, Passenger, and Other vessel types. Four or fewer Cruise/Ferry tracks occurred per month, except for a peak of 13 during October of 2019.

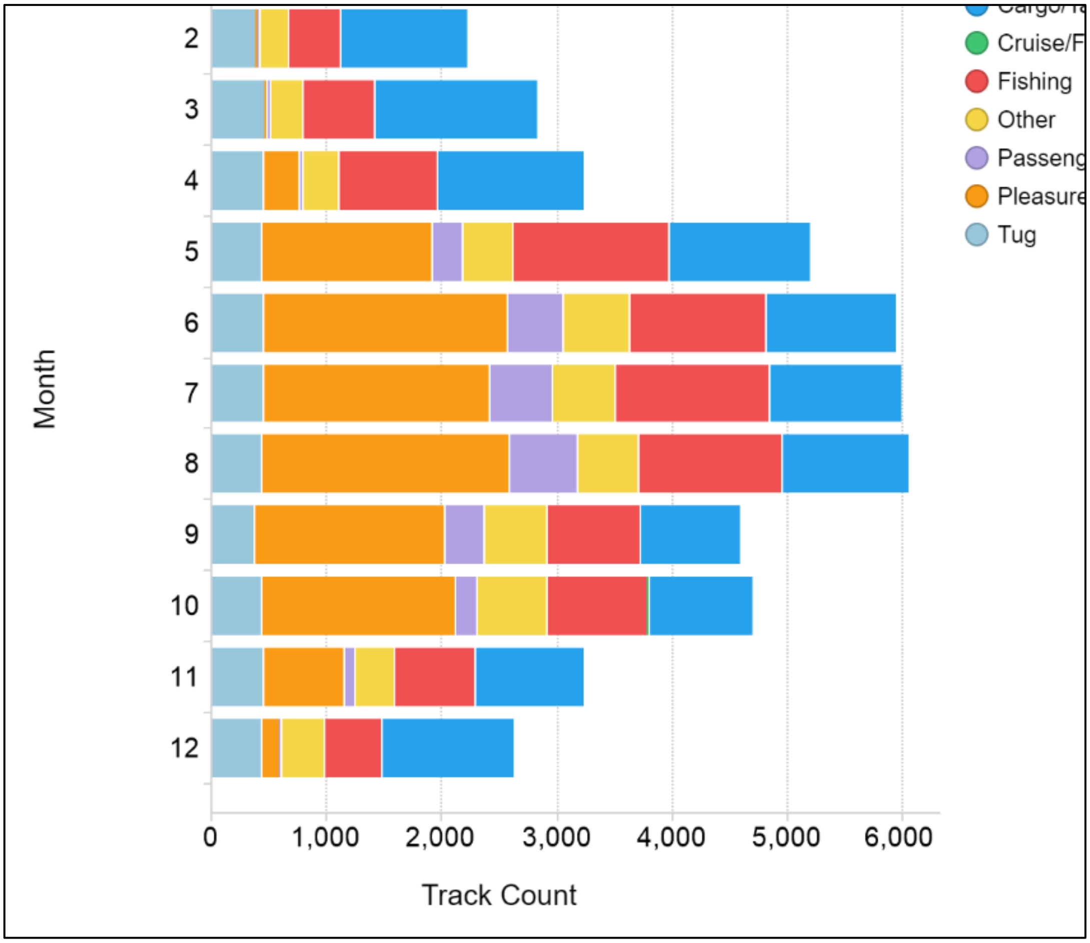


Figure 2-53 Track Count per Month in the Traffic Survey Area[6]

For purposes of comparison, Figure 2-55 shows the same data another way.

Focusing on the traffic near the Lease Area (Figure 2-54) , September and October were peak months for Tug, Cargo/Carrier, and Tanker traffic. In and near the Lease Area the Fishing traffic did not dramatically increase in the summer; it is comparatively stable through the year.

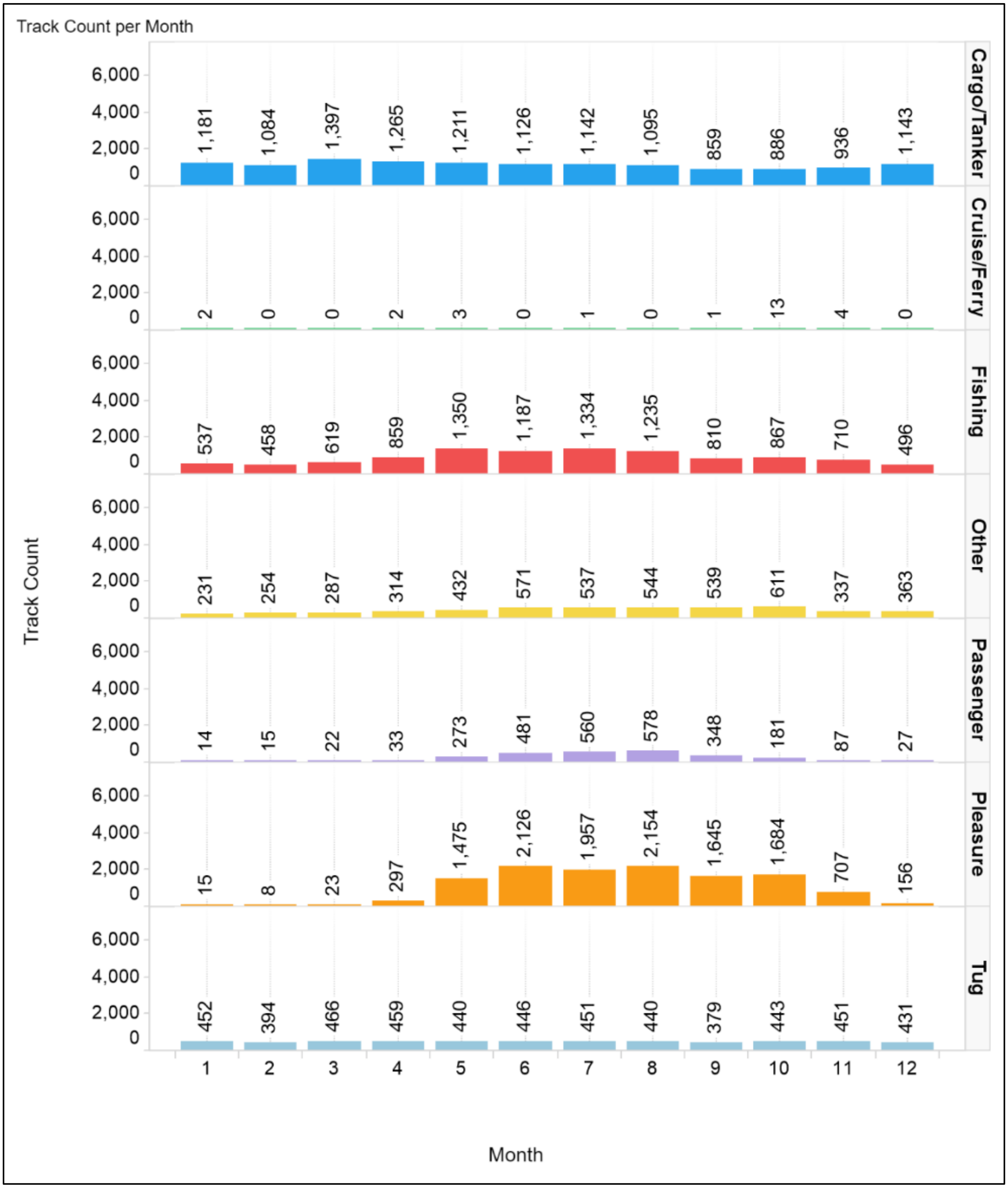


Figure 2-54 Seasonality of Traffic per Vessel Type in the Traffic Survey Area[6]

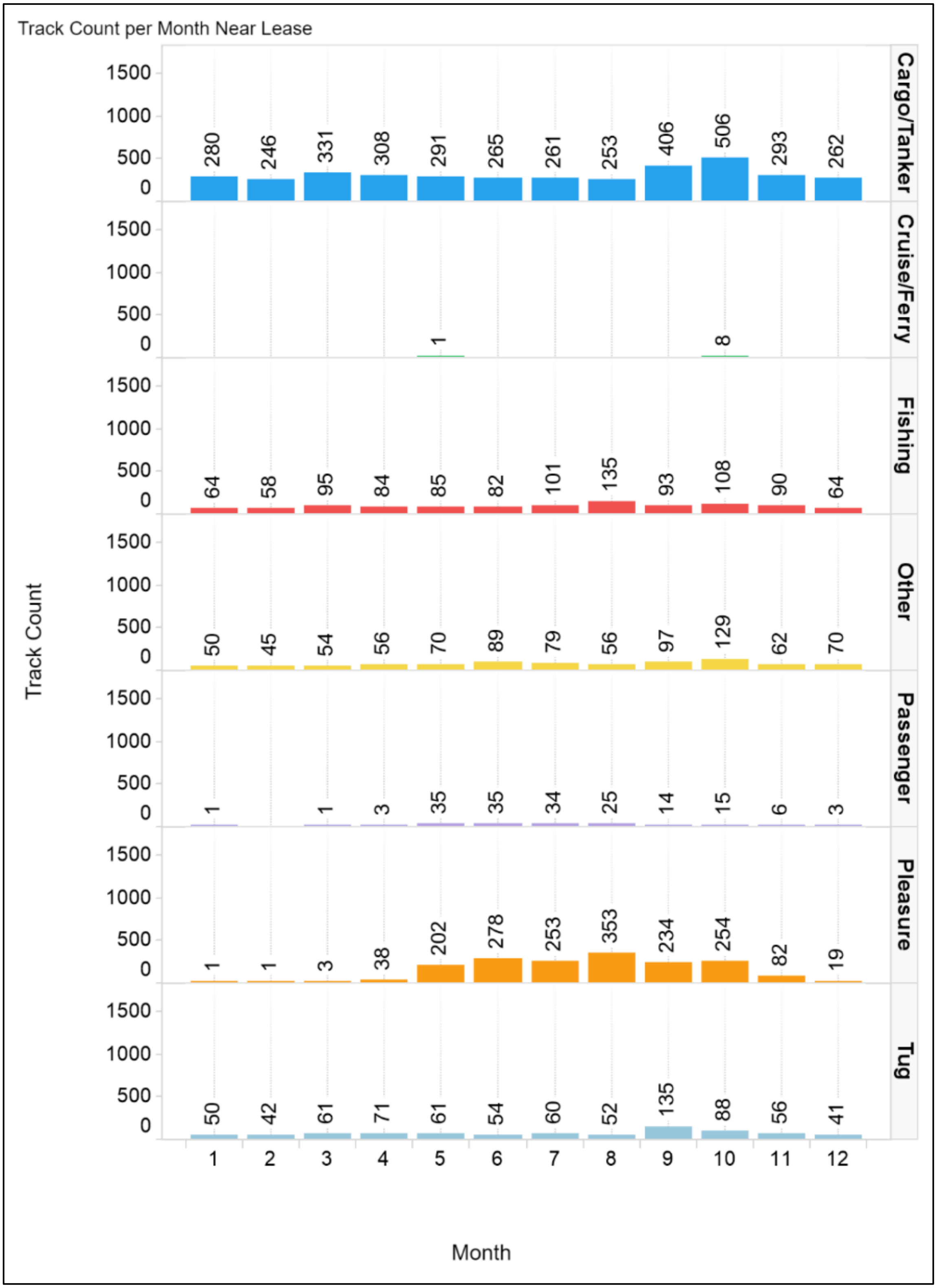


Figure 2-55 Seasonality of Vessel Tracks Near the Lease Area[6, 9]

3 OFFSHORE ABOVE-WATER STRUCTURES

This section describes:

- Hazards posed by Project components to vessels (Section 3.1)
- Project clearances and vessel types (Section 3.2)
- Emergency rescue activities in the Lease Area (Section 3.3)
- Noise as a result of the Project (Section 3.4)
- Potential damage to Project components from allision by a passing vessel (Section 3.5)

3.1 Hazards to vessels

A hazard identification exercise was completed to determine the primary hazards posed by the Project to vessels when the Project is operational. The results related to above-water structures are presented in this section. Construction-phase navigation risks are presented in Section 5.1.

3.1.1 Air gap

The following structures could pose a hazard to a vessel with a mast or other structural component taller than the following heights above MHHW:

- WTG – 34.7 m (114 ft)
- OSS platform – 21.6 m (70.9 ft)
- Met tower upper access platform – 20.0 m (65.6 ft)

Section 3.2 discusses this hazard.

3.1.2 Keel clearance

The primary scenario of concern for keel clearance would be allision with the foundation of the Met tower. The Met tower will have three legs, which will be approximately 15 x 15 x 21 m (50 x 50 x 71 ft) apart on the sea bed. 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 structure. Vessels passing at a safe distance as per International Regulations for Preventing Collisions at Sea (COLREGs) will be well away from support legs. See Section 6 for a discussion on water depths.

3.1.3 Subsea (buried) cable

A subsea cable could pose a hazard to a vessel if an anchor penetrated the sea bed to the depth of the cable. See further discussion in Section 4.

3.1.4 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 their signals (DOE, 2013). See discussion in Section 10.2 and Section 10.3.

3.1.5 Noise

Sound from Project components will add to background noise levels. See discussion in Section 3.4.

3.1.6 Stationary object at or near the waterline

The following potential scenarios that could lead to an allision with a Project structure were identified:

(1) A vessel (passing or fishing) on course with the foundation

(2) A vessel adrift in the direction of a foundation

(3) A vessel taking evasive maneuvers to avoid a collision with a vessel *transiting* in the outbound lane of the Delaware Bay Southeastern Approach.

(4) A vessel taking evasive maneuvers to avoid a collision with a vessel *crossing* the outbound lane of the Delaware Bay Southeastern Approach.

The risks from scenarios (1) and (2) are analyzed in Section 11.0. Section 11.1 discusses the consequences of an allision with a Project structure and Section 11.2.3 presents modeled estimates of the likelihood, or frequency, of an allision with a Project structure. The risk from scenarios (3) and (4) are analyzed in Section 3.1.1.

3.1.7 Project vessels transiting between port and the Lease Area

Project-related vessels transiting between local ports and the Lease Area will add to the baseline traffic described in Section 2. The Project COP Volume I Section 4 contains descriptions of the transits and identifies potential ports.

During the construction phase of the Project, the comparative level of Project-related traffic will be much higher than during the operations phase of the Project, and activities outside the Lease Area will include laying of cable along the permitted cable route. Construction phase marine traffic will increase for a relatively short span of time and additional safety measures will be in place to reduce the risk of collisions with Project vessels. Section 5.1 discusses construction phase risks and mitigations.

During the operations phase of the Project, vessels supporting operations and maintenance (O&M) activities will transit between local ports, primarily Ocean City, and the Lease Area. Section 5.2 discusses operational phase risks and mitigations.

3.1.8 Fishing vessels fishing in the Project Area

Interactions between mobile and fixed-gear and Project structures could result in damage or loss of the gear and/or damage to the vessel. Fishing gear in the Lease Area could snag on a foundation or ancillary components, such as J-tubes on the outside of a monopile. The risk of a fishing vessel allision with a Project structure during transit through the Project Area is assessed in Section 11.

Table 3-1 summarizes the hazards posed by above water components of the Project to recreational and commercial fishing vessels and fishing activities.

Table 3-1 Above Water Hazards to Fishing Vessels and Fishing Activities in the Project's Operational Phase

Activity and Species	Location and Methods	Description of Hazard
Bottom otter trawling – mixed species †	Throughout the Lease Area; most effort has been in central and southern portions. † Based on AIS data, the local preference is to make multiple straight-line tows with gear on the sea bed along a narrow path, preferably at a constant depth of water. †	Allision with a Project structure – possible. The range of potential consequences is described in Section 11.1.2. This risk can be mitigated by the readily visible structures on radar, lighting and marking of structures, structure locations indicated on charts, and collision-related mitigations listed below. Collision with another vessel – possible. The range of potential consequences is described in Section 11.1.1. This risk can be mitigated by: (1) communication between vessels that are actively fishing in the vicinity of Project structures; (2) slowing speed by fishing vessels exiting the Lease Area; and/or (3) heightened awareness by all vessels transiting in in the vicinity of Project structures, including diligence in watchkeeping.
Potting/trapping – black sea bass, conch (whelk); less common: eels, crabs, and lobster †	Throughout the Lease Area; more intense along eastern and southeastern boundaries. † Strings 1 to 36 pots/traps are set and left for a day, a week or potentially longer, then retrieved, emptied, and reset. † Should surface markers become detached from the gear, a grapnel is dragged to recover the gear. †	Allision with a Project structure – possible. The range of potential consequences is described in Section 11.1.2. This risk can be mitigated by the readily visible structures on radar, lighting and marking of structures, structure locations indicated on charts, and collision-related mitigations. Collision with another vessel – possible. The range of potential consequences is described in Section 11.1.1. This risk can be mitigated by: (1) communication between vessels that are actively fishing in the vicinity of Project structures; (2) slowing speed by fishing vessels exiting the Lease Area; and/or (3) heightened awareness by all vessels transiting in in the vicinity of Project structures, including diligence in watchkeeping.
Bottom tending gillnetting – dogfish, skate, monkfish, sea bass, and some other species	Throughout the Lease Area; † Nets are set in strings, up to 610 m (0.32 NM, 2,000 ft) or longer , anchored in place, and retrieved within a wide range of durations. † Gear is recovered via buoy lines, potentially dragging anchors along the sea bed. †	Allision with a Project structure – possible. The range of potential consequences is described in Section 11.1.2. This risk can be mitigated by the readily visible structures on radar, lighting and marking of structures, structure locations indicated on charts, and collision-related mitigations. Collision with another vessel – possible. The range of potential consequences is described in Section 11.1.1. This risk can be mitigated by: (1) communication between vessels that are actively fishing in the vicinity of Project structures; (2) slowing speed by fishing vessels exiting the Lease Area; and/or (3) heightened awareness by all vessels transiting in in the vicinity of Project structures, including diligence in watchkeeping.
Floating/drift gillnetting – including bluefish, weakfish, and several species of shark †	Can occur in the Lease Area, with more in the northern portion; however, most drift gillnet effort occurs inshore of the Lease Area. † The string, potentially more than a mile long, is set after locating (marking) target species with onboard electronics, gear is supported by buoys and remains attached to the vessel, and is hauled after a relatively short time period, which can be less than an hour. †	Allision with a Project structure – possible. The range of potential consequences is described in Section 11.1.2. This risk can be mitigated by the readily visible structures on radar, lighting and marking of structures, structure locations indicated on charts, and collision-related mitigations. Collision with another vessel – possible. The range of potential consequences is described in Section 11.1.1. This risk can be mitigated by: (1) communication between vessels that are actively fishing in the vicinity of Project structures; (2) slowing speed by fishing vessels exiting the Lease Area; and/or (3) heightened awareness by all vessels transiting in in the vicinity of Project structures, including diligence in watchkeeping.

Activity and Species	Location and Methods	Description of Hazard
Surf clam and ocean quahog dredging	Possible throughout the Lease Area but is currently conducted at very low levels compared to deeper offshore waters, and may not be commercially viable at this time. † The hydraulic dredges may be towed at 3 to 4 kn up to two at a time, liquifying and removing sediment. With multiple passes, potentially to a cumulative depth of more than 1 m (3 ft). †	Allision with a Project structure – possible. The range of potential consequences is described in Section 11.1.2. This risk can be mitigated by the readily visible structures on radar, lighting and marking of structures, structure locations indicated on charts, and collision-related mitigations. Collision with another vessel – possible. The range of potential consequences is described in Section 11.1.1. This risk can be mitigated by: (1) communication between vessels that are actively fishing in the vicinity of Project structures; (2) slowing speed by fishing vessels exiting the Lease Area; and/or (3) heightened awareness by all vessels transiting in in the vicinity of Project structures, including diligence in watchkeeping.
Scallop dredging	Currently there is little suitable scallop habitat or scallop fishing in the Lease Area; although the Area has been historically significant to the scallop fishery. † Based on AIS data, the local preference is to make multiple straight-line tows for 3 to 4 NM (5.6 to 7.4 km) at 4.5 to 5 kt with gear on the sea bed along a narrow path, preferably at a constant depth of water. The radius of a turn with gear down can be less than 0.3 NM (0.6 km). †	Allision with a Project structure – possible. The range of potential consequences is described in Section 11.1.2. This risk can be mitigated by the readily visible structures on radar, lighting and marking of structures, structure locations indicated on charts, and collision-related mitigations. Collision with another vessel – possible. The range of potential consequences is described in Section 11.1.1. This risk can be mitigated by: (1) communication between vessels that are actively fishing in the vicinity of Project structures; (2) slowing speed by fishing vessels exiting the Lease Area; and/or (3) heightened awareness by all vessels transiting in in the vicinity of Project structures, including diligence in watchkeeping.
Fishing with other commercial gear	Purse seine fishing for schooling bait fish may occasionally occur within the Lease Area (anecdotal). † Longline for pelagics occurs further offshore (Fishing vessel transit risk is assessed in Section 11). †	Should purse seine fishing occur in the Project Area, the risks would be similar to or less than those from floating/drift gillnetting. NA
Recreational fishing	Possible throughout the Lease Area and is expected to increase after Project structures are present. Sport fishing primarily uses hook/line, but also may uses pots/traps.	Allision with a Project structure – possible. The range of potential consequences is described in Section 11.1.2. This risk can be mitigated by the readily visible structures on radar, lighting and marking of structures, structure locations indicated on charts, and collision-related mitigations. Collision with another vessel – possible. The range of potential consequences is described in Section 11.1.1. This risk can be mitigated by: (1) communication between vessels that are actively fishing in the vicinity of Project structures; (2) slowing speed by fishing vessels exiting the Lease Area; (3) heightened awareness by all vessels transiting in in the vicinity of Project structures, including diligence in watchkeeping.

Activity and Species	Location and Methods	Description of Hazard
Locating (marking) of fish using onboard electronics – bluefish, weakfish, and several species of shark	Most of this activity occurs between the Lease Area and shore. Drift gillnetting and several other activities use marking to identify targets.	Allision with a Project structure – possible. The range of potential consequences is described in Section 11.1.2. This risk can be mitigated by the readily visible structures on radar, lighting and marking of structures, structure locations indicated on charts, and collision-related mitigations. Collision with another vessel – possible. The range of potential consequences is described in Section 11.1.1. This risk can be mitigated by: (1) communication between vessels that are actively fishing in the vicinity of Project structures; (2) slowing speed by fishing vessels exiting the Lease Area; and/or (3) heightened awareness by all vessels transiting in in the vicinity of Project structures, including diligence in watchkeeping.

* Assuming cables are at or below their target burial depths

† Fisheries Assessment Report, COP Appendix II-F2 (Sea Risk Solutions, 2021)

‡ 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.

3.1.9 Risk to a vessel in the TSS taking evasive maneuvers

DNV offers this calculation at the request of and as support for the USCG's evaluation of navigation safety. There are two general approaches to authorities' acceptance or rejection of projects that have the potential for major accidents: (i) a risk-based approach and (ii) a consequence-based approach. A risk-based approach considers the combination of frequency and consequence as a pair, while a consequence-based approach views the worst credible consequences as the most important factor to consider. The frequency evaluation in Section 11 provides information for a risk-based evaluation of the Project, and this section provides information for a consequence-based evaluation. In some high-risk industries, both are used. The USCG will select the approach to be applied for the Project and on what basis a determination of acceptability will be made.

Adequate sea room is an important consideration for a vessel attempting to avoid a collision in the TSS. Although mariners desire to and take actions to avoid encounters, encounters occur nonetheless. The United Nations Convention on the Law of the Sea (UNCLOS) Article 60 (United Nations, 1982) requires that, "Artificial islands, installations and structures and the safety zones around them may not be established where interference may be caused to the use of recognized sea lanes essential to international navigation." The COLREGS state that "when two power-driven vessels are crossing so as to involve risk of collision, the vessel which has the other on her starboard side (the give-way vessel) must keep out of the way of vessels in the shipping lane (Rule 15)" and "shall, so far as possible, take early and substantial action to keep well clear. (Rule 16)" Applied to the TSS outbound lane adjacent to the Project, a cargo vessel in the outbound lane of the Delaware Bay Southeastern Approach must try to avoid crossing ahead of the crossing vessel and take substantial action to stay clear.

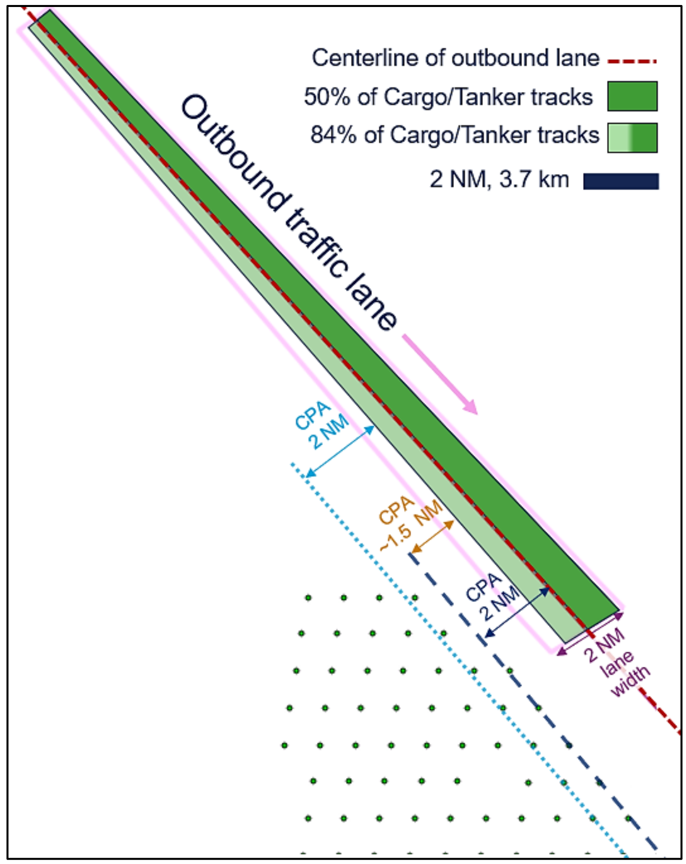
Regarding traffic crossing the TSS, notable portions of COLREGS Rule 10 (IMO, 1972) are:

> (c) A vessel shall, so far as practicable, avoid crossing traffic lanes but if obliged to do so shall cross on a heading as nearly as practicable at right angles to the general direction of traffic flow.
>
> (h) A vessel not using a traffic separation scheme shall avoid it by as wide a margin as is practicable.
>
> (i) A vessel engaged in fishing shall not impede the passage of any vessel following a traffic lane.
>
> (j) A vessel of less than 20 metres in length or a sailing vessel shall not impede the safe passage of a power-driven vessel following a traffic lane.

Applied, the COLREGS lead to a conclusion that the siting of structures should not interfere with the ability of a vessel in the TSS to give way to a vessel emerging from the Project. The minimum distance required to take substantial action to give way is evaluated below in two ways: time (and distance traveled) to detect a vessel emerging from a wind farm; and distance needed for an extreme evasive maneuver.

Analysis of AIS data in Appendix E (Section E.2.7) shows that vessels transiting the TSS have a very strong tendency to transit down the center of a TSS lane. The analysis of the distribution of tracks within a cross-section of the outbound TSS lane shows that, based on 2019 AIS data [6], it is reasonable to anticipate the following vessel transit CPAs from proposed structures in the preferred layout:

- Approximately 950 Cargo/Carrier and Tanker transits per year (50% of the outbound transits) will have a minimum 2 NM CPA from all structures.
- Approximately 1,211 Cargo/Carrier and Tanker transits (84%) will have an estimated minimum 1.5 NM CPA from all structures. The vessels transiting Delaware Bay not the largest among the world fleet; they have an average LOA of about 200 m (660 ft) (see Section 2.1.3.2). According to AIS data, 84% have an LOA less than 232 m (761 ft), with a resulting rule-of thumb turning circle radius of 1.3 NM (2.5 km)[12]. Therefore, should circumstances warrant extreme evasive maneuvers by a Cargo/Carrier or Tanker and the selected course of action be a round turn to starboard, based on the AIS data for 2019, 37 transits per year could be potentially exposed to an allision hazard from up to 21 structures, assuming the TSS is extended.[13]
- By design, all of the Cargo/Carrier and Tanker transits in the outbound TSS lane (1,442, 100%) will have a minimum 1 NM CPA from all structures.



The frequency of this event is a small fraction, justifiably much less than 10%, of the modeled powered allision accident frequency for Cargo/Carrier and Tankers, which has an estimated recurrence interval of 1 every 610 years. **Therefore, an estimate of recurrence for this specific evasive scenario is a maximum of 1 accident every 6,000 years.**

This analysis suggests that in the overwhelming majority of crossing situations, a vessel traveling in the outbound lane of the TSS would have distance and time to observe and avoid a vessel that was attempting to cross the TSS at, as nearly as

[12] See the discussion at the end of this section on Rule of thumb distance required for an extreme evasive maneuver.
[13] If the TSS is not extended, approximately 6 structures could pose a hazard to the largest outbound Cargo/Carrier and Tanker vessels in the last few miles of the TSS lane.

practicable, right angles to the direction of traffic flow if both vessels were operating in accordance with COLREGS Rule 10 (c).

Time and distance traveled to evaluate Closest Point of Approach

WTGs do not meaningfully interfere with AIS reception, so vessels transmitting AIS would be visible even inside the Project, which is critical information for vessels transiting the TSS. However, WTGs can interfere with radar signals, and it is possible that a vessel not transmitting AIS could emerge from inside the Project and might only come visible on the radar of a vessel in the TSS after passing an exterior WTG. In good visibility with vigilant watchkeeping, this is not an issue. However, when visibility is reduced, time is required to calculate the Closest Point of Approach (CPA). According to a study by the World Association for Waterborne Transport Infrastructure (PIANC, 2018),

> "Wind farms cause radar interference in addition to the effect of swapping targets. The safe distance to avoid interference has been determined by deep sea pilots to be 0.8 NM and surveys have identified a minimum distance of 1.5 NM from a OWF is necessary to minimise the interference on ship born radar and the automatic radar plotting acquisition."

The USCG requested that DNV estimate the sea room required for a full round turn as a possible extreme evasive maneuver. The below calculations are not intended to describe steering or rudder control failures, as the direction of the rudder is a key factor affecting whether an allision occurs, and therefore the steering failure scenario is included in the allision frequency modeling presented in Section 11.

Distance required for an extreme evasive maneuver

Despite requirements, planning, and good intents of mariners, it is possible that a vessel in the TSS might need to take extreme evasive maneuvers to avoid a collision with a vessel exiting the Project. Representatives of the pilots and the Chamber of Shipping of America indicated strong hesitancy to take any evasive maneuvers that would result in their vessel entering a wind farm. DNV interprets this to indicate that these mariners would first evaluate other options prior to deciding to implement a full round turn to starboard, when it would bring the vessel close to Project structures.

The required distance from the TSS for a full round turn to starboard is calculated two ways: (1) based on vessel design standards and (2) based on a rule of thumb and current correction. Each is described below.

(1) Vessel design standards include minimum required maneuvering capabilities of deep draft vessels (IMO, 2002), which can serve as a reasonable basis for a minimum clear distance between a TSS and a row of WTGs. Applicable to this analysis, the tactical diameter for a full round turn should not exceed 5 ship lengths (MSC.137 (76) and MSC/Circ.1053).

In line with the principle that a TSS, by design, should allow a vessel in any part of a TSS lane to act in accordance with COLREGS, the room for a full round turn is measured from the edge rather than the center of the TSS lane. However, the probability of a vessel at the edge of the TSS is low based upon actual vessel traffic patterns noted in the data, as discussed above.

For the Delaware Bay Southeastern Approach, this study estimates the minimum distance needed for an evasive full round turn is 1.56 NM for a vessel that is 400 m (1312 ft) long, as depicted in Figure 3-1. This is a conservative calculation based on larger vessels than are anticipated to enter the Delaware Bay during the Project's permitted lifetime. The calculation is based on a vessel with LOA of 400 m (1312 ft) and assumes that all evasive maneuvers are taken by the vessel transiting the TSS. The longest vessel in the Traffic Survey Area in 2019 was the Essen Express, with LOA of 366 m (1,200 ft) [6]. No 400 m vessels have transited the Delaware Bay TSS as of September 2021. Although the global and regional trend toward larger cargo and container vessels is well documented, the project to deepen the Delaware River Main Channel to 45 ft

(14 m) was funded in 1992 and was completed in Feb 2020 (USACE, 2021). Future dredging to 50 ft (15 m) would enable 400-m LOA vessels and to transit the Delaware Bay waters, but is not proposed at this time. Because of funding requirements, the presence of pipelines, and the duration of planning processes, further deepening is unlikely to occur during the Project's operational life.

The minimum distance shown in Figure 3-1 is estimated as follows:

- Prior to beginning an extreme evasive maneuver, the vessel will begin to deviate from its course, taken as a minimum of 0.3 NM (0.55 km).
- The vessel must be able to take a full round turn within 5 vessel lengths (1.1 NM, 2 km).
- A minimum distance from a WTG foundation is assumed to be one rotor diameter (approximately 300 m, 984.3 ft).

For the preferred layout with 119 structures, shown in previous Figure 1-3, the structure closest to the recommended TSS extension is N09, at a distance of 1.0 NM (1.9 km) from the outer boundary. This is less than the 2 NM (3.7 km) recommended distance in the Marine Planning Guidelines. This conservative set of assumptions results in a turning radius greater than is provided by Project layouts including 126 and 119 structures. However, when transiting along the center of the TSS lane, there is 2 NM of available water to both starboard and port; no Project structures are within the minimum turning radius for a vessel with a 400 m LOA transiting in the center of the lane, as is the current practice (see Appendix E, Section E.2.7).

No 400 m vessels have transited this TSS to date; the largest vessel in 2019 had an LOA of 367 m.

Risk is the combination of frequency and consequence. The above distance is an estimate applicable to a scenario wherein a very large merchant vessel is unable to fully execute a 180-degree turn to starboard while operating on the extreme outside of the TSS traffic lane, and it allides with a Project WTG structure located 1 NM (1.9 km) from the outer edge of the TSS traffic lane. The frequency of this isolated scenario is significantly less than the estimated frequency of a powered allision by any deep draft vessel (discussed in Section 11.2.2 and 11.2.8). Additional conditional probabilities should be considered:

- The distribution of traffic in the outbound lane (a multiplier of at least 0.5)
- Only a small proportion of the Project Area boundary adjacent to the TSS presents the specified hazard. There is significant distance between WTGs compared to the size of the WTGs' hazard footprints.

The consequences of this event would likely include significant damage to both the vessel and the WTG, and possible release of fuel or oil into the waterway. A risk-based evaluation accounts for the combination of frequency and consequences of extreme events.

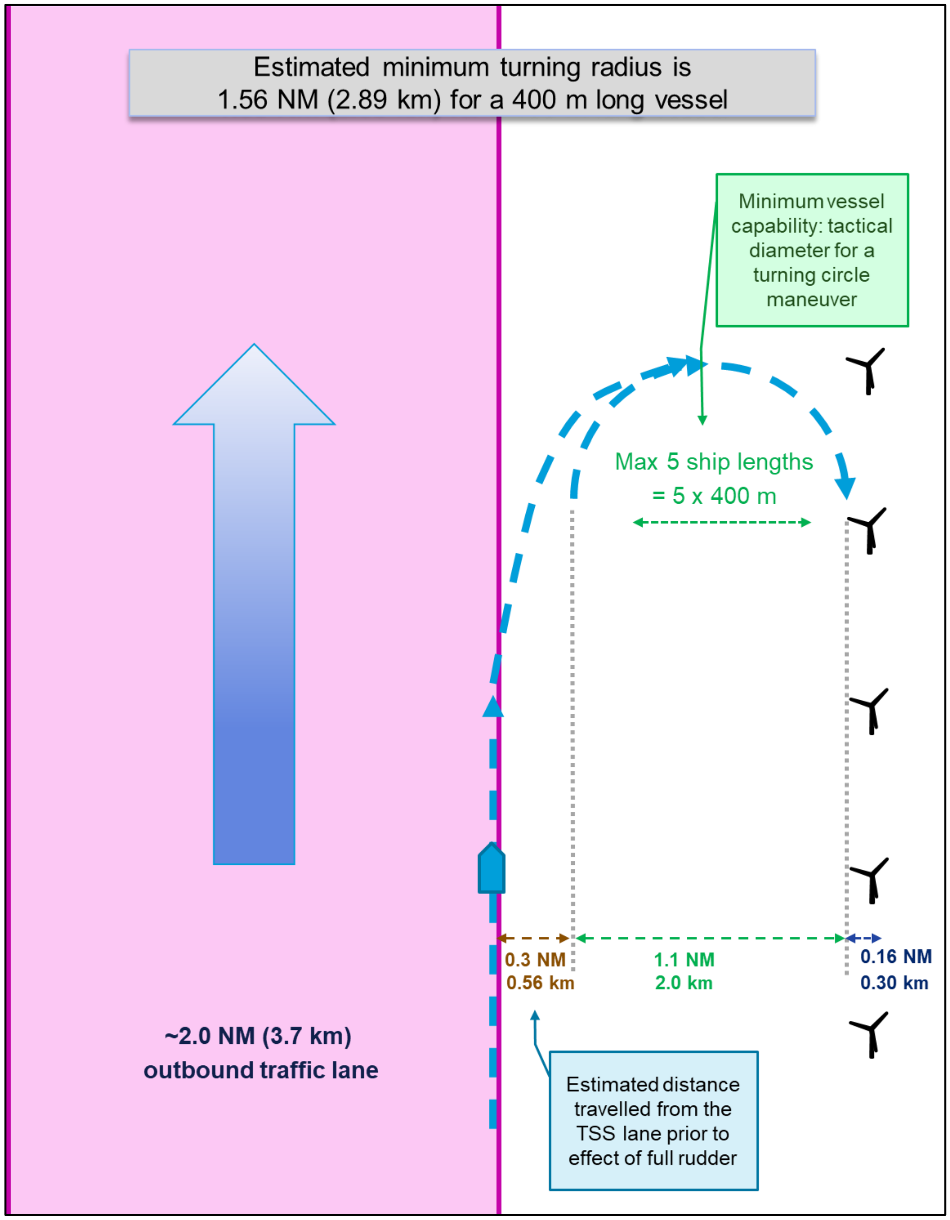


Figure 3-1 Minimum Design Turning Radius Calculation

The above approach does not account for the role of yaw, pivot point, swept area, angular momentum contributions to the turning circle, set/drift of currents, wind speed/direction and vessel sail area, hull cleanliness, or sluggish response due to possible interaction of the hull in shallow water. To account for these factors, the USCG Navigation Center recommends using a much more conservative rule-of-thumb approach.

(2) A rule-of-thumb approach quantifies the turning circle radius by using a 400 m ship and 6 x LOA (based on recommendations PIANC, 2018) and accounts for the influence of current. The calculation is (from USCG, 2022a):

1. The vessel length (0.400 km) times a factor of 6, plus the two buffers as above (0.56 km and 0.30 km), which yields 3.26 km or 1.76 NM.

2. To account for the influence of current, assuming 10 minutes to execute the full round turn times a current speed of 0.25 and 0.5 m/s (see previous Figure 6-2) yields an additional 225 m or 0.12 NM.

The resulting minimum required safe distance between the vessel and Project structures of 1.88 miles, which is less than the distance between the edge of the TSS and the row of nearest Project structures.

3.1.10 Multiple-vessel interactions

The possibility exists that two or three vessels could be in close proximity to one another and therefore, it is possible that more than one vessel might need to take evasive maneuvers to avoid vessel collision and/or allision with a Project structure. There are many factors that could lead to occurrence of this scenario, and the human element is often a contributor to the event or its escalation.

Smaller vessels, like those which are anticipated to enter the Project Area, are not required to, and many do not, carry AIS transmitters. Even vessels that do carry AIS transceivers do not always have them on or working properly. Radar may require adjustments to provide an indication of other small vessels within the Project Area, and may not indicate a vessel that is very close to a WTG. Such a vessel is likely transiting at less than 4 kt, and its slow speed will provide additional time to locate and avoid it.

Commercial Fishing vessels engaged in the types of fishing identified in the area generally transit at 4 kt or less and are likely to have limited maneuverability while fishing (see hazard evaluation in Section 3.1.8). Vessels that are marking targets or engaged in transit through the Project Area may transit at faster speeds and should be keeping watch, but may be distracted from doing so.

A collision or allision from a multiple-vessel interaction is possible during the operational lifetime of the Project. The average Fishing vessel in the Traffic Survey Area has an LOA of 23 m (75 ft) and therefore, there is an average of 56 vessel lengths between any two Project structures. This is adequate sea room for vessels to take evasive maneuvers; however, the risk factors of radar effects, lack of AIS, and potential lack of watchkeeping are key influences that could lead to realization of this scenario, which is unlikely but possible during the operational life of the Project.

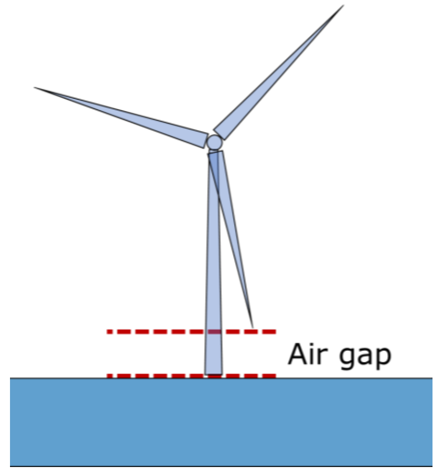
The most likely consequences are significant damage to a small vessel, with less damage to the other involved vessel(s). The consequence of a fatality always exists with accidents at sea, but lesser consequences are much more likely.

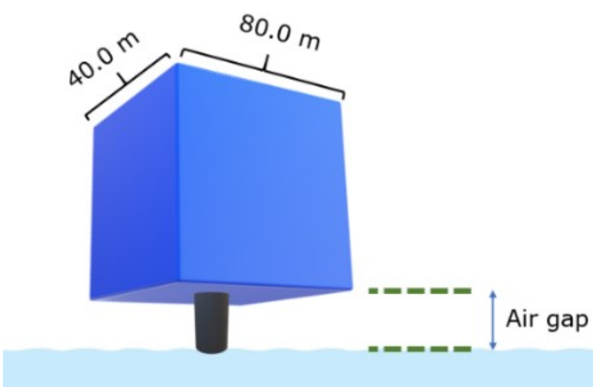
3.2 Vessel clearances from Project components

3.2.1 Air gap

The air draft of a vessel is the distance between the waterline and the highest point on the vessel. To evaluate the potential for accidents, the Project structures' minimum air clearance was compared to the sizes and types of vessels in the AIS data.

Project WTGs will have a minimum air gap of 34.7 m (114 ft)





For Project OSS, the minimum air gap is 21.6 m (70.9 ft). The largest possible air clearance hazard from an OSS would result from the topsides, with maximum dimensions of 40 x 80 m (131 x 262 ft).

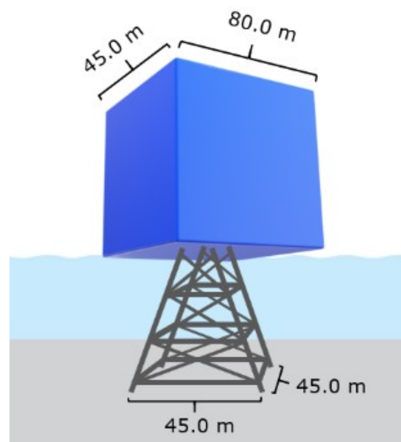
The following types of vessels transiting and fishing in the Lease Area are likely to have air drafts that exceed the air gap on Project structures, including:

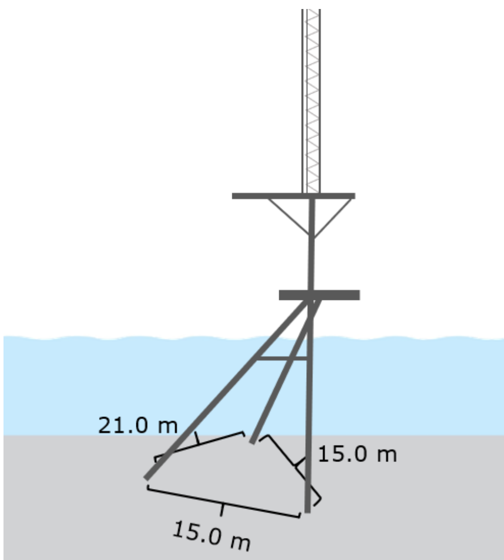
- Cargo/Carrier and Tankers
- Cruise Ships
- Larger Fishing vessels
- Larger Pleasure and Passenger vessels
- ATB and large Tugs
- Vessels under sail/sailboats

3.2.2 Keel clearance

WTGs will have monopile foundations and are not anticipated to be a subsea hazard to passing vessels.

The largest evaluated OSS foundations are jackets with a sea bed footprint of 45 m x 45 m (168 ft x 168 ft). For the purposes of modeling conducted to estimate collision, allision, and grounding risk, the footprint of the total hazard from an OSS accounts for the air hazard from OSS topsides and the keel hazard from the foundation. The structure is assumed to be a cylinder rising from the sea bottom representing the resulting footprint (45 m x 80 m; 168 ft x 262 ft), resulting in a hazard diameter of 92 m (302 ft). (US Wind, 2022)





The Project's Met tower also potentially poses a below-water hazard to a vessel keel. The Met tower has two supporting legs that extend away from the main mast. The footprint of the legs on the sea bed is 15 m x 15 m x 21 m (50 ft x 50 ft x 71 ft) (US Wind, 2022). A jacket leg could pose a hazard to any size vessel if the vessel was extremely close to the structure. Vessels passing at a safe distance as per COLREGS will be well away from support legs.

3.3 Emergency rescue activities and project components

The USCG is the U.S. maritime search-and-rescue (SAR) coordinator. In the event of an emergency situation, response assets (vessels, aircraft) from federal, state, local, commercial, and private sources may be utilized within the Lease Area.

The NJPARS (USCG, 2022a) and Chesapeake Bay PARS (USCG, 2021b) examine potential navigation safety and SAR issues associated with anticipated offshore wind farm development from waters off Virginia to New Jersey.

As requested in NVIC 01-19, Table 3-2 lists key component heights relevant to SAR (US Wind, 2022).

Table 3-2 WTG Rotor Tip Hazard Envelope (US Wind, 2022)

Blade tip height	Extreme value
Maximum upper blade tip height (MSL)	286 m 938 ft
Minimum lower tip height (MHHW)	34.7 m 114 ft
Maximum hub height (MLLW)	161 m 528 ft
Maximum rotor diameter	250 m 820 ft

In an emergency, the control center will lock the rotation and yaw of turbine blades in rotation and feather the blades to mitigate hazards as a result of blade movement during a SAR air response mission (US Wind, 2022).

In 2005, the United Kingdom (UK) Maritime & Coastguard Agency (MCA) conducted helicopter trials at the UK North Hoyle Wind Farm (UK MCA, 2005), comprising 5 MW WTGs (smaller than the Project) with closer spacing than the Project. The UK MCA identified effects of varying levels regarding:

- "Radar returns from structures. Side lobes [depth estimated at less than 50 m] limited target detection when vessels were within 100 m (328 ft) of turbines."
- "Limitations in approach distances from turbines in clear weather."
- "Inability to effect surface rescues within wind farms in restricted visibility."
- "Tracking, by vessel or shore-based marine radar, of helicopter movements within wind farms was generally poor."
- "Increase of aircraft power requirements downwind of the wind farm." (UK MCA, 2005)

The study identified measures that reduced risk to rescue activities, both of which are included in the Project design (US Wind, 2022):

- Ability for an operator to remotely lock turbine blades in rotation and in yaw and feather the blades
- Uniformly spaced turbines will allow helicopters to be used for radar search

The UK MCA also concluded that the wind farm had no noted effects on:

- Radio communications to and from the aircraft
- Very high frequency (VHF) homing system
- Compass readings
- Helicopter flight into a regularly spaced wind farm and launch of a surface rescue vessel in good visibility

3.4 Noise

Pile driving, if utilized for elements of construction, presents the most significant noise level of any Project-related activity. It is possible that the USCG will implement a safety zone surrounding construction-related vessels and activities (see Section 5.1 for additional details regarding safety zones). Noise levels outside the designated safety zone are not anticipated to have negative effects on navigation safety or USCG missions.

While operational, no negative effects from wind turbine noise on USCG missions or navigation safety are anticipated from the Project.

Operational noise resulting from an offshore wind farm is primarily generated by mechanical equipment or aerodynamic interactions. The mechanical noise from the WTGs and OSS are anticipated to be minimal. Aerodynamic noise is strongly dependent on conditions local to the Project, such as wind speed, and is anticipated to fall within similar ranges of the predicted levels for Horns Rev 3: 111 dB(A) to 113 dB(A), for 8 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-hour average assuming 8 m/s (26.2 ft/s) wind and 10 MW turbines operating continuously).

The BOEM Realtime Opportunity for Development Environmental Observations (RODEO) program funded a study performed by HDR to quantify operational sound generated from the Block Island Wind Farm during winter and summer conditions. Noise recorded in 8 to 9 m/s wind speeds 50 m (164 ft) from the turbine were near background levels and often not measurable due to other natural and anthropogenic noise present including waves or vessel sounds. Noise levels ranged from 63 to 67 dB at 50 m (164 ft) from the turbine but were difficult to identify separately from ambient noise (HDR, 2019).

COLREGs Annex III (IMO, 1972) describes the required sound signal intensity and range of audibility for vessels by length. Requirements are summarized in Table 3-3. The COLREGs requirements assume an average background noise level at the listening posts of a vessel to be 68 dB (IMO, 1972). 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.

Table 3-3 Intensity Requirements of Whistle (IMO, 1972)

Length of vessel	$^{1}/_{3}$-octave band level at 1 m (3.28 ft) in dB	Audibility range in NM
200+ m 656 ft	143	2
75-200 m 246-656 ft	138	1.5
20-75 m 65.6-246 ft	130	1
<20 m <65.6 ft	120 / 115 / 111*	0.5

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

3.5 Project structure impact analysis

This section describes the potential damage to a Project structure from a marine accident and provides a sense of whether or not structures may present a hazard to navigation if struck. Potential consequences to vessels from allision accidents are described in Section 11.1.2.

The damage from a powered allision is generally more severe than from a drift allision (because of the higher energy of impact and contact closer to the center of mass of the vessel) and, as such, presents the most conservative damage case. Therefore, this assessment focuses on the consequences from a powered allision of a structure 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 vessel to the structure, which is dependent on the weight and speed of the vessel. Specific consequences of an allision with a structure are highly dependent on its inherent design strength. The discussion below relates to generic design.

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 a 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, a monopile foundation is likely to deform below sea level, nearer to the sea bed, but is not likely to 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 structure at a low speed, the damage to a 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 and is denoted by the dashed line in Figure 3-2.

Given the range of vessel sizes (Table 3-4) and speeds (Table 3-5) found in the AIS data set, a range of impact energies is estimated for each vessel type, shown in Table 3-4. The dead weight tonnage (DWT) bins are based on the observed distributions of unique vessels that transited with 8 km of the Lease Area. High DWT is the 75th percentile, medium is the median (50th percentile), and low is the 25th percentile.

Table 3-4 Vessel Sizes in the AIS Data[6]

Vessel type	Number of unique vessels that transited within 8 km of the Lease Area	DWT (metric tons)		
		Low	Medium	High
Cargo/Tanker	895	24,464	40,994	60,847
Cruise Ships and Large Ferries	5	NA [14]	8,452	NA [10]
Other	289	523	5,123	51,400
Tug	134	20*	40*	352*
Fishing	193	7	9	11
Passenger	27	4	7	19
Pleasure	762	2	4	7

* Tug DWT are the values reported in the AIS data, which do not include the tonnage of a towed barge.

The speeds in Table 3-5 are based on the speed profiles in the AIS data within 8 km (5 miles [mi]) of the Lease Area. High speed is calculated as 120% of the representative (average) speed based on AIS data. The low speed is 50% of the representative speed.

Table 3-5 Assumed Vessel Speed When Allision Occurs

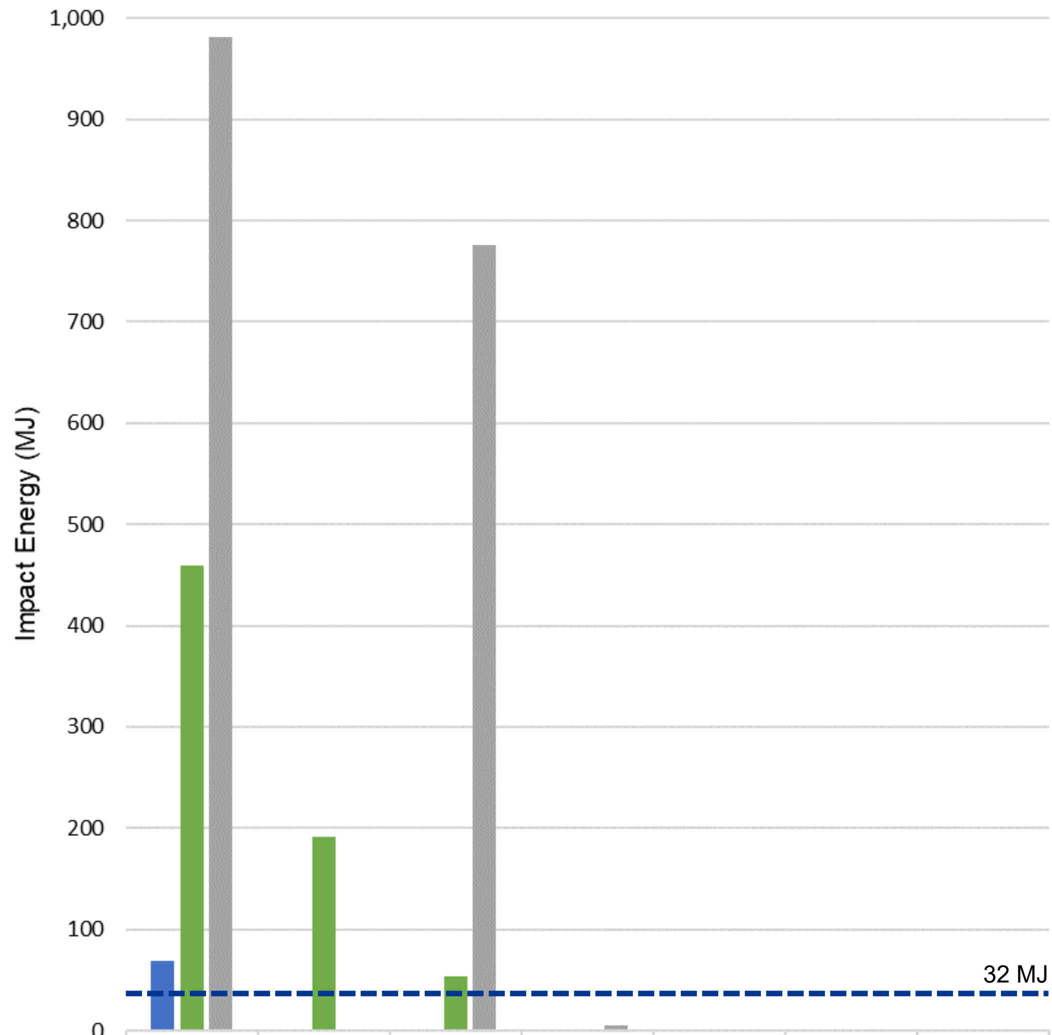
Vessel type	Low speed (kt)	Representative speed (kt)	High speed (kt)
Cargo/Tanker	4.6	9.2	11.0
Cruise Ships and Large Ferries	6.6	13.1	15.8
Other	4.4	8.9	10.7
Tug	4.2	8.3	10.0
Fishing	3.8	7.6	9.1
Passenger	6.1	12.3	14.8
Pleasure	6.7	8.3	10.0

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

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

Figure 3-2 gives the resulting ranges of kinetic energy.

[14] Low and high values are not provided for Cruise Ships and Large Ferries because of the small number of these vessels that transited within 8 km (5 mi) of the Lease Area.



	Cargo/ Tanker	Cruise Ships/ Ferries	Other/ Undefined	Tug	Fishing	Passenger	Pleasure
Low	68.5	-	1.4	0.0	0.0	0.0	0.0
Avg	459.1	191.9	53.7	0.4	0.1	0.1	0.0
High	981.4	-	775.8	4.6	0.1	0.5	0.1

Figure 3-2 Ranges of Impact Energy per Vessel Type

The estimated energies are considered extreme bounds because the kinetic energy is assumed to be received by the 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 allision (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 foundation because of their low tonnage and average speeds. Deep draft vessels such as Cargo vessels and Tankers have a greater potential to cause damage to a monopile or jacket, even at lower speeds. Among the towing vessels, ATBs have greater potential to have an impact similar to a small tanker. Powered allision by a barge on towline is less likely due to the unlikely geometry of a direct powered impact.

The highest postulated consequences would be from allision by a Cargo/Carrier or Tanker vessel. An impact by a large vessel at average cruising speed is expected to cause severe damage to the vessel and the structure, and potentially, failure of the structure, depending on the impact geometry and the design of the foundation.

As previously stated, it is not anticipated that any deep draft / large vessel types will transit within the Lease Area. Based on MARCS model results, the annual frequency of a powered allision with a WTG involving a tanker, cruise ship, or cargo/carrier is 0.0016 per year; a 1-in-600-years event.

During construction, the primary risk is from an on-site construction vessel allision with a structure while transiting through the Lease Area. 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 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 rotate the vessel around the turbine instead of deforming the vessel or Project structure.

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

4 OFFSHORE UNDERWATER STRUCTURES

The Project does not include underwater devices. Structures on the sea bed will extend above water but may pose a risk to vessels as described in Section 3.2.2.

All cables will be buried below the sea bed or protected on the sea bed. After cable installation, NOAA navigation charts will be updated to reflect the presence of the cables. The metallic armoring layer of the cable combined with appropriate burial depths and concrete matting where necessary, are design features intended to minimize the risk of damage to cables.

The greatest risk of contact with an export cable is posed by anchoring and fishing with bottom trawl and dredge gear, particularly hydraulic dredges. To understand the risks associated with these hazards, a preliminary Drag Embedment Anchor Penetration Study was completed for the Project by ESS Group, Inc. (2019). The Anchor Penetration Study estimated anchor sizes for the largest vessels anticipated to taxi throughout the Lease Area broken into Indian River Bay, the export cable route, and the Lease Area.

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 Lease Area and transit in historical or designated lanes; however, smaller vessels, such as pleasure vessels and commercial fishing vessels, will likely transit the Lease Area. Some of these vessels will fish in the Lease Area and some will transit through the Lease Area and not fish during the transit. See Section 2.3 for a discussion on the current and potential future Pleasure vessel traffic. A cable burial risk assessment will determine the appropriate burial depth and mitigation measures to be implemented.

4.1 Outside the Lease Area

The only offshore Project component outside the Lease Area will be subsea cables. Anchoring and bottom trawling or dredging activities pose the greatest risk of contact with subsea cables associated with the Project. The Anchor Penetration Study used sediment characteristic data and vessel anchor sizes to estimate the maximum anchor penetration below the present bottom. From those analyses, anchor penetration is anticipated to be no greater than 3.05 m (10 ft) within Indian River Bay and 3.1 m (10.2 ft) along the evaluated export cable route (ESS, 2019).

The Drag Embedment Anchor Penetration Study for the Maryland Offshore Wind Project (ESS, 2019) concluded:

> “Based on the U.S. Navy guidance [for anchors], the deepest anchor penetration within Indian River Bay is expected to be associated with the cable lay vessel that will install the proposed submarine cable.”
>
> “The operators of this vessel and its anchor handling tugs will have extremely detailed location data for the laid cables and highly accurate GPS navigation data to ensure that anchor handling and cable installation activities do not damage any installed cables.”

To identify potential interactions between subsea cables and fishing activities, Sea Risk Solutions was contracted by US Wind to conduct a study of fisheries and fishing activities in and around the Lease Area. From their findings, the primary fishing methods utilized outside the Lease Area include pots or traps, gillnets, trawling, and longline in much smaller concentrations. The proposed depth of burial for subsea cables outside the Lease Area was determined to be adequate to avoid mechanical damage to the buried cable system from vessel sinking’s or groundings, anchor snags, or offshore fishing gear (ESS, 2019).

4.2 In the Lease Area

Similarly, within the Lease Area, anchoring and bottom trawling or dredging activities pose the greatest risk of contact with subsea cables associated with the Project. The Drag Embedment Anchor Penetration Study estimated maximum anchor penetration within the Lease Area to be 2.68 m (5.9 ft) below the sea bottom (ESS, 2019).

The largest vessel anticipated to anchor within the Lease Area is a large cable lay vessel or feeder vessel utilizing a 4,989.5-kilogram (kg) (11,000-pound [lb]) Flipper Delta anchor with a 2.68 m (5.9 ft) fluke length. The primary fishing gear utilized in the vicinity of the Lease Area includes dredges, trawls, gillnets, and pots or traps. The proposed depth of burial for subsea cables within the Lease Area has been found adequate to avoid mechanical damage to the buried cable system from vessel sinkings or groundings, anchor snags, or offshore fishing gear (ESS, 2019).

Interactions between mobile or fixed gear and Project structures could result in damage or loss of the gear and/or damage to the vessel. Fishing gear in the Lease Area could snag on a foundation or ancillary components, such as J-tubes on the outside of a monopile. The risk of a fishing vessel allision with a Project structure during transit through the Project Area is assessed in Section 11.

Table 4-1 summarizes the hazards posed by below water components of the Project to recreational and commercial fishing vessels and fishing activities.

Table 4-1 Below Water Hazards to Fishing Vessels and Fishing Activities in the Project's Operational Phase

Activity and Species	Location and Use	Description of Hazard
Bottom otter trawling – mixed species †	Throughout the Lease Area; most effort has been in central and southern portions. † Based on AIS data, the local preference is to make multiple straight-line tows with gear on the sea bed along a narrow path, preferably at a constant depth of water. †	Cable snag – trawling is not expected to interact with array cables or the export cable, as sea bed penetration is not expected to reach the depth of the array or export cables. * † Gear snag on Project structure – possible, and more likely if turns are made close to a structure with gear on the sea bed. † The most likely consequences of a gear snag are damage to or total loss of the gear, while the most extreme postulated consequences are loss of vessel stability and/or damage to the vessel assuming human error contributes to escalation of the event. This risk can be mitigated by (1) making tight turns after retrieving trawl doors to the vessel (leaving the net in the water), (2) hauling the gear completely onboard to dump the catch and make a turn, or (3) making wide turns with gear on the sea bed.

Activity and Species	Location and Use	Description of Hazard
Potting/trapping – black sea bass, conch (whelk); less common: eels, crabs, and lobster †	Throughout the Lease Area; more intense along eastern and southeastern boundaries. † Strings 1 to 36 pots/traps are set and left for a day, a week or potentially longer, then retrieved, emptied, and reset. † Should surface markers become detached from the gear, a grapnel is dragged to recover the gear. †	Cable snag from pot/trap or anchor – potting/trapping is not expected to interact with array cables or the export cable, as substantive sea bed penetration by pots/traps is unlikely and undesirable. Penetration of dragged line anchors is not expected to reach the depth of the array or export cables. * † Cable snag from grapnel – grapnel dragging to retrieve pots/traps is relatively shallow and is not expected to interact with array cables or the export cable. * † Grapnel or anchor snag on Project structure – possible if pots/traps are set on the scour protection around each foundation, or if gear moves after being set. * The most likely consequences of a grapnel or anchor snag are damage to or total loss of the gear, while the most extreme postulated consequences are loss of vessel stability and/or damage to the vessel assuming human error contributes to escalation of the event. This risk can be mitigated through setting gear outside the scour protection, and fishing vessel awareness of the hazards associated with gear snagged on a Project structure.
Bottom tending gillnetting – dogfish, skate, monkfish, sea bass, and some other species	Throughout the Lease Area; although most drift gillnet effort has been in northern portion. † Nets are set in strings, up to 610 m (0.32 NM, 2,000 ft) or longer , anchored in place, and retrieved within a wide range of durations. † Gear is recovered via buoy lines, potentially dragging anchors along the sea bed. †	Cable snag from net anchor – bottom tending gillnet anchors are not expected to interact with array cables or the export cable, as sea bed penetration is not expected to reach the depth of the array or export cables. * † Cable snag from grapnel – grapnel dragging to retrieve gear detached from a surface marker is relatively shallow and is not expected to interact with array cables or the export cable. * † Gear snag on Project structure – possible during the Project lifespan, the frequency is likely to increase as string length increases and as gear is placed closer to structures. The most likely consequences of a gear snag are damage to or total loss of the gear, while the most extreme postulated consequences are loss of vessel stability and/or damage to the vessel assuming human error contributes to escalation of the event. This risk can be mitigated by (1) using shorter strings and setting them between rather than adjacent to Project structures; and (2) setting strings outside the scour protection around each foundation.
Floating/drift gillnetting – including bluefish, weakfish, and several species of shark †	Can occur in the Lease Area; however, most occurs inshore of the Lease Area. † The string, potentially more than a mile long, is set after locating (marking) target species with onboard electronics, gear is supported by buoys and remains attached to the vessel, and is hauled after a relatively short time period, which can be less than an hour. †	Gear snag on Project structure – possible during the Project lifespan, the frequency is likely to increase as string length increases and as gear is placed closer to structures. The most likely consequences of a gear snag are damage to or total loss of the gear, while the most extreme postulated consequences are loss of vessel stability and/or damage to the vessel assuming human error contributes to escalation of the event. This risk can be mitigated by (1) using shorter strings and setting them between rather than adjacent to Project structures; and (2) setting strings outside the scour protection around each foundation.

Activity and Species	Location and Use	Description of Hazard
Surf clam and ocean quahog dredging	Possible throughout the Lease Area but is currently conducted at very low levels compared to deeper offshore waters, and may not be commercially viable at this time. † The hydraulic dredges may be towed at 3 to 4 kt up to two at a time, liquifying and removing sediment. With multiple passes, potentially to a cumulative depth of more than 1 m (3 ft). †	Cable snag – The potential for any impacts from this activity is low at this time due to a shift in the resource further offshore. The effect zone for single-pass hydraulic dredging does not reach the target burial depths of the array or export cable. However, should the fishery move back into the Lease Area or export cable route, multiple dredge passes at the same location could occur and contact the array cable or export cable. * † Such contact has the potential to lead to vessel damage and/or instability‡ and cable damage. This risk can be mitigated through cable burial at greater depths or fishing vessel awareness of the presence of the cable and hazards associated with gear snagged on the cable. Gear snag on structure scour protection – The potential for any impacts from this activity is low at this time due to a shift further offshore. However, should the fishery move back into the Lease Area or cable route, depending on the type of scour eventually selected in each area, snagging on the scour protection is possible. † The most likely consequences of a dredge snag are damage to or total loss of the gear, while the most extreme postulated consequences are loss of vessel stability and/or damage to the vessel assuming human error contributes to escalation of the event. The consequences can be mitigated by (1) modification of hydraulic dredges to enable safe passage over the selected type(s) of scour protection; (2) selection of scour protection designs that allow safe passing of hydraulic dredges via NOAA charts or other means; (3) communication of locations of any scour protection that is likely to pose a hazard to hydraulic dredge tows; or (4) should the risk be deemed sufficiently great and unmanageable via engineered means, federal action or guidance recommending against use of hydraulic dredges between offshore wind structures and along high risk cable routes.
Scallop dredging	Currently there is little suitable scallop habitat or scallop fishing in the Lease Area; although the Area has been historically significant to the scallop fishery. † Based on AIS data, the local preference is to make multiple straight-line tows for 3 to 4 NM (5.6 to 7.4 km) at 4.5 to 5 kt with gear on the sea bed along a narrow path, preferably at a constant depth of water. The radius of a turn with gear down can be less than 0.3 NM (0.6 km). †	Cable snag – scallop dredging is not expected to interact with array cables or the export cable, as sea bed penetration is typically less than 12 inches and not expected to reach the depth of the array or export cables. * † Gear snag on Project structure– possible, but unlikely at this time due to the lack of resource in the Lease Area. † However, should the Lease Area become more suitable as scallop habitat and scallop dredging returns, gear snag would be more likely should turns be made close to a structure with gear on the sea bed. The most likely consequences of a snag are damage to or total loss of the gear, while the most extreme postulated consequences are loss of vessel stability and/or damage to the vessel assuming human error contributes to escalation of the event. This risk can be mitigated by making turns allowing for sufficient sea room around structures.
Fishing with other commercial gear	Purse seine for schooling bait fish may occasionally within the Lease Area (anecdotal). † Longline for pelagics occurs further offshore (Fishing vessel transit risk is assessed in Section 11). †	Should purse seine fishing occur in the Project Area, the risks would be similar to or less than those from floating/drift gillnetting. NA

Activity and Species	Location and Use	Description of Hazard
Recreational fishing	Possible throughout the Lease Area. Sport fishing primarily uses hook/line, but also may uses pots/traps.	Gear snag on Project structure – possible. The frequency is likely to increase as lines are cast or pots are set closer to structures. The most likely consequences of a gear snag are damage to or total loss of the gear. This risk can be mitigated by avoidance of casting toward Project structures.
Locating (marking) of fish using onboard electronics – bluefish, weakfish, and several species of shark	Most of this activity occurs inshore of the Lease Area. Drift gillnetting and several other activities used marking to identify targets.	No cable hazards identified that are associated with the fishing activity.

* Assuming cables are at or below their target burial depths

† Fisheries Assessment Report, COP Appendix II-F2 (Sea Risk Solutions, 2021)

In addition to the Project posing potential hazards to Fishing vessels, fishing activity can pose hazards to Project vessels. A Project or other vessel could snag its propeller on the line between the gear and the buoy used to retrieve the gear. The consequence is likely low, but could be as severe as a loss of propulsion, which would be of particular concern if it occurred during personnel transfer between a CTV and a Project structure.

5 NAVIGATION WITHIN OR CLOSE TO A STRUCTURE

This section assesses:

- The safety of navigation in the Lease Area during construction and decommissioning
- The safety of navigation in the Lease Area during operation
- Potential effects on anchorage areas

The Project 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

Navigation safety during Project construction includes the hazards discussed for the operations phase to an increasing extent as construction progresses. It also includes hazards related to Project vessels required in the vicinity to assure safe and successful placement of each structure, cable, and connection. Offshore construction activity will temporarily increase vessel traffic in and around Ocean City and through Ocean City Inlet. A relatively high frequency of collision would result from fishing or other non-Project vessels in proximity to construction vessels and activity.

A key aspect of risk mitigation will be Project communication about planned activities among the construction team and with other mariners. US Wind is committed to proactively communicating Project plans to mariners via several channels of communication, including providing information to be included in USCG Notices to Mariners (US Wind 2022). During construction, US Wind will work with the USCG to ensure mariner safety is supported through adequate risk control measures (US Wind, 2022).

Prior to any construction activity, an installation strategy will be developed and finalized based on the selected turbine design and the vessels selected to conduct installation activities. The installation methods and means used in Project construction vary per type of infrastructure:

- WTG and support structure: individual components or pre-assembled sections of the WTG are installed resulting in multiple offshore lifts. This would typically see the foundations and the tower section(s) lifted, followed by the nacelle and hub and finally the blades.

  For example, a jack-up vessel or a heavy lifting vessel will install the foundations, comprised of a monopile and a transition piece. Then, a jack-up vessel will install the WTGs. During the installation phase, the installation vessels will remain within the Lease Area while the components will be brought from shore to the Lease Area on feeder barges. Each feeder barge will carry multiple components of several wind turbines. The fleet for WTG installation may include heavy lift vessels, feeder barges and tugs, crew transfer vessels (CTVs), and offshore supply vessels.

- OSS: Similar to the WTGs, the OSSs are installed in two phases: first the foundation (jacket or monopile) is installed on the sea bed, then the topside is lifted with a heavy lift vessel (HLV) onto the foundation. The fleet for OSS installation may include one HLV, feeder vessels and barges, CTV, and offshore supply vessels.
- Subsea cables: The subsea cables will be installed by dedicated vessels, simultaneously trenching and laying the cable into the sea bed. During this phase the cable laying vessels will have a restricted ability to maneuver due to the unspooling of cable between the vessel and the sea bed.

The available information concerning Project vessel types and usage is provided in the COP Volume I Section 3.6. Offshore construction activities could be a hazard and Project construction vessels could experience hazards from proximate vessels.

During construction, the emerging hazards from new structures in the water will require vigilance and awareness of mariners in the area. The risks that arise during construction will increasingly include the operational phase risks described in Section 3.1 as construction progresses. It will also include the immediate construction area and the addition of construction-related vessels in the area, which will relocate over the duration of the construction. For the safety of the construction activity and the safety of other vessels, it is standard practice that all non-Project vessels, including Fishing vessels, avoid a specified zone surrounding the construction vessels and activity.

Three primary means of reducing the above risks are: safety zones around the construction activity (typically 500 m), regular updates to mariners, and/or Project safety/standby vessel(s) and/or personnel.

A safety zone is a land or water area to which, for safety or environmental purposes, access is limited by the Coast Guard to authorized persons, vehicles, or vessels. The Coast Guard's authority for safety zones around Offshore Renewable Energy Installations extends into the Exclusive Economic Zone beyond the territorial sea and may be applied around offshore wind structures. Procedures for establishing Safety Zones are provided in 33 CFR 165.

Mariner awareness will be vital during Project construction, as it is during all marine activities. All mariners are to follow COLREGs (IMO, 1972). Vessel operators have the obligation to use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt, the vessel operator should assume that there is a risk of collision (IMO, 1972). Accordingly, vessel operators should take special precautions when navigating within the vicinity of any offshore structure, 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 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's Master 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 navigation hazards

Passing vessels and Project construction vessels may experience hazards from weather or sea state and from each other. Offshore standard work safety practices in the industry include team briefings or toolbox meetings, work procedures that define acceptable environmental working windows and stop-work conditions, and proactive monitoring of conditions and forecasts.

During construction, some Project construction vessels will return to Ocean City every evening, while some, such as the wind turbine installation vessel, will remain in the Project Area for the duration of the construction season. The level of vessel traffic in and out of Ocean City inlet, quantified in Section 2.1.3, will increase during the construction season(s), and with it, the risk of collision between vessels and groundings. To assist in monitoring these risks, US Wind will remain in contact with the Army Corps of Engineers and the Delmarva Water Transport Committee, the harbor safety committee for the port. US Wind will continue to work with them concerning a future need for traffic studies and/or mitigation.

The risks from decommissioning activities closely resemble risks from construction, described above. Prior to decommissioning, US Wind will consult with BOEM and submit a decommissioning application for review and approval in line with regulations in place at the time (US Wind, 2022). An approved decommissioning plan will dictate the removal of Project components and is planned to essentially reverse the construction and installation process.

5.2 Operations phase navigation risks

This section provides a qualitative evaluation of operational risks from the Project. Section 11.1 provides a quantitative assessment of operations-phase risks to non-Project vessels transiting in the MARCS Study Area.

Navigation within the Project will not be prohibited by any offshore wind-related regulations or requirements. However, mariners are required to adhere to COLREGs (IMO, 1972): to be aware of the prevailing environment and to avoid unsafe situations.

The Project will lay on charted depths of 12.3 to 41.6 m (40 to 136 ft) and vessels that choose to navigate through the Project will not be draft limited; however, it is anticipated that deep draft and commercial vessels (excluding commercial fishing vessels) will not choose to transit through the wind farm. The Project design includes a distance between offshore structures that is 1.0 NM (1.9 km) north-south by 0.76 NM (1.4 km) east-west (US Wind, 2022). This design is a navigation risk mitigation measure and provides sufficient room for anticipated vessels to transit through and safely maneuver within the Project.

Project-related service vessels such as CTVs will also regularly transit between Ocean City and the Lease Area, and within the Lease Area between the different infrastructures. The level of vessel traffic in and out of Ocean City inlet, quantified in Section 2.1.3, will increase during Project operations, and with it, the risk of collision between vessels and groundings. To assist in monitoring these risks, US Wind will remain in contact with the Army Corps of Engineers and the Delmarva Water Transport Committee, the harbor safety committee for the port. US Wind will continue to work with them concerning a future need for traffic studies and/or mitigation.

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 Project design 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 28 straight lines of orientation through the Project:

- Twelve 1.0 NM (19 km) wide oriented east-west and vice-versa, which is the predominant direction of Fishing vessels transiting through the Lease Area (See Figure 2-12 and Figure 5-1).
- Sixteen 0.76 NM (1.4 km) wide oriented north-south and vice-versa, which is the second most significant direction of Fishing vessels transiting through the Lease Area.

Section 11 presents the results of modeling that was conducted to assess the increase in frequency of collision, allision, and grounding events from the Project, including Fishing, Pleasure, and Project vessels. Transit counts for existing traffic are summarized for each vessel type in Section 2.1.3. Transit counts for Project vessels are summarized in Section 2.3.

The above corridors align with the NJPARS calculation illustrating safe navigation parameters for vessels anticipated to transit through the Lease Area. The report “finds the minimum width for a transit lane between offshore structures for vessels 200 ft (61 m) in length between 0.6 and 1.1 . Larger and less maneuverable vessels will likely avoid transiting within the lease area, therefore formal establishment of shipping safety fairways or other routing measures within a wind farm are not necessary.” (USCG, 2022a)

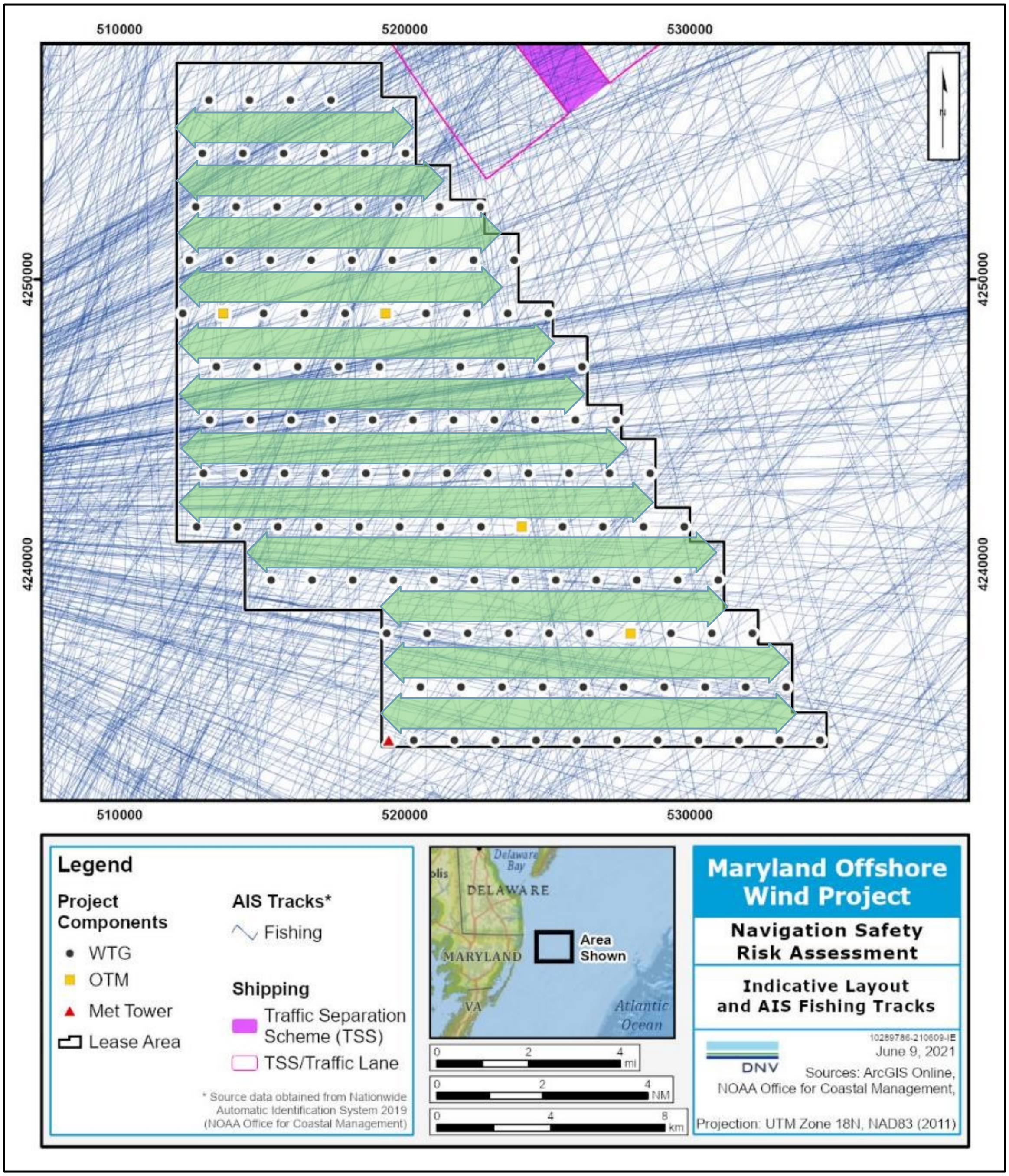


Figure 5-1 126-Structure Layout with AIS Tracks of Fishing Vessels and Selected Lines of Orientation

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 existing and planned anchorage areas in the vicinity of the Lease Area as well as the anchoring Activity indicated by AIS speed through the year 2019.

Significant anchorage activity by deep draft vessels was observed north of the Lease Area, and within the northern part of the Lease Area. However, it is anticipated that the deep draft vessels (Cargo/Carrier and Tanker) would not anchor within the Lease Area after the installation of Project structures but would anchor north, across the Delaware Bay Southeastern approach TSS instead, where an additional anchorage area is recommended in the NJPARS (USCG, 2022a).

The existing anchorage area (“Anchorage A”) is located 30 NM northeast of the Lease Area, within the Delaware Bay and should not be affected by the Project. The locations of the proposed or recommended anchorages were selected to provide safe locations for vessels after the offshore wind Projects are constructed.

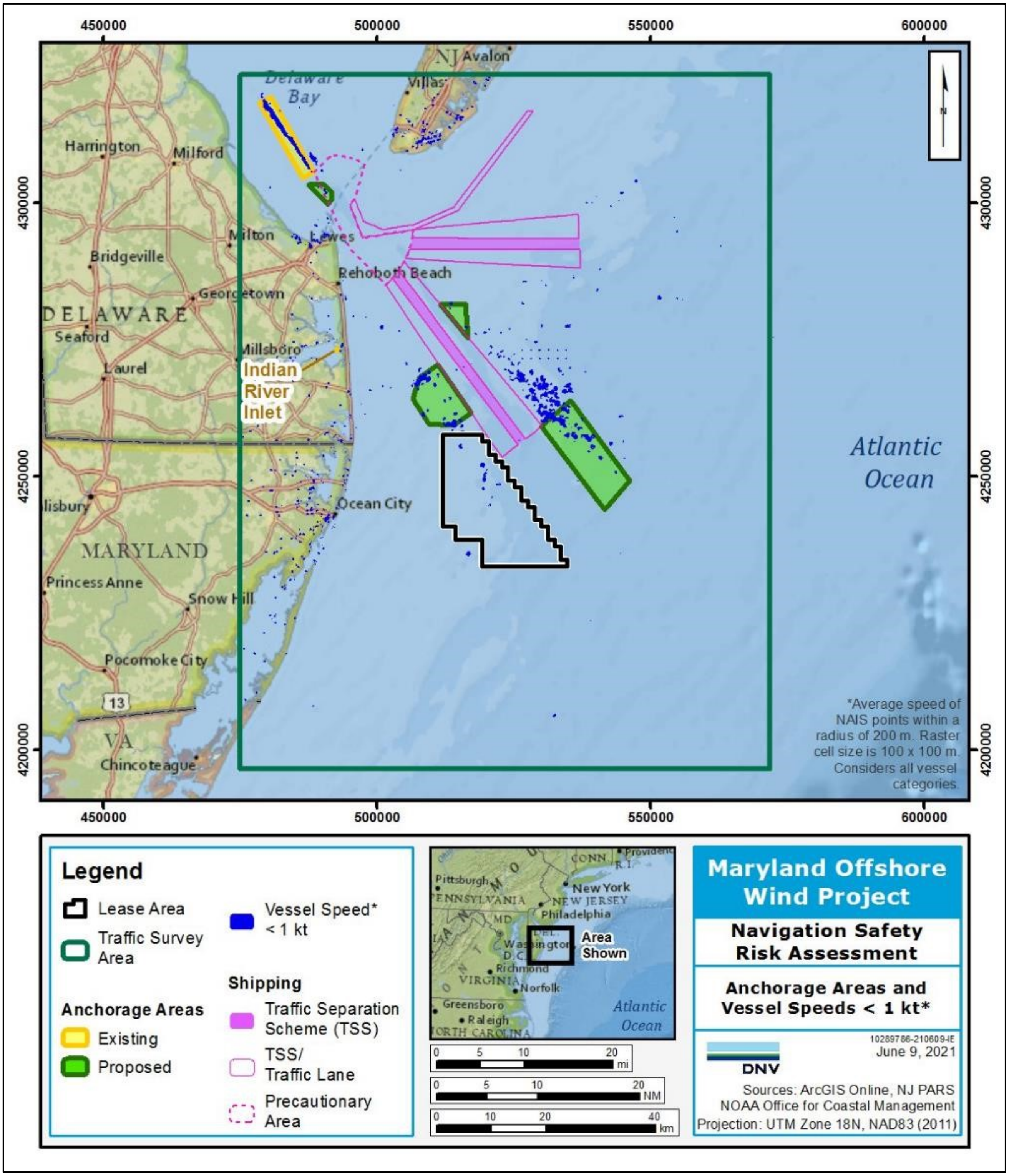


Figure 5-2 Anchorage Areas and Anchorage Activity (USCG, 2021a)[6]

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 11 NM (20 km) east of Ocean City, Maryland. The primary hazards to navigation along the coast are outlying sand shoals and fog (see Section 7.3). Table 6-1 provides a summary of the waterways' characteristics and Figure 6-1 shows the Lease Area 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 and recreational vessels, in contrast to the routes in deeper waters taken further offshore by most Cargo/Carrier and Tanker vessels (Section 2.1.1). Two notable shoals are also located 3 NM west of the Lease Area.

Table 6-1 Summary of Waterways Characteristics in the Vicinity of the Lease Area

Site Characteristic	Summary	Source
Tidal range	Maximum range: 3.5 ft (1.1 m) Mean range: 2.1 ft (0.6 m)	Ocean City, MD (NOAA station 8570283, NOAA Coastal Chart 12211) and Cape May Point, NJ (NOAA station 8536110, NOAA Coastal Chart 12214)
Tide height	Less than 3.5 ft	Coast Pilot 3 (NOAA, 2021a) Cape May Point, NJ (NOAA station 8536110, NOAA Coastal Chart 12214)
Tidal stream speed (surface)	Less than 1 kt, cyclical	NOAA, Tide and Currents (NOAA, 2021b)
Tidal stream direction (set)	Predominantly aligned with a NE-SW direction: - rising tide: from SW - ebb tide: from NE	NOAA, Tide and Currents (NOAA, 2021b) Coast Pilot 3 (NOAA, 2021a)
Current speed (surface)	Maximum 3.2 kt (1.65 m/s) Maximum mean monthly velocity (in January): 0.46 kt (0.25 m/s)	OceanReports (marinecadastre.gov) (BOEM and NOAA, 2020)
Current direction (set)	Predominant: South Range: NNW to NNE	OceanReports (marinecadastre.gov), (BOEM and NOAA, 2020)
Water depth	12 to 42 m below MLLW	NOAA National Geophysical Data Center (NGDC) (1999)
Waves	Monthly average significant wave height: Minimum (July): 0.89 m Maximum (March): 1.3 m	OceanReports (marinecadastre.gov), (BOEM and NOAA, 2020)

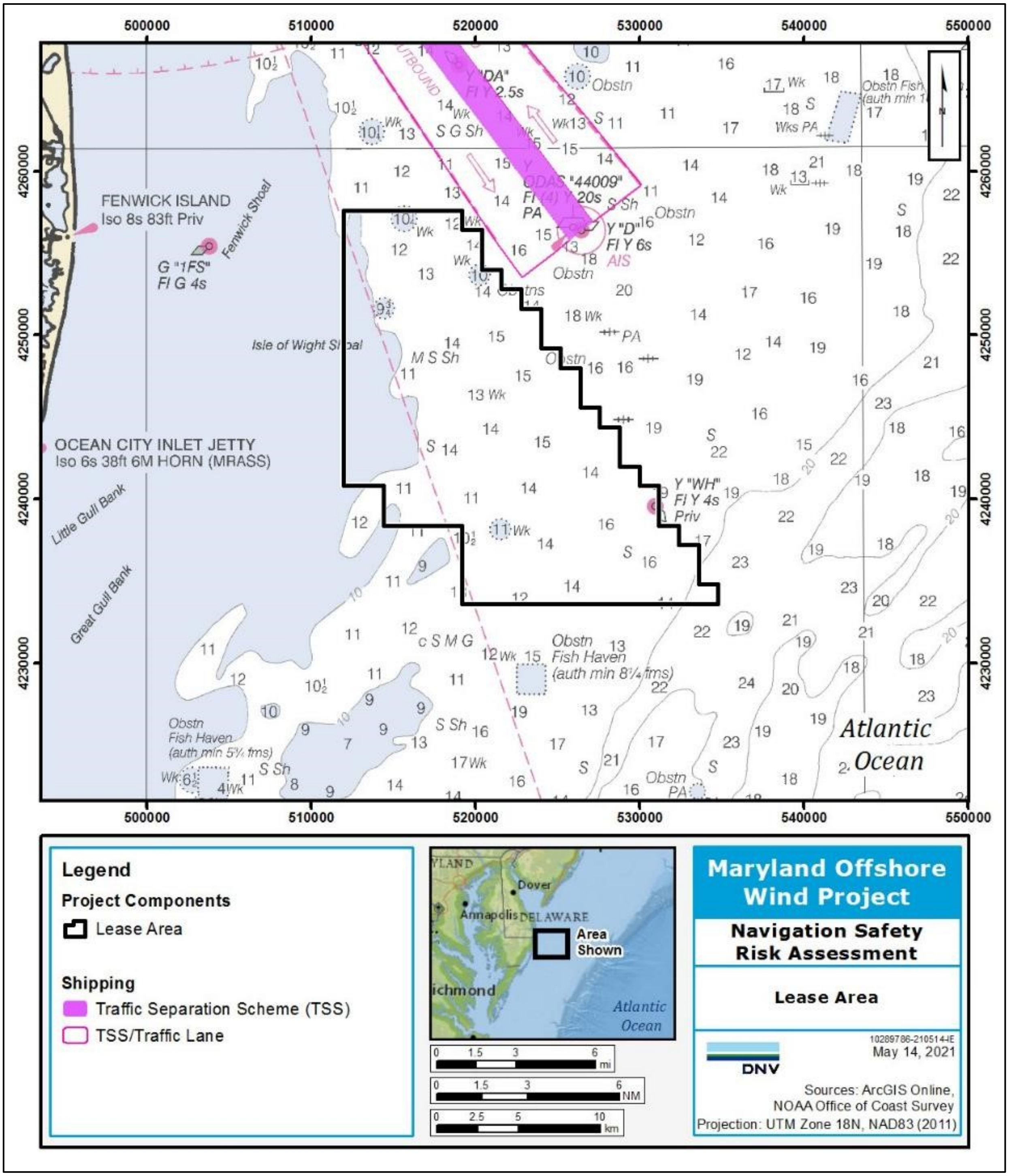


Figure 6-1 Navigation Chart in the Vicinity of the Lease Area

6.1 Tides and tidal stream

Tidal influences on water depth are minor compared to average water depths in the vicinity of the Lease Area: the tidal range is less than 1.1 m (3.5 ft) (see Table 6-1).

The tidal current is stronger close to the coast, especially in the Delaware Bay inlet, at 20 NM from shore. In the Lease Area, the tidal current is attenuated and does not exceed 1 kt (NOAA, 2021b). The modeling conducted to estimate collision, allision, and grounding risk described in Section 11 includes a steady current of 0.25 kt from the north..

6.2 Ocean surface currents

In the vicinity of the Lease Area, the ocean surface current is predominantly from the north at an average speed of less than 0.25 m/s (0.46 kt) but can reach a maximum of 1.6 m/s (3.1 kt). Further offshore, 60 NM east of the Lease Area, the Gulf stream travels in the opposite direction, from the south to the north.

Despite its low average speed, the oceanic current would push a disabled vessel from the TSS toward the Lease Area, and can have an impact on the allision risk. Therefore, this current was considered in the modeling conducted to estimate collision, allision, and grounding risk described in Section 11 as relevant.

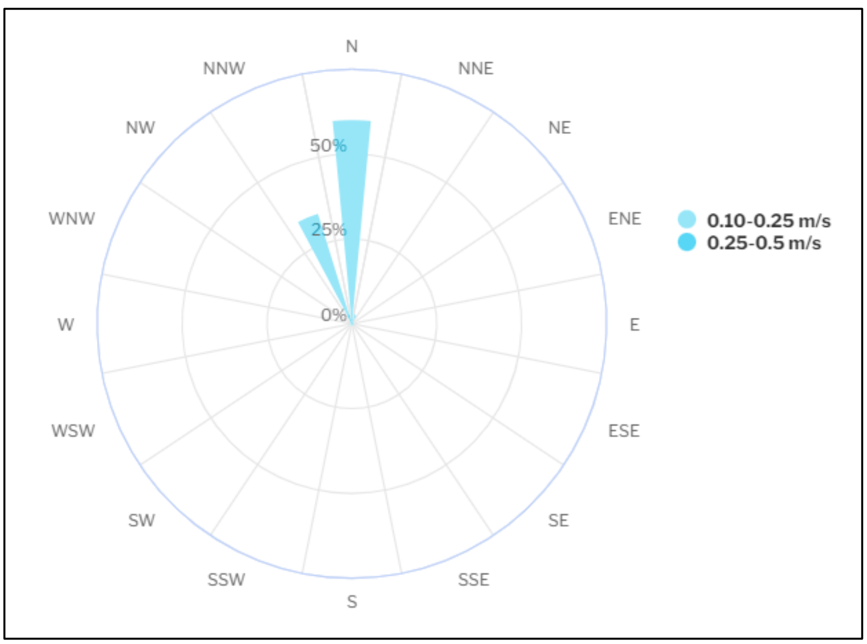


Figure 6-2 Surface Current Direction in the Vicinity of the Lease Area, 1992 – 2012 (BOEM and NOAA, 2020)

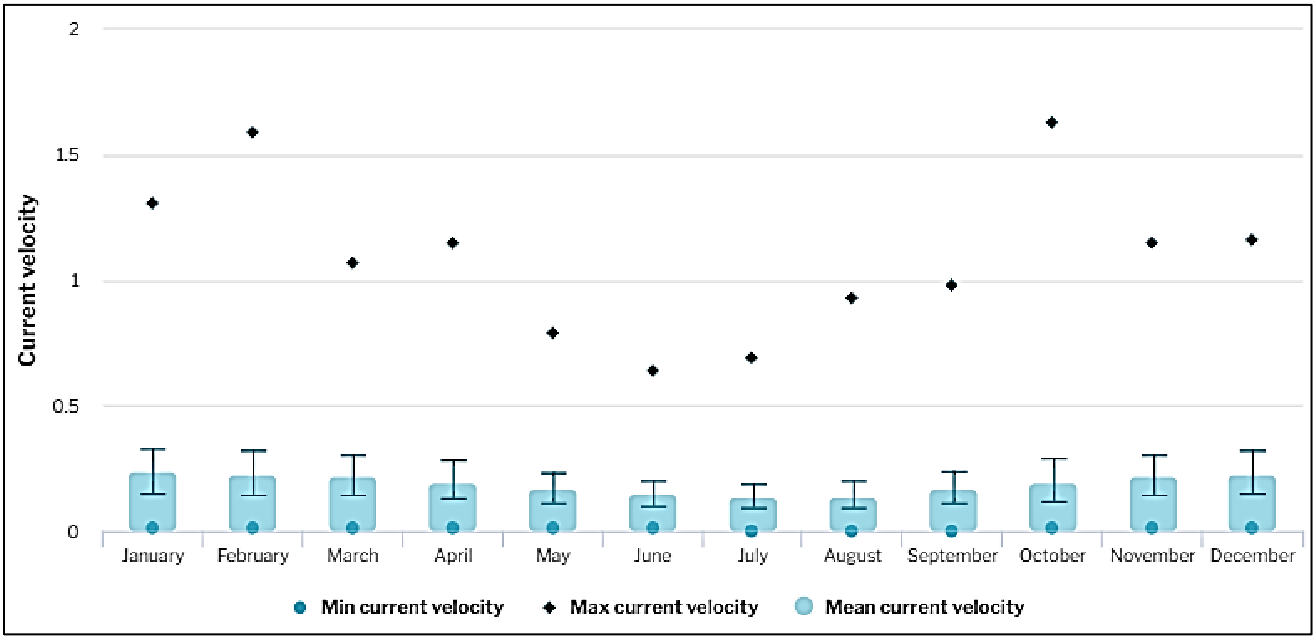


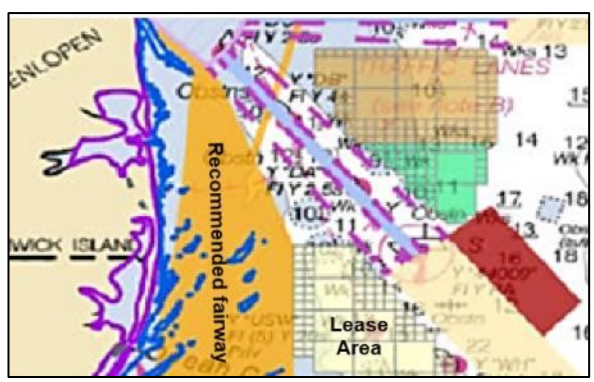
Figure 6-3 Surface Current Speed in the Vicinity of the Lease Area, 1992 – 2012 (BOEM and NOAA, 2020)

6.3 Bathymetry

Data from the National Geophysical Data Center was used to determine water depths across the Lease Area (Figure 6-4). Water depths in the Lease Area range from 12.3 to 41.6 m (40 to 136 ft).

Two notable shoals are located approximately 3 NM (5.6 km) west of the western boundary of the Lease Area: the Isle of Wight Shoal at a depth of 5.8 m (19 ft), and the Fenwick Shoal, at a depth of 4.8 m (16 ft); however, two wrecks on the shoal have a least depth of 3.4 m (11 ft). A lighted buoy marks the southwest end of this shoal. These shoals can affect sea state by locally increasing the height of the swell waves and generate breaking waves. The shoals may present a grounding risk for deep draft (Cargo/Carrier and Tanker) vessels; however, the traffic of this type of vessel passes further to the north and to the east.

There is sufficient sea room west of the Lease Area for safe passage of marine traffic. This is supported by the conclusions and recommendations in the NJPARS (USCG, 2022a). The USCG Fifth District studied the available sea room for existing and future marine traffic between the coast and the Lease Area. In the NJPARS report, the USCG Fifth District recommends creation of a fairway adjacent to the Lease Area. If implemented together with the other recommended routing measures, the USCG determined that it provides for an acceptable level of navigation safety.



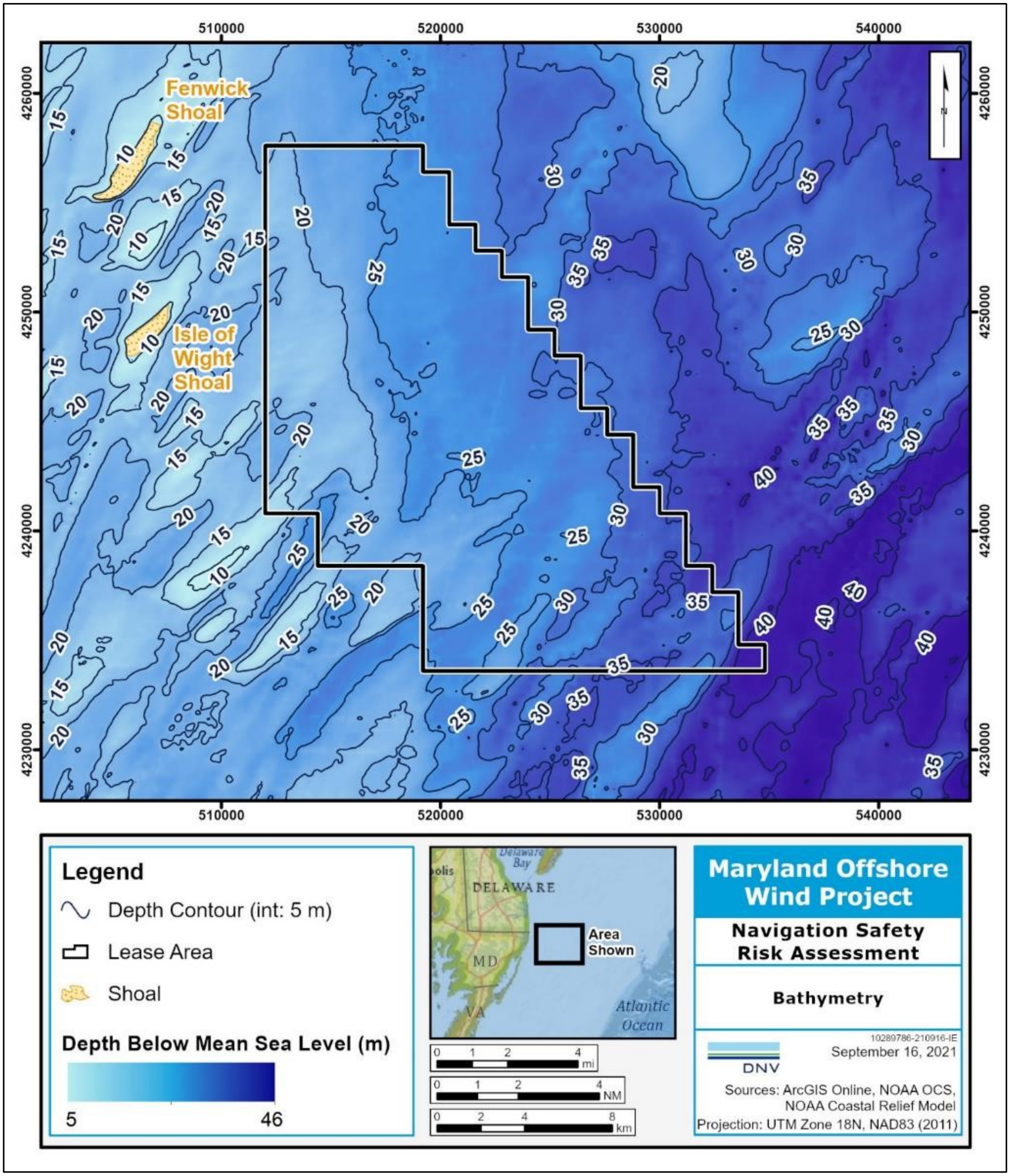


Figure 6-4 Bathymetry in the Vicinity of the Lease Area (NOAA, 1999)

6.4 Waves

The wave direction for the Lease 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 ft to 4.3 ft), with the winter months experiencing the higher waves (BOEM and NOAA, 2020).

Winds coming from anywhere from the south to the northeast of the Lease Area have unlimited fetch, and therefore generate sea swells that can travel for thousands of miles.

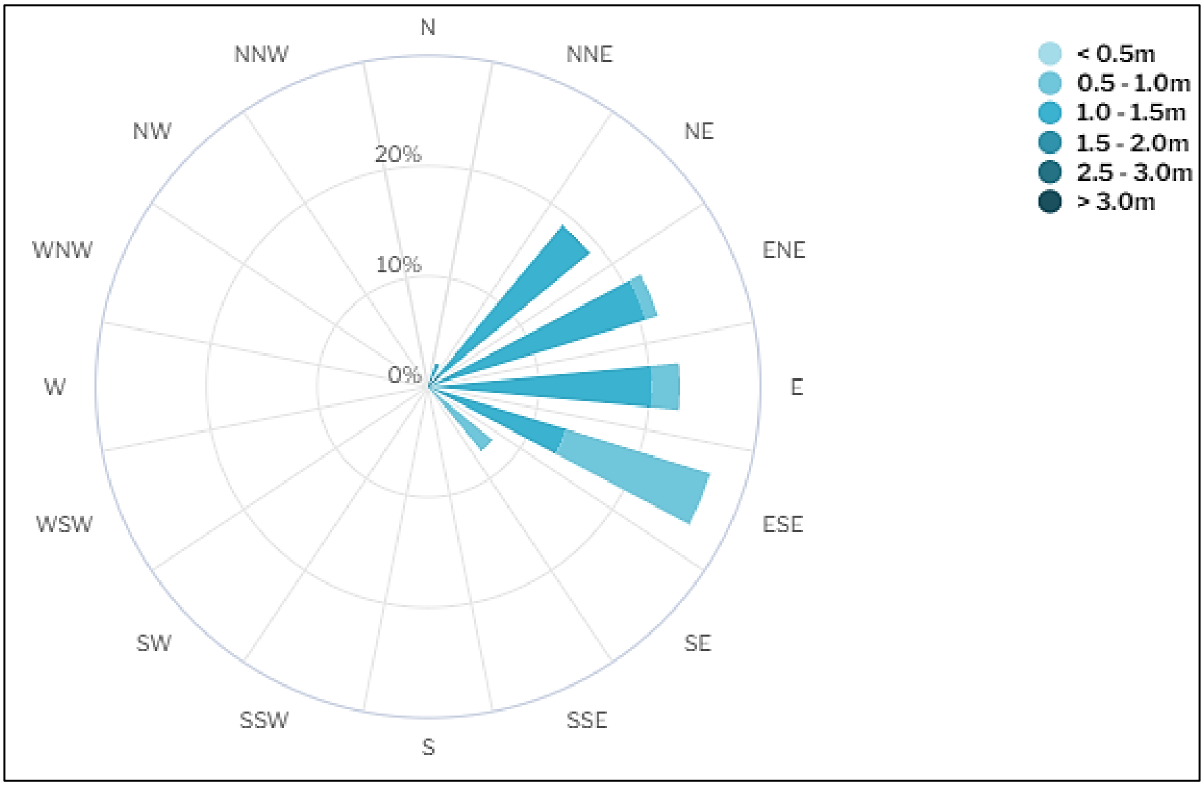


Figure 6-5 Wave Rose and Monthly Average Significant Wave Height Representative of the Lease Area, 1980 to 2009 (BOEM and NOAA, 2020)

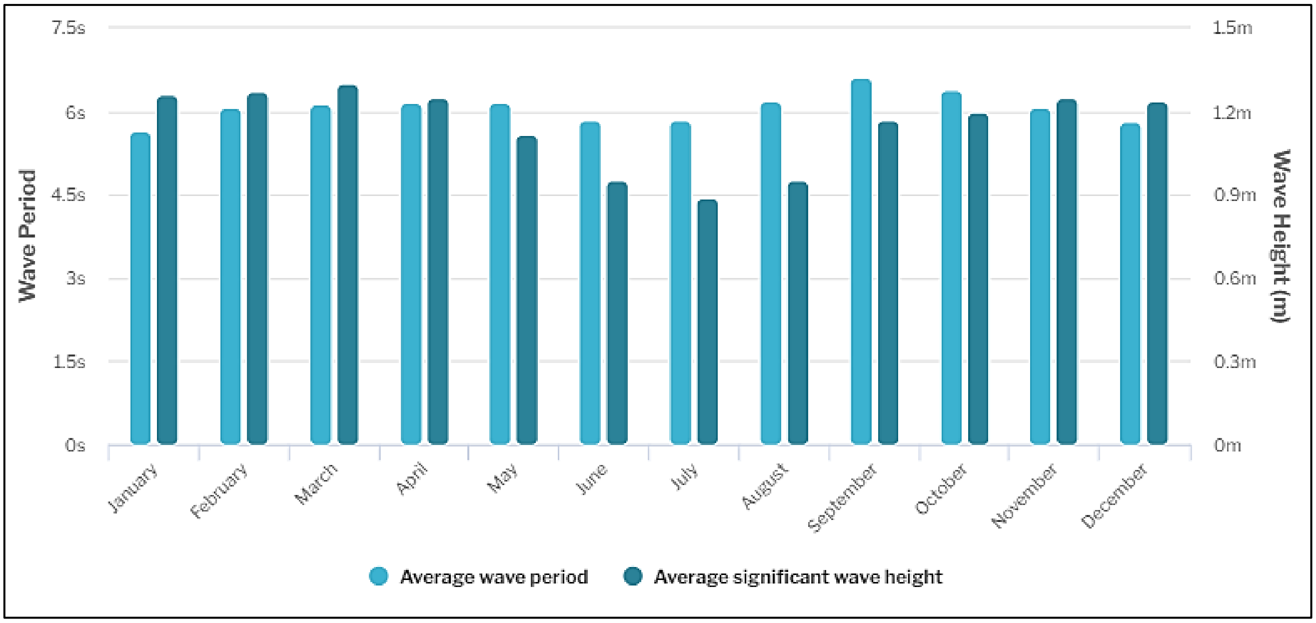


Figure 6-6 Wave Rose and Monthly Average Significant Wave Height Representative of the Lease Area, 1980 to 2009 (BOEM and NOAA, 2020)

The offshore wave measurement station closest to the Lease Area with detailed historical data available to the public, is the National Data Buoy Center (NBDC) station 44009, which is located at the terminus of the Delaware Bay Southeastern Approach TSS, 3 NM northeast of the Lease Area. More than ten years of wind and wave data recorded by this station are used for this analysis.

Average significant wave height recorded at the NBDC station 44009 is 1.2 m (3.9 ft) from 2008 through 2017. 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.

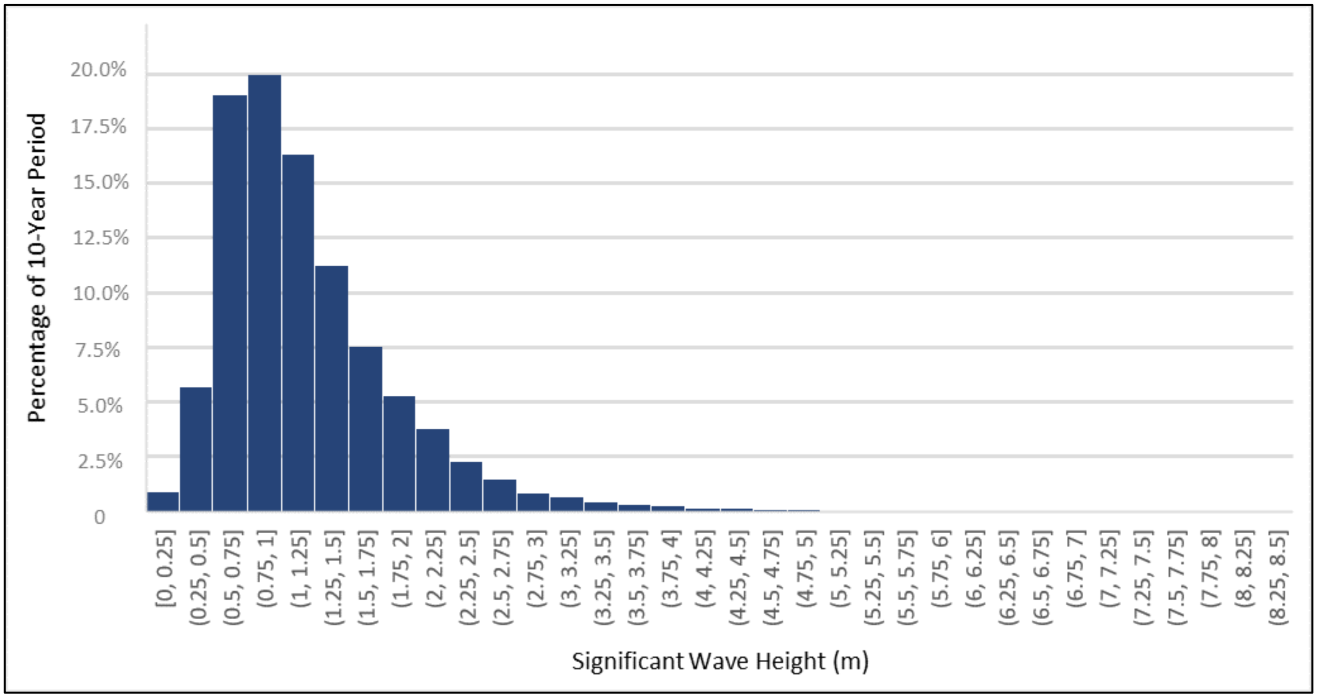


Figure 6-7 Significant Wave Heights at National Data Buoy Center Station 44009, Delaware Bay (2008-2017) (NOAA, 2020d)

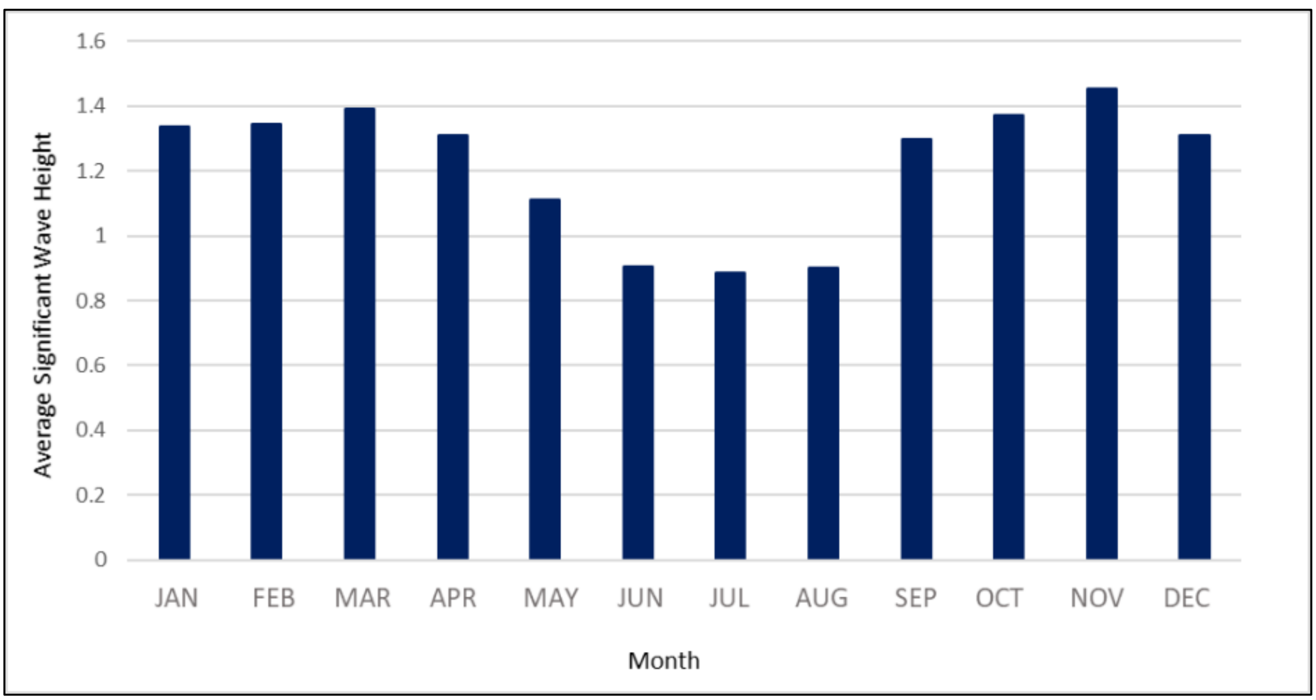


Figure 6-8 Average Significant Wave Heights per Month (in meters) at National Data Buoy Center Station 44009, Delaware Bay (2008-2017) (NOAA, 2020d)

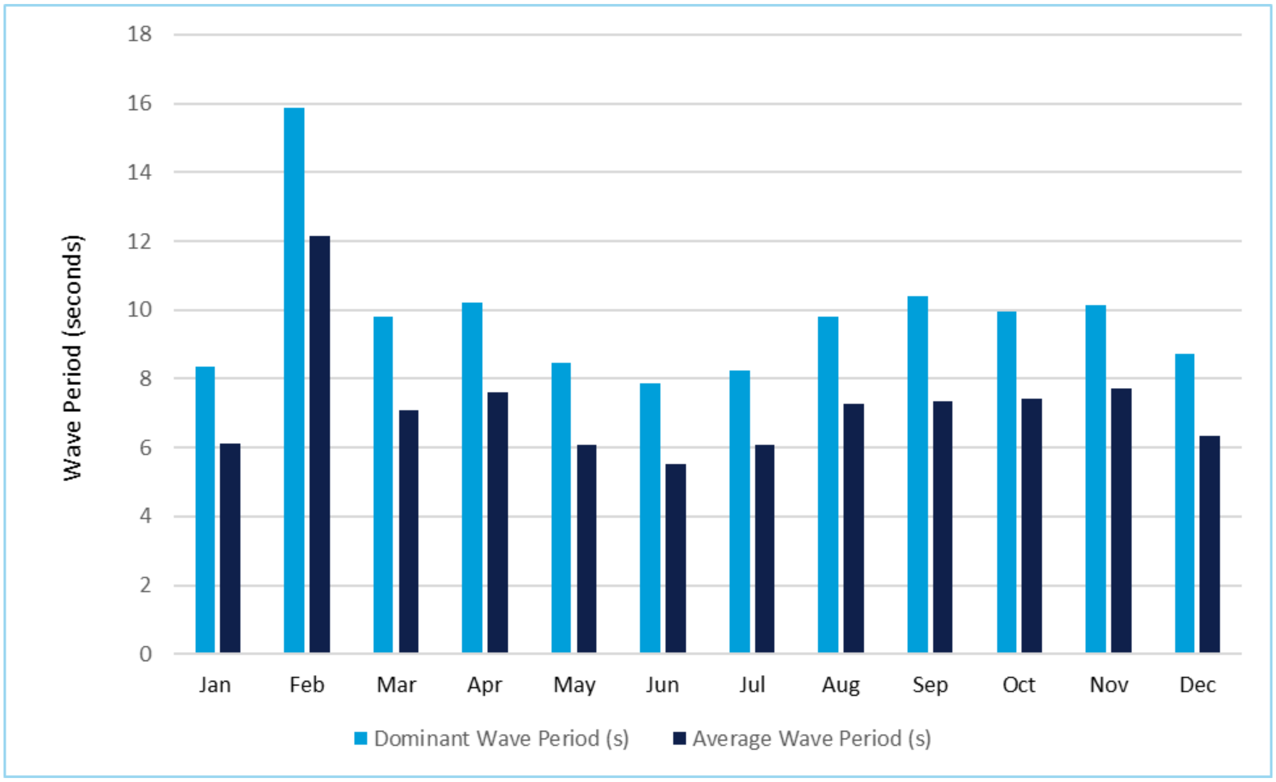


Figure 6-9 Average Wave Periods at National Data Buoy Center Station 44009, Delaware Bay (2008-2017) (NOAA, 2020d)

7 WEATHER

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, 2021a). During the winter months, the region experiences low-pressure weather systems. These systems are often associated with wind speeds that present hazards to navigation (NOAA, 2021a). Mariner vigilance is required for safe navigation due to fog, currents, winds, and waves. These hazards and their effects on a vessel experiencing engine or steering failure are directly accounted for the risk modeling described in Section 11.

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

7.1 Wind

Wind data covering a period of more than 10 years are needed to develop a complete picture of offshore wind conditions over the long term. The closest offshore wind speed measurement station to the Project is NBDC station 44009, which is located at the end of the Delaware Bay Southeastern Approach TSS, 3 NM northeast of the Lease Area. This station has collected more than ten years of wind data but given the relative lack of reported values during winter months, the data described below are considered to be of higher quality for purposes of describing offshore conditions and of risk modeling in this NSRA.

Smoothed daily averages of speed and direction from eight years of QuikSCAT measurements (1 January 2000 through 31 December 2008) were obtained from the Climatology of Global Ocean Winds (COGOW) website (2009).[15] The data were downloaded for the location shown in Figure 7-1 and used to generate wind rose plots and wind speed and direction statistics. The results were found to reasonably compare to statistical summaries of offshore wind speed data presented by Global Wind Atlas (2020) and Marine Cadastre's OceanReports (BOEM and NOAA, 2020) platforms.

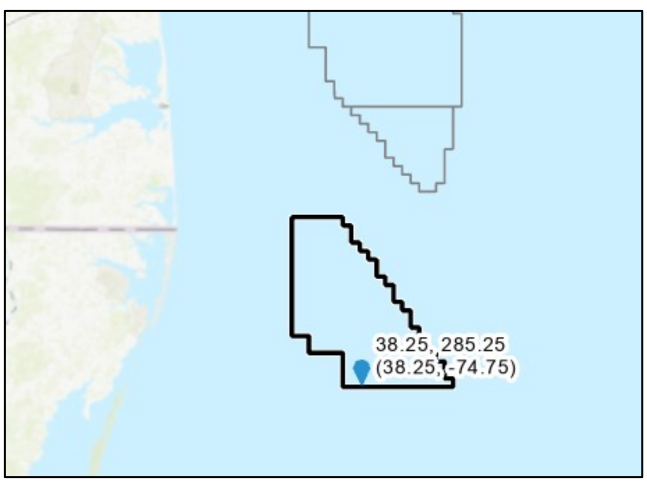


Figure 7-1 Location Represented by Downloaded COGOW Wind Data (1999-2009) (COGOW, 2009)

[15] Provided courtesy of Oregon State University's Cooperative Institute for Oceanographic Satellite Studies (CIOSS) (Risien and Chelton, 2006)

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 wind speeds of 70 to 75 kt are indicated in Coast Pilot 3 (NOAA, 2020a). Therefore, the wind speed distribution used in the MARCS model (see Appendix E) was based on the COGOW data, which were adjusted as follows:

- The detailed COGOW data were summarized for each of the eight compass directions and proportions were determined for wind categories calm (< 20 kt), fresh (20 to 30 kt), gale (30 to 45 kt), and storm (> 45 kt).
- 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. Based on DNV’s past comparison of confidential offshore LIDAR data with buoy and COGOW datasets, 2% of the gale winds in the COGOW data summary were re-assigned to storm.

The resulting wind speed/direction distributions are shown in Table 7-1.

Table 7-1 Wind Speed Distribution Used in NSRA Modeling

Wind Speed Category	North	Northeast	East	Southeast	South	Southwest	West	Northwest	Total
Calm	5.1391%	4.9184%	4.1299%	3.9499%	4.1556%	4.5439%	5.2089%	5.6191%	37.7%
Fresh	9.0605%	9.1305%	8.7516%	0.0000%	8.2983%	8.6277%	8.8274%	8.8863%	61.6%
Gale	0.2404%	0.2471%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.2504%	0.7%
Storm	0.0049%	0.0050%	0.0000%	0.0000%	0.0000%	0.0000%	0.0000%	0.0051%	0.0%
Total	14.4%	14.3%	12.9%	3.9%	12.5%	13.2%	14.0%	14.8%	100.0%

The distribution of wind directions in the COGOW data is shown in Figure 7-2. Note that 2% of the gale winds were reassigned to storm level winds for the purposes of modeling collision, allision, and grounding risk.

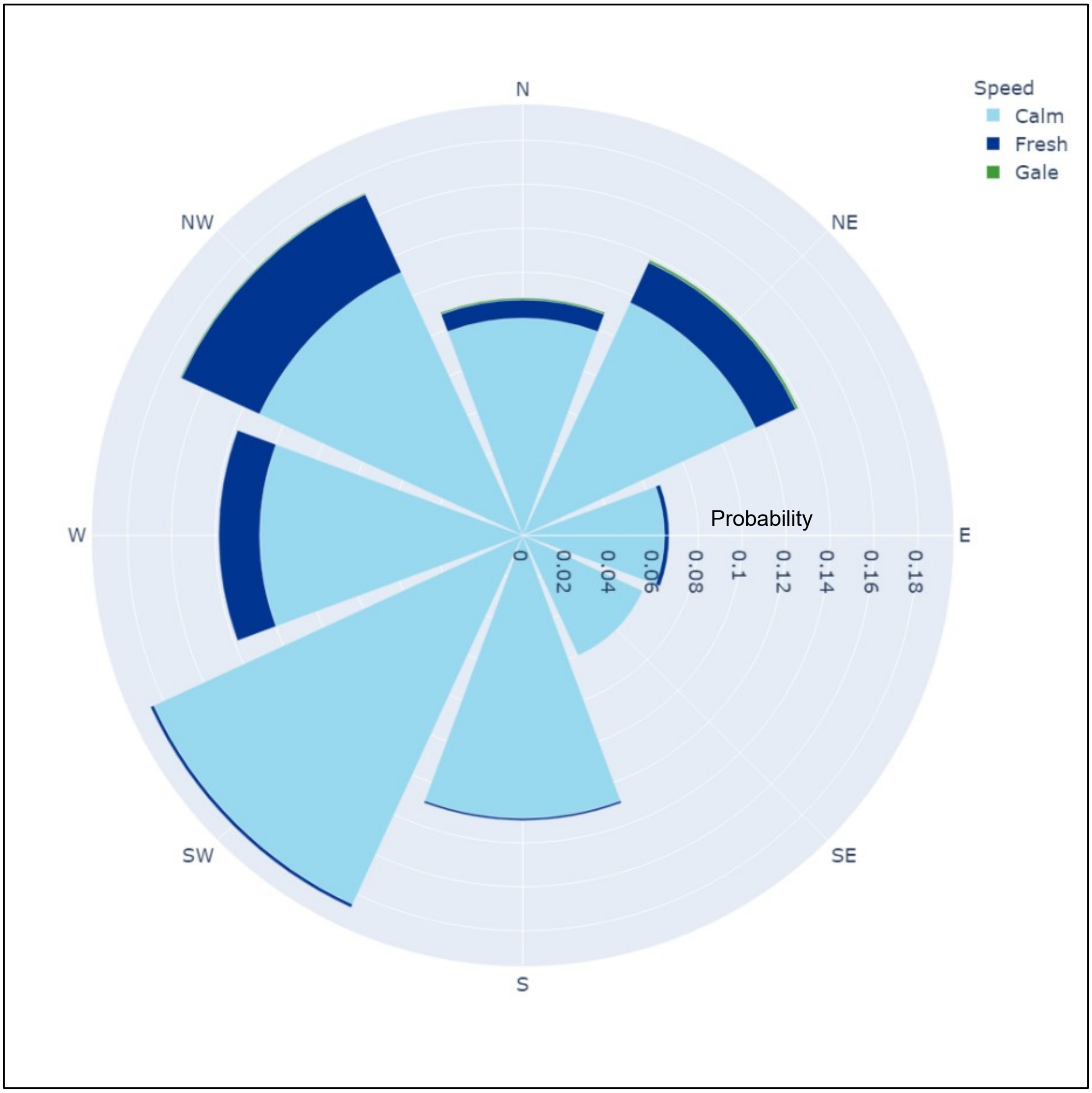


Figure 7-2 Wind Direction Distribution at 10 m (33 ft) Height Above MSL

The prevailing wind direction is from the southwest and northwest, with lower contributions from other directions. However, the Fresh wind comes almost exclusively from a sector between west and northeast, and the gale wind from north to northeast. 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 10 m (33 ft) elevation is 13.1 kt (6.7 m/s).

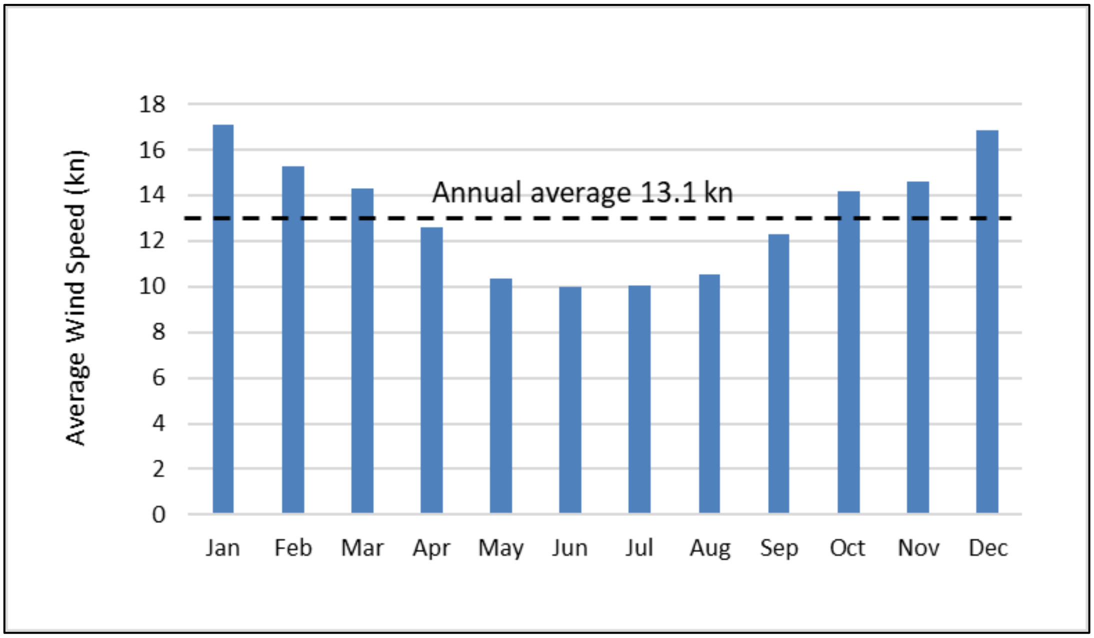


Figure 7-3 Average Hourly Wind Speeds at 10 m (33 ft) Height Above MSL (COGOW, 2020)

The International Best Tracks for Climate Stewardship database provided the data for hurricanes that passed within five degrees of the Lease Area between 1970 and 2020 (NOAA, 2021d; Knapp et. al., 2010; Knapp et. al. 2018) (shown in Figure 7-4).

Hurricanes are not common in the vicinity of the Lease 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.

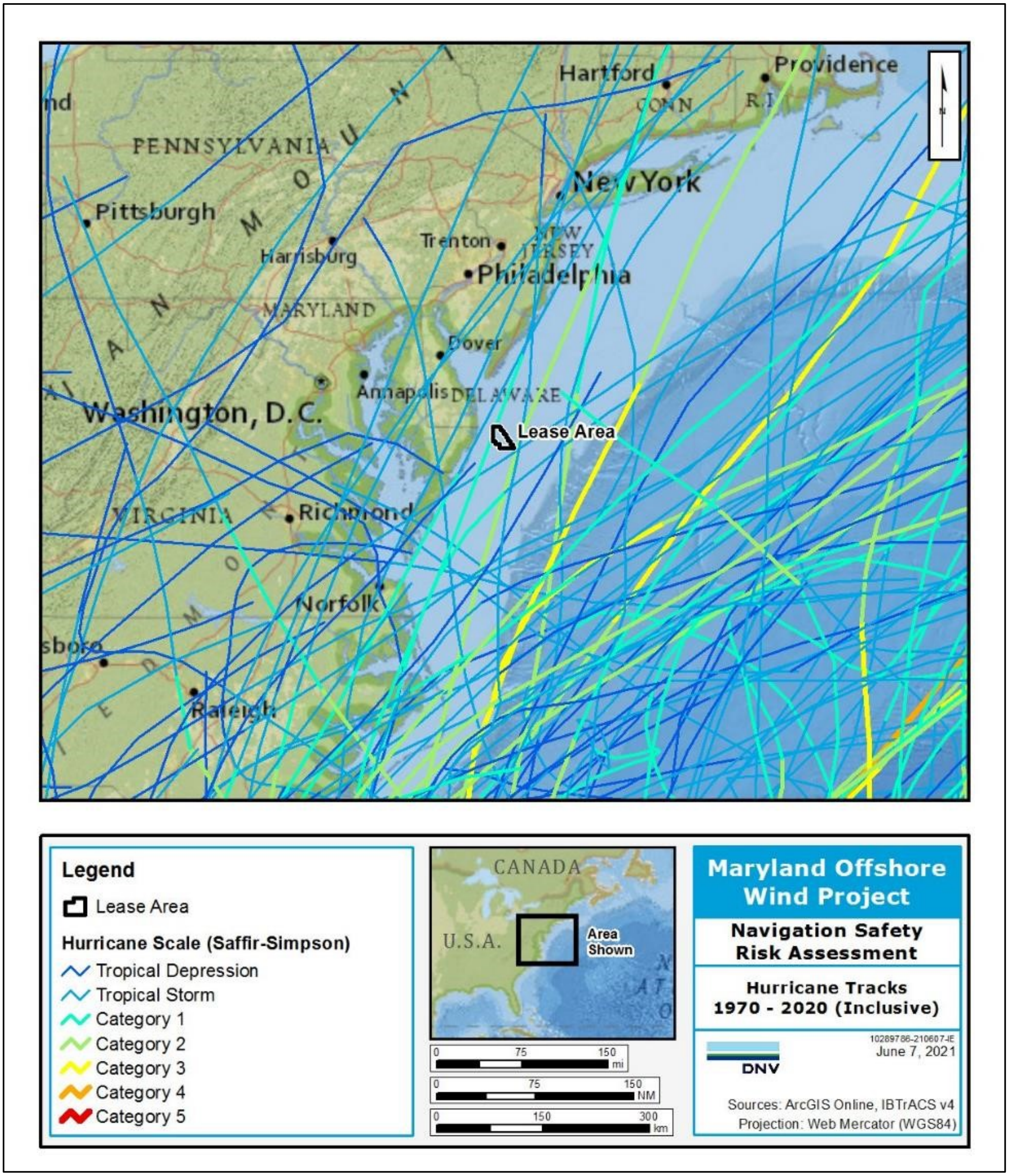


Figure 7-4 Tracks of Cyclones within 5 Degrees of the Lease Area (1970-2020) (NOAA, 2021d)

7.2 Consideration of vessels under sail

Vessels under sail could enter the Lease Area. In line with rules of prudent seamanship, such vessels should proceed with caution near any structure that decreases visibility. Potential hazards to vessels under sail from Project structures were assessed, 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 an offshore structure 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 Ocean City Municipal Airport. This is the closest station with long-period 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 Ocean City Municipal Airport station. Visibility was less than 2 NM 7.6% 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. Visibility is accounted for in the collision, allision, and grounding risk modeling described in Section 11.

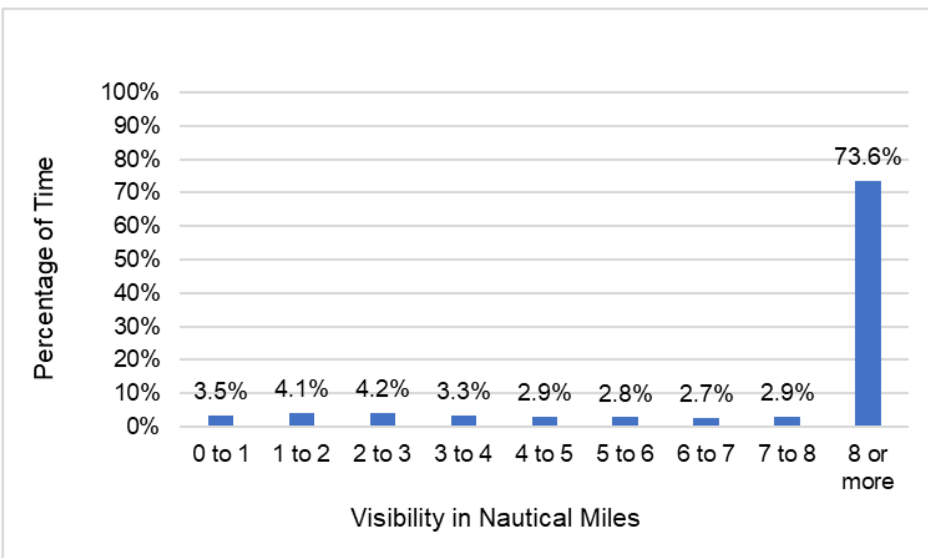


Figure 7-5 Summary of Visibility Measurements at Ocean City Municipal Airport, 2011 – 2020 (NOAA, 2021c)

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.

7.4.1 Floating ice

Coast Pilot 3 (NOAA, 2021a) discusses ice within the New Jersey intercoastal waterway, waters of Delaware Bay and River, and other inland waterways. Sea ice is not found at latitudes below 45° North (NASA, 2016), which intersects Maine's coast. Pack ice usually lies well north of 40°N latitude and pack ice that does drift south is always well east of the Lease 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.

7.4.2 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. Both are known to occur from onshore wind turbines in extreme northern climates in the U.S. and more so in Canada. However, the data is not gathered on an industry-wide basis.

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 change, 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. Vibration sensors are part of the typical system used to monitor the condition of the turbine equipment. As a result of the widespread use of vibration monitoring, ice throw occurs rarely 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 because the requisite atmospheric conditions for icing, such as cold and icing climate[16], may not occur during the Project lifetime. Based on DNV expert opinion, qualitatively, the risk of ice throw is on the order of 1 in 100 years, 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 recommends that a wind farm operator 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.

[16] Low temperature is defined as more than 9 days below -20 per year or long-term atmospheric icing annually (IEA, 2003)

8 CONFIGURATION AND COLLISION AVOIDANCE

NVIC 01-19 recommends a site-specific evaluation will be conducted of the potential impacts (both positive and negative) to SAR (Search and Rescue) services in and around the Project. This report provides input to the USCG's assessment of whether the risk to SAR missions is mitigated to as low as reasonably practical (ALARP). An ALARP assessment evaluates any additional risk reduction measures with the goal of weighing the potential benefits against the costs.

SAR operations have two main components, the first is a successful search, the second is a successful rescue. Search is the primary aspect that can be affected by an array of offshore structures. Search is required when an event is believed to have occurred and the locations of the survivor(s) are uncertain (Soza and USCG, 1996). When a situation includes a person or vessel adrift that is subject to the influences of wind and current, the uncertainty in the location increases with time while the probability of survival decreases with time. The USCG has invested significant resources to plan searches, with the aim of increasing the efficiency of the where and how of search activities.

The search pattern followed by vessels and helicopters is generated by the USCG's SAROPS software, using inputs such as location, wind, current, level of emergency, and water temperature. By restricting the possible flying and sailing routes, the Project's offshore structures could affect the selected search pattern. In addition, SAROPS software is not designed to account for fixed offshore structures. As a result, the tools and procedures used to develop search patterns will need to be updated once a significant number of offshore structures are constructed in U.S. waters, by any developer.

The available information about a possible SAR incident is often incomplete when the USCG is initially alerted (Soza and USCG, 1996). The high-level process used to gather more information is typical of an investigation (Figure 8-1).

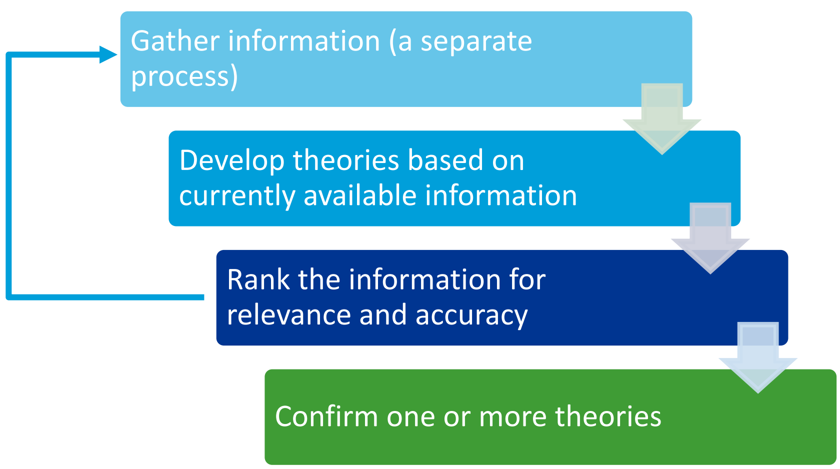


Figure 8-1 Indicative Search Process

Information gathering is critical part of the search process. The presence of structures in the water provides potential opportunities to obtain information in ways that are not possible without structures. This is discussed further in Section 12.

8.1 Current USCG capabilities

The information summarized in this paragraph was provided in discussions with USCG Sector Delaware Bay (2021c). The USCG's on-water assets that would respond to a SAR call in the Lease Area are at Station Ocean City, MD, 12 NM west of the Lease Area, Station Indian River Inlet, DE, 15 NM (28 km) northwest of the Lease Area, and Training Center Cape May, NJ, 28 NM (52 km) north of the Lease Area. From Station Ocean City, the USCG operates two 47 ft motor lifeboats. From Station Indian River Inlet, the USCG operates two 47 ft motor lifeboats. Additionally, from Training Center Cape May, the USCG operates three 47 m (154 ft) fast-response cutters and three 26.5 m (87 ft) patrol boats. The cutters and patrol boats may be deployed as far as 200 NM from shore.

The fast-response cutter is most likely to be involved in search activity in the vicinity of the Lease Area. Its capabilities include:

- Speed: 30 kt
- Cruising range: 5,000 NM
- Endurance: 10 days (unreplenished)
- Maximum seas: No limitation
- Towing capability: 500 displacement tons

In addition to vessels that may respond, a SAR operation can include a helicopter to perform the search more efficiently. USCG helicopters most likely to conduct SAR operations in the vicinity of the Lease Area would be the HH-65 Dolphin, which would respond from Atlantic City, NJ, approximately 56 NM from the Lease Area. The characteristics of the HH-65 short range recovery helicopter are:

- Cruise speed: 148 kt
- Range: 350 NM
- Maximum weight: 4,300 kg (9,480 lb)
- Rotor diameter: 11.9 m (39.17 ft)
- Length: 13.5 m (44.4 ft) (USCG, 2021d)

8.2 Inputs to layout development

Developers of offshore wind farms in the U.S. provide power at a specified, agreed price. When deciding whether and how much to bid on a particular lease area, potential energy production is a key factor. Once the area is leased, the potential energy production is refined based on higher-resolution information concerning geology of the sea bed, wind direction, and wind speed. For this Project, navigation safety and consideration of other marine uses were other refining factors, resulting in a proposed layout with 1.0 NM (1.9 km) between structures in a north-south direction and 0.76 NM (1.4 km) between structures in an east-west direction (US Wind, 2022). The nacelle height is 166 m (545 ft).

Assuming a limited area in which to construct an offshore wind farm, when a layout is based on longer distances between WTGs of a specified size, one can reasonably expect:

- A decreased risk to vessels or low flying aircraft in the area, particularly in storm conditions or reduced visibility
- A reduction in the number of WTGs that can be located within the area, and therefore a reduction of the potential maximum delivered power
- An increase in delivered power from downwind turbines due to decreased wake effects
- An increase in the length of inter-array cable per WTG.

8.3 SAR risk and mitigations

Project structures could pose a risk to SAR vessels and aircraft during missions within the Lease Area. The USCG has ascertained that 1.0 NM lanes between structures provide access to conduct an air-facilitated rescue, but not to effectively search for a small object.

Based on information provided by the USCG, the probability of locating a person in the water is 52% using aircraft, assuming ideal conditions. The probability of success is estimated to decrease to 8% after construction of wind turbines with 1.0 x 1.0 NM spacing between turbines,[17] which is larger spacing that is proposed for the Project. The decrease is appreciable, and merits change to prevent degradation of USCG mission success.

There is no known and tested suite of mitigations or new processes that will increase the likelihood of success for offshore search missions in a wind development.

The data concerning SAR activity are discussed in Section 12. Key takeaways are:

- Based on the mission data provided to US Wind (USCG, 2021g) over a 10-year period, the USCG executed 8 SAR missions in the Lease Area, and 1,026 missions within 20 NM (37 km) of the Lease Area. On an annual basis, this represents an average of 0.8 SAR missions per year in the Lease Area and 103 per year within 20 NM (37 km).
- The great majority of SAR missions occur near the coast and are unlikely to require search within the Lease Area.

Based on the risk drivers identified in the above list, the types of mitigations that might be effective are:

- Facilitate self-reported location accuracy - For search activities in the proximity of the Lease Area, an optimized set of available data, tools, and search processes are not yet identified. The ideal set would result in quicker location of the majority of persons and vessels needing aid compared to the situation today. Below is a list of possible ways to improve self-reported location to considerably reduce the demand for extended search operations within the Lease Area:
  - The Project's lighting and marking
  - Offshore cellular phone connectivity
  - VHF call triangulation system

[17] Assuming the person has a floatation device and the helicopter's altitude is 91 m (300 ft).

- Utilize additional technologies to locate objects in the water:
  - Closed-circuit television cameras on selected structures
  - Radar monitoring of craft within the Lease Area
  - Unmanned search craft

Given the current status of offshore wind developments in the U.S., prior to development of the Project, the USCG pilots will have the opportunity to develop and test approaches to SAR within a wind development.

Section 11.3 discusses and evaluates the collected list of potential risk controls for the Project.

9 VISUAL NAVIGATION

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 were reviewed. No significant obstruction was noted. Based on the review and discussions with mariners, the Project is not anticipated to affect a mariner's ability to use marked ATON or the coastline as reference for navigation due to the Lease Area's location. The Project will provide the necessary data concerning the Project to the USCG and NOAA (US Wind, 2022) to assure that Project structures and seaward components are clearly marked on NOAA nautical charts.

During operation, each WTG foundation will serve as an ATON for mariners, as WTGs are large structures that will be lighted and marked as required by applicable regulations and USCG Private Aids to Navigation (PATON) permits. The marking scheme for Project structures is described in Section 13.

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. 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 has a tube diameter of 12 m (39 ft). An additional 1 m was added on either side to account for ancillary equipment, resulting in an effective diameter of 14 m (46 ft). Using this additional factor, a vessel up to 46 ft long could be completely obstructed by a monopile from an observing vessel on the opposite side of the monopile. A vessel longer than 46 ft could also be completely obstructed if the observing vessel were significantly closer to the monopile than the obstructed vessel.

A safety buffer of 10 m (33 ft) 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 24 m (79 ft), representing a credible maximum potential for visual obstruction.

For a vessel travelling at 5 kt, the visual obstruction would be 9.3 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 0.013 NM (24 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	9.3
10	4.7
15	3.1

The Project layout evaluated in this assessment (see Section 1.2) has a minimum of 0.76 NM (1.4 km) between Project structures. For the average Fishing vessel in the Traffic Survey Area, with an LOA of 23 m (75 ft), this distance represents 56 vessel lengths, which should provide sufficient distance and time to transit safely and observe other vessels in the vicinity of Project structures.

A situation wherein two vessels each have a constant heading with reducing distance between them within the Project Area is likely to occur as a common event. Should a Project structure block the view of one to the other for a period, and watchkeeping be insufficient, a collision or allision at speed could result. The consequences to the vessels and occupants could be significantly more severe than an accident occurring at a lesser speed. A more detailed discussion of the hazards associated with navigating within the boundaries of the Project is included in Section 3.1 and Section 5.

10 COMMUNICATIONS, RADAR, AND POSITIONING SYSTEMS

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. WTGs and the movement of turbine blades have the potential to interfere with communication signals from radio and radar transmitters by either blocking or reflecting signals.

Publicly available literature was reviewed concerning potential impacts of offshore WTGs on communication and navigation systems in addition to conversations with NOAA Integrated Ocean Observing System (IOOS) regarding high frequency radar (HFR).

No risks to the health of vessel crews are anticipated from the power and noise generated by Project structures, see Section 3.4 for more information regarding noise from Project structures. The Project will comply with applicable laws and regulations concerning electromagnetic interference and human health and safety (US Wind, 2022).

10.1 Effects on communications

This section describes potential effects of a wind farm on marine communications, including ship-to-ship and ship-to-shore communications systems. 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. VHF radio wave propagation recovers quickly from structural interference. The USCG's advanced command, control, and direction-finding system, "Rescue 21," is unlikely to experience meaningful degradation from the Project. The Rescue 21 architecture and VHF propagation characteristics overcome interference associated with fixed structures such as wind turbines.

Relevant 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 to 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 returns on routes transited by commercial ships are not anticipated to be affected. Smaller vessels operating in the vicinity of the Project may experience radar clutter and shadowing. AIS signals are not similarly affected and can be used instead to mitigate for marine radar signal degradation that may occur while transiting in proximity to WTGs.

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 USCG. In general, the studies found that offshore wind turbines impact marine radars and that effective and accessible mitigations are available to mariners.

A recent study published by the National Academies of Sciences (NAS, 2022), assessed impacts of offshore WTG on marine vessel radar and identified techniques that can be used to mitigate those impacts. The study identified the following primary effects of WTGs on marine vessel radars:

- WTG interference decreases the effectiveness of radar mounted on all vessel classes, worsened by the larger sizes of proposed WTGs and anticipated number of wind farms across the Outer Continental Shelf.
- WTG interaction with radar will lead to unforeseen complications due to heightened effects of propagation, multipath, shadowing, and degrading performance of Automatic Radar Plotting Aids.
- Maritime SAR assets rely on radar to search for smaller boats as their primary targets in the conduct of ordinary SAR operations. A loss of contact with smaller vessels due to the various forms of radar interference could complicate marine transportation operations, and is therefore particularly consequential when conducting maritime surface SAR operations in and adjacent to an offshore wind farm (NAS, 2022).

The study recommended the following actions to mitigate effects on marine vessel radars:

- Approaches external to radar design such as
  - Enhancing the radar cross section (defined as a measure of the strength of the backscattered signal from a target to the radar with units of square meters) of small vessels or other objects that are difficult to detect
  - Reducing topside scattering from the own vessel structure to reduce false (angle and range ambiguous) returns
  - Improving operator training
- The marine stakeholder community could incentivize innovation in radar products by manufacturers to promote radar designs with increased immunity to WTG interference. For example, development of new, Doppler-based, solid-state radar with WTG resilience is possible.
- Modifications to the WTGs themselves could potentially reduce the WTG radar signature. Previous modeling and simulation efforts have shown, for example, that incorporation of radar absorbing materials and tower shaping can reduce the radar cross section of WTGs.

The USCG noted in its final PARS for the Areas Offshore of Massachusetts and Rhode Island (MARIPARS) report (2020) that various factors play a role in potential marine radar impacts:

> "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 MARIPARS report found that structures may have some effect upon radar, but they do not render radar unworkable. These findings are consistent with USCG'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 with larger turbines. The USCG 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 U.S. It consists of five WTGs 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 (HDR, 2019).

10.3 Effects on High Frequency Radar

NOAA operates over 160 coastal HFR sites designed primarily to collect sea surface wind, wave, and current data. HFR functions as a remote, low-cost, low-power method of performing ocean current monitoring, aid in oil spill containment, and vessel tracking among other uses. Although HFR has no role in vessel collision, allision, or grounding avoidance, data from the system are used by the USCG in its SAR computer models for drift modeling to narrow search areas for people and vessels lost at sea (NOAA, 2021e).

HFR data are anticipated to experience signal losses from the presence of an operational offshore wind farm, as seen in Figure 10-1. Mitigation measures for HFR signal losses are presently being studied by BOEM, the Department of Energy funded National Offshore Wind Research & Development Consortium (NOWRDC), and NOAA IOOS. Presently, the Wind

Turbine-Radar Interference Mitigation (WTRIM) Working Group has set goals for 2025 that include removing radar interference as an impediment to future wind energy development and ensuring long-term resilience of radar operations in the presence of wind turbines (DOE, 2021).

HFR manufacturer-specific mitigations to wind turbine interference are possible solutions but require real-time feeds of each turbine's rotor speed and nacelle position. NOAA's proposed mitigation strategy includes instrumenting offshore wind farms with oceanographic sensors (current and wave meters) that telemeter their real-time data stream to NOAA's IOOS (NOAA, 2021e). This direct stream of measurements would fill the data gaps created by the operational wind farms thus maintaining clarity for SAR operations. Collaboration between federal agencies, radar manufacturers, and wind farm developers and operators will aid in formulating comprehensive mitigation measures.

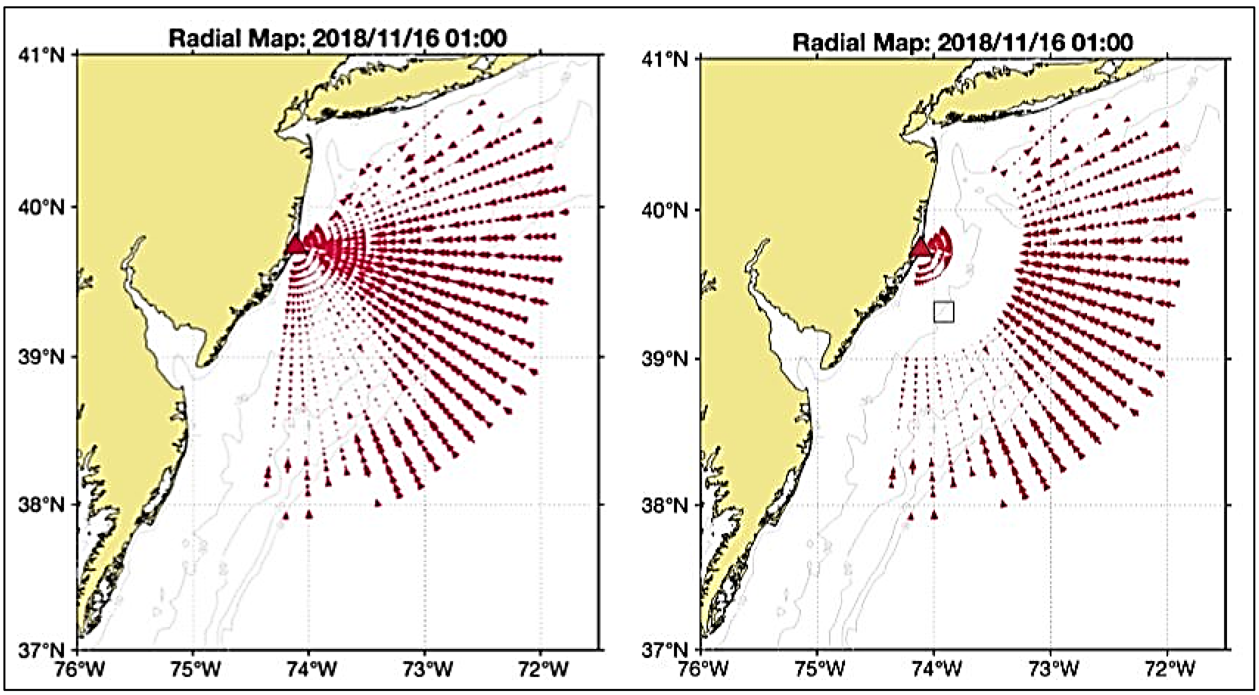


Figure 10-1 HFR Data Before (left) and After (right) Installation of an Offshore Wind Farm (NOAA, 2021e)

Relevant studies commissioned by BOEM in 2018 and 2020 on the potential impacts to HFR from offshore wind farms are discussed below.

Key findings of the 2018 BOEM (2018b) study include:

- 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 Electromagnetics 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 revolutions per minute were provided by the turbine operator.

Key findings of the BOEM 2020 study (Colburn et. al., 2020) include:

- Wind turbine interference impacts the SeaSonde ocean current measurements by processing turbine echoes as part of the sea echo, allowing the turbine echoes to be processed as part of the sea echo thus changing the angular measurement for the radial current vectors.
- SeaSonde's manufacturer, CODAR Ocean Sensors, is engaged with BOEM in a project to reduce or eliminate the interference experienced by HFR from offshore wind turbines. This will be done by:
  - Assessing the impact of turbine interference, spreading out in-range Doppler space, on radar-derived physical oceanographic measurements
  - Providing the HFR community a software package for mitigating interference capable of real-time integration with the existing operational SeaSonde data processing tool chain.
- BOEM should consider drafting agreements with wind farm developers and operators to:
  - Share real-time data-sharing for radar signal processing modifications. The Project is willing to share data and to discuss how data sharing can be enabled.
  - Require in-fill radar placements where impact is significant. It is unclear at this time which, if any, portions of the Lease Area will have significant impact. US Wind is open to further engagement on this issue (US Wind, 2022).

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 and AIS data transmission. 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 a 2019 correspondence to BOEM (Glander, 2019), the USCG 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 USCG 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.”

Correspondence with NOAA IOOS identified mitigation strategies for HFR most notably including real time filtering of data to remove noise from turbines and the installation of oceanographic sensors (current and wave meters) that telemeter their real-time data stream to NOAA’s IOOS (NOAA, 2021e). This effort would require early collaboration between federal agencies, radar manufacturers, and wind farm developers and operators.

In conjunction with BOEM, NOAA, the American Clean Power Association, and the DOE WTRIM working group, US Wind is working with the agencies to mitigate the potential impacts of the Project to the SeaSonde HFR system (US Wind, 2022).

11 COLLISION, ALLISION, AND GROUNDING ASSESSMENT

This section presents a qualitative estimate of accident consequences for collision, allision, and grounding (i.e., a marine accident) in the MARCS Study Area from operation of the Project. This section also presents the modeled estimated frequencies of these accidents from the Project, and risk mitigation measures to reduce the identified risks. This assessment builds upon earlier work conducted to understand traffic patterns, vessel sizes, types, and speeds (Section 2); the hazards posed to vessels by the Project (Section 3); and stakeholder discussions (Appendices B and C).

In this context, risk is the combination of frequency and consequence. The assessment of collision, allision, and grounding risk herein consists of software modeling to estimate the frequency or likelihood of accidents (Section 11.1) and a consequence analysis (Section 11.2) based on a “what if” approach. The frequency of accidents is estimated using DNV’s proprietary, validated model, MARCS.

11.1 Consequences of marine accidents

11.1.1 Consequences from a collision

Vessel collision is the structural impact between two vessels, and can occur whether or not the Project is constructed. The presence of the Project structures may lead to vessels altering their route plans to avoid the structures, resulting in an increased number of encounters in specific areas and therefore increased collision risk in those areas and potentially decreased collision risk in other areas. Collision risk arises from vessels that alter their route plans and those that do not. Section 11.1 discusses the magnitude of the change in frequency of occurrence, and that it is primarily to Passenger and Pleasure vessel types. Section 11.2 presents additional detail on the vessel types and sub-areas related to this risk.

Should a collision occur, the consequence to the vessels involved can range from minimal (almost no consequence) to catastrophic. Collisions can result in severe outcomes because both vessels are moving and contributing energy to the impact. The level of consequence depends on vessel speed, vessel size, collision angle, and location of contact on the vessels. The most extreme collisions in the historical data resulted in fatalities and total loss of both vessels.

Vessel collisions are rare events because the maritime community and authorities have implemented various types of risk control measures to reduce their likelihood. Important controls include the use of AIS, radar, adherence to COLREGs, communications protocols, bridge management, and vessel inspection/classification. Additional industry standard risk control measures are discussed in Section 11.3.

The most recent available USCG Marine Casualty and Pollution Data (Marine Information for Safety and Law Enforcement [MISLE] system) was analyzed for the 13.5 year period from January 2002 to July 2015. Figure 11-1 shows the average number of Marine Casualty cases per year and the types of vessels involved within the MARCS Study Area. An average of approximately 1 collision per year occurred during that period. The involved vessels were primarily recreational (Pleasure), Passenger, and commercial fishing (Fishing).

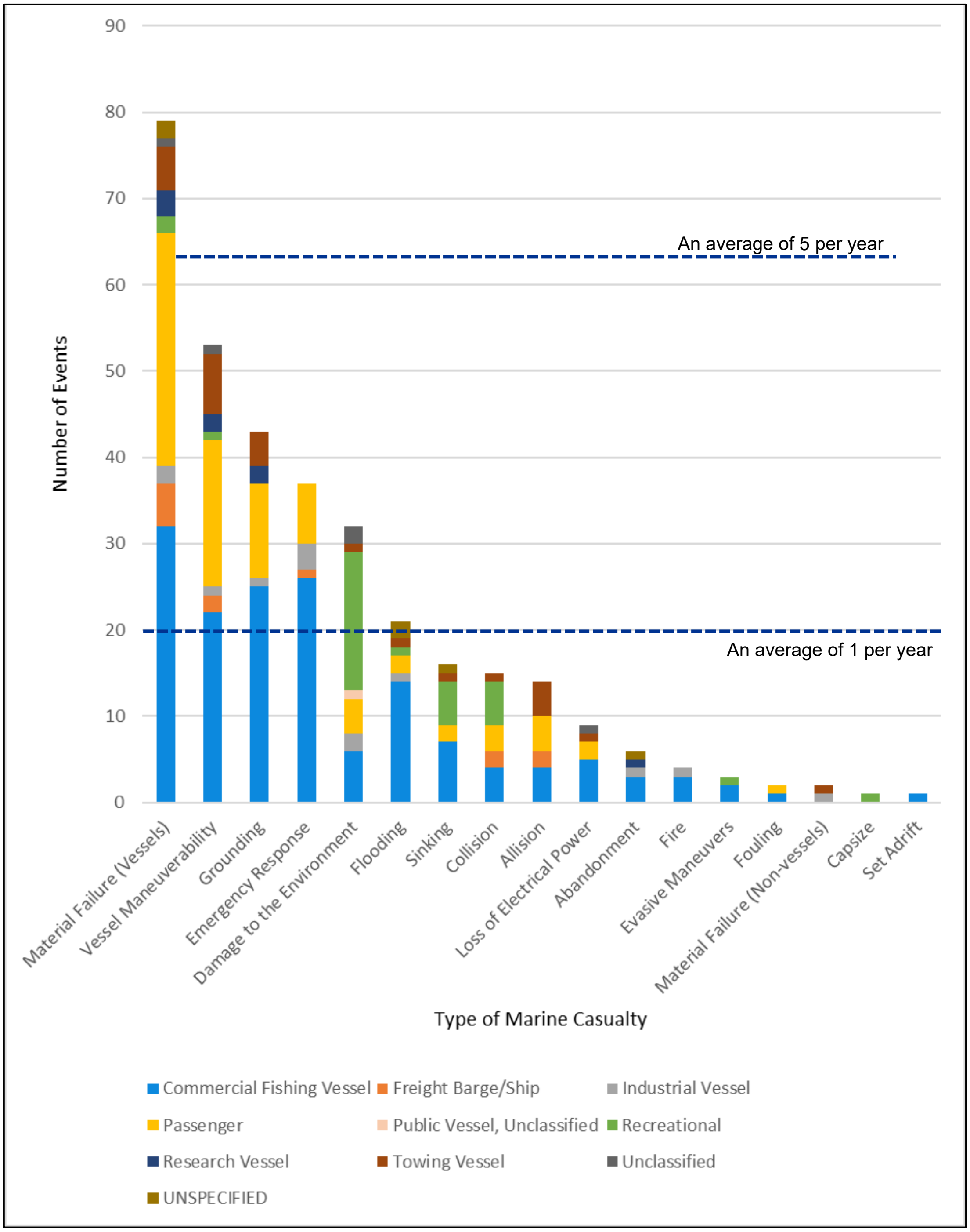


Figure 11-1 Types of Marine Casualty Cases in MARCS Study Area (2002-2015) (USCG, 2015b)

11.1.2 Consequences from an allision

There are two types of allisions which are discussed: drift allision and powered allision.

When a vessel's propulsion fails, it is adrift until:

- An anchor is successfully dropped
- Repairs are made onboard
- A suitable fastening is made and the vessel is under tow, or
- The vessel grounds.

A drift *allision* would occur if the wind and/or waves push an adrift vessel into an offshore structure. Wind has greater influence on ships that have a large windage area, like cargo vessels, and waves/currents are more influential for ships that sit lower to the water, like barges.

A powered allision occurs when a vessel's propulsion system is functioning and the vessel strikes an offshore structure at some speed. The most common cause of powered allisions is human error; however, rudder failure is also a notable contributor to this risk.

Consequences from drift and powered allisions are described below.

Drift Allision

Specific to the Project, the most likely drift allisions in fair seas and weather are anticipated to result in minor damage to both the vessel and the Project structure. Based on the modeling conducted for allision risk, 64% of the allision accidents would involve Pleasure or Fishing vessels.

Good sailing conditions are prevalent in the area; however, poor conditions occur more frequently in the winter and spring. In poor weather, a vessel driven multiple times into a structure by the wind and waves could sustain substantial hull damage. For vessels with large LOA compared to the WTG diameter of 12 m (39 ft), continued energetic strikes broadside are unlikely unless the initial striking point is central on the side of the vessel. If the contact point is toward either the vessel's fore or aft, the vessel will rotate and be driven away from the structure. Based on DNV's expert judgment, 90% of the modeled drift allisions will have minor/no consequence.

A vessel that is adrift for long enough will generally drift with its highest point away from the wind. As a result, a drifting oil tanker could contact a WTG on its stern quarter rather than on its bow, increasing the possibility of a cargo or bunker fuel spill. (Not all bunker tanks in the current world tanker fleet are protected by double hulls.[18])

[18] Most deep draft ships have bunker fuel tanks near the stern or along the keel, so the probability of orientation to allide at the bunker tank is not high.

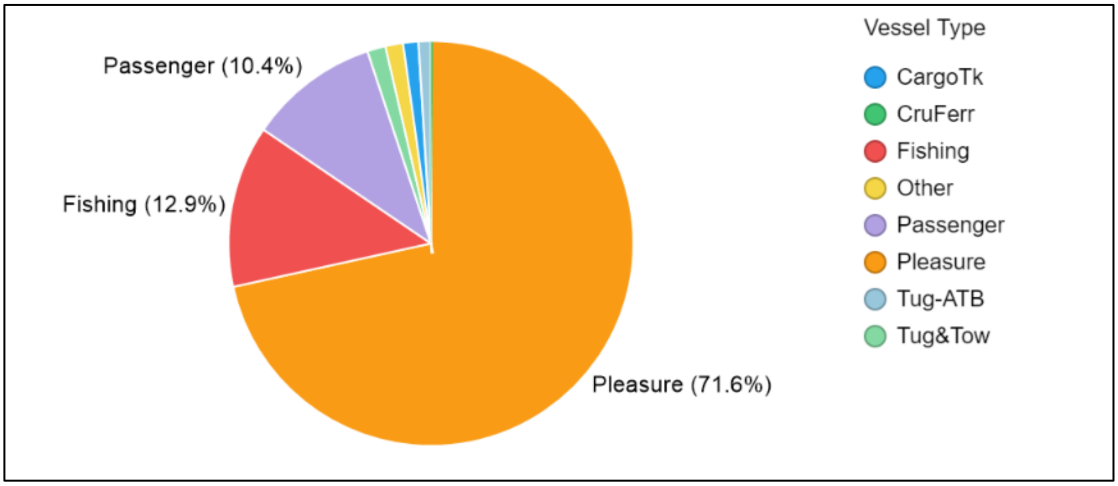


Figure 11-2 Future Case Modeling Results: Vessels Involved in Drift Allision Accidents

Powered allision

A wide range of potential consequences to a vessel exists should a powered allision occur. The least severe consequence is a smaller vessel (e.g., less than 20 m [65 ft] LOA) at low speed. In this event, there may be surficial damage to both the vessel and the Project structure. In this scenario, the personnel, passengers, and structures are unlikely to experience injury or significant damage. The modeling indicates that Pleasure, Fishing, and Passenger vessels are the mostly likely to strike a Project structure and together represent more than 96% of the powered allision risk from the Project (Figure 11-3).

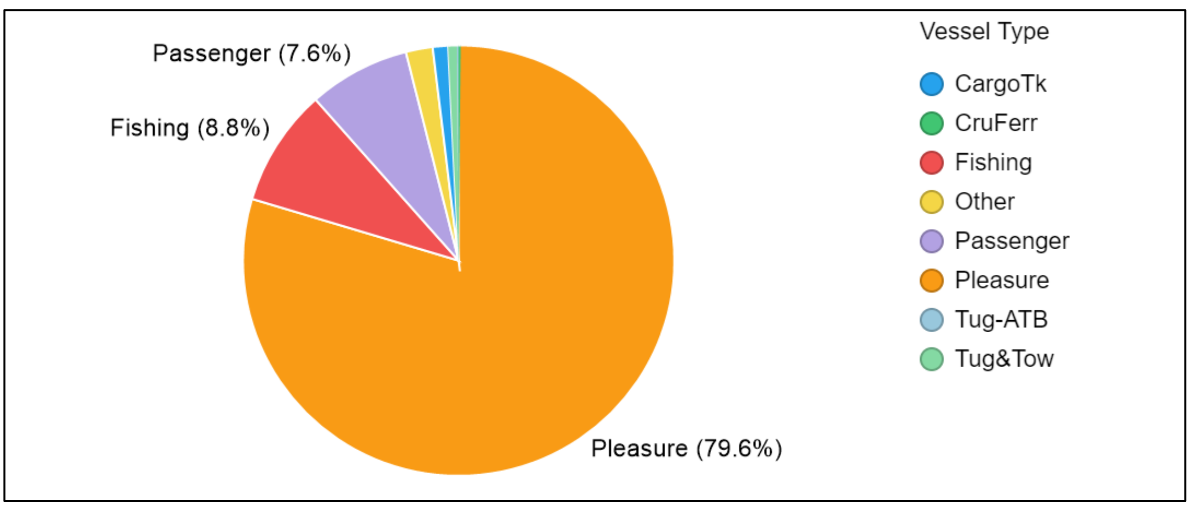


Figure 11-3 Modeling Results: Vessels Involved in Powered Allision Accidents

As the impact energy increases (a function of effective speed and weight), the severity of consequences from an allision increases. A powered allision (i.e., occurring at speed) has potential for severe consequences to both the vessel and the

Project structure. Powered allisions involving CTVs have occurred in European wind farms. Injuries have occurred, but no fatalities have been recorded.

Based on typical speeds and weights of vessels in the MARCS Study Area (see Section 2.1.3), the following consequences are the most likely:

- Pleasure, fishing, passenger, and non-ATB tugs (typical displacements of 25 to less than 1,300 tonnes):
    - At speeds less than 4 kt the most likely consequence is minor damage to the vessel and minor/no damage to the structure. This speed is commonly recognized as the maximum speed while actively fishing.
    - At speeds greater than 4 kt, significant vessel damage is likely with potential minor damage to the structure. Fishing vessels transiting from Ocean City and the fishing grounds through the Lease Area have an average speed between 9 and 15 kt. Tugs in the vicinity of the Lease Area have speeds between 6 and 12 kt, with ATBs more likely to transit at speeds greater than 8 kt.
- Barge vessels on towlines (typical DWT of 20,000 to 50,000 DWT and speeds between 6 and 12 kt):
    - The most likely consequence to a towline tug is significant vessel damage with minor/no damage to the structure, assuming the tug alone is the alliding vessel.
    - The most likely consequence to the towed barge alliding at speed is significant vessel damage including a compromised cargo tank with minor/no damage to the structure.
- Cargo/Carrier and Tanker vessels and Cruise/Ferries (typical DWT of 50,000 to 300,000 DWT and average speeds between 12 and 15 kt) in the vicinity of the Lease Area:
    - The most likely consequence to the deep draft vessel is significant vessel damage with significant structure damage. Compromise of a bunker fuel tank is possible, as some tank vessels do not have double hull protection of the fuel tank. A break of a cargo tank is possible, but unlikely due to the specific allision geometry that would be required for this to occur.

The maximum consequences from a powered allision are:

- 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. No allisions to date have been identified that caused major damage to an offshore wind structure.

11.1.3 Consequences from a grounding

The sea bed where groundings could occur along the Maryland and Delaware coasts is generally sand/mud/shell rather than rock (NOAA, 2021a). A grounding in this kind of substrate is termed a soft grounding.

According to USCG MISLE data illustrated in previous Figure 11-1 (USCG, 2015b), the historical frequency of reported groundings in the MARCS Study Area is approximately 3 per year. Soft groundings by small non-commercial vessels may not be included in the reported cases, as there may be no regulatory requirement to report.

The most likely consequence to a vessel from soft grounding in this area is minor, if any, vessel damage, because of the low energies typically involved and because seas are calm most of the time. Grounding severity depends on: hardness of the shoreline, speed of grounding, tidal range, and weather/storms. Tidal changes and storms can break a vessel that is stuck fast. Should a vessel ground, the prevalent soft bottom substrates are not able to penetrate the double hull of a tanker or barge, even at normal sailing speed.

A less likely, greater consequence is possible. As noted in Section 6.3, there are marked shoals and a wreck approximately 3 NM (5.6 km) west of the Lease Area. Mariners are aware of the hazard and avoid the shoals. However, accidents can occur: mechanical failures could result in a drift grounding and powered grounding is mainly the result of human error. The USCG MISLE data for 13.5 years (2002 to 2015) (USCG, 2015b) indicates no groundings within 5 NM of the wreck and shoal.

During the winter and into the spring, winds exceeding 28 kt and wave heights exceeding 3 m (10 ft) occur about 10% of the time. A grounding leading to capsizing is a possibility in adverse seas. In addition, should a vessel ground and remain so for a period of time, the stranded vessel may experience continued wave impacts could lead to eventual structural failure of the vessel.

As discussed in Section 6.3, the availability of sea room, including west of the Lease Area, precludes an increase in vessel groundings as a direct effect from the presence of Project structures. The grounding risk from the Project is directly related to the additional transits that were estimated to occur after the Project is operational. The modeled incremental grounding risk from the Project generally occurs in the vicinity of Ocean City and comprises recreational transits assumed to be attracted by the Project (Pleasure type) (79% of the increase) and the CTVs supporting the Project (Passenger type) (18% of the increase) (Figure 11-4).

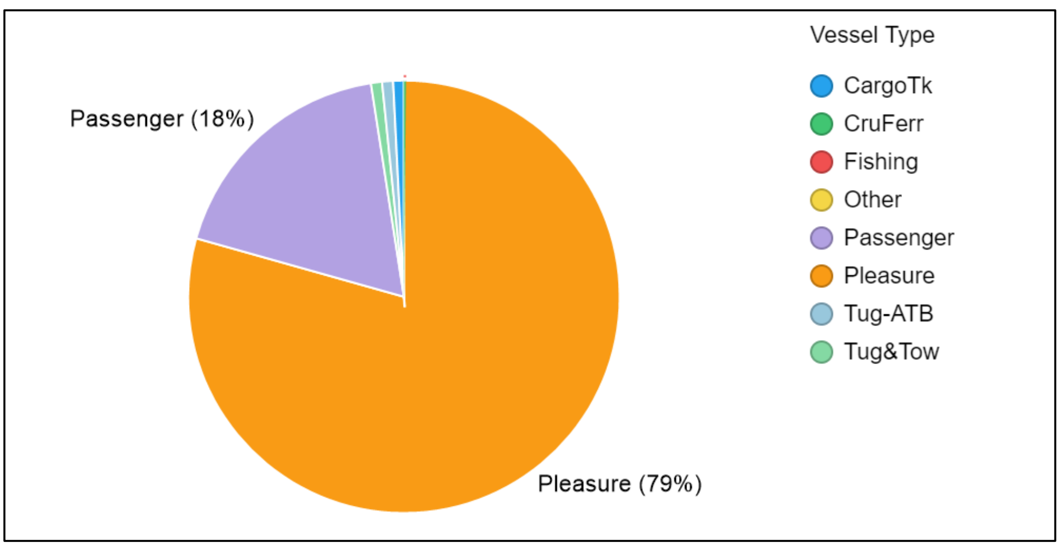


Figure 11-4 Modeling Results: Vessels Involved in Grounding Accidents

11.2 Frequencies of marine accidents

Separate models are built in MARCS to estimate (1) the frequency of a marine accidents without the Project and (2) the frequency of marine accidents with the Project. The approach is to calculate the difference between them, the change in risk, which is attributed to the Project. Risk models are generally conservative and by design, predict higher numbers of events than come to fruition.

Three potential layouts were compared to assess the risk of a deep draft vessel powered allision with a Project structure. The summary results of the layout sensitivity analysis for Cargo/Carrier and Tanker vessels per-structure allision frequency are shown in Table 11-1. The layout containing 119 structures has a deep draft vessel allision recurrence of less than 1 allision every 100 years. US Wind has identified this as the preferred Project layout, which has no structures within 1 NM (1.9 km) of the adjacent Traffic Separation Scheme (TSS).

Table 11-1 Modeled Sensitivity of Cargo/Carrier/Tanker Allision Frequency Per Structure (allisions/year; years/allision)

Allision type	126 Structures	119 Structures (none within 1 NM of the TSS)	98 Structures (none within 2 NM of the TSS)
Drift	0.0086 allisions/year (1 allision every 117 years)	0.0080 allisions/year (1 allision in 125 years)	0.0063 allisions/year (1 allision in 158 years)
Powered	0.0023 allisions/year (1 allision in 437 years)	0.0016 allisions/year (1 allision in 611 years)	0.0004 allisions/year (1 allision in 2,445 years)
Total allision frequency per structure per year	**0.0108 allisions/year (1 allision in 92 years)**	**0.0096 allisions/year (1 allision in 104 years)**	**0.0068 allisions/year (1 allision in 148 years)**

A summary of the resulting modeled accident frequencies (i.e., annual rates of occurrence in units of accidents per year) is provided in Table 11-2. The main takeaways from the modeling effort are:

- Collision risk increases (mainly due to the assumed increase in traffic generated by the wind farm), but from a small baseline level to the predicted future collision risk total of 0.04/year, or 1 accident every 25 years.
- Allision risk increases. This is an inevitable consequence of developing offshore wind energy to reduce greenhouse gas emissions. About 90% of this allision frequency is due to smaller ships navigating within the Lease Area. The consequence of these allisions is likely to be low for both the vessel and the structure. The frequency of higher consequence allisions (powered allision of ships with LOA > 100 m) is 0.0095 per year, or 1 allision in 105 years, which is 4 times the design lifetime of the wind farm.
- Grounding risk increases mainly due to the assumed/predicted traffic increase due to the wind farm. The developer does not have much influence over these risks. In addition, the risk model has not been optimized to assess these grounding risks. The developer has influence over the risk of its own vessel groundings, which may be mitigated by crew selection and training (reduced human error probabilities) and transit rules (e.g., no transits during poor visibility or strong wind).

Table 11-2 Summary of Modeled Incremental Change in Accident Frequencies per Accident Type from the Project

Accident type	Base Case Event Frequency (without Maryland Wind) (events/yr)	Future Case Event Frequency (with Maryland Wind) (events/yr)	Increase in Frequency from the Project (events/yr)
Allision, Drift	<0.0005	0.147	0.147
Allision, Powered	<0.0005	0.141	0.141
Collision	0.015	0.040	0.024
Grounding, Drift	0.384	0.476	0.092
Grounding, Powered	0.325	0.595	0.270
Total	0.724	1.399	0.675

This study identified four documented accidents, which occurred in European Union and UK waters [19]:

- A drift allision of a cargo vessel Julietta D with the jacket foundation of an under-construction OSS in Dutch waters in January 2022 (TenneT, 2022).
- A powered allision of a CTV with a WTG owned by another wind farm operator in German waters in April 2020, due to human error (MarineInsight, 2020).
- A powered allision of a fishing vessel with a WTG in UK waters on May 2016, due to inattention (BBC, 2016; OffshoreWind.Biz, 2016).
- A drift allision of a container ship with a WTG in UK waters, due to steerage failure (BOEM, 2018a).

The resulting average accident rate for UK waters, neglecting wind farm operational vessels, is 1 allision per 10,000 turbine years. Notably, no instances of groundings attributed to offshore wind structures were identified by a literature search conducted for this NSRA. If the UK allision rate were applied to the Project, the resulting allision frequency would be an average of 0.38 allisions per year[20], which is approximately the same level of risk as the modeled result of 0.29 allisions per year shown in Table 11-2.

Information about Modeling

MARCS has been utilized globally to assess navigation risk of more than 20 offshore wind farms. The tool is used to calculate accident frequency and locations for collision between vessels, allision with Project structures, and grounding because of the establishment of Project structures.

MARCS comprises a set of risk parameters and calculation tools that have been developed to quantify marine risk. It 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.

[19] Accidents involving vessels that were working for the owner/operator of the affected wind turbine are not included in this summary.
[20] Assuming 121 WTGs and 25 years of operation.

The model is used to estimate the average annual frequency of occurrence for each accident type in each grid cell. It accounts for Project- and location-specific environmental, traffic, and operational parameters, including:

- Vessel speed
- Vessel direction/route
- Distance traveled on the route
- Probability of steering and/or propulsion failure
- Probability of error in navigation
- Distribution of wind direction and effect on sea state
- Probability of visibility greater than 2 NM (3.7 km)
- Whether another vessel or object is within 0.5 NM (0.93 km) (in a critical situation or on a dangerous course)
- Conditional probability that the crew will successfully take actions to recover from a dangerous situation, including dropping anchor

The MARCS Study Area and sub-areas are shown in Figure 11-5. Six sub-areas were created using DNV's expert judgement to facilitate understanding of the locations of Project risks. The sub-areas are simple polygons drawn for the purpose of reporting model results. The intention is to provide clarity on locations where risks are affected by the Project and insights into contributing factors and affected vessel types.

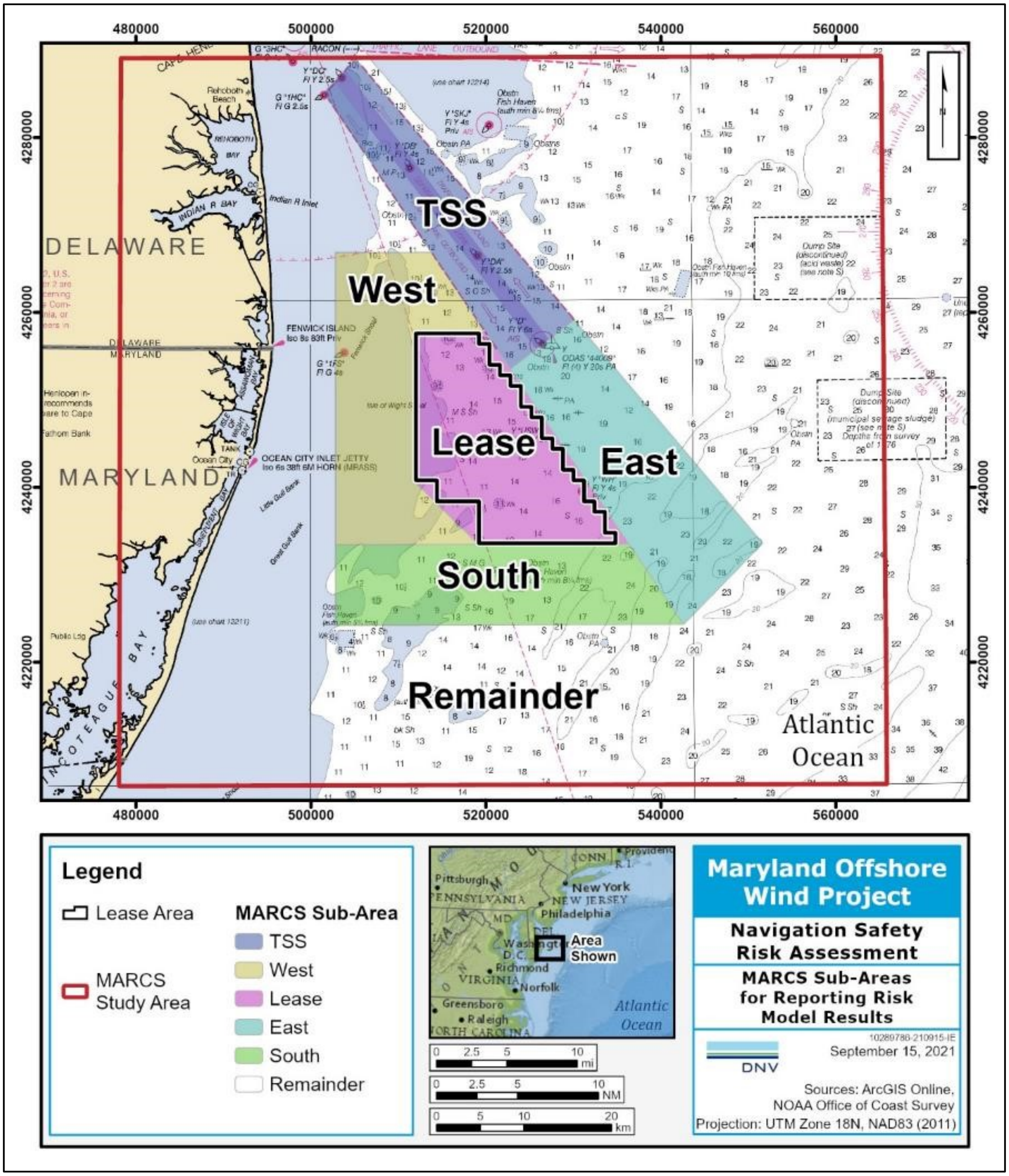


Figure 11-5 Sub-Areas Defined for Reporting of Risk Model Results

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

The model accounted for risk control measures that are in common use such as modern navigation equipment on vessels in international trade, electronic charts, and Port State Control. (See Appendix D Section D.3.2 for descriptions of each risk control in MARCS.) The model did not account for other risk controls that are widely regarded as beneficial. This results in an over-estimation of risk, including higher risk estimates for drift allision than would be estimated with a model that included them. Specific risk controls not accounted for in the Project-specific MARCS model include:

- PATON to be installed by the Project. Insufficient data are available to support quantifying the effects of this measure in the model. Enhanced Aids to Navigation may assist vessels in more accurately determining their position as well as identifying potential hazards. The Project will request PATON permits from the USCG and this NSRA will provide input to the review.
- Tug capability and availability to intervene and prevent a drift allision by a vessel that has lost power. The model assumes a vessel can drift for 24 hours. Accounting for interventions to aid drifting vessel would require a detailed evaluation of availabilities and capabilities in the region. The modeling takes a conservative approach, resulting in higher risk estimates for drift allision than would be estimated with a model that included intervention measures.

The AIS vessel tracks accounted for in the modeling are discussed in Section 2.1.1 for each vessel type. Additional transits were incorporated into the model to account for non-AIS vessel traffic, summarized in Section 2.3.

The following sections present the resulting Project collision, allision, and grounding risk.

11.2.1 Total accident frequency – MARCS Study Area

Table 11-3 presents the incremental accident frequency attributed directly or indirectly to the Project, due to the presence of structures, foreseeable additional transits, and changes to traffic routes.

Table 11-3 Modeled Incremental Change in Accident Frequencies per Vessel Type from the Project in the MARCS Study Area

Vessel type	Increase in frequency of any accident (number per year)	Percentage of total increase in accident frequency
Cargo/Carrier & Tanker	0.013	2.0%
Cruise/Ferry	<0.0005*	<0.05%*
Fishing	0.028	4.1%
Other	0.007	1.0%
Passenger	0.090	13.3%
Pleasure	0.527	77.7%
Tug-ATB	0.004	0.7%
Tug-Towline	0.009	1.3%
Total	**0.675**	**100.0%**

* Grey cells indicate frequencies with a recurrence of less than 5 in 10,000 years.

The MARCS model shows that the frequency of marine accidents increases by 0.68 accidents per year. Marine accidents involving Pleasure vessels represent 78% of the increase (Figure 11-6).

To put the results into regional context, there are an average of approximately 102 SAR cases per year in the MARCS Study Area[21] based on the SAR data provided for this NSRA (USCG, 2021g). The reader should note that this modeled accident increase represents accidents of all levels of consequence, including small and zero damage incidents such as bumping into a foundation while drifting.

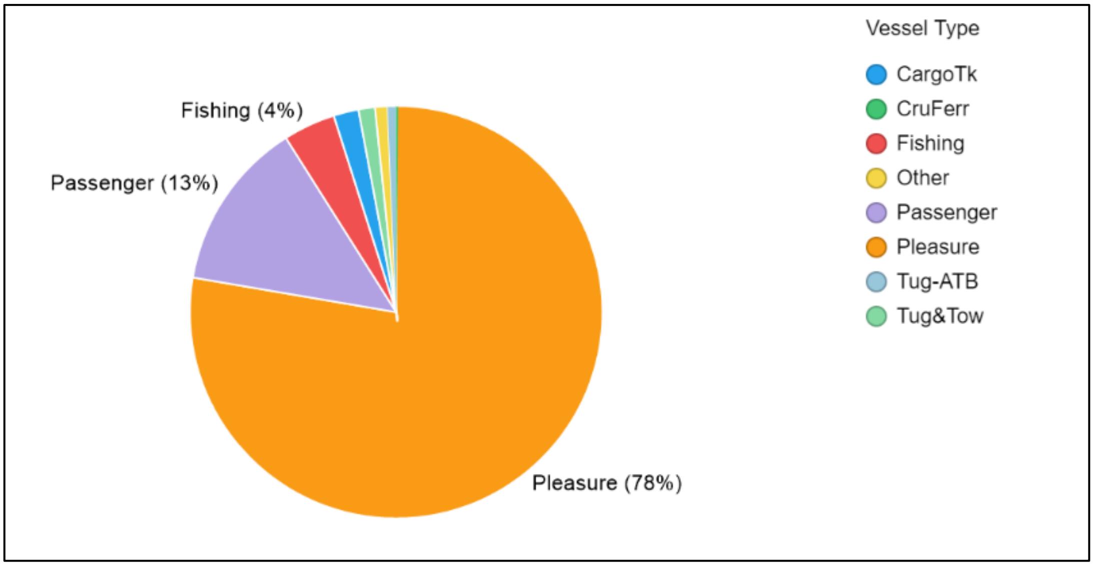


Figure 11-6 Relative Contribution to Project Risk from Each Vessel Type in the MARCS Study Area

Table 11-4 shows the same results summarized by accident type.

Table 11-4 Modeled Incremental Change in Accident Frequencies from the Project for Each Accident Type in the MARCS Study Area

Accident type	Increase in accident frequency (number per year)	Percentage of Total
Allision, Drift	0.147	21.8%
Allision, Powered	0.141	20.9%
Collision	0.024	3.6%
Grounding, Drift	0.092	13.7%
Grounding, Powered	0.270	40.0%
Total	**0.675**	**100.0%**

[21] Not all accidents modeled in MARCS are expected to require SAR activities.

Allision accidents comprise 43% of the increase in accidents from the Project and are modeled to occur an average of 2.9 times every 10 years. Grounding accidents comprise 44% of the increase in accidents from the Project and are modeled to occur an additional 3.7 times every 10 years.

Quantitative details concerning the vessel types and Sub-areas associated with collision, allision, and grounding frequencies are discussed in depth in the following sections. Sub-area boundaries are shown in previous Figure 11-5.

Figure 11-7 provides a high-level comparison of the increase in accident frequencies across the Sub-areas. It shows that the great majority of the frequency lies in two Sub-areas: the Lease Area and the “Remainder” of the MARCS Study Area.

Additional significant figures are provided in the tables in the following sections to facilitate discussion of risk tradeoffs between vessel types and accident locations.

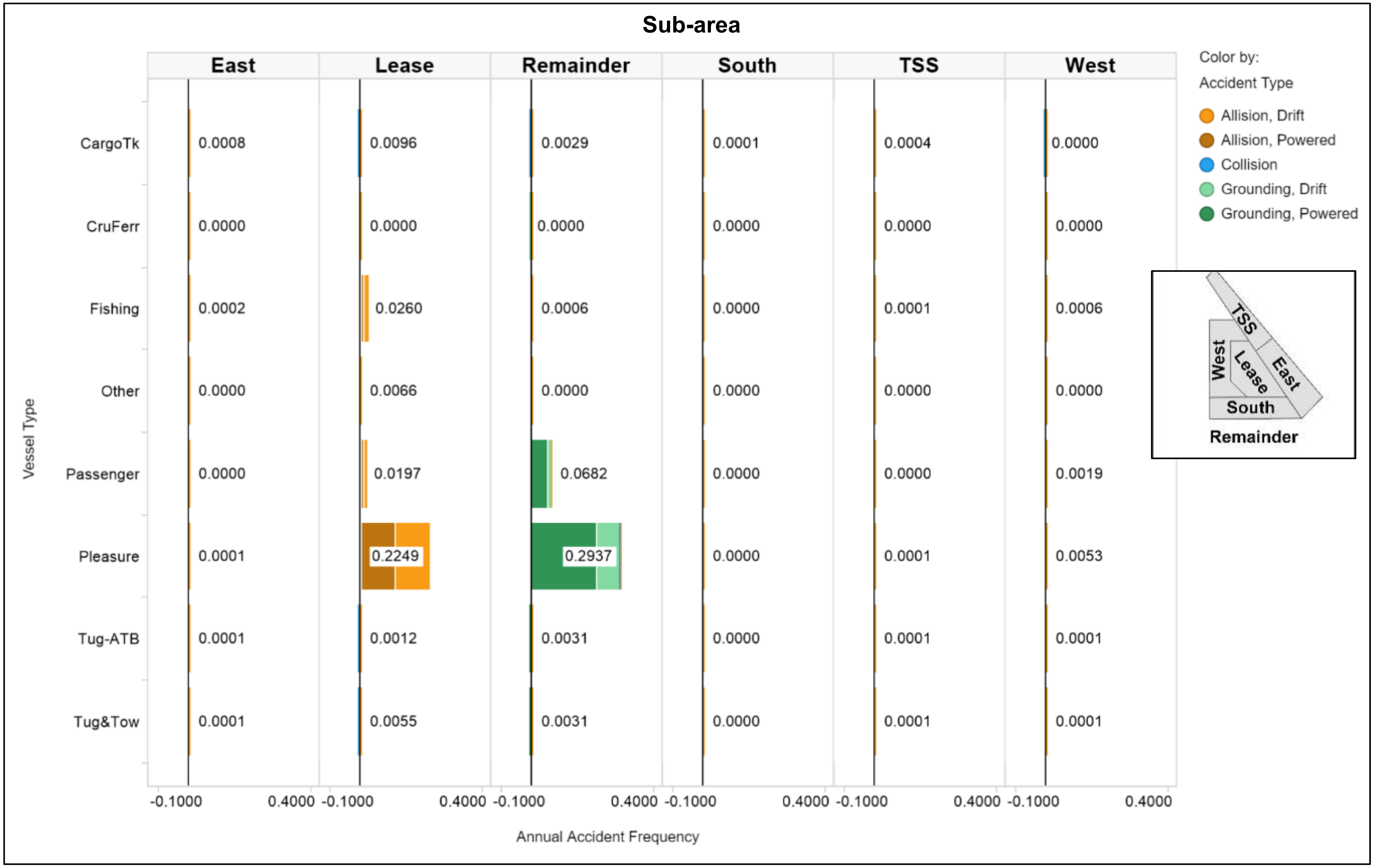


Figure 11-7 Detailed Project Accident Frequency per Sub-area, Vessel Type, and Accident Type

11.2.2 Accident frequencies within the Lease Area

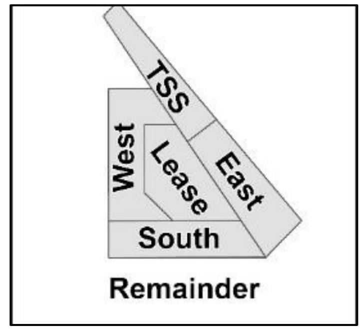


Table 11-5 presents the increase in accident frequency from the Project within the Lease Area.

The summed increase in accident frequency within the Lease Area is 0.29 marine accidents per year, an average of 2.9 additional accidents of any severity every 10 years. Because of vessel routing around the Project once constructed, the frequency of collisions within the Lease Area decreases as a result of the Project for many vessel types. New (i.e., additional) transits of Passenger and Pleasure vessels were estimated to occur as a result of the Project, which results in an increase in collision frequency for these two vessel types.

Table 11-5 Modeled Incremental Change in Accident Frequencies from the Project in the Lease Area (Annual Accident Frequencies)*

Vessel type	Allision, Drift	Allision, Powered	Collision	Grounding, Drift	Grounding, Powered	Total
Cargo/Carrier & Tanker	0.0080	0.0016	<0.0005* (-0.0004)	-	-	0.0093
Cruise/Ferry	<0.0005	<0.0005	<0.0005	-	-	<0.0005
Fishing	0.0132	0.0125	<0.0005 (<0.00005)	-	-	0.0260
Other	0.0037	0.0028	<0.0005	-	-	0.0066
Passenger	0.0077	0.0107	0.0013	-	-	0.0197
Pleasure	0.1088	0.1124	0.0037	-	-	0.2249
Tug-ATB	0.0010	0.0002	<0.0005 (-0.0001)	-	-	0.0011
Tug-Towline	0.0046	0.0009	<0.0005 (-0.0001)	-	-	0.0054
Total	**0.1470**	**0.1412**	**0.0049**	-	-	**0.2930**

* Grey cells indicate risk less than 5 in 10,000 years.

The frequency of Pleasure vessel accidents in the Lease Area increases by 0.22 marine accidents per year, comprising 77% of the total increase in frequency within the Lease Area (previous Figure 11-8).

Since, by design, all Project structures are in the Lease Area, all of the modeled allision accidents occur in this Sub-area. However, the initiating events could occur elsewhere. For instance, a vessel in the West Sub-Area could lose propulsion and drift into a Project structure. This accident is attributed to the Lease Area because that is the area where the modeled accident occurs. Grounding risk is not anticipated in the Lease Area because of the water depths.

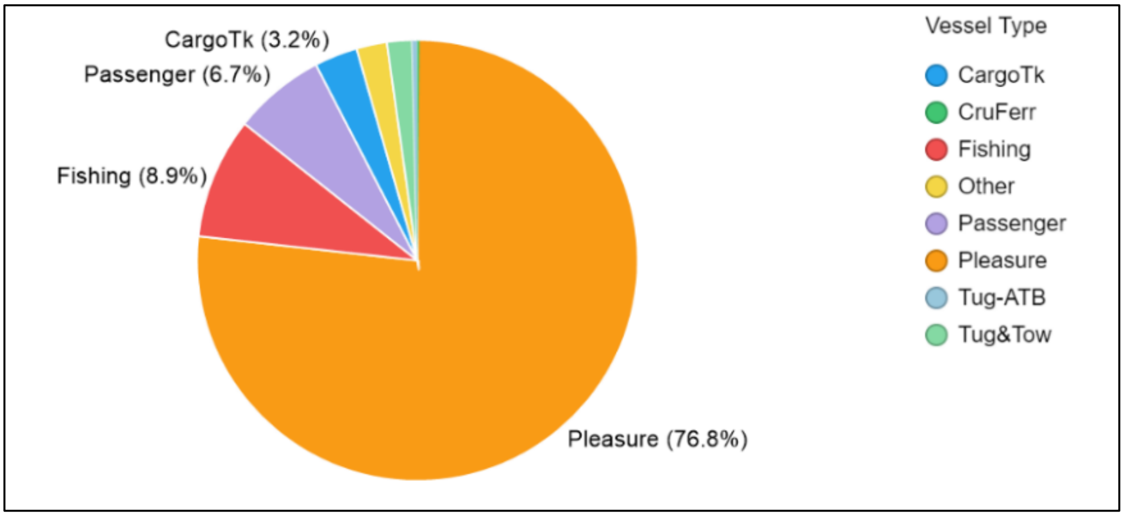


Figure 11-8 Relative Contribution to Incremental Change in Accident Frequency from Each Vessel Type in the Lease Area

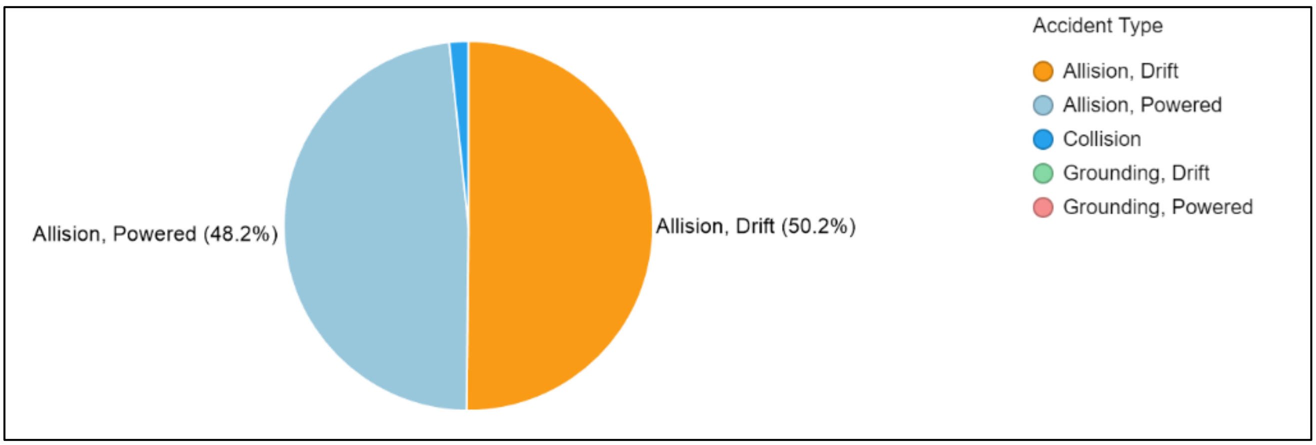


Figure 11-9 Relative Contribution to Incremental Change in Accident frequency from Each Accident Type in the Lease Area

Focusing solely on deep draft vessels in the Lease Area (Cargo/Carrier/Tanker and Cruise/Ferry), the risk increase for this group of vessels is 0.010 per year, equivalent to 1 additional accident every 100 years. Figure 11-10 shows that the most common accident is drift allision. The failure contributing the most to this drift allision scenario is mechanical failure (propulsion and/or steering) in which the error/failure perhaps occurs outside the Lease Area, and potentially leads to the vessel drifting into a Project structure.

Based on consultations with the shipping industry, including the MAC, which represents offshore industry vessel operators, it is assumed that merchant ships will not attempt to navigate between Project structures due to the restricted sea room. The most likely threat leading to powered allision with a structure is from human error on the bridge of the ship, e.g., watchkeeper absent, distracted, or incapacitated. The proximity of the Project to port should mean mariners are more attentive to their vessel's position than in open seas although outbound vessels could begin stand down on the bridge, and the crew could be distracted by other tasks. The modeling supports that a powered allision scenario wherein an errant deep draft ship under power deviates from its route to the extent that it comes into the Lease Area is not a likely event. It has a recurrence interval of less than 2 in 1,000 years for Cargo/Carrier and Tanker vessels. This conclusion is based on the deep draft vessel routes identified in the area and the anticipated changes in routing due to the Project, and effective planned risk control measures such as making mariners aware of the Project through Notices to Mariners, charts, lights, and markings

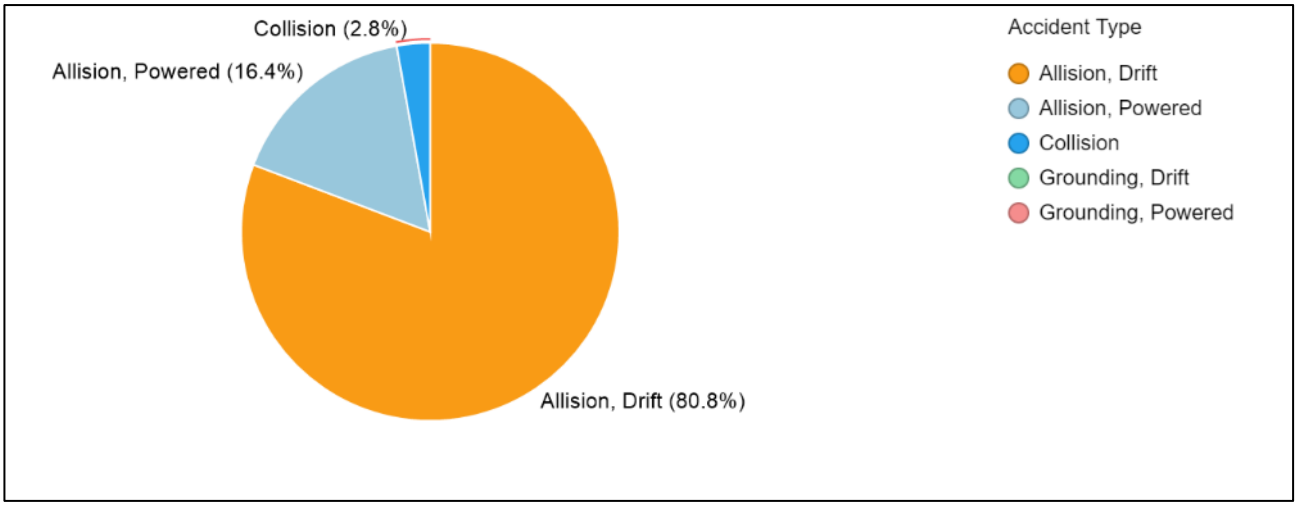


Figure 11-10 Relative Contribution of Accident Types Among Deep Draft Vessels in the Lease Area

The allision frequency results per Project structure are shown in Figure 11-11. The frequencies are not depicted on a logarithmic scale because they are within the same order of magnitude, within a multiple of ten.

As discussed in Section 11.1, the consequences of powered allision is generally of greater concern than the consequences of drift allision. For WTGs, the recurrence intervals (inverse of frequencies) of powered allision range from 1 in 1,900 years to 1 in 450 years. The recurrence intervals per structure for OSS are greater than those of WTGs because OSS are larger. The OSS recurrences range from a minimum of 1 in 430 years to a maximum of 1 in 180 years. The Met tower has a recurrence interval of 1 in 1,000 years. Notably, the Met tower poses less risk than the average structure.

Because the results for individual structures as shown in Figure 11-11 are within a multiple of ten, at this overview level, there is little differentiation between risk from a given structure based on location. However, differences between structure locations are more apparent when viewing the frequencies per vessel type, discussed below. There is a strong correlation between structure size and powered allision frequency.

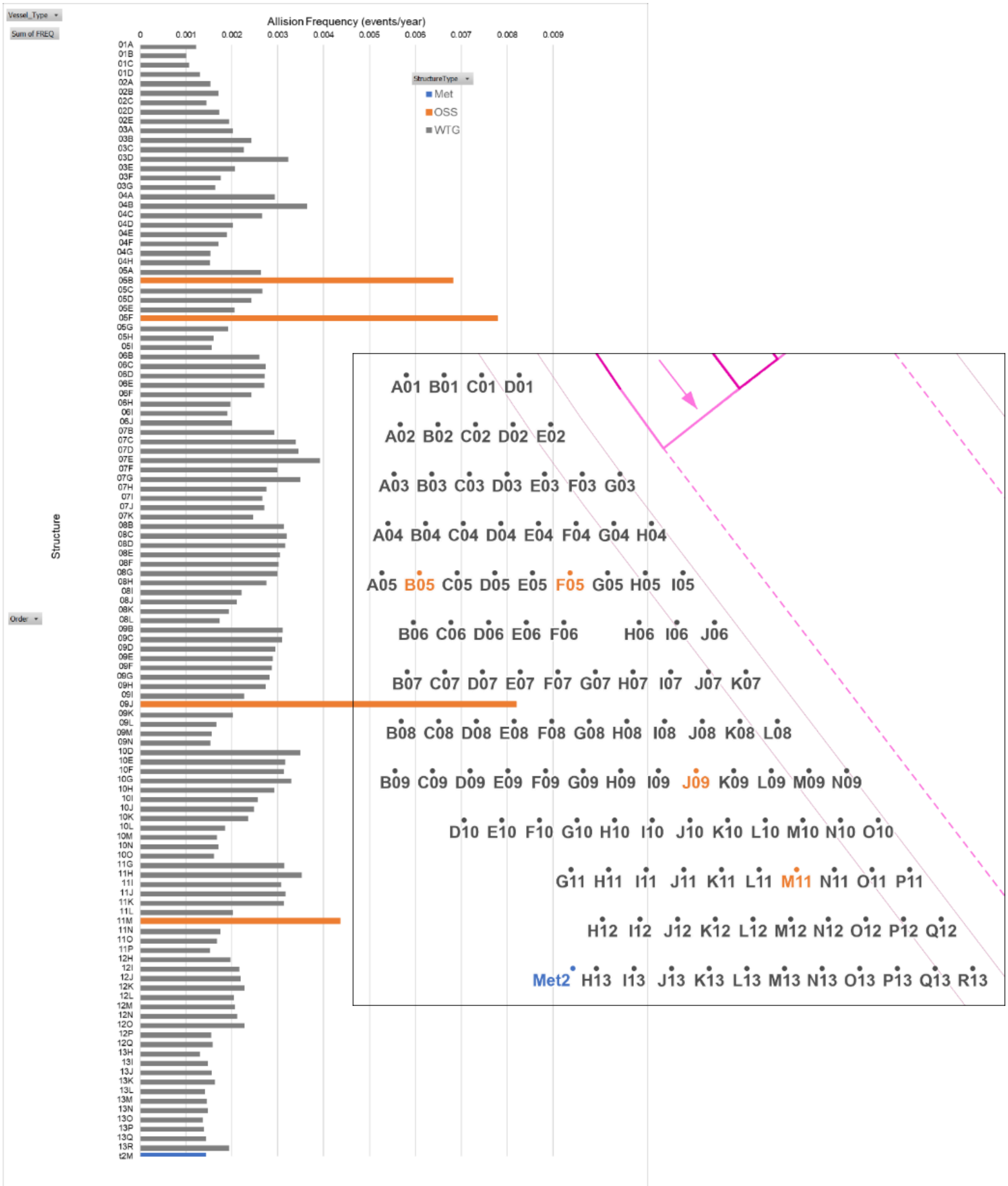
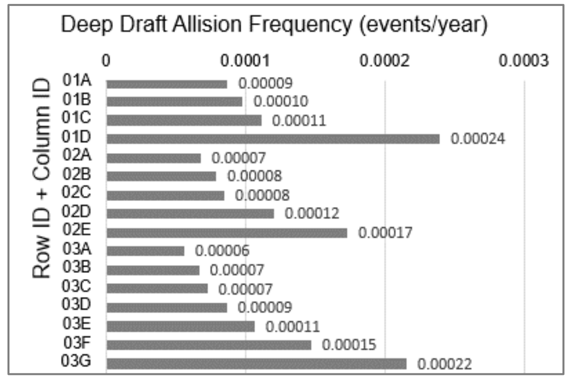


Figure 11-11 Total Allision Frequency Per Structure (ID Not In Line With Planned Marking Scheme)[4]

When viewed per vessel type, the following patterns are apparent:

- Cargo/Carrier and Tanker vessels and Cruise ships/Ferries show a consistent pattern across the entire Lease Area. The structures closest to the Southeastern Approach TSS (e.g., columns D, E, and F) have higher allision frequencies than the structures farther from the TSS (e.g., columns A and B).



  The accident scenario of greatest consequence from a single event is a potential powered allision of a Cargo/Carrier or Tanker with a Project structure (see Section 11.1.2). The total modeled frequency of powered allision of these vessels with any structure is 0.0016 per year. The relative distribution of the total frequency per structure is shown in Figure 11-12.

  The modeling indicates that the structures on the northeast and southeast ends of the eastern Lease Area, along the TSS outbound traffic route, contribute the most to the frequency, and to the risk. If the recommended TSS extension is implemented (see Section 2.2.3), the risk at the southeast corner would be expected to be significantly less because vessels will continue transiting to the southeast another 5 NM (9 km) instead of making the turn to the south after passing the last structure on the southeast corner.

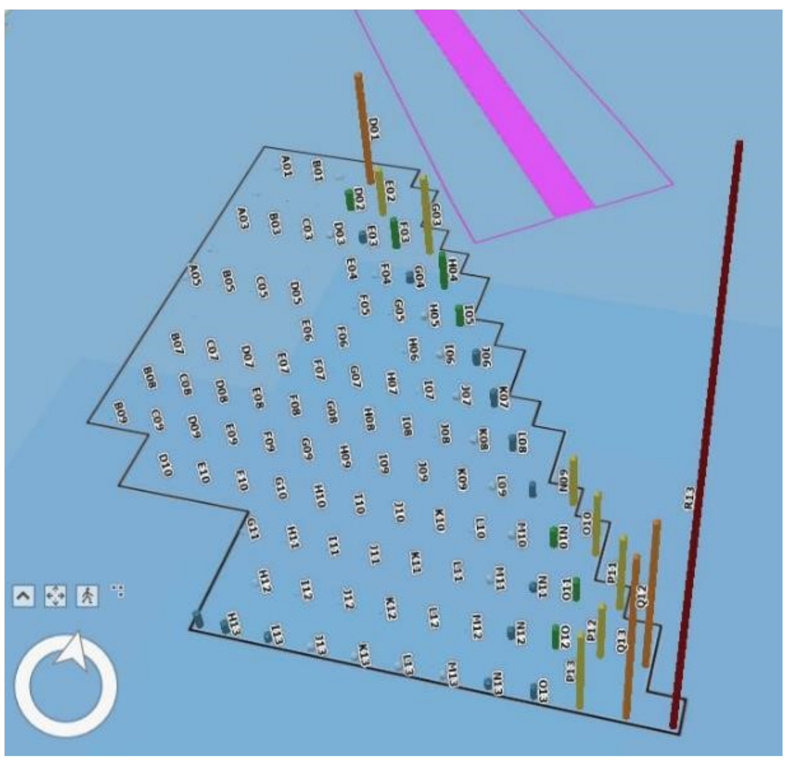
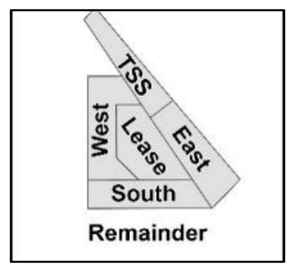


Figure 11-12 Modeled Powered Allision Frequency for Cargo/Carrier and Tanker Vessels[4]

Other key findings from a review of results per vessel type per structure are as follows:

- Powered allision frequency for Cargo/Carrier and Tanker Vessels is not uniform for the structures adjacent to the TSS boundary. Structures in the middle of the adjacent boundary reflect significantly lower frequencies. The MARCS results provide a view of the risk from the revised traffic flow after all the leases are built out, disregarding the recommended routing measures. Should the TSS be extended, as is recommended in the NJPARS (USCG, 2022a), the frequency of deep draft powered allision is anticipated to be less than indicated by the modeling in this report.
- Fishing allision risk per structure is highest for the OSS (0.00046 to 0.00086 allisions per year), but is otherwise relatively flat for all other structures, approximately 0.0002 allisions per year per structure.
- Additional Pleasure vessel transits are included in all Future Case models, anticipating increased interest in recreational boating and fishing in the Lease Area. The resulting model shows Pleasure vessel allision risk per structure is generally highest for the OSS (a maximum of 0.0065 allisions per year). For WTGs, allision risk is highest for structures closer to Ocean City (up to 0.0033 allisions per year).
- ATBs and Towline Tugs have similar patterns: The highest risk structure is R13 (0.00045 allisions/year) at the southeast corner of the Lease Area, followed by adjacent Q13 (0.00015 allisions/year), and then A01 (0.00014 allisions/year).
- Other vessels show a pattern similar to the general pattern in Figure 11-11, providing few insights except that there is no predominant route structure for this group in the AIS data.

11.2.3 Accident frequencies within the TSS Sub-area



Within the TSS Sub-area, there is a small increase in collision frequency; however, there is no grounding or allision risk because of the water depths and lack of structures in the TSS. Table 11-5 presents the increase in risk from the Project. The summed risk increase within the TSS Sub-area is 0.0007 (7 in 10,000 years) marine accidents (all collisions) per year, which is a very small increase.

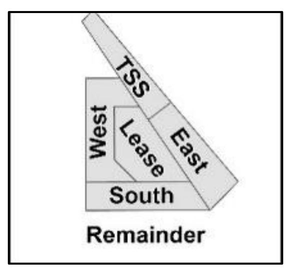
Table 11-6 Modeled Incremental Change in Accident Frequencies from the Project in the TSS Sub-area (Annual Accident Frequencies)*

Vessel type	Allision, Drift	Allision, Powered	Collision	Grounding, Drift	Grounding, Powered	Total
Cargo/Carrier & Tanker	-	-	<0.0005 (0.0004)	-	-	<0.0005
Cruise/Ferry	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Fishing	-	-	<0.0005 (0.0001)	-	-	<0.0005
Other	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Passenger	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Pleasure	-	-	<0.0005 (0.0001)	-	-	<0.0005
Tug-ATB	-	-	<0.0005 (0.0001)	-	-	<0.0005
Tug-Towline	-	-	<0.0005 (0.0001)	-	-	<0.0005
Total	-	-	**0.0007**	-	-	**0.0007**

* Grey cells indicate risk less than 5 in 10,000 years.

The vessels in the Delaware Bay Southeastern Approach TSS show a very strong tendency to transit down the centerline of the TSS (see Section E.2.7 in Appendix E). This pattern is assumed to continue in the future, after the Project is constructed. Mariners are urged to avoid crossing a TSS, and when necessary, exercise extreme caution when crossing a TSS. This is supported by the historical record of marine casualties in the vicinity of the TSS (see Section 11.2.3). In the 13.5 years of historical records (USCG, 2015b) analyzed for the MARCS Study Area, the data include one vessel collision in the Southeastern Approach TSS in 13.5 years, involving a fishing vessel. Six collisions occurred during that same time period in the East Sub-area (USCG, 2021a). Modeling confirms that given the estimated future traffic crossing the TSS, the low level of traffic in the outbound lane (an average of 5 vessel tracks per day), and tendency for deep draft vessels to transit in the center of the lane, the presence of the Project is not anticipated to meaningfully increase collision risk in the TSS or the recommended TSS extension.

11.2.4 Accident frequencies within the East Sub-area



Within the East Sub-area, there is a calculated increase in collision frequency; however, there is no grounding or allision risk because of the water depths and lack of structures in the East Sub-area. Table 11-7 presents the increase in risk from the Project. The summed risk increase within this Sub-area is 0.0012 (less than 2 in 1,000) marine accidents (all collisions) per year, which is a small increase.

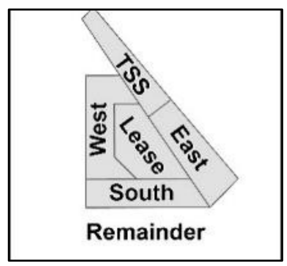
Table 11-7 Modeled Incremental Change in Accident Frequencies from the Project in the East Sub-area (Annual Accident Frequencies)*

Vessel type	Allision, Drift	Allision, Powered	Collision	Grounding, Drift	Grounding, Powered	Total
Cargo/Carrier & Tanker	-	-	0.0008	-	-	0.0008
Cruise/Ferry	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Fishing	-	-	<0.0005 (0.0002)	-	-	<0.0005
Other	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Passenger	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Pleasure	-	-	<0.0005 (0.0001)	-	-	<0.0005
Tug-ATB	-	-	<0.0005 (0.0001)	-	-	<0.0005
Tug-Towline	-	-	<0.0005 (0.0001)	-	-	<0.0005
Total	-	-	**0.0012**	-	-	**0.0012**

* Grey cells indicate risk less than 5 in 10,000 years.

The East Sub-area is effectively an extension of the TSS. Similar to the TSS Sub-area, the modeling confirms that the risk increase from deep draft vessels is 0.0008 (8 in 10,000) marine accidents (all collisions) per year, which is a very small increase. This is based on AIS-based routes for traffic crossing the TSS and the low level of traffic in the TSS lanes (an average of 5 vessel tracks per day per lane).

11.2.5 Accident frequencies within the South Sub-area



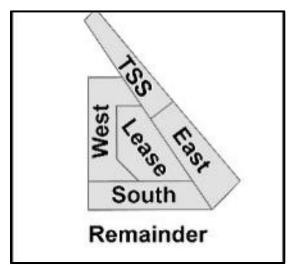
Within the South Sub-area, there is no meaningful change in accident frequency from the Project, as shown in Table 11-8.

Table 11-8 Modeled Incremental Change in Accident Frequencies from the Project in the South Sub-area (Annual Accident Frequencies)*

Vessel type	Allision, Drift	Allision, Powered	Collision	Grounding, Drift	Grounding, Powered	Total
Cargo/Carrier & Tanker	-	-	<0.0005 (0.0001)	-	-	<0.0005
Cruise/Ferry	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Fishing	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Other	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Passenger	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Pleasure	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Tug-ATB	-	-	<0.0005 (0.00005)	-	-	<0.0005
Tug-Towline	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Total	-	-	<0.0005 (0.0002)	-	-	<0.0005 (0.0002)

* Grey cells indicate risk less than 5 in 10,000 years.

11.2.6 Accident frequencies within the West Sub-area



Within the West Sub-area, there is a small increase in collision frequency (Table 11-9). The summed risk increase within this Sub-area is 0.008 (8 in 1,000) marine accidents (all collisions) per year, which is a small absolute number representing an increase of approximately three times the Base Case collision frequency in this Sub-area. Less than 2% of this increase is from re-routing of tugs around the Lease Area; approximately 90% of the increase is a result of the estimated additional CTV and Pleasure vessel traffic to the Lease Area out of Ocean City and Indian River Inlet. Figure 11-14 shows that Pleasure, Passenger, and Fishing vessels comprise more than 96% of the frequency change.

Table 11-9 Modeled Incremental Change in Accident Frequencies from the Project in the West Sub-area (Annual Accident Frequencies)*

Vessel type	Allision, Drift	Allision, Powered	Collision	Grounding, Drift	Grounding, Powered	Total
Cargo/Carrier & Tanker	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Cruise/Ferry	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Fishing	-	-	0.0006	-	-	0.0006
Other	-	-	<0.0005 (<0.00005)	-	-	<0.0005
Passenger	-	-	0.0019	-	-	0.0019
Pleasure	-	-	0.0053	-	-	0.0053
Tug-ATB	-	-	<0.0005 (0.0001)	-	-	<0.0005
Tug-Towline	-	-	<0.0005 (0.0001)	-	-	<0.0005
Total	-	-	**0.0080**	-	-	**0.0080**

* Grey cells indicate risk less than 5 in 10,000 years.

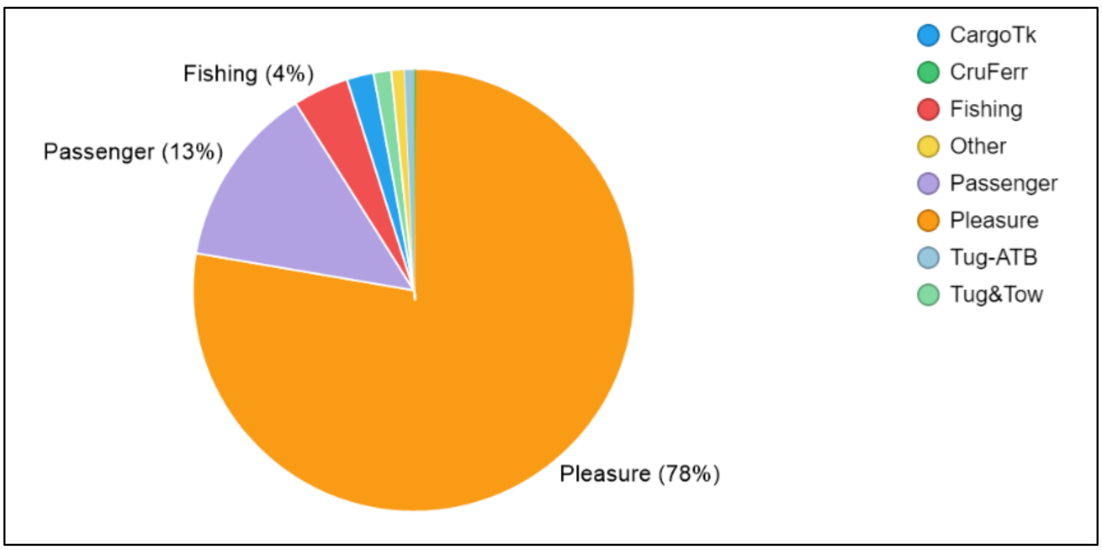
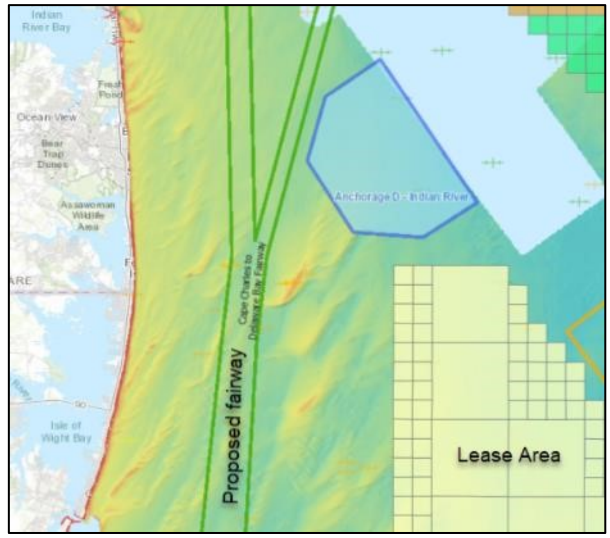


Figure 11-13 Relative Contribution to Project Risk from Each Vessel Type in the West Sub-area

Compared to Pleasure and Passenger vessels, the increase in Tug collision frequency is small, 2 in 10,000 (0.0002) events per year). As described in Section 2.3, ATBs and towline tug tracks within 1 NM of the Lease Area were re-routed in the Future Case in the modeling consistent with AIS-indicated tug routes. If all coastal transiting tugs near Maryland had been assigned to the Cape Charles to Delaware Bay Fairway, the modeled collision frequency would likely be slightly higher than the results shown above.

The modeling for this Project NSRA did not assume the currently recommended fairways would include all tugs transiting coastwise to or from Delaware Bay for two reasons:

- **The fairways may be modified.** The recommendations in the NJPARS will be considered by USCG headquarters and could be adjusted prior to rulemaking.
- **Use of the fairways will be optional.** Rulemaking following the ongoing ACPARS may eventually lead to adoption of the recommended fairways to improve waterway safety in this region. However, use of the fairways will not be mandatory; therefore, masters may continue to plan their routes to make use of the available water. DNV believes this type of route planning is reflected in the AIS tracks for tug vessels that transited the Maryland coast in 2019, and therefore the modeling conducted for this NSRA likely incorporates a reasonable representation of future tug traffic patterns.



11.2.7 Accident frequencies within the Remainder Sub-area

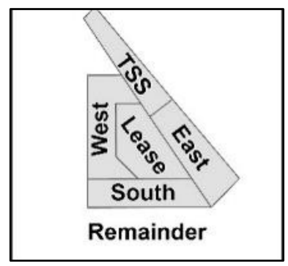


Table 11-10 presents the increase in accident frequency from the Project within the Remainder portion of the MARCS Study Area. The summed increase in accident frequency within the Remainder is 0.37 marine accidents per year, an average of 3.7 additional accidents of any severity every 10 years.

Table 11-10 Modeled Incremental Change in Accident Frequencies from the Project in the Remainder of the MARCS Study Area (Annual Accident Frequencies)*

Vessel type	Drift allision	Powered allision	Collision	Drift grounding	Powered grounding	Total
Cargo/Carrier & Tanker	-	-	<0.0005 (<0.00005)	0.0029	<0.0005 (<0.00005)	0.0028
Cruise/Ferry	-	-	<0.0005 (<0.00005)	<0.0005 (<0.00005)	<0.0005 (<0.00005)	<0.0005
Fishing	-	-	<0.0005 (<0.00005)	<0.0005 (<0.00005)	<0.0005 (<0.00005)	0.0006
Other	-	-	<0.0005 (<0.00005)	<0.0005 (<0.00005)	<0.0005 (<0.00005)	<0.0005
Passenger	-	-	0.002	0.0115	0.0544	0.0682
Pleasure	-	-	0.006	0.0719	0.2156	0.2937
Tug-ATB	-	-	<0.0005 (<0.00005)	0.0030	<0.0005 (<0.00005)	0.0031
Tug-Towline	-	-	<0.0005 (<0.00005)	0.0030	<0.0005 (<0.00005)	0.0031
Total	-	-	0.0092	0.0923	**0.2699**	**0.3715**

* Grey cells indicate risk less than 5 in 10,000 years.

The frequency of accidents involving Pleasure vessels in the Remainder Sub-area is modeled to increase by 0.29 marine accidents per year from the Project, comprising 79% of the total change to risk from the Project within this Sub-area (Figure 11-8). Almost all of the accident frequency, 97%, is from groundings. The model did not include any allision structures in the Remainder Sub-area, although buoys and other small structures exist. DNV's expert judgment is that adding them to the model would not provide additional insights and would complicate the model without benefit. The Remainder Sub-area is the largest sub-area and consequently contains the largest collision frequency. These results have not been normalized on a per area basis.

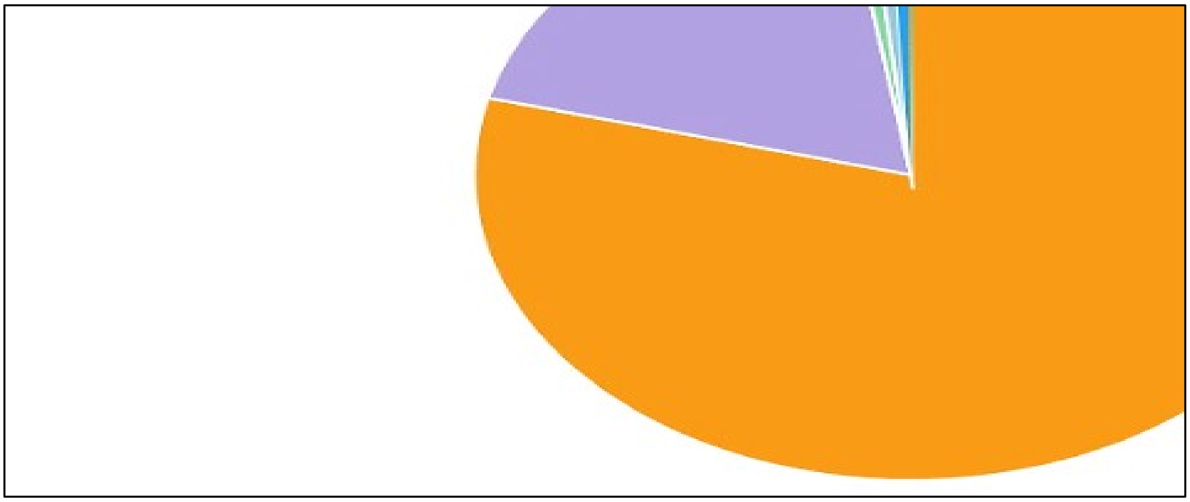


Figure 11-14 Relative Contribution to Incremental Change in Accident Frequency from Each Vessel Type in the Remainder of the MARCS Study Area

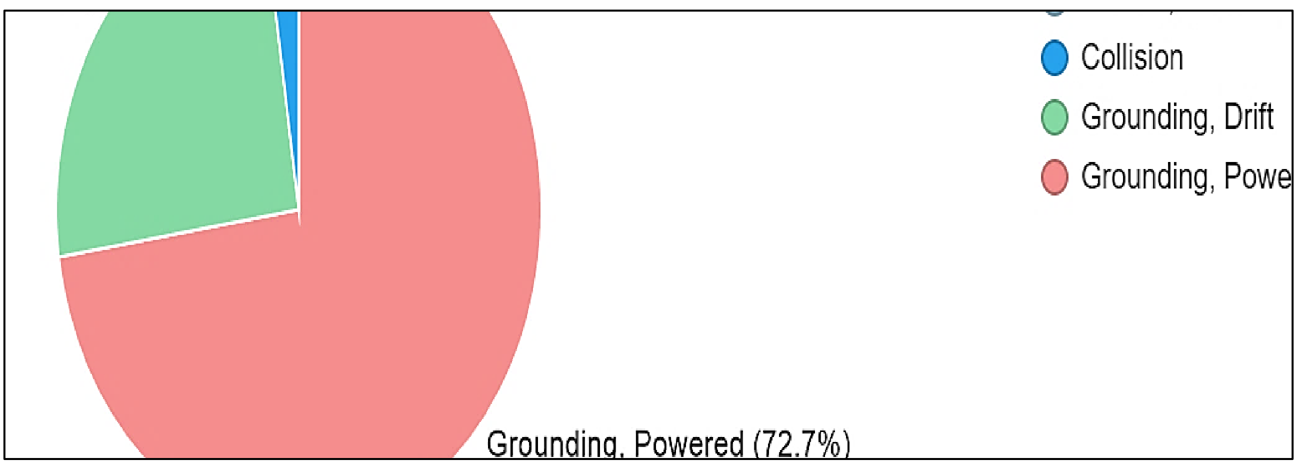


Figure 11-15 Relative Contribution to Incremental Change in Accident Frequency from each Accident Type in the Remainder of the MARCS Study Area

Grounding frequency in the Remainder of the MARCS Study Area

The great majority of the modeled grounding frequency (0.36 events per year) from Project-influenced increases in traffic occurs in the vicinity of Ocean City with a portion occurring in the vicinity of Indian River. These are areas where Fishing, Passenger, and Pleasure traffic is inbound toward the coast (see Section 2.1.1) and if a human error or a failure occurs, there may be little time to react to prevent a grounding.

The increase in grounding frequency for ATBs and Tugs with towlines from the Project is 0.006, equivalent to 6 in 1,000 years, and increase of approximately 10% over the Base Case grounding frequency. The availability of adequate sea room west and east of the Lease Area is an influential aspect on the risk to these vessels in the coastal trade. More than half of the tug traffic that currently transits through the Lease Area will likely proceed east of the Project after it is constructed whenever conditions allow, because their apparent destinations are north of Delaware Bay.

The increase in grounding frequency for Cargo/Carrier and Tanker vessels from the Project is 0.003 per year, equivalent to 3 in 1,000. This is approximately a 4% increase over the Base Case grounding frequency of 0.068 per year for these vessels. The modeling results are in line with the relatively few deep draft vessel tracks following the coast and are a direct benefit of the presence of the existing TSS as a navigation safety measure that serves to separate deep draft vessel traffic from tug traffic.

Collision frequency in the Remainder of the MARCS Study Area

The incremental increase in collision frequency in the Remainder of the MARCS Study Area is 0.0092 per year (9.2 in 1,000). Approximately 90% of this increase is modeled collision of Pleasure and Passenger vessels (Figure 11-16).

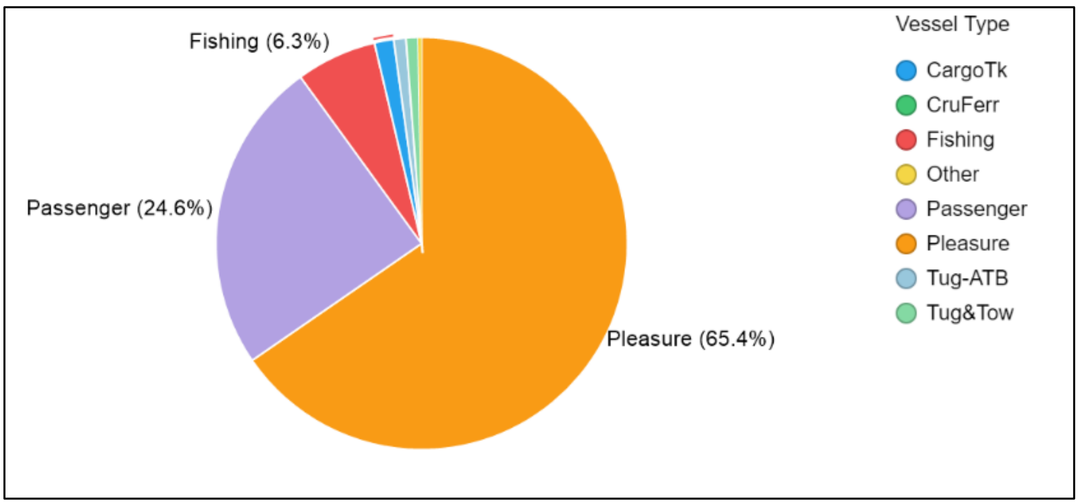


Figure 11-16 Relative Contribution to Collision Frequency from Each Vessel Type in the Remainder of the MARCS Study Area

11.2.8 Evaluation of Potential TSS Extension

Based on the content of the NJPARS report (USCG, 2022a), it is possible that USCG would request that the IMO adopt an extension to the Delaware Bay Southeastern Approach TSS. This section presents the results of a sensitivity study to assess the effect of the extension on the frequency of powered allision with Project structures by Cargo/Carrier and Tanker vessels.

The extension is not anticipated to have any meaningful effect on the frequency of accidents involving vessels that do not transit the TSS, such as Fishing, Passenger, Pleasure, and Tug vessel types. The primary effect on risk from establishment of a TSS is to add predictability to vessel transit patterns and thereby reduce the frequency of and possibly the consequences of accidents involving large vessels, which often carry hazardous and/or valuable cargoes. Should the Project be constructed, one of the primary risk benefits from extending the Delaware Southeastern Approach TSS would be a reduction in the frequency of powered allision by Cargo/Carrier and Tanker vessels. This section presents the quantified reduction in the frequency of this accident event.

The evaluated extension was included in the September 2021 draft NJPARS report (USCG, 2021a), and is shown in Figure 11-17.

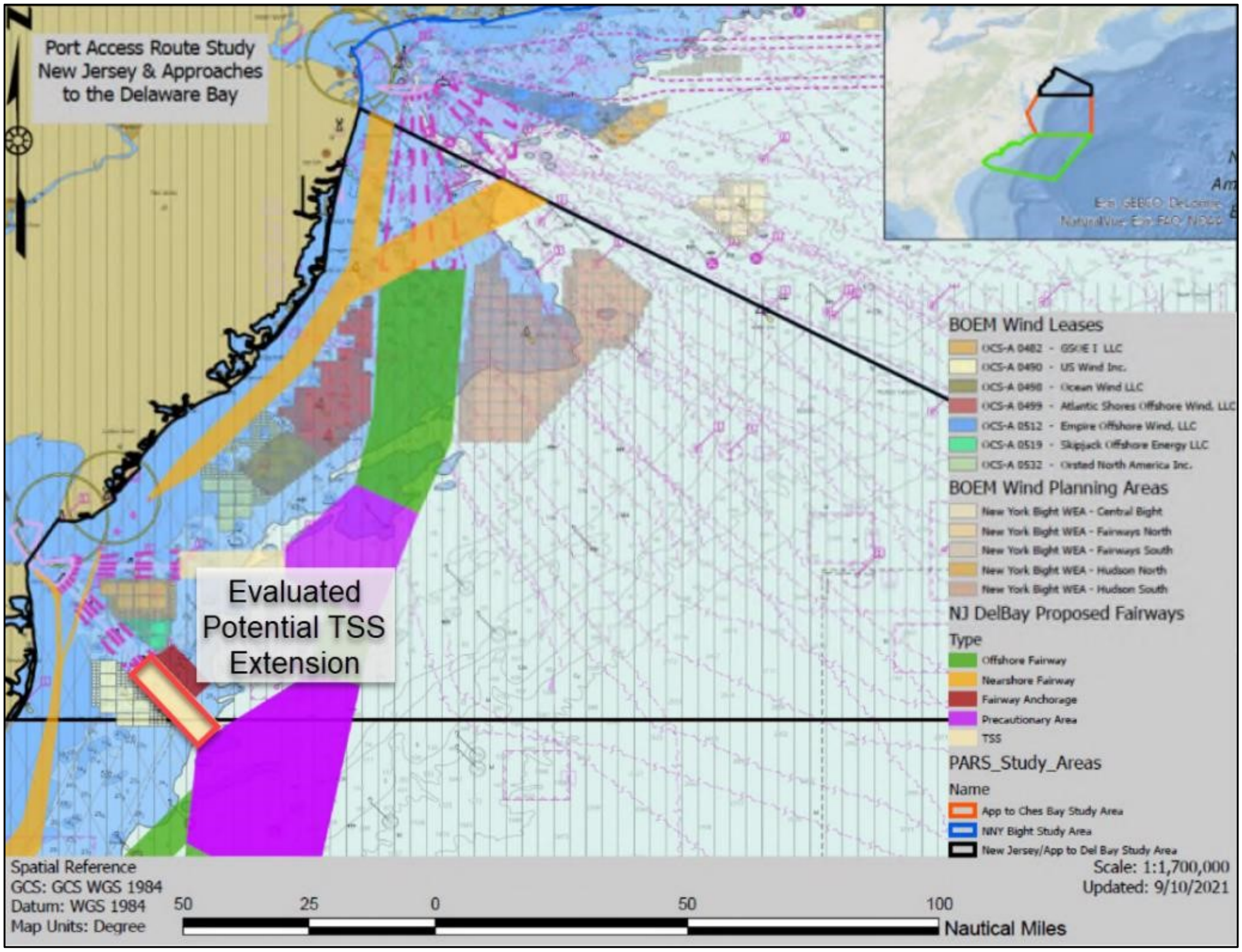


Figure 11-17 Evaluated Potential TSS Extension (image taken from USCG, 2021a)

The modeling compared two situations, with a focus on powered allision of Cargo/Carrier and Tanker vessels with Project structures:

- Current TSS Scenario – This scenario estimated the change in accident frequency from the Project with the TSS as it is currently (as of May 2022). This situation is the same as the modeling and frequency results presented in

Sections 11.2.1 through 11.2.7. As described in Section 11.2, in the Future Case, Cargo/Carrier/Tanker and Tug traffic was routed around the Project Area.

- Extended TSS Scenario – This scenario estimated the change in accident frequency from the Project with the TSS extended as shown in Figure 11-17. In the Future Case for this scenario, Cargo/Carrier/Tanker and Tug traffic transiting the TSS as indicated in the AIS data was routed through the extended TSS lanes, which end more than 5 NM (9.3 km) from the nearest Project structure. The non-TSS Tug traffic was routed around the Project Area. All other aspects of the modeling remained the same as the Current TSS Scenario.

Both Scenarios were modeled for the three evaluated Project layouts.

Table 11-11 presents the modeled change in accident frequency from the Project.

Table 11-11 Modeled Incremental Change in Powered Allision Frequency from the Project for Cargo/Carrier & Tanker Vessels (Annual Accident Frequencies)

Scenario	126-Structure Layout (complete buildout)		119-Structure Layout (minimum 1 NM from TSS)		98-Structure Layout (minimum 2 NM from TSS	
	Frequency (events per year)	Recurrence Interval (years per event)	Frequency (events per year)	Recurrence Interval (years per event)	Frequency (events per year)	Recurrence Interval (years per event)
Current TSS	0.0023	430	0.0016	610	0.0004	2,400
Extended TSS	0.0010	1,000	0.0008	1,200	0.0003	3,200
Reduction in Frequency from the TSS Extension	0.0013 events per year 58% reduction due to extension		0.0009 events per year 52% reduction due to extension		0.0001 events per year 24% reduction due to extension	

The effect of the TSS extension is summarized in the bottom row of the table. The preferred layout has 119 structures, all of which are at least 1 NM (1.9 km) from the outer boundary of the TSS. With the extended TSS, the recurrence interval for powered allision of a large vessel is 1 event in 1,200 years, half-as-often as 1 event in 610 years for the current TSS.

For the complete buildout with 126 structures, the TSS extension makes a larger difference, reducing the recurrence interval from the current TSS by more than half, from 1 event in 430 years to 1 event in 1,000 years.

For the 98-structure buildout with a 2 NM (3.7 km) setback from the TSS, the TSS extension makes less of a difference, reducing the recurrence interval by about a quarter, from 1 in 2,400 years to 1 in 3,200 years.

There are no publicly available risk criteria for offshore wind projects in the U.S. The following discussion is to provide a sense of scale for the above results without suggesting that the U.S. risk tolerance in the mid-Atlantic is the same as the tolerance adopted by other countries. The German Federal Maritime and Hydrographic Agency (BSH) published minimum criteria in their design standards document, “Minimum requirements concerning the constructive design of offshore structures within the Exclusive Economic Zone (EEZ)” (BSH, 2015). The BSH requires that the frequency be less than 0.001 per year for severe allision events that penetrate the vessel’s outer hull allowing release of pollutants from a side tank or double floor. The frequency of the event discussed in this section is analogous to this limiting event for BSH acceptability, and the preferred layout with the extended TSS would likely meet the minimum German risk criteria.

11.2.9 Comparison of accident frequencies for three layout options

A sensitivity study was conducted to assess the potential change in accident frequency, and based on the results discussed above, focused on allision frequency. Three alternative layouts of Project offshore structures were modeled (See Appendix E Section E.7.3). The same Base Case MARCS model was used to compare the three alternative Future Cases.

The Cargo/Carrier and Tanker traffic in the Base Case fans out at the southeastern terminus of the outbound lane of the adjacent TSS, as shown in previous Figure 2-7. The Future Case for the alternatives assumes that the TSS outbound traffic continues on to the southeast, turning to the south only after passing the Lease Area with a minimum clearance of 1NM from the WTG to the edge of the traffic lane. The principle behind this assumption is that the Future Case traffic follows the same general pattern (regarding course/speed) as the traffic in the Base Case.

For the purposes of comparing the layout options, three Future Cases were modeled, one for each layout, by removing selected structures closest to the Southeastern Approach TSS. The routes built in the model were reviewed to determine if any of them should be revised as a result of the removal of structures, but none required modification.

The NJPARS recommends extending the TSS to the southeast, more than 5 NM beyond the Lease Area to improve navigation safety. If the recommendation is eventually adopted, the historical pattern of deep draft vessels maintaining course in the TSS is likely to continue after the TSS is extended. The traffic would not turn until the TSS ends, continuing past the Lease Area for an additional 5 NM (9.3 km). This is anticipated to decrease allision risk for vessels transiting the TSS. The frequency results presented in this NSRA do not account for the possible extension of the TSS. Therefore, the modeled frequencies presented in this section and other portions of this report are higher than would be expected if the TSS is extended.

The summary results of the layout sensitivity analysis are shown in Table 11-12. The preferred layout proposed by US Wind is the layout with no structures within 1 NM of the Delaware Bay Southeastern Approach TSS, which contains 119 structures. It is the modeled layout presented in detail in the previous portions of Section 11.2.

Table 11-12 Modeled Sensitivity of Allision Frequency for the Project (allisions/year; years/allision)

Allision type	126 Structures	119 Structures (none within 1 NM of the TSS)	98 Structures (none within 2 NM of the TSS)
Drift	0.15 allisions/year (1 allision every 6 years)	0.15 allisions/year (1 allision every 6 years)	0.13 allisions/year (1 allision every 6 years)
Powered	0.15 allisions/year (1 allision every 6 years)	0.14 allisions/year (1 allision every 7 years)	0.13 allisions/year (1 allision every 8 years)
Total allision frequency per structure per year	**0.30 allisions/year (1 allision** every **3 years)**	**0.29 allisions/year (1 allision** every 3 **years)**	**0.25 allisions/year (1 allision** every **3 years)**

It is intuitive that fewer structures have a lower allision frequency and zero structures results in zero allision risk. The challenge is balancing the desire to produce low-carbon energy with providing as much space for safe transit between structures while maintaining a safe distance from the TSS.

The alternative layouts were selected to address the consequence of greater concern associated with a deep draft vessel powered allision. The summary results of the layout sensitivity analysis for Cargo/Carrier and Tanker vessels per-structure allision frequency are shown in Table 11-13. The preferred layout has a deep draft vessel allision recurrence of less than 1 allision every 100 years. The data show that the benefit of removing a single structure decreases as more structures are removed from the layout. Therefore, any selection process for removal of structures should consider structures that have the greatest frequency of allision.

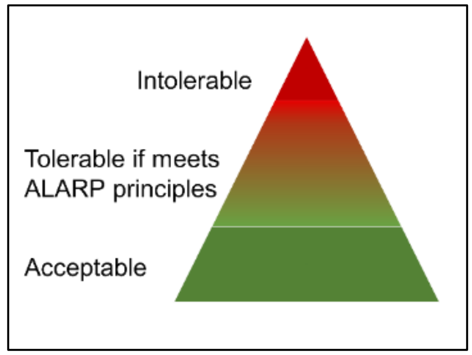
Table 11-13 Modeled Sensitivity of Cargo/Carrier/Tanker Allision Frequency for the Project (allisions/year; years/allision)

Allision type	126 Structures	119 Structures (none within 1 NM of the TSS)	98 Structures (none within 2 NM of the TSS)
Drift	0.0086 allisions/year (1 allision every 110 years)	0.0080 allisions/year (1 allision in 120 years)	0.0063 allisions/year (1 allision in 150 years)
Powered	0.0023 allisions/year (1 allision in 430 years)	0.0016 allisions/year (1 allision in 610 years)	0.0004 allisions/year (1 allision in 2,400 years)
Total allision frequency per structure per year	**0.0108 allisions/year (1 allision in 92 years)**	**0.0096 allisions/year (1 allision in 100 years)**	**0.0068 allisions/year (1 allision in 140 years)**

11.3 Risk mitigation for marine accidents

Numerous tools exist to identify and assess acute risks, the types that cause immediate harm to people, the environment, or assets, such as maritime accidents. The greater challenge is selecting a method to inform complex risk decisions and select risk mitigations. The most common methods involve risk targets, also called risk criteria. The UK utilizes this approach in its evaluation and approval process for new offshore wind developments, outlined in "MGN 654. Safety of Navigation: Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety, and Emergency Response" (UK MCA, 2021).

The preceding sections 11.1 and 11.2 described the level of baseline risks without the Project and inherent risks associated with introduction of the Project. When using a risk criteria method, no activities are permitted that have risks in the intolerable range. Said another way, any risks that exceed the tolerability criterion must be reduced to tolerable, or eliminated entirely.



All risks within the tolerable range require that additional risk controls be included in the Project until the incremental risk reduction from the remaining options is grossly disproportionate to the cost of the controls. At that point, the Project plan meets ALARP principles.

Risk criteria methods usually include another criterion defining "acceptable risk," below which the risk is trivial or negligible. Risks in this range do not require evaluation of additional risk controls.

For industries established in a region, for which the risks are well understood, implementation of industry good practice can often be used to demonstrate that a project meets ALARP principles. For high hazards, complex or novel situations, industry good practice is a starting place, upon which more formal techniques are used, including cost-benefit analysis, to inform the final decision.

The USCG has not published criteria defining intolerable and acceptable maritime accident risk. Based on DNV's experience undertaking hundreds of acute risk assessments in the U.S., maritime accident risk tolerance varies between regions, based in part on the sensitivity of the environment and on the level of engagement by stakeholders. In the UK, criteria exist for the risk of human fatalities; however, NSRA risk criteria can be determined by those undertaking the assessment, as long as satisfactory justification is provided (UK MCA, 2021).

A reasonable principle to incorporate in any such undertaking is phrased clearly in MGN 654,

> "Developers should aim to achieve agreement with stakeholders that risks in the hazard log are reduced to a level that is as low as reasonably practicable (ALARP)." (UK MCA, 2021)

The USCG routinely conducts studies to assess the need to improve waterway safety and efficiency. Many of these include consultations with federal agencies, state representatives, waterway users, and the general public (see Section 11.3.1 on existing risk controls). Selected studies being undertaken or finalized as of February 2022 include:

- Port Access Route Study: Seacoast of New Jersey Including Offshore Approaches to the Delaware Bay, Delaware (NJPARS) (87 FR 16759) (USCG, 2022a)
- Port Access Route Study: Approaches to the Chesapeake Bay, Virginia (CBPARS) (86 FR 32052) (USCG, 2021b)

Both NJPARS and CBPARS reports state that data and risk analysis support the need for mitigation and recommend mitigations such as extension of an existing TSS, and new precautionary areas, routes, and shipping safety fairways. The

NJPARS report recommends a "..combination of measures [that] provides a balanced approach to marine planning and ensures future safety of navigation" (emphasis added).

The supposition underlying the above recommendations is that the current level of marine accident risk in the vicinity of the Project is acceptable. The reports also imply that without mitigation, the risk with OREI would be above the acceptable level, but it is unclear whether the risk would be in the intolerable or in the tolerable/ALARP ranges.

11.3.1 Existing maritime risk controls

The safe marine transit of crew, passengers, and cargo has long 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. This section provides an overview of existing maritime and offshore wind industry practices that have been established to control maritime and navigational risks. This section describes the primary requirements relevant to the assessment of navigation safety for the Project.

11.3.1.1 Vessel design, construction, and operation

Some of the first international requirements related to vessel design and construction resulted 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 Convention – 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 – 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 Convention – 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.)
- ISM Code –International Management Code for the Safe Operation of Ships and for Pollution Prevention (33 CFR 96 et. seq.)

Other vessel inspections and safety guidelines support safe vessel condition and operations. For example:

- Periodic vessel inspections for vessels such as tugs engaged in commercial trade that have shallow draft and are less than 1600 Gross Tons (46 CFR Subchapter M, Subchapter T, and Subchapter K).

- Safety initiatives and industry-specific guidelines are promulgated by various industry groups, such as the Oil Companies International Marine Forum. An example is, “USA Barge Operations: Guidelines and Best Practices for Liquid Hydrocarbon Barges and Associated Tugs.” (OCIMF, 2014).

11.3.1.2 Routing measures

The IMO also establishes internationally recognized 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 in the vicinity of the Lease Area have been established by the USCG, which has the primary responsibility to ensure safety of life and property at sea. The USCG administers navigation and vessel inspection laws and regulations governing marine safety and environmental protection. The USCG 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.

Studies and resulting improvements conducted by the USCG to improve waterway safety and efficiency, including consultations with federal agencies, state representatives, waterway users, and the general public.

One type of study conducted by the USCG is a Port Access Route Study (PARS), which reviews potential traffic density and the need for safe access routes for vessels. A primary purpose of a PARS is to reconcile the need for safe access routes with other waterway uses, such as offshore wind developments.

The final and draft PARS relevant to this assessment published as of August 2021 are:

- Port Access Route Study: Approaches to the Chesapeake Bay, Virginia (CBPARS), October 2021 (USCG, 2021b) (86 FR 58684)
- Port Access Route Study: Northern New York Bight, July 2021 (USCG, 2021e) (86 FR 50546)
- Port Access Route Study: Seacoast of New Jersey Including Offshore Approaches to the Delaware Bay, Delaware (NJPARS), March 2022 (USCG, 2022a) (87 FR 16759)
- Final Atlantic Coast Port Access Route Study (USCG, 2016) (81 FR 13307)

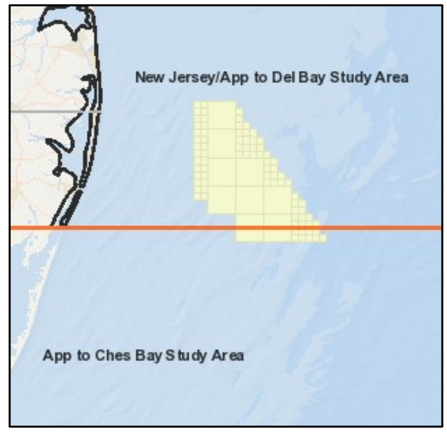
There is also an ongoing PARS in the region as of September 2021:

- Ongoing Atlantic Coast Port Access Route Study: Port Approaches and International Entry and Departure Transit Areas (ACPARS) announced on 15 March 2019 (84 FR 9541)

Conclusions from PARS reports are intended to “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.” (USCG, 2017[22]).

[22] A discussion of USCG recommended routing measures is in Section 11.4.

A small portion of the Lease Area lies within the CBPARS study area. Information in the CBPARS report is cited in this assessment; however, the CBPARS does not include specific findings or recommendations related to safe distances of structures from TSS or related to the Project.



Most of the Lease Area lies within the NJPARS study area. The NJPARS recommendations and conclusions (USCG, 2022a) include:

- "…a combination of IMO resolutions (modified TSS, two-way routes, and additional precautionary areas) and modifications to the ANPRM for shipping safety fairways. It is the conclusion, based on data contained in this study, that this combination of measures provides a balanced approach to marine planning and ensures future safety of navigation." The measures include (see previous Figure 2-45):
  - Extending both Delaware Bay Traffic Separation Schemes
  - Precautionary Areas
  - Two-way route along the Delaware seacoast
  - Chesapeake Bay to Delaware Bay Eastern Approach Cutoff Fairway
  - Delaware Bay Connector Fairway
  - Cape Charles to Delaware Bay Fairway
  - Barnegat to Narragansett Fairway
  - New Jersey to New York Connector Fairway
- A fairway anchorage adjacent to the southeastern TSS

In another section of the report, the NJPARS states, "The NJPARS will not specifically direct transit lanes or buffers but will encourage review under the NEPA process." This NSRA provides additional data and assessment to inform decisions concerning a buffer distance from the TSS edge to the edge of a line of offshore structures.

11.3.1.3 Situational awareness

The following risk controls serve to increase situational awareness for a mariner, which is vital to maritime safety:

- Federal ATON, which include audio, visual, radar, and radio systems (e.g., lights, buoys, sound signals, range markers, and radio beacons).
- Broadcast Notice to Mariners from USCG.
- Local Notice to Marines from USCG.
- Transit Advisories, transit recommendations for deep draft vessels, and anchorage guidance from the Mariners Advisory Committee for the Bay and River Delaware (the local harbor safety committee).
- Weather reports, forecasts, warnings, navigational information, and other data from NOAA. Two NOAA offices, the National Ocean Service and the National Weather Service, offer data and services that directly support safe navigation.

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

11.3.2 U.S. offshore wind industry good practices

Offshore wind developments have been in operation since 1991. Good industry practices have advanced and, like the maritime industry risk controls listed in Section 11.3.1, continue to evolve and improve over time. A risk in the tolerable/ALARP range requires that industry good practices be implemented to reduce the risk, in line with ALARP principles.

During the design and construction stages of an offshore wind development, a set of design and construction standards define the minimum requirements. In the U.S., 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).

The following have been identified by this assessment as good industry practices that DNV anticipates will be become standard in the U.S., some of which are included in adopted regulations and guidelines (grouped by topic). All of the below good practices that are applicable to the Project have been incorporated in the Project's COP inasmuch as they are in the control of the Project's developer.

Design/Plans:

1. Structures distanced from regularly-transited routes (the optimized distance is dependent on the number of and size of passing vessels)
2. Lighting and marking in accordance with internationally recognized practices. 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
3. Uniform spacing of offshore structures.
4. Marking of air gap height on the structure and indication of relevant area of hazard on nautical charts.
5. Risk-based determination of cable burial depth.
6. Clear and distinguishable Electronic Navigation Chart symbology for offshore wind boundaries, structures, and export cables
7. Enabling the use of development structures as ATON through implementation of:
   - Lighting coordinated to clearly delineate development boundaries and contiguous developments
   - Sound signals
   - Structure identifiers that are predictable when crossing from one development into another, where applicable.
8. U.S. and/or SOLAS standards regarding construction, safety equipment, and crew for all Project vessels.
9. AIS on all Project vessels.
10. Emergency response planning and exercises
11. Safety zone of 500 m (1,642 ft) around construction vessels during wind farm construction

Activities:

12. Familiarization of commercial fishers and recreational boaters with safe transit through the Lease Area. Vessel safety for shallow draft vessels (i.e., generally vessels with drafts less than 15 m [49.2 ft]) is a potential concern because these vessels are more likely to transit within a wind farm. This is a key human aspect to achieving use of extra caution, employing proper watch, and assessing risk prior to entering or exiting an offshore wind farm.
13. Familiarization of merchant mariners and vessels in international trade with the changes to ATON and navigation hazards in the vicinity of the Lease Area.
14. Timely and effective notices to mariners regarding offshore activity and new hazards.
15. Locking and/or feathering of turbine blades during potential or confirmed emergencies, including icing. (This capability is normally included in offshore wind farm design and control systems.)
16. Dynamic fishery avoidance (likely not applicable to the Project).

Monitoring and post-event activities are not strictly considered risk controls but form an important part of effective risk management. The following monitoring programs been identified by this assessment as good industry practices in the U.S.:

17. Monitoring of export cable location annually for initial years of operation, with potential for reduced frequency of monitoring thereafter.
18. Annual Remotely Operated Vehicle (ROV) surveys around WTG foundations to monitor fishing gear and inform frequency and locations of lost gear removal.

11.3.3 Additional risk controls incorporated into the project design and plans

The following risk controls are also included in the Project's plans:

1. Robust inspection and onboard life safety for Project vessels
2. Work with the agencies to mitigate the potential impacts of the Project to the SeaSonde HFR system

11.3.4 Additional risk control measures considered in this assessment

This section provides information to enable the USCG to review whether Project risks are reduced to meet ALARP criteria. The risk control measures listed in Sections 11.3.1 and 11.3.2 as standard industry practices or good industry practices are included in the Project's design and plans, in line with ALARP principles, and therefore are not evaluated further. The evaluation of risk controls should consider the hierarchy order of preference for risk controls and layers of protection.

Hierarchy of controls

It is considered good practice to apply a preferential order when selecting risk controls for further review in the ALARP process. The hierarchy of controls commonly used and applied in this assessment is:

1. Elimination of risk by removing the hazard
2. Substitution of a hazard with a less hazardous one
3. Prevention of potential events

4. Separation of people from the consequences of potential events
5. Control of the magnitude and frequency of an event
6. Mitigation of the impact of an event on people
7. Emergency response and contingency planning, including search and rescue

Elimination is the most effective control; however, as a practical matter, not all hazards can be eliminated.

Layers of protection

For many potential accidents, several protective layers act as barriers to prevent, reduce or mitigate them. A robust control measure regime includes a range of independent layers. Examples of independent layers are typically identified in the following groupings:

- Design standards taken together with manufacturing, construction, and equipment integrity assurance processes
- Operational control and detection systems together with emergency operational processes
- Systems that facilitate a quick and effective response to an accident, such as automatic warning systems, offshore communications, technologies to locate a person or small craft in the water, and processes to rescue a person or gain control of a vessel.

A common mode failure is where two or more controls may fail as a result of a single cause. It is therefore essential this type of evaluation considers such common causes, since the perceived degree of protection provided by the controls may be overly optimistic if this failure mode is not considered. Common mode failures should be considered for all types of risk control.

Evaluated measures

Table 11-14 lists the measures evaluated in this NSRA using ALARP principles. The table is intended to represent a comprehensive list of credible measures, which were evaluated individually as discussed in the subsequent sections of this report.

Table 11-14 Measures Evaluated per ALARP Principles

Order of Preference	Risk Control Measure
1. Elimination of risk by removing the hazard	None identified
2. Substitution of a hazard with a less hazardous one	• Prohibit use of specified designs/kinds of commercial fishing gear in the wind farm • Designation of the site as an area to be avoided (ATBA)
3. Prevention of potential events	• Maximum LOA for vessels allowed to transit the wind farm Fishing / transits limited to daytime

Order of Preference	Risk Control Measure
	• Ice hazard protocol • Measures to improve quality of onboard equipment for highest risk vessels in the Lease Area, i.e., inspection and maintenance requirements • Real-time vessel monitoring in the wind farm by radar, AIS, video or other means • Vessel traffic services • Continuous watch by multi-channel VHF, including DSC • Requirement for vessels in Project Area to carry radar reflectors that provide a minimum recommended radar cross-section • AIS transmitters on selected exterior structures
4. Separation of people from the consequences of potential events	• None identified
5. Control of the magnitude and frequency of an event	• Vessel design and equipment maintenance requirements for all vessels entering a wind farm • Additional safety factor for depth of cover for buried cable • Measures to improve quality of onboard equipment for highest risk vessels in the Lease Area, i.e., inspection and maintenance requirements • Pilotage of vessels transiting the TSS • Project structures along perimeter equipped with radar beacon to allow clear identification via radar • Area to be Avoided of 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 • Fishing vessel transit lane(s) through the Lease Area
6. Mitigation of the impact of an event on people	• Extension of cellular service • Increased requirements for life safety equipment onboard all vessels transiting the development • Offshore structures are accessible and can be used as a potential place of refuge
7. Emergency response and contingency planning, including search and rescue	• Offshore cameras (to facilitate SAR) • Creation of an Emergency Response Cooperation Plan with the SAR organization covering the construction phase onwards

Measures not evaluated further

The following measures were screened out of the assessment because they provide minor/no risk benefit because of lack of effectiveness, or they would mitigate minor risk contributors and thus offer *de minimis* directly identifiable benefit:

- 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
- Tug on standby to assist vessels in distress
- Implementation of routing measures within or near to the development.
- Safety zone of 50 m around WTGs
- Safety zone of 500 m around WTGs
- Appropriate means for OREI operators to notify, and provide evidence of, the infringement of safety zones
- Design OREI structures to minimize risk to contacting vessels or craft
- Update the NSRA periodically
- Use of guard vessels where appropriate
- AIS on every offshore Project structure

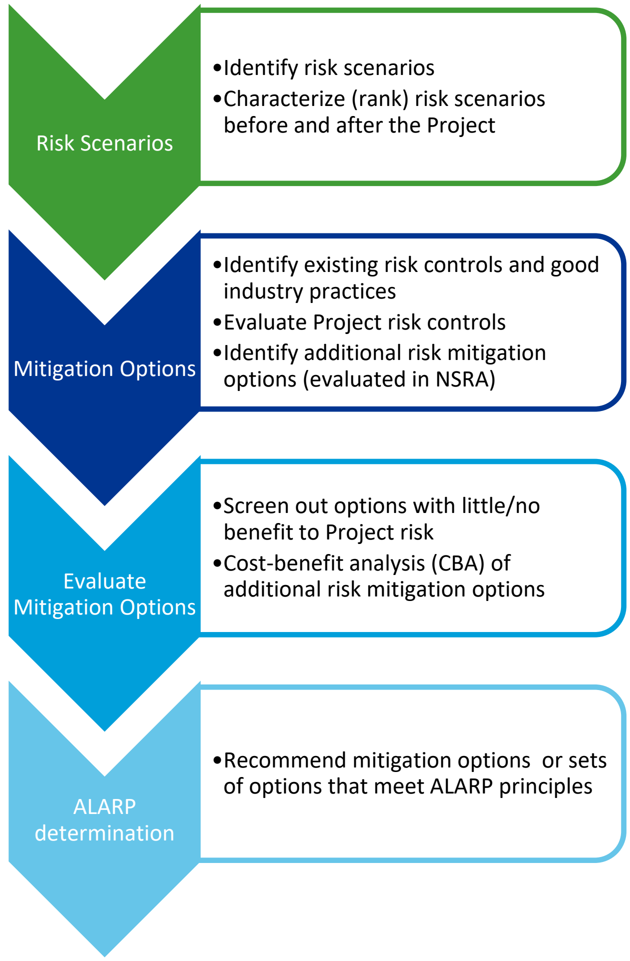
11.3.5 ALARP evaluation of risk mitigation measures

The ALARP process used to support the recommendations in this section is shown below.

An ALARP determination for a project is a statement that the project includes risk controls that reduce its risk to a level that is As Low As Reasonably Practicable. To demonstrate this, a developer must document that all reasonable options to reduce risks have been included in the proposed project, and no practicable options exist that would reduce the risks further.

One of the principles inherent in ALARP is the concept of gross disproportion:

> "The concept of gross disproportion requires duty-holders to weigh the costs of a proposed control measure against its risk reduction benefits. Specifically, it states that a proposed control measure must be implemented if the 'sacrifice' (or costs) are not grossly disproportionate to the benefits achieved by the measure." (UK HSE, 2021)



The output of the process is a set of ALARP-based recommendations. The documented process and recommendations are intended to inform decisions about risk management, but they are not conclusory. There may be, and likely are, other important factors that are not readily incorporated into the cost-benefit calculation, such as risk equity and which parties bear the cost of implementation.

In a non-established industry, an ALARP demonstration documents the process taken to systematically examine each major accident event to ensure that the project incorporates all reasonably practicable control measures – ensuring that the risks posed by operation of the project will be ALARP. For a mature industry, most often an ALARP demonstration does not include a cost-benefit analysis because there is a body of knowledge on which to build and novel approaches are not as relevant.

11.3.5.1 Risk scenarios

A list of major accident scenarios was developed to identify credible events and (Table 11-15).

Table 11-15 Risk Scenarios

ID	Scenario	Vessel type(s)	Existing maritime risk controls[23]	Relevant standard U.S. risk controls[24]
1	Collision by a fishing vessel exiting the Project and a commercial vessel transiting the TSS	Cargo/Carrier/Tanker, Cruise ship, ATB	X	1, 3, 6, 13
2		Fishing	X	1, 3, 12
3		Tug and towline	X	1, 3, 6, 13
4	Collision by a tug with a barge and another vessel along the coast, west of the Project, due to increased traffic density.	ATB, Tug and towline	X	1, 3, 13
5	Collision by other vessel types	Pleasure	X	1, 3, 6, 12
6		Passenger	X	1, 3, 6, 12
7	Powered deep draft vessel to structure allision	Cargo/Carrier/Tanker, Cruise ship	X	1, 2, 3, 4, 6, 7, 13
8	Powered shallow draft vessel to structure allision (not including barges)	Fishing	X	2, 3, 4, 7, 12
9		Passenger		
10		Pleasure		
11	Powered tug and barge vessel to structure allision	ATB, Tug and towline	X	1, 2, 3, 4, 6, 7, 13
12	Drift deep draft vessel to structure allision	Cargo/Carrier/Tanker, Cruise ship	X	1, 2
13	Drift shallow draft vessel to structure allision (not including barges)	Fishing	X	2
14		Passenger		
15		Pleasure		
16	Drift tug and barge vessel to structure allision	ATB, Tug and towline	X	1, 2
17	Grounding of a vessel	Cargo/Carrier/Tanker, Cruise ship	X	Not Applicable (Project is distanced from the coastline)
18		ATB,Tug and towline		
19		Fishing		
20		Passenger		
21		Pleasure		

[23] Specifically, this refers to the requirements for vessels in international and coastal trade.
[24] The list of Industry Good Practices/Project risk controls is in Section 11.3.2.

ID	Scenario	Vessel type(s)	Existing maritime risk controls[23]	Relevant standard U.S. risk controls[24]
22	Anchor snagging on a Project array cable	Cargo/Carrier/Tanker, Cruise ship	X	1, 5
23		Fishing, Pleasure, Passenger		5
24		ATB,Tug and towline	X	1, 5
25	Anchor snagging on a Project export cable	Cargo/Carrier/Tanker, Cruise ship	X	5, 13, 14
26		Fishing, Pleasure, Passenger		5, 14
27		ATB,Tug and towline	X	5, 13, 14
28	Ice fall/throw strikes a vessel	All		14, 15
29	Strike of a vessel under sail by a turbine blade	Pleasure/sailing	X	4
30	Fishing gear snagged on a Project structure (WTG or OSS foundation)	Fishing		

To assess the need for additional mitigation, the consequences of each scenario are assigned a Severity Index, and the frequency, from MARCS modeling or design criteria, is assigned a Frequency Index. The following index definitions are used, in line with the IMO FSA Guidelines (IMO, 2017).

Severity Index	Definition
1	Spill < 1 tonne
2	Spill 1-10 tonnes
3	Spill 10-100 tonnes
4	Spill 100-1,000 tonnes
5	Spill 1,000-10,000 tonnes
6	Spill >10,000 tonnes

Frequency Index	Description	Definition
1	Insignificant	Likely to occur less than once every 100,000 years of Project operation
2	Extremely remote	Likely to occur once every 10,001 – 100,000 years of Project operation
3	Remote	Likely to occur once every 1,001 – 10,000 years of Project operation
4	Unlikely	Likely to occur once every 101-1,000 years of Project operation
5	Possible	Likely to occur once every 11-100 years of Project operation
6	Reasonably probable	Likely to occur once every 1 - 10 years of Project operation
7	Frequent	Likely to occur more than once per year of Project operation

Recent PARS include USCG determinations concerning the acceptability of existing and future waterways risks. The maritime casualty data in the PARS reports (USCG, 2021a/b) provides qualitative indications of risk tolerance in the vicinity of the Project and was used as a general guide.

The risk level for each scenario is labeled as “Intolerable” when the sum of the two indices is 10 or greater. The risk level is labeled “Tolerable if ALARP” for sums from 4 to 9, and “Acceptable” for sums less than 4. The acceptability levels are based on comparisons of USCG acceptance or non-acceptance of current risks in the CBPARS and NJPARS.

The resulting ranking for the scenarios is shown in Figure 11-18.

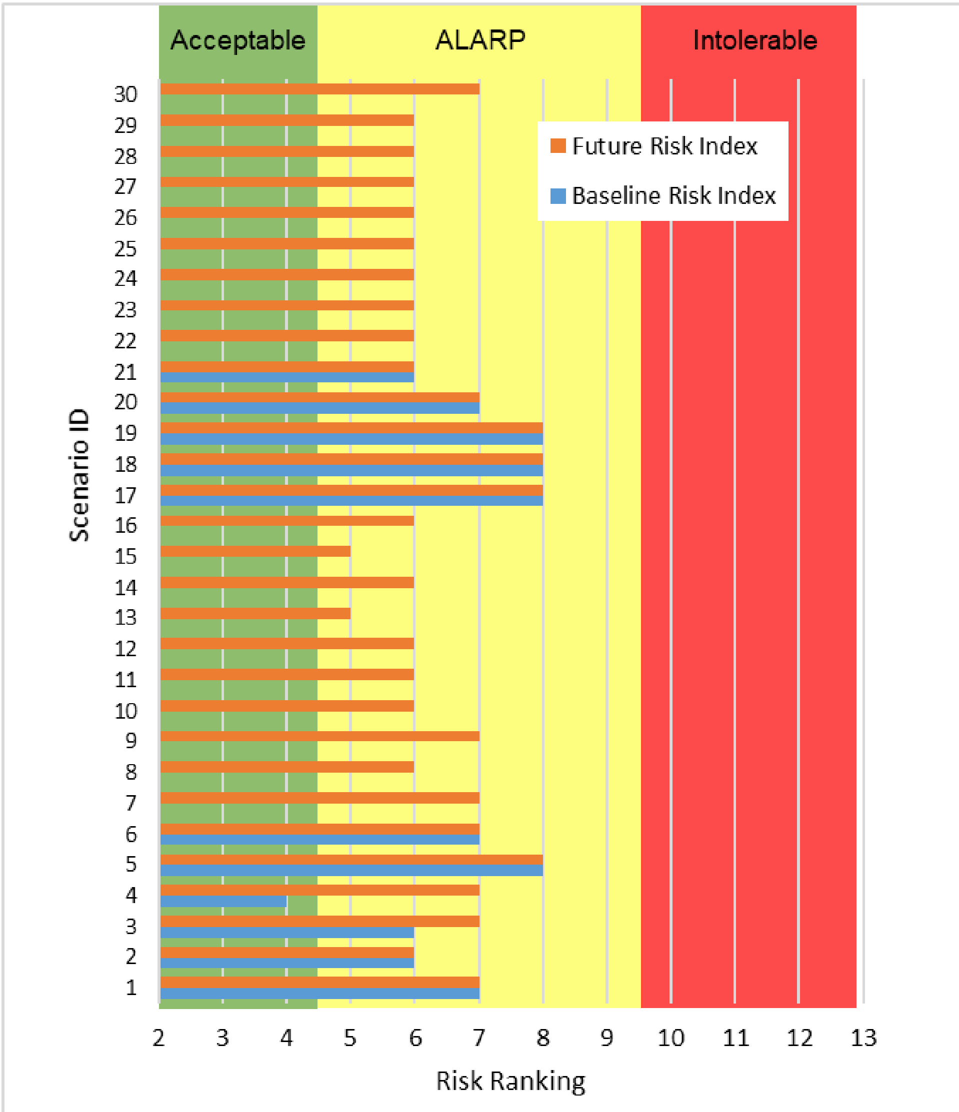


Figure 11-18 Risk Ranking Prior to Additional Mitigation

None of the scenarios were in the Intolerable range of risks. Patterns in the risk rankings include:

- Scenarios 1 through 6 are collisions, which were evaluated in the PARS and modeled in MARCS. Only one of these is materially increased by the Project.
- Scenarios 7 through 16 are allisions with Project structures; therefore, the Baseline risk is zero.
- Scenarios 17 through 21 are groundings, which are not materially affected by the Project.

- Scenarios 22 through 27 are anchor-cable snags. The target cable burial depth is the primary mitigation for cable snags, and the cable burial risk assessment has a maximum target risk which limits the risk from the Project to the Tolerable if ALARP range of risk.
- Scenario 28 is ice fall/throw which will exist only after the Project is operational; therefore, the Baseline risk is zero.
- Scenario 29 is striking of a sailing vessel by a turbine blade; therefore, the Baseline risk is zero.
- Scenario 30 is fishing gear snagged on a Project structure; therefore, the Baseline risk is zero.

11.3.5.2 Mitigation options

The list of additional risk control measures considered in this assessment is in previous Table 11-14. Each risk control measure is evaluated to identify the scenarios for which it was relevant, i.e., the mitigation could reduce the scenario's risk.

Rejection of controls

A number of the evaluated risk controls are not recommended for implementation, all of which were not cost-beneficial except as noted otherwise. Rejection of a risk control during the ALARP review process does not imply that it has no value. Some of the below risk controls are preferred by the Project and may become important agreed aspects of the Project for other reasons, but not on the basis of cost-effective reduction in navigation risk.

The below controls were rejected for the following reasons:

1. The schedule, administrative, and potentially cost burden is borne by other entities rather than the Project, i.e., operators of Fishing and Pleasure vessels. (This control might be cost-beneficial.)
   - Measures to improve quality of onboard operating equipment for highest risk vessels in the Lease Area, i.e., inspection and maintenance requirements
   - Robust assurance process for life safety equipment onboard all vessels transiting the development
   - Designation of the Project Area as an ATBA. (This control might be cost-beneficial.)
2. Introducing other risks/hazards (project/environment/schedule risk should also be considered)
   - Project structures along perimeter equipped with radar beacon to allow clear identification via radar
3. Conflicting with other risk reduction strategies or company/project/government policy and/or standards
   - Additional safety factor for depth of cover for buried cable
   - Area to be Avoided of 500 m (1,642 ft) around offshore structures during wind farm operations
4. Adversely affecting operational performance of the Project or other maritime entities
   - Pilotage of vessels transiting the TSS (no extension of the Vessel Traffic Information System [VTIS])
   - Transit or fishing only with functioning and active VHF and AIS installation
   - Fishing vessel transit lane(s) through the Lease Area
   - Eliminate structures within 1 NM (1.9 km) of a TSS
   - Eliminate structures within 2 NM (3.7 km) of a TSS

5. Creating significant maintenance/upkeep burden and/or an associated exposure risk
    - Continuous watch by multi-channel VHF, including DSC
    - Offshore structures are accessible and can be used as a potential place of refuge
6. Resulting in little benefit given effort of application
    - Real-time vessel monitoring in the wind farm by radar, AIS, video or other means by the Project (equivalent to a VTIS)
    - Continuous watch by multi-channel VHF, including DSC.
    - Vessel Traffic Services
7. Not consistent with good practice
    - None identified
8. Not supportable with a cost-benefit analysis - Note: cost-benefit analysis should not be the principal reason for rejection of a control
    - Extension of cellular service
    - Offshore cameras (to facilitate SAR)

Controls recommended on the basis of ALARP

Cost-benefit analyses were conducted for each measure, and the following measures were identified as potentially effective and having cost-to-benefit ratios less than 10, that is their costs exceeded their benefits by a multiple of 10 or less:

- No use of hydraulic clam dredges (specified designs/kinds of commercial fishing gear) in the wind farm
- Ice hazard protocol
- Creation of an Emergency Response Cooperation Plan with the SAR organization covering the construction phase onwards.

Cost and benefit are informative factors considered in decision making concerning risk mitigations, but they are not the only factors to consider. Other factors are common among industries with major accident risk. The following list is taken from *Tools for Making Acute Risk Decisions* published by the Center for Chemical Process Safety (CCPS, 1995):

- "Alternatives available for reducing or eliminating the risks
- Availability of capital
- Codes, standards and regulations and good industry practices
- Company and/or personal liabilities
- Company image
- Costs of implement available alternatives
- Economic impact of the activity on the local community

- Employment opportunities provided by the activity
- Frequency level(s) of the risk
- Inequities in how the risk and benefits are distributed among members of society
- Number of people at risk
- Perceived benefit of the activity and its impact on the public and/or stockholder image
- Profitability of the activity
- Societal component of the risk, such as the maximum number of people impacted by a single event
- Strategic importance of the activity to eh company's growth and survival
- Type(s) of risk, such as human fatality, injury, and acute environmental damage"

ALARP determination

Given the Project's plans and adoption of the additional risk controls recommended on the basis of ALARP, the Project meets the ALARP principles.

11.4 Cumulative effects

Cumulative effects from proposed offshore wind farms on navigation are quantified within the MARCS Study Area and are evaluated on a qualitative basis for the other BOEM leases in the Traffic Survey Area (Figure 11-19).

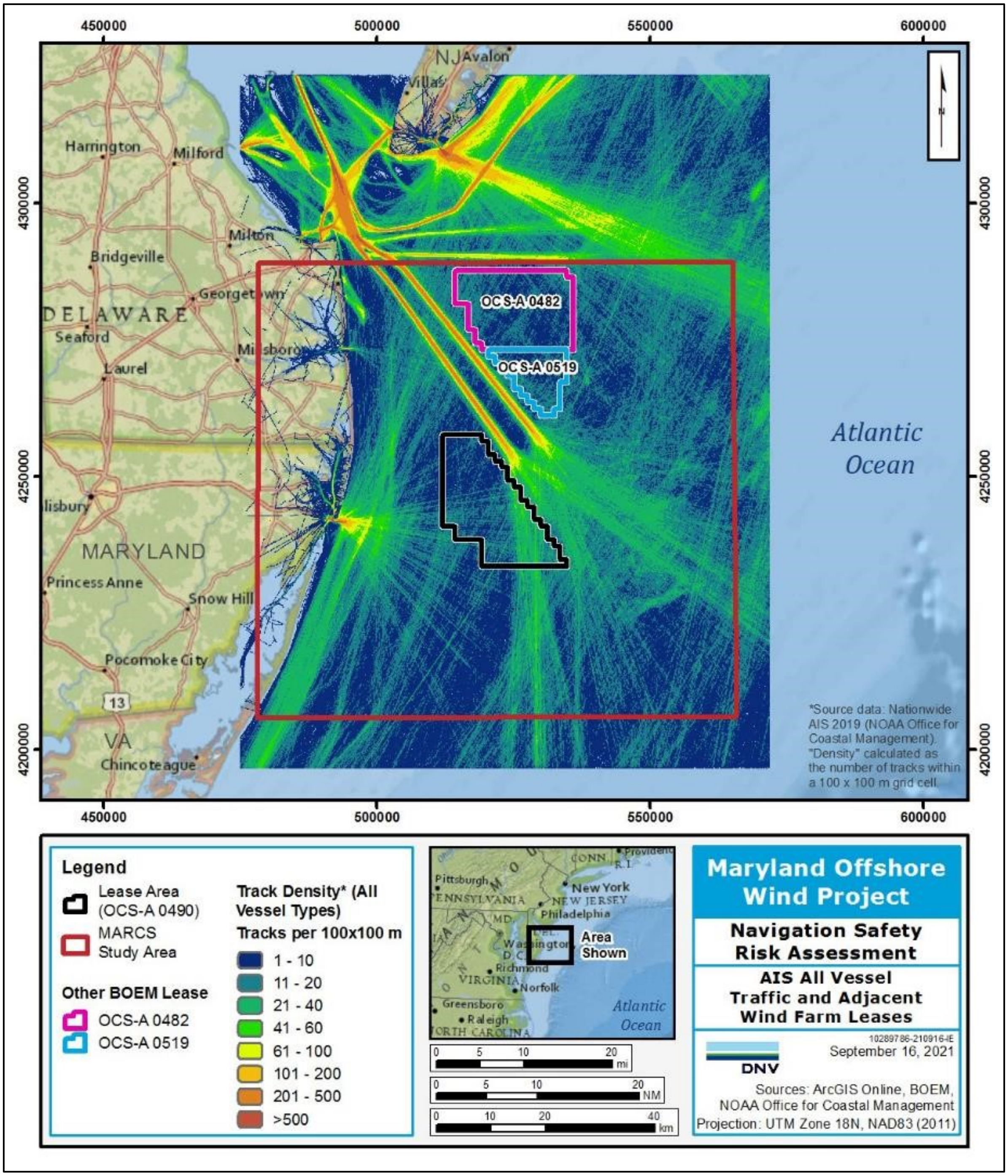


Figure 11-19 AIS Traffic and BOEM Leases[6]

The increase in frequency of collision and grounding for the MARCS Study Area presented in Section 11 represents a Future Case wherein deep draft and tug vessels route around the leases in the model. The frequency of allision represents only the risk from the Project, not structures in other leases.

When the modeling for this NSRA was finalized in September 2021, the draft NJPARS (USCG, 2021a) proposed routing measures and identified routes for deep draft and tug traffic to transit around the existing leases, including the Project Lease Area (Figure 11-20).

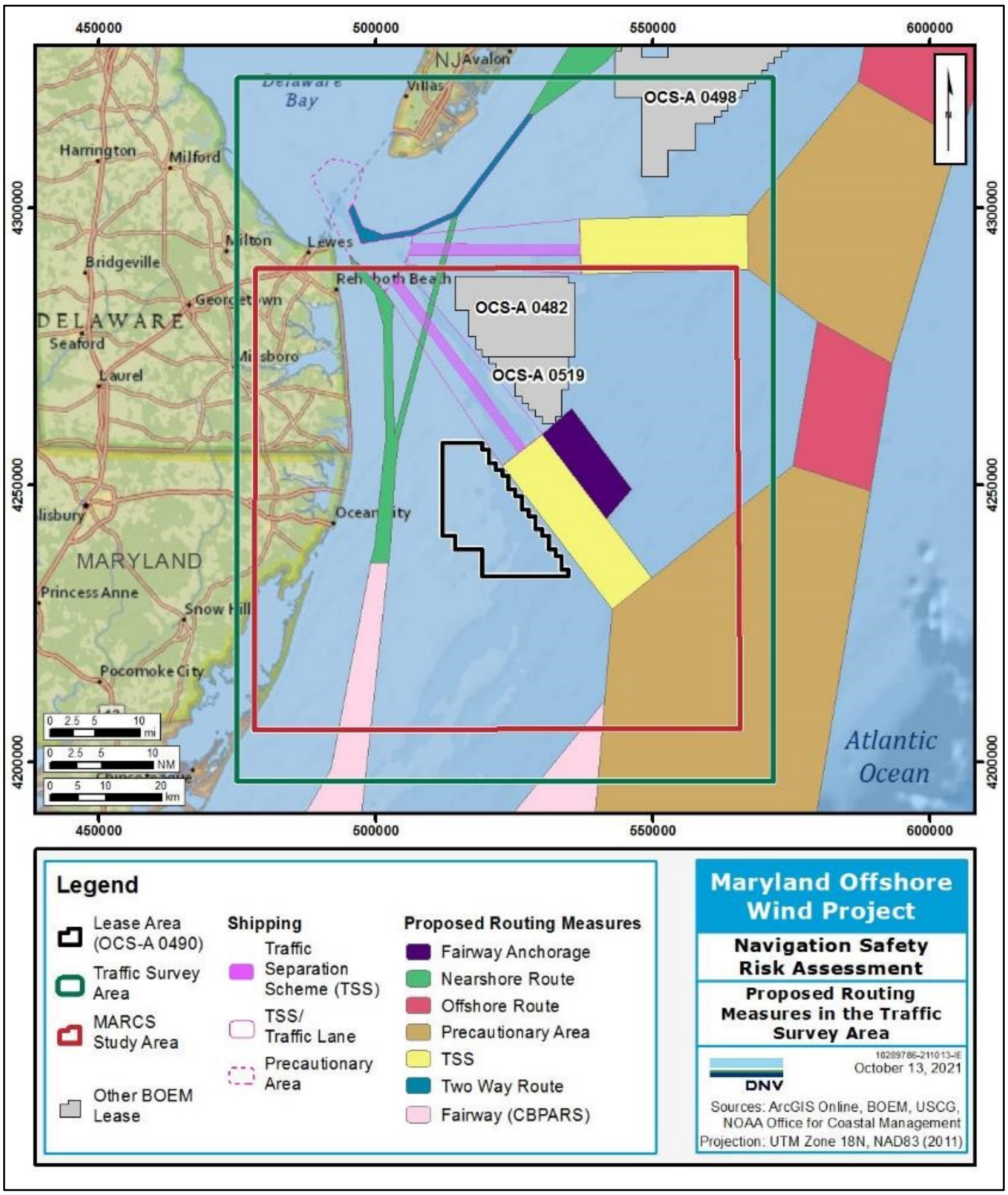


Figure 11-20 Proposed Routing Measures in the Traffic Survey Area (USCG, 2021a)

The modeling conducted in MARCS routed all deep draft and tug vessels around the other leases in the MARCS Study Area but did not require future traffic to transit within the USCG draft proposed routing measures shown in Figure 11-20. Instead, shortest reasonable paths were created based on dialogues with tug operators (see Appendix C), and courses / apparent destinations in the AIS data.[6] Vessel masters will not be required to utilize the fairways, if adopted, so some are likely to choose other routes. This behavior was observed in the CBPARS concerning existing routing measures (USCG, 2021b).

The MARCS results provide a view of the risk from the revised traffic flow after all the leases are built out, disregarding the currently recommended routing measures. If all vessel types were to utilize their relevant recommended routes, the risk would be less than is indicated by the modeling results.

The conclusions concerning cumulative effects on navigation, supported by engagement with waterway users (Appendices B and C), the PARS (USCG, 2021a; USCG, 2021b; USCG, 2020) and DNV modeling (Section 11.2) are:

1. The collision frequency may increase over the current baseline. The model results include effects from Project vessels in the traffic, plus estimates of future additional Fishing and Pleasure vessel traffic to the Lease Area. All of the Cargo/Carrier/Tanker or Tug traffic that currently transits through the Project and enters Delaware Bay was modeled as taking the coastal route in the future, and all such traffic heading north of Delaware Bay was modeled as taking a route west of the Project in the future.
2. Commercial fishing traffic that currently transits through the Lease Area may continue to do so, or instead, they may decide to take routes around the WEAs. The modeling assumes fishing traffic continues to transit through the Lease Area, which is a conservative approach regarding increase in allision risk.
3. An increase in distance sailed and resultant increase in vessel transit time, which are minor in comparison to the 2019 baselines per vessel type. The increased distance sailed per vessel type is shown in Table 11-16.

Table 11-16 Modeled Incremental Change in Miles Sailed in the MARCS Study Area

Vessel type	Modeled Additional Distance Sailed (NM per year)	Percentage Increase Over Total Miles Sailed in the MARCS Study Area
Cargo/Carrier/Tanker	5,489	1.3%
Cruise/Ferry	-	-
Fishing	-	-
Other	-	-
Passenger	18,929*	4.5%
Pleasure	68,030*	16.0%
Tug-ATB	639	0.2%
Tug-Towline	639	0.2%
Total	**93,723**	**22%**

* These are from new transits rather than from route deviations

The preliminary identified effects from additional miles sailed are:

- Use of additional fuel / increased fuel cost and additional air emissions
- Longer exposure time for the potential failure of propulsion and steerage equipment, which increases the risk of being adrift approximately in proportion to the additional amount of time spent transiting

4. Commercial and recreational fishing patterns may change in the future, changes which are largely unpredictable at this time. Estimates to account for a potential increase in activity in the Lease Area were incorporated in the risk modeling.
5. SAR efforts by aircraft may be more challenging in bad visibility or in high seas. Since no other WEAs are contiguous with the Lease Area, turns would be possible outside the array of structures, which is made possible by the Project’s proposed layout of structures in linear rows and columns. Because no commercial-scale offshore wind developments have been constructed in U.S. waters, the solutions that will be implemented by SAR aircraft in the Lease Area have not been finalized at this time. The USCG has committed to continuing to fulfill its missions, including SAR, and the Project has committed to work together with the USCG in this regard. The assessment of Project effects on SAR is presented in Section 12.

12 EMERGENCY RESPONSE CONSIDERATIONS

To support USCG's evaluation of how to mitigate the potential effects of the Project on USCG missions, this section provides information on potential effects of the Project on SAR and marine environmental protection/response (MEP) and identifies measures for consideration.

To determine the potential effects of the Project on emergency response missions, baseline levels of SAR and MEP mission data were evaluated from the following sources:

- USCG SAR mission data provided to US Wind for the period 2010 through 2020 (USCG, 2021g)
- Summary SAR statistics and maps in the draft USCG PARS reports (USCG, 2021a/b)
- USCG Marine Casualty and Pollution Data for Researchers: January 2002 through July 2015 (USCG, 2015b)
- Marine environmental protection mission data for various time periods covering 19 to 21 years(USCG, 2022b).

Concerning the timeframes from which data are available, SAR mission data for a recent 10-year interval is reasonable given that many cases occur per year, the changes that can occur in waterway uses, and the changes that can occur in locations and availability of SAR resources. In contrast, MEP missions occur with a lower frequency, and may warrant a longer time interval for the review.

Clearances of Project components relevant to emergency rescue assets are listed in previous Section 3.3.

12.1 Search and rescue

Based on the mission data provided to US Wind (USCG, 2021g) over a 10-year period, the USCG executed 8 SAR missions in the Lease Area, and 1,026 missions within 20 NM (37 km) of the Lease Area. On an annual basis, this represents an average of 0.8 SAR missions per year in the Lease Area and 103 per year within 20 NM (37 km).

The search area for each SAR mission is case-dependent, and because it changes during the course of a mission, is not readily evaluated in retrospect. The reported Primary location for each case is shown in Figure 12-1.

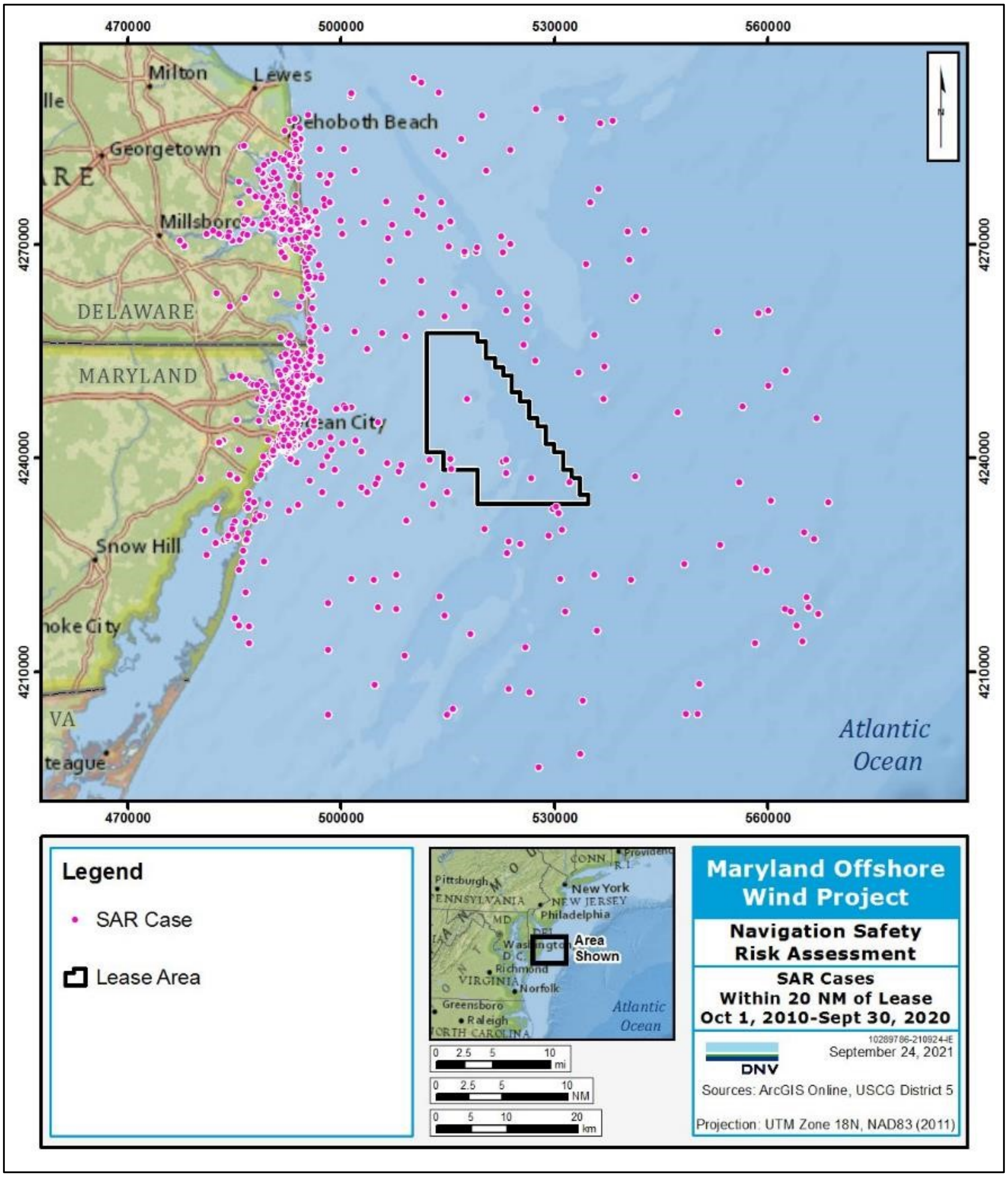


Figure 12-1 Locations of SAR Cases in Mission Data Provided to US Wind: Oct 1, 2010 – Sept 30, 2020 (USCG, 2021g)

The information requested in NVIC 01-19 (USCG, 2019a) about the SAR missions in the Lease Area is summarized in Table 12-1. The cases summarized in the table do not include SAR cases that drift into the Lease Area, SAR assets transiting through the Lease Area to reach a SAR location, and towing/transporting a disabled vessel through the Lease Area.

Table 12-1 Summary of SAR Cases Initially Located in the Lease Area (USCG, 2021g)

Situation	Number of occurrences Oct 2010 – Sept 2020
SAR missions conducted by USCG within 20 NM of the Lease Area over a ten-year period	1,026
SAR cases conducted by USCG within the Lease Area over a ten-year period	8 cases
Cases involving aircraft (helicopter, fixed-wing) searches	Not specified in the available data
Cases involving helicopter hoists	Not specified in the available data
Cases at night or in poor visibility/low ceiling	2 cases at night
Number of times commercial salvors responded to assist vessels in the proposed structure region over the last ten years	Not specified in the available data; a suitable source of this information was not identified
Additional SAR cases due to allision with the Project structures, estimated by modeling vessel transits	1 allision per 3.4 years, with the vast majority not requiring rescue (conservative maximum estimate based on modeling described in Section 11)

At a high level, based on DNV's mapping of SAR cases along the mid- and north-Atlantic coasts related to several proposed offshore wind projects, the density of USCG SAR missions appears to have a high association with the density of vessels in an area at a given time. This association seems reasonable from an event tree analysis perspective as well. Therefore, DNV suggests there could be an increase in the annual number of response missions beyond that indicated by the transit frequency modeling (Section 11.2). The NVIC 01-19 guidance requests information specifically about SAR cases from allisions with Project structures. Modeling was used to estimate allisions *from vessel transits*; however, allisions associated with other types of vessel activities could also occur, and are discussed below.

The frequencies of accidents that occur when a vessel is not transiting are highly dependent on the type of activity, its duration, and whether adequate watch is kept onboard during the activity. For commercial fishing activities, the risk of allision is discussed in Section 3.1.8 and Section 5. Other possible non-transit vessel activities include fishing, wildlife viewing, and diving.[25]

Outside the Project Area, where allision with a Project structure is not possible, modeling was used to estimate the frequencies of accidents such as groundings and collisions associated with *transit* of new marine traffic and Project vessels outside of the ports.

In summary, the Project is reasonably anticipated to increase the demand for USCG response missions from:

- Responses related to an increased presence of people aboard vessels, such as medical emergencies.
- Allisions in the Project Area - by transiting vessels (modeled frequencies), by vessels engaged in commercial fishing, and by vessels engaged in other activities (these accident frequencies are dependent on several factors that are subjective, and so are not estimated in this assessment)
- Groundings, and to a lesser extent, collisions in offshore waters between local ports, primarily Ocean City – by transiting Pleasure and Project vessels between the inlets and the Project Area

[25] Accidents from these types of events cannot be reasonably estimated using a MARCS-type of model.

The conservative estimates of additional vessel traffic from the Project, developed for the purposes of modeling, represent approximately a doubling of the current transits to and from Ocean City. An extreme bounding estimate of additional SAR missions within 20 NM of the Lease Area, a significant portion of which occurred offshore of Ocean City (see previous Figure 12-1), can be approximated by scaling the current annual average (within 20 NM of the Lease Area) by the estimated increase in traffic (for Ocean City Inlet). The historical data and resulting future estimates are shown in Table 12-2.

Table 12-2 Historical and Estimate of Future Number of Annual SAR Missions

Area	Historical SAR Missions over 10 years	Future Estimate with the Project
Within 20 NM of the Lease Area	103 per year on average	209 per year on average (bounding conservative estimate)
Within the Lease Area	0.8 per year on average	1.1 per year on average (0.8 plus 0.3 modeled accidents while transiting) plus Unknown number from other types of events

The USCG depends on NOAA's SeaSonde HF radar system, which supports USCG's Search and Rescue Optimal Planning System (SAROPS) computer model search pattern design tool (DOE, 2021). As discussed in Section 10.4, NOAA and other agencies are currently assessing potential impacts to the SeaSonde system from offshore wind developments. While impacts to the SeaSonde system may be determined and mitigated, the USCG is best positioned to evaluate impacts and identify mitigations related to SeaSonde and the SAROPS model. The NJPARS report (USCG, 2022a) acknowledges that "mission policy guidance and practical operations parameters may change in the future."

Based on USCG MISLE data from January 2002 to July 2015, 74% of the vessels involved in marine casualties in the MARCS Study Area were commercial fishing vessels or passenger vessels (USCG, 2015b). Material failure of the vessel and maneuverability were the two most common event types, comprising 35% of the casualties.

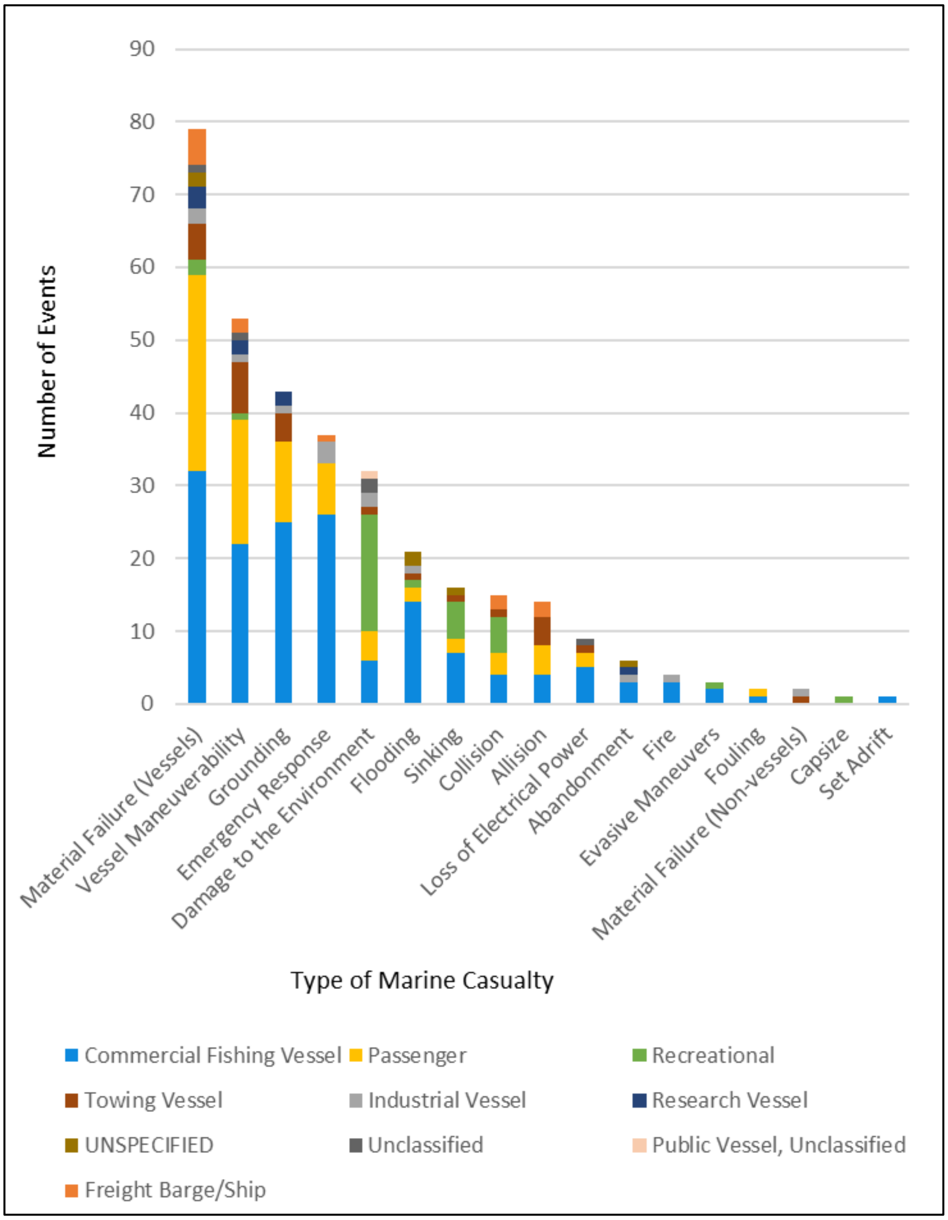


Figure 12-2 Casualty Event Types in MARCS Study Area: January 2002 – July 2015 (USCG, 2015b)

12.2 Marine environmental protection and response

The historical number of marine environmental/pollution (MEP) cases was evaluated in two ways: (i) based on mission sortie data available for a period of approximately 19 years, and (ii) based on incident investigation data available for a period of approximately 21 years (USCG, 2022b).

For MEP response cases (i.e., sorties), there were:

- Zero MEP sorties within 2 NM (3.7 km) of the Lease Area,
- Six MEP sorties within 20 NM (37.0 km) of the Lease Area.

On an annual basis, this represents an average of 0.3 response cases per year within 20 NM (37.0 km) of the structures.

Additionally, for MEP investigation of incidents with pollution (discharge/release), there were:

- Zero MEP investigations within 2 NM (3.7 km) of the Lease Area,
- Four MEP investigations within 20 NM (37.0 km) of the Lease Area.

On an annual basis, this represents an average of 0.2 response cases per year within 20 NM (37.0 km) of the structures.

The summed allision and collision frequencies for commercial traffic (Cargo/Carrier/Tanker, ATB, and Tug-Tow) estimated via modeling (Section 11.2) is 0.018 per year, of which only a small portion would result in a pollution case. Very likely, less than 1 in 10 accidents would result in a spill of any size. The resulting estimate from the project is 0.0018 additional cases per year (equivalent to 1 case in 571 years).

The reported primary locations of offshore MEP sorties and investigations are shown in Figure 12 and Figure 12-4, respectively. Additional details, including incident dates and the types of assets used in each response, are provided in Table 12-3 and Table 12-4.

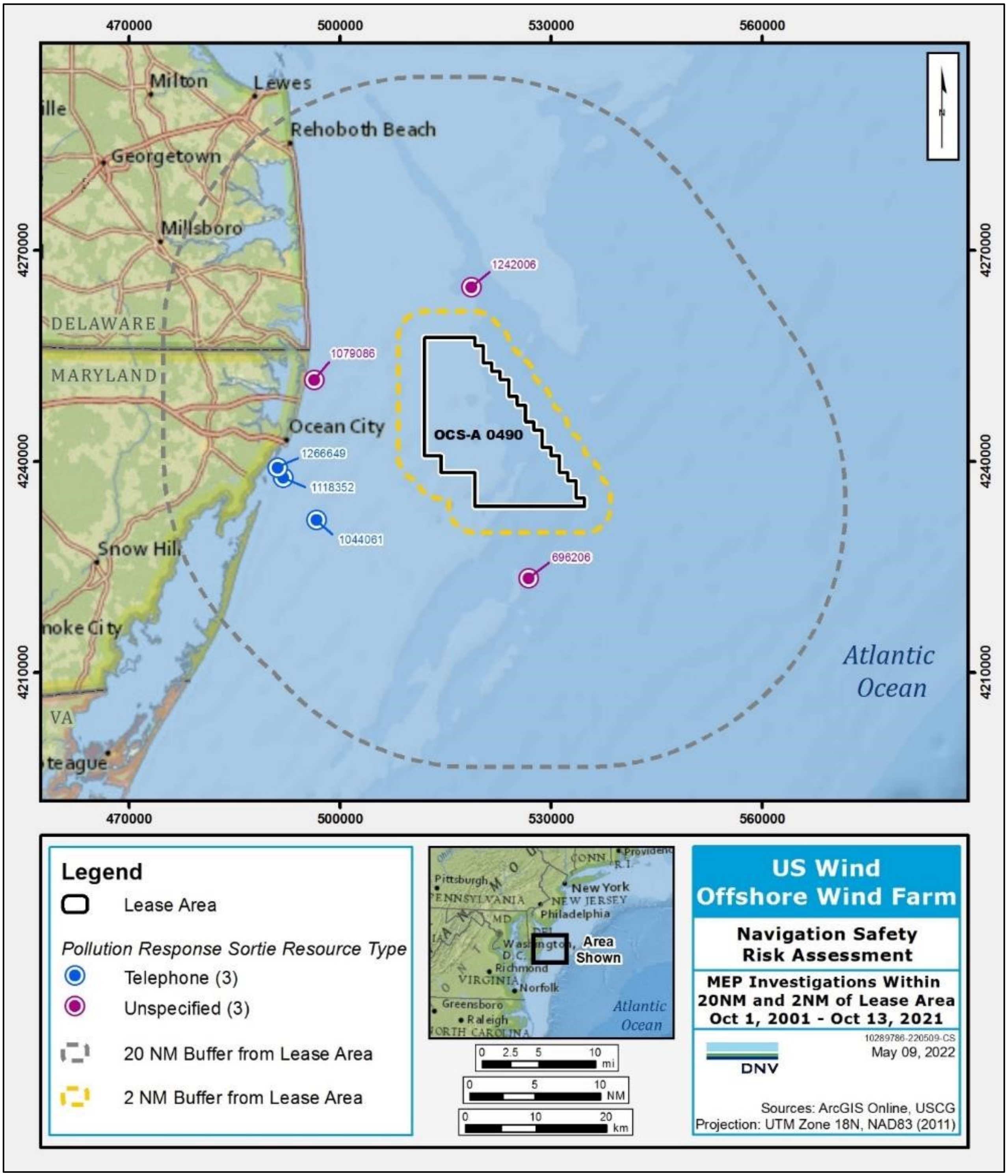


Figure 12-3 Locations of MEP sorties (labelled by Case ID) within 2 NM and 20 NM of the lease area for a period of approximately 19 years (USCG, 2022b)

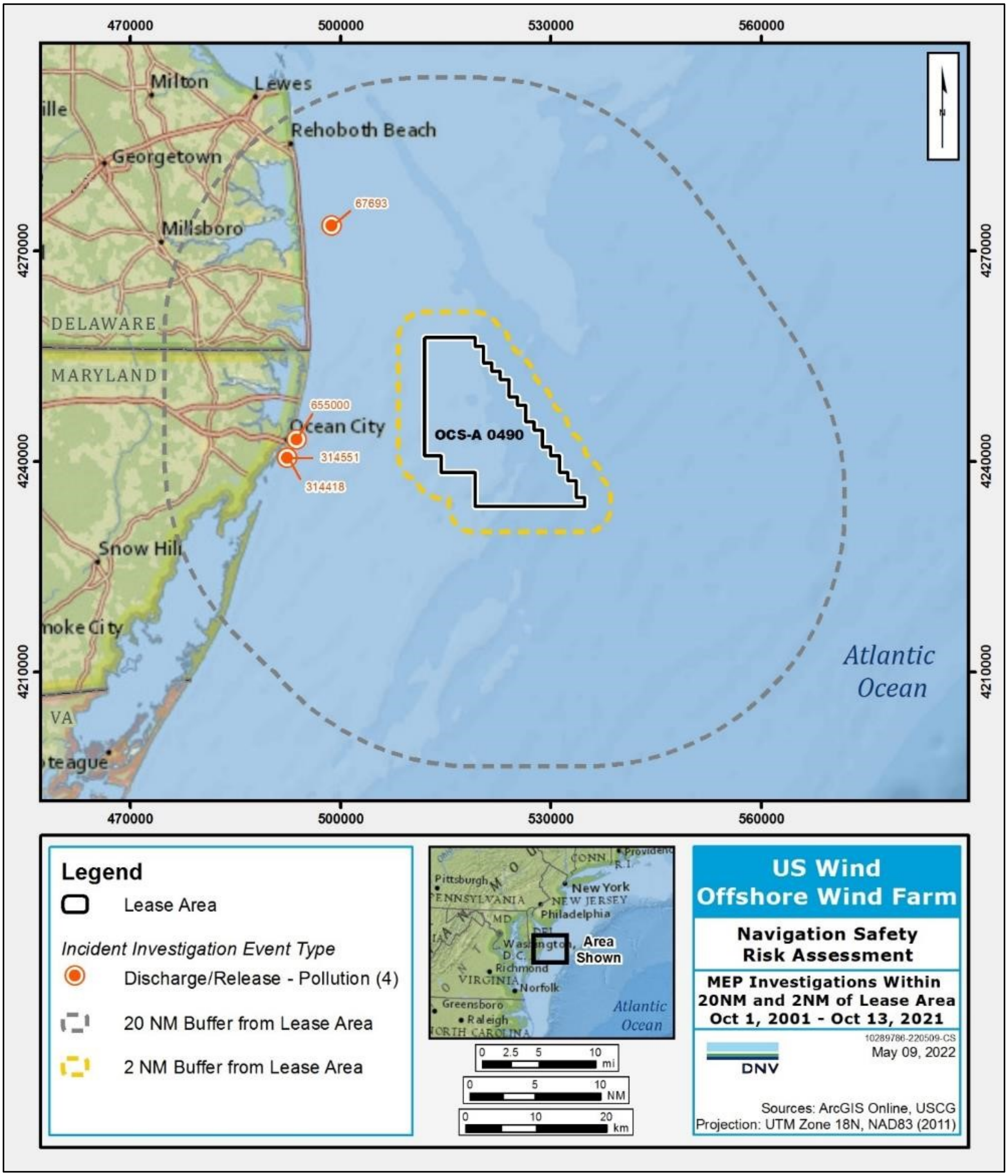


Figure 12-4 Locations of MEP investigations of incidents with pollution (labelled by Case ID) within 2 NM and 20 NM of the lease area for a period of approximately 21 years (USCG, 2022b)

Table 12-3 MEP sorties within 20 NM of the lease area for a period of approximately 19 years (USCG, 2022b)

Case ID	Distance to lease area	Latitude	Latitude	Activity date	Resource type	Resource name
1242006	3.9 NM (7.2 km)	38.53	-74.8	11/9/2020	Other	Unspecified
696206	5.5 NM (10.2 km)	38.16	-74.7	8/13/2014	Unspecified	Unspecified
1079086	8.4 NM (15.6 km)	38.41	-75.0	5/16/2017	Unspecified	Unspecified
1044061	9.6 NM (17.8 km)	38.23	-75.0	6/2/2017	Telephone	USCG Watchstander
1118352	10.9 NM (20.2 km)	38.29	-75.1	3/1/2018	Telephone	USCG Watchstander
1266649	11.3 NM (20.9 km)	38.30	-75.1	6/27/2021	Telephone	USCG Watchstander

Table 12-4 MEP investigations of incidents with pollution within 20 NM of the lease area for a period of approximately 21 years (USCG, 2022b)

Case ID	Distance to lease area	Latitude	Latitude	Activity date	Oil spilled in water (gallons)
655000	9.8 NM (18.2 km)	38.34	-75.07	9/1/2013	55
314418	10.5 NM (19.5 km)	38.31	-75.09	9/11/2006	1
314551	10.5 NM (19.5 km)	38.31	-75.09	9/11/2006	20
67693	11.2 NM (20.7 km)	38.61	-75.01	11/11/2014	15

In addition, an analysis was conducted of marine casualty data from January 2002 through July 2015 (USCG, 2015b). Casualties that included environmental spills during this period are summarized in Figure 12-5.

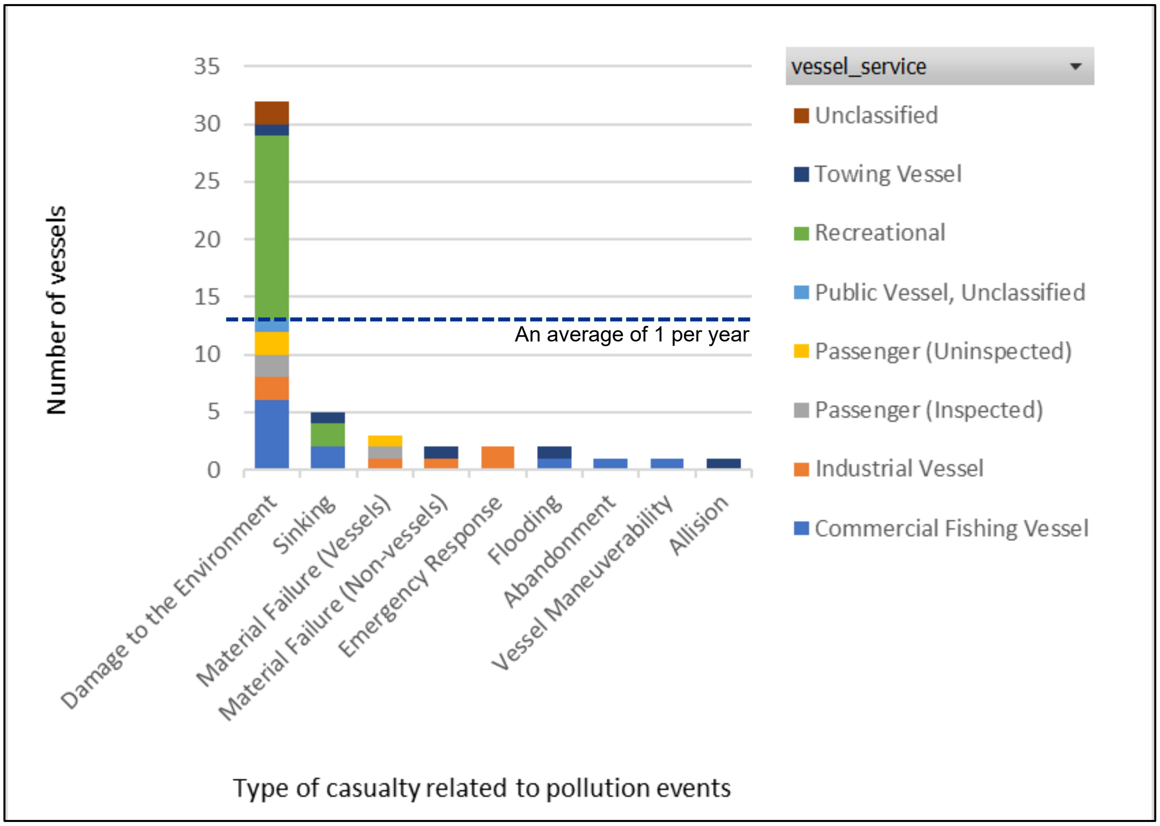


Figure 12-5 Number of Marine Casualties Involving Damage to the Environment in the MARCS Study Area: January 2002 – July 2015 (USCG, 2015b)

Although the spill data are more than six years old, there is a long-period trend of declining number of spills and declining quantity spilled that has continued since 1970 (Figure 12-6, USCG, 2012 and ITOPF, 2021). Therefore, statistics based on data from 2002 to 2015 provide a slightly conservative (high) estimate of the historical spill rate.

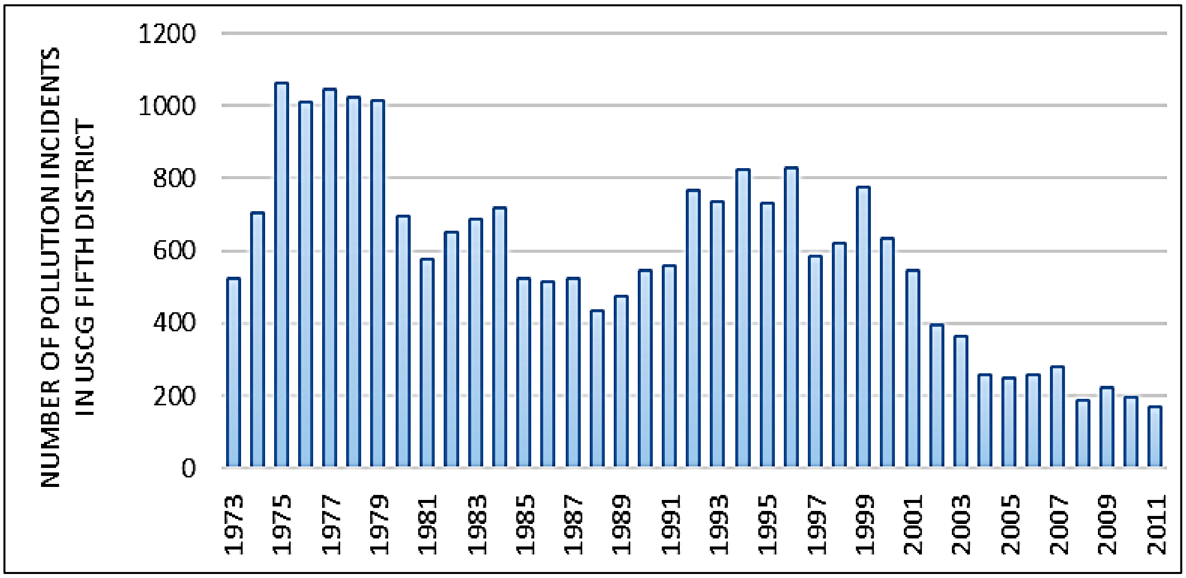


Figure 12-6 Number of Marine Pollution Incidents in USCG Fifth District: 1973 – 2011 (taken from USCG, 2012)

Based on the recorded locations of pollution events over 14 years in the USCG MISLE database (USCG, 2015b), there have been 28 suspected or acknowledged pollution events in the MARCS Study Area; an average of 2 per year. The largest estimated spill quantity was 473 liters (125 gallons) and 25 of the 28 spills were less than 76 liters (20 gallons) or less. The primary vessels involved (67%) were fishing or recreational vessels (Figure 12-7).

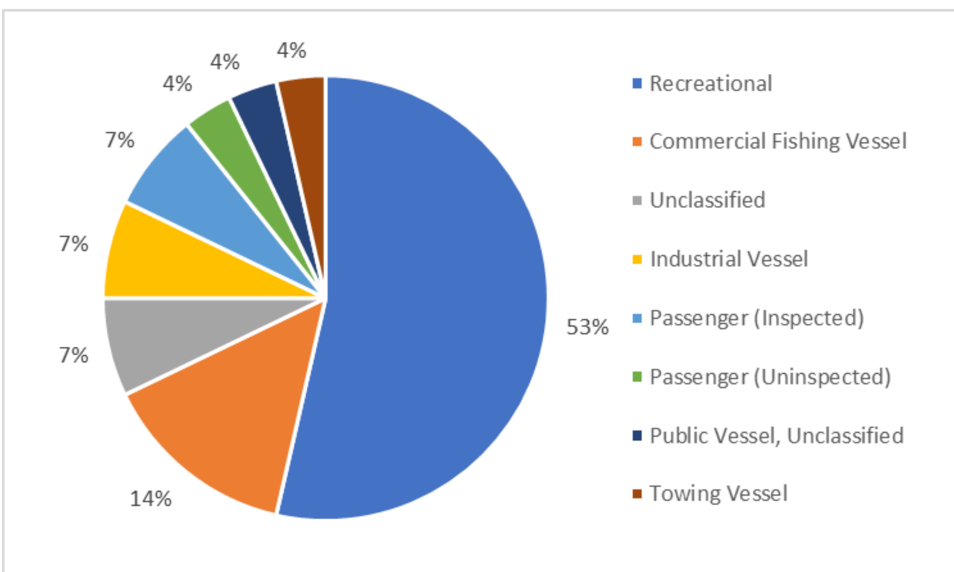


Figure 12-7 Vessel Service at the Time of a Marine Pollution Event in the MARCS Study Area (USCG, 2015b)

Over the same period, there were approximately 339 vessels involved in marine casualties in the MARCS Study Area, a ratio of about 8.3 reported/suspected spills per 100 marine casualties. (USCG, 2015b)

The pattern of spill size and rate of occurrence (low consequence/high frequency and high consequence/low frequency) is consistent with historical data from the U.S. and around the world. Events that involve quantities greater than 7 tonnes (approximately 2,200 gallons) have global frequencies of zero to several per year and have been decreasing over time (ITOPF, 2021) (Figure 11-1).

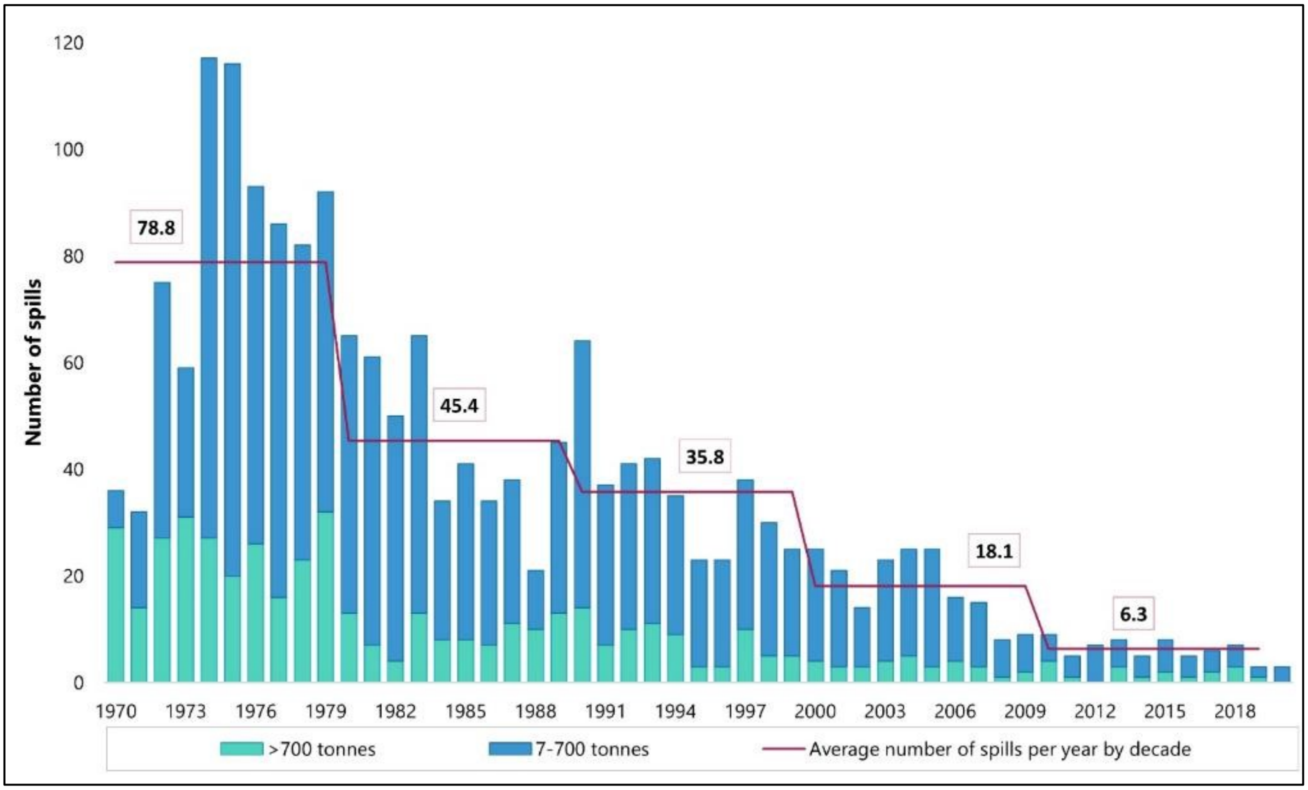


Figure 12-8 Global Oil Spill Trend from Tankers (ITOPF, 2021)

The most common material spilled is oil. Historically, vessels with oil cargoes were the primary sources of spill; however, the Oil Pollution Act of 1990 has phased in double hulled tanks, and other sources have become the majority (USCG, 2012). The continuing downtrend in maritime spills reflects the prevailing focus on continued improvement in maritime safety in the U.S. and globally.

12.3 Mitigation of potential effects on emergency response

The Project has identified potential mitigations for continued discussion with the USCG to identify an optimal set of design and operational features to facilitate future USCG missions in the vicinity of the Lease Area, with a focus on reducing the need for search activities. These include:

1. Options to reduce the range of and potentially the need for search operations, including:
   - Marking of each above water structure with a unique identifier
   - Installing marine navigation lights and aeronautical warning lights on every structure
   - Extended cell phone coverage
   - A continuously manned Operations Center
   - 24/7 monitoring of the Lease Area
   - Vessel traffic coordination
   - Radar
   - Thermal imaging
   - Drone use
2. Options to increase vessel and/or aircraft safety within the Lease Area:
   - Exercising shutdown protocols and procedures
   - AIS transponders on selected Project structures, clearly identifying the structure
   - Coordinating with the USCG units to conduct emergency training exercises

Another relevant aspect identified in this NSRA is that the presence of structures which will allow their markings / lighting to assist with position reporting, potentially assisting responders.

The layout of the Project is a factor that will be considered by the USCG when planning SAR activities in the Lease Area. Project WTGs and OSS will be equally spaced in a pattern, 1.0 NM (1.9 km) north-south by 0.76 NM (1.3 km) east-west (US Wind, 2022). This conforms to the visual flight rules in 14 CFR 91.155 specifying a minimum of 0.5-statute-mile visibility in daytime without clouds.

13 FACILITY CHARACTERISTICS

Marking of offshore structures is specified in international standards and USCG guidance. The most relevant standards include:

- Fifth Coast Guard District Local Notice to Mariners 17/21, NC – VA – MD – DE – NJ - ATLANTIC OCEAN-OFFSHORE STRUCTURE PATON MARKING GUIDANCE (USCG, 2021h)
- International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) Recommendation O-139 on the Marking of Man-Made Offshore Structures (IALA, 2013)
- The Convention on International Civil Aviation Annex 14 (ICAO, 2013), released by the International Civil Aviation Organization (ICAO) for marking of wind turbines with regard to safety of aviation
- “Guidelines for Lighting and Marking of Structures Supporting Renewable Energy Development” (BOEM, 2021b)

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

Marking and lighting of the structures will be subject to future permitting and BOEM and USCG oversight, including USCG availability standards. Project ATON will include the following, plus additional aspects that may be specified in permits:

- Identification marking
- Lighting
- Sound signals
- AIS transponder signals

Aviation lights may be controlled by an Aircraft Detection and Lighting System (ADLS) and AIS to be lit when triggered (ICAO, 2013). The customary design of aviation lights on offshore wind farm structures limits the potential for mariners to mistake the lights for the coastline or ATON.

No effects are anticipated to existing Federal ATON near the Project, shown in previous Figure 2-51. The WTG lights are expected to be clearly distinguishable from lights on the coast. Visual navigation is not expected to be affected by interactions of lights, backscatter, geographic versus visible horizon, or turbine spacing.

After the operational phase, the Project will be decommissioned. A decommissioning plan will be developed and submitted to relevant agencies. It is industry practice to remove offshore structure foundations at or just below the sea bed during decommissioning. No need is foreseen at this time for post-decommissioning marking or lighting of offshore structures (as there will be none).

14 DESIGN REQUIREMENTS

Project design will include the facility marking characteristics outlined in Section 13. The WTGs and OSS(s) will be controlled from a shore-based operations center, with the ability to fix the blades and shut down systems should an emergency arise (US Wind, 2022).

15 OPERATIONAL REQUIREMENTS

Personnel in the onshore control center will monitor the offshore wind Project 24 hours per day, 7 days per week. The Project's Safety Management System (COP Appendix I-B) and Emergency Response Plan will be developed and continue to be updated as the Project progresses design, construction, and operations. In their implemented form, these documents will specify the tools (such as current navigation charts) and contact numbers that will be available for use in an emergency (US Wind, 2022). In addition, they will specify information to be shared about the facilities with emergency response agencies and organizations.

16 OPERATIONAL PROCEDURES

The philosophy of the operations and maintenance plan is to conduct as much preventive maintenance in the summer as is practical (US Wind, 2022). Prior to operational status, the Safety Management System and Emergency Response Plan will be implemented, which are anticipated to include:

- Sharing contact numbers with appropriate agencies
- Testing of communication protocols
- Testing of shutdown procedures
- Procedure for evaluation of structural integrity of an offshore structure after an incident

17 CONCLUSIONS AND PROJECT RISK MITIGATIONS

The primary conclusions of this study are as follows:

1. Site location and coordinates	• The preferred Project layout includes 119 offshore structures, including 4 OSS and 1 Met tower. • The OSS and WTGs will be aligned and have a distance of 1.0 NM (1.9 km) between them in the north-south direction, and 0.76 NM (1.4 km) between them in the east-west direction. • The distance between the recommended TSS extension and the closest Project structure in the preferred layout is at least 1 NM (1.9 km) from the TSS outer boundary.
2. Traffic survey	• North and northeast of the Lease Area, the traffic is composed primarily of deep draft (Cargo/Carriers and Tanker) vessels entering and exiting the Delaware Bay Southeastern approach TSS. • Vessel traffic that crosses the Lease Area, predominantly in an east – west direction, includes commercial Fishing vessels that transit between Ocean City and the fishing grounds east of the Lease Area. • Current levels of fishing activity and recreational vessel activity in the Lease Area are light compared to activity in the region. • Tugs primarily transit west of the Lease Area along the coast, toward Delaware Bay, or through the Lease Area toward ports to the north. • 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. Standard industry 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. • 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. • Helicopter-aided SAR may be a higher-risk activity within the Project Area, more so in poor visibility. Emergency rescue procedures will likely be adjusted to account for the Project structures once they are in place. • 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. The primary hazards to transiting vessels include powered and drift allision.

4.	Offshore under water structures	• WTGs will have monopile foundations and are not anticipated to be a subsea hazard to passing vessels • The inter-array cable will be buried or protected to limit the risk of anchor interaction. The only offshore Project component outside the Lease Area will be buried export cables. Anchoring and bottom trawling or dredging activities pose the greatest risk of contact with subsea cables associated with the Project but will be mitigated by an appropriate burial depth as determined in a cable burial risk assessment for the Project to be completed in the future.
5.	Navigation within or close to a structure	• Any offshore structure in sufficient water poses a potential risk of allision. • During construction, global best 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. Important risk controls during construction include safety zones, communication to local mariners, and on-scene guard vessel(s). • 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 sea bed, 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 comparatively low level of influence on navigation risk related to the Project. • Two notable shoals and shipwrecks are located approximately 3 NM (5.6 km) west of the western boundary of the Lease Area: These shoals can affect sea state by locally increasing the height of the swell waves and generate breaking waves. The shoals may also present a grounding risk for deep draft and tug vessels; however, the deep draft traffic passes further to the north and to the east, and the tugs have sufficient room west of the shoals to ensure safe passage.

7.	Weather	• High winds and low visibility can have significant effects on navigation risk in an offshore wind farm. The risk modeling conducted for this assessment accounts for these factors.
		  • Gale and storm winds occur 0.7 % of the time.
		  • The visibility in the area is less than 2 NM (3.7 km) 7.6 % of the time
		• Hurricanes are not common in the vicinity of the Lease Area during the early summer months. In August and September there is a threat of tropical storms and tropical depressions.

8.	Configuration and collision avoidance	• Search effectiveness will be reduced for the current uses of air and surface assets. Emergency rescue procedures will likely be adjusted to account for the Project structures once they are in place. 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 (US Wind, 2022). 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	• 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	US Wind has selected the preferred Project structure layout as 119 structures, with no structures within 1 NM (1.9 km) of the adjacent TSS lane. This decision was informed by the modeling conducted for this NSRA.
	
	Based on typical speeds and weights of vessels in the MARCS Study Area (see Section 2.1.3), the following consequences are the most likely:
	
	• Pleasure, fishing, passenger, and non-ATB tugs:
	  • At speeds less than 4 kt the most likely consequence is minor damage to the vessel minor/no damage to the structure. This speed is commonly recognized as the maximum speed while actively fishing.
	  • At speeds greater than 4 kt, significant vessel damage is likely with potential minor damage to the structure. Fishing vessels transiting from Ocean City and the fishing grounds through the Lease Area have an average speed between 9 and 15 kt. Tugs in the vicinity of the Lease Area have speeds between 6 and 12 kt, with ATBs more likely to transit at speeds greater than 8 kt.
	• Barge vessels on towlines:
	  • The most likely consequence to a towline tug is significant vessel damage with minor/no damage to the structure, assuming the tug alone is the alliding vessel.

- The most likely consequence to the towed barge alliding at speed is significant vessel damage including a compromised cargo tank with minor/no damage to the structure.
- Cargo, carrier, tanker, cruise ship, and large ferry vessels
  - The most likely consequence to the deep draft vessel is significant vessel damage with significant structure damage. Compromise of a bunker fuel tank is possible, as some tank vessels do not have double hull protection of the fuel tank. A break of a cargo tank is possible, but unlikely due to the specific allision geometry that would be required for this to occur.

The main takeaways from frequency modeling of the preferred layout (119 structures) are:

- Collision risk increases (mainly due to the assumed increase in traffic generated by the wind farm) but from a small baseline level to the predicted future collision risk total of 0.04/year, or 1 accident every 25 years.
- Allision risk increases. This is an inevitable consequence of developing offshore wind energy to reduce greenhouse gas emissions. About 90% of this allision frequency is due to smaller ships navigating within the Lease Area. The consequence of these allisions is likely to be low for both the vessel and the structure. The frequency of higher consequence allisions (powered allision of ships with LOA > 100 m) is 0.192 per year or 1 allision in 520 years, which is 20 times the design lifetime of the development.
- Grounding risk increases mainly due to the assumed/ predicted traffic increase due to the wind farm. The developer does not have much influence over these risks. In addition, the risk model has not been optimized to focus on these grounding risks. The developer has influence over the risk of its own vessel groundings, which may be mitigated by crew selection and training (reduced human error probabilities) and transit rules (e.g., no transits during poor visibility or strong wind).
- The Project poses very little risk in the closest, outbound lane of the Delaware Bay Southeastern Approach TSS.
- The TSS extension would reduce the frequency of Cargo/Carrier and Tanker powered allision by approximately half.
- The MARCS results provide a view of the risk from the revised traffic flow after all the leases are built out, disregarding the recommended routing measures. If draft routing measures were implemented and all vessel types were to utilize their relevant recommended routes, the risk would be less than is indicated by the modeling results.
- A comprehensive evaluation of risk controls and risk mitigations is summarized in Section 11.3. Table 17-1 lists a set of measures to which the Project is committed. These may be replaced with equivalent or more beneficial measures, if such are identified at a later date.

12. Emergency response considerations	• A conservative average of 1 allision every 3.4 years is indicated by the modeling results. In line with global experience, most allision events are not anticipated to require emergency rescue operations.
13. Facility characteristics	• The Project will comply with USCG requirements for lighting, sound signals, and marking of structures, as applicable and as determined in consultation with the USCG and BOEM (US Wind, 2022). • No effects are anticipated to existing Federal ATON near the Project. • PATON will be maintained to meet conditions the USCG may impose in conjunction with its PATON permits (US Wind, 2022).
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 (US Wind, 2022).
15. Operational requirements	• Project operations will be monitored 24 hours per day every day and Project emergency contact channels will be provided to the USCG and other relevant agencies (US Wind, 2022)
16. Operational procedures	• Emergency procedures will be developed and reviewed with relevant agencies, including the USCG (US Wind, 2022)

Potential Project mitigation measures

Table 17-1 lists a set of measures to which the Project is committed (US Wind, 2022). These may be replaced with equivalent or more beneficial measures, if such are identified at a later date. The “Type” 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 is discussed in Section 11.

Table 17-1 Summary of Project Risk Controls (US Wind, 2022)

Type*	Risk Control
D	Uniform spacing of offshore structures
D	Structures distanced from regularly-transited routes (the optimized distance is dependent on the number of and size of passing vessels)
D	Lighting and marking in accordance with internationally recognized practices. 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 - Lighting coordinated to clearly delineate development boundaries and contiguous developments - Sound signals - Structure identifiers that are predictable when crossing from one development into another, where applicable.
D	Marking of air gap height on the structure and indication of relevant area of hazard on nautical charts
D	Risk-based determination of cable burial depth
P	Safety zone of 500 m (1,642 ft) around construction vessels during wind farm construction
P	U.S. and/or SOLAS standards regarding construction, safety equipment, and crew for all Project vessels.
E	Robust inspection and onboard life safety for Project vessels
E	AIS on all Project vessels
O	Work with the agencies to mitigate the potential impacts of the Project to the SeaSonde HFR system
P	Emergency response planning and exercises
P	Familiarization of commercial fishers and recreational boaters with safe transit through the Project Area. Vessel safety for Fishing, Passenger, and Pleasure vessels is a potential concern because these vessels are more likely to transit within a wind farm. This is a key human aspect to achieving use of extra caution, employing proper watch, and assessing risk prior to entering or exiting an offshore wind farm.
P	Familiarization of merchant mariners and vessels in international trade with the changes to ATON and navigation hazards in the vicinity of the Project Area.
P	Timely and effective notices to mariners regarding offshore activity and new hazards.

Type*	Risk Control
P	Locking and/or feathering of turbine blades during potential or confirmed emergencies, including icing. (This capability is normally included in offshore wind farm design and control systems.)
P	Monitoring of cable location annually for initial years of operation, with potential for reduced frequency of monitoring thereafter.
P	Annual Remotely Operated Vehicle (ROV) surveys around WTG foundations to monitor fishing gear and inform frequency and locations of lost gear removal.

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

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APPENDIX A AIS TRAFFIC MAPS

THIS PAGE IS A PLACEHOLDER – IT WILL BE REPLACED BY INSERTION OF THE PDF OF THE SEPARATE APPENDIX A FILE PRIOR TO DELIVERY

APPENDIX B LIST OF PARTIES CONTACTED

The Project's COP Appendix II-L2 discusses stakeholder participation and Appendix I-1 discusses agency coordination. The following are entities, organizations, and groups that US Wind has conducted outreach with and will continue to undertake throughout Project development (US Wind, 2022).

B.1 Fisheries

All Tackle
American Saltwater Guides Association
American Sportfishing Association
Anglers for Offshore Wind
Anglers Marina
Atlantic Coast Sportfishing Association
Atlantic Tackle
Bahia Marina
Congressional Sportsmen Foundation
Delaware Surf Fishing
Dusk to Dawn Bowfishing
Fishermen's Wharf, Lewes DE
Fish in OC
FishTalk Magazine
Frederick Saltwater Anglers
Maryland Saltwater Sportfishing Association
Recreational Fishing Alliance
Hooked on OC
Hook 'em & Cook 'em
HUK - Big Fish Classic Tournament
Indian River Marina
Lead Pot Bait & Tackle
Lucky Break Inshore Charters
Martin Fish Company
Maryland Artificial Reef Initiative
Maryland Watermen's Association
Mid-Atlantic Fisheries Management Council
New England Fisheries Management Council
Northeast Fisheries Science Center
Ocean City Fishing Center
OC Guide Service
Ocean City Marlin Club
Ocean City Power Squadron

F/V Betty C
F/V Boss Hogg
F/V Bottom Bouncer
F/V Captain Bob II
F/V Captain Ike II
F/V Delphinus
F/V Della Marie
F/V Dreamcatcher
F/V Drifter
F/V Dusk to Dawn
F/V Fin Chaser
F/V Fish Finder
F/V Fish Killers
F/V Fish On
F/V Get Sum
F/V Instigator
F/V Integrity
F/V Judith M
F/V Judy V
F/V Labradoodle
F/V Last Call
F/V Lisa
F/V Morning Star
F/V Ocean City Girl
F/V Ocean Princess
F/V Paka
F/V Pelican
F/V Pirate King II
F/V Primary Search
F/V Pumpin' Hard
F/V Reel Chaos
F/V Rita Diane
Rhonda's Osprey

Ocean City Reef Foundation
Ocean Pines Anglers Club
Omega Protein
Osprey Charters
Responsible Offshore Development Alliance
Responsible Offshore Science Alliance
Seaborn Fisheries
Southern Connection Seafood
Sunset Marina
Sunset Provisions
White Marlin Open
F/V Action Jackson
F/V All In
F/V Allison
F/V Amethyst
F/V Angler
Ben Fabryka - Captain of former F/V Ashlee E. (sunk) and replacement vessel
F/V RoShamBo
F/V Salacia
F/V Sea Born
F/V Second to None
F/V Shorebilly
F/V Skilligalee
F/V Spring Mix II
F/V Stella Marie
F/V Talkin' Trash
F/V Toe Jam
F/V Tony & Jan
F/V Turnin Fins
F/V Valerie Marie
F/V Virginia Reel
F/V Woolly Bully
F/V Wrecker

B.2 Maritime/Shipping

American Waterway Operators
Baltimore Harbor Safety Committee
Baltimore Port Alliance
Chamber of Shipping of America
Canton Port Services LLC
Delaware Bay Launch Service
Delmarva Water Transport Committee
Dockside Services Ocean City
Harbor East LLC
Mariners Advisory Committee for the Bay and River Delaware
Maritime Applied Physics Corp.
Maryland Port Administration
Maryland Overpak
McAllister Towing
McLean Contracting
Millers Launch
Moss Marine
Moss Wind
Moran Towing
Ocean City Power Squadron
Port of Baltimore Harbor Safety and Coordination Committee
Tradepoint Atlantic
Vane Bros. Towing

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. The summary of stakeholder feedback is provided below.

Appendix B lists major stakeholder organizations with which the Project engaged. The list is not all-inclusive.

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.

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

- **Commercial fishing**: Commercial fishing stakeholders expressed concerns about:
  - Habitat changes caused by electrical magnetic field around cables, and low-frequency noise from turbine operations.
  - Restricted access to traditional fishing areas and potential obstructions due to turbine placement relative to selected fishing spots.
  - concerns about how scour protection will affect benthic habitat, especially for horseshoe crabs.
  - Navigational safety during conditions of poor visibility and bad weather conditions.

- **Recreational boating and fishing**: Feedback from recreational boaters and fishing is generally positive as they are looking forward to increased species. 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.

- **Commercial vessel operators and pilots**: Commercial vessels will make slight adjustments to their traditional courses to avoid the Lease Area completely. Their main concern is to keep a safe distance between the vessels and the offshore structures. Anchorage area are needed at the entrance of the Delaware bay.

- **Tug's operators**: Tugs operator generally expressed concerns with regard to the new routes they will be required to take to transit between the New York and other ports southern of the Delaware Bay. The Tugs will adjust their routes to avoid the Lease Area completely, passing either closer to shore, with higher transit density, or further offshore, with potentially worse weather conditions.

  Tugs operators also expressed positive feedback with regard to the potential business opportunities associated with the Project construction.

- **USCG**: with regard to the SAR operations, the main concern expressed by the USCG is the interaction between the offshore structures and the search activities, potentially limiting the ability for a helicopter to follow search pattern across the Project. However, the presence of Project vessels and the presence of marked and lighted structures have the potential to also have a positive impact on the SAR 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 additional risk controls 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.

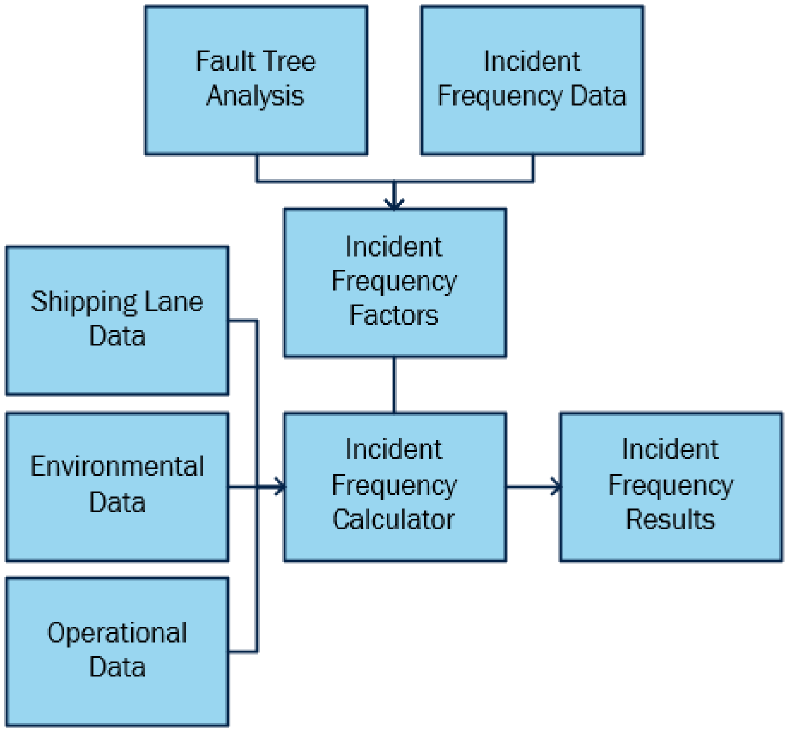

Figure D-1 Block Diagram of MARCS Incident Frequency Model

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.

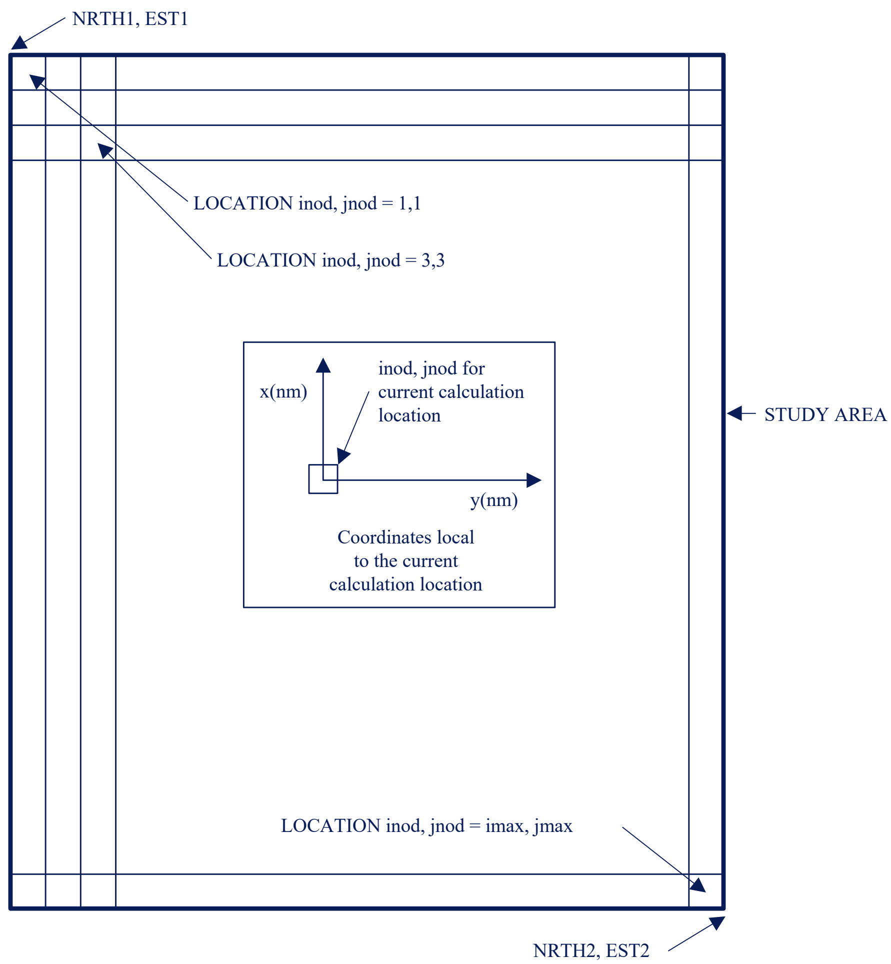

Figure D-2 Basic Definitions and Coordinate Sets

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 (NM) 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 symbols in the fault tree are defined in Figure D-3.

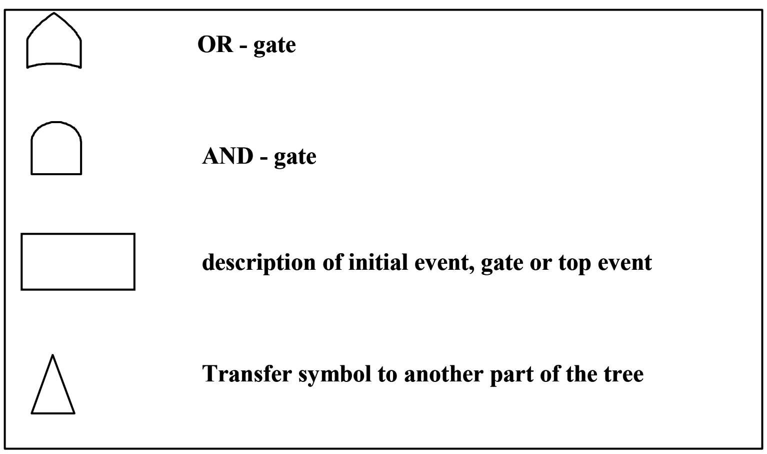

Figure D-3 Fault Tree Symbols

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(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}).

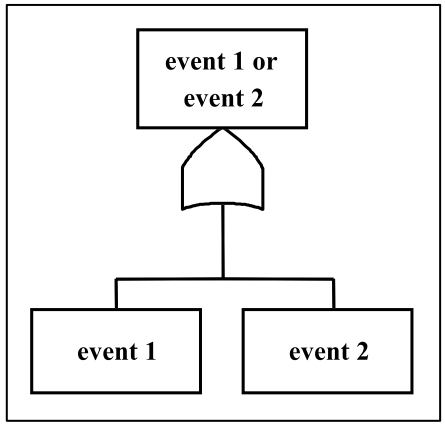

Figure D-4 OR Gate

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

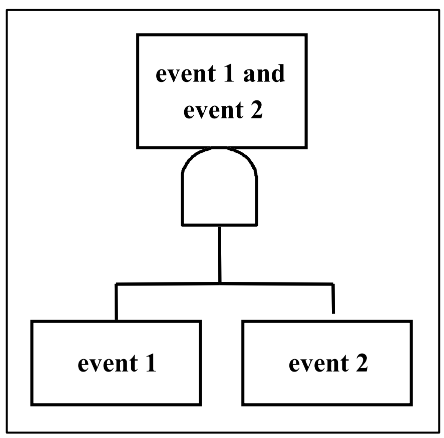

Figure D-5 AND Gate

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.

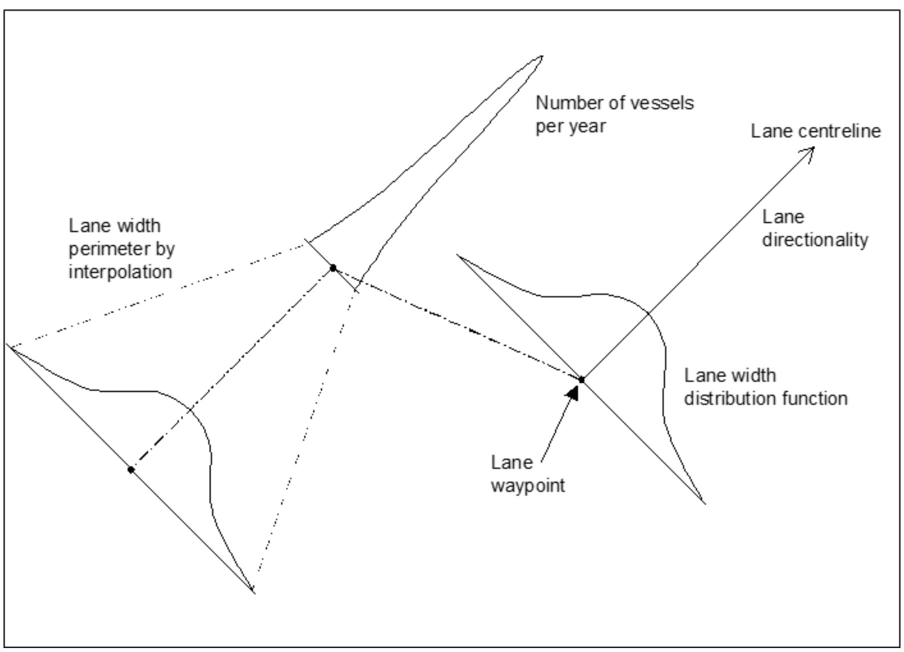

Figure D-6 Shipping Lane Representation Used in MARCS

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.

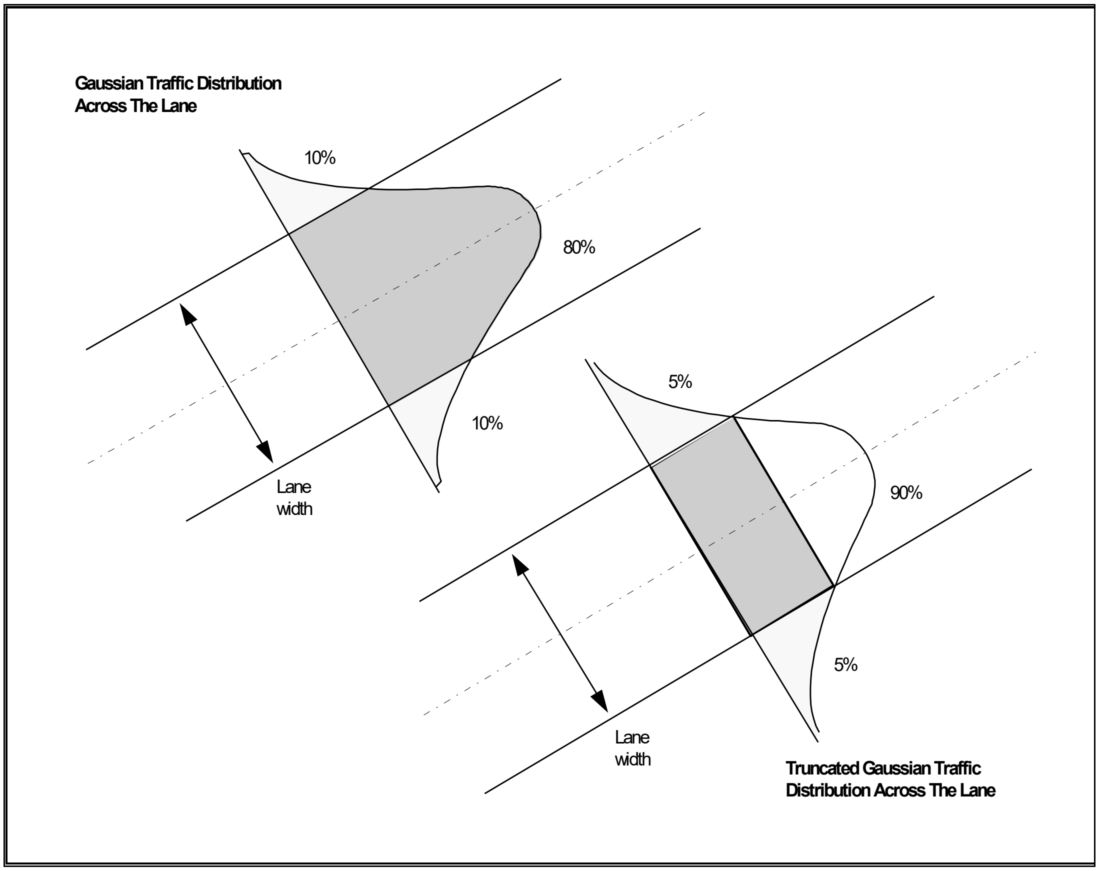

Figure D-7 Shipping Lane Width Distribution Functions Used in MARCS

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%)
- Fraction of vessels travelling faster and slower than the average speed (generally ± 20%)
- Fraction of vessels that exhibit “rogue” behavior (generally set to 0%, 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 are 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.

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 kt to 20 kt, Beaufort 0 to 4); fresh (20 kt to 30 kt, Beaufort 5 to 6); gale (30 kt 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 enable 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 location 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 NM 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.

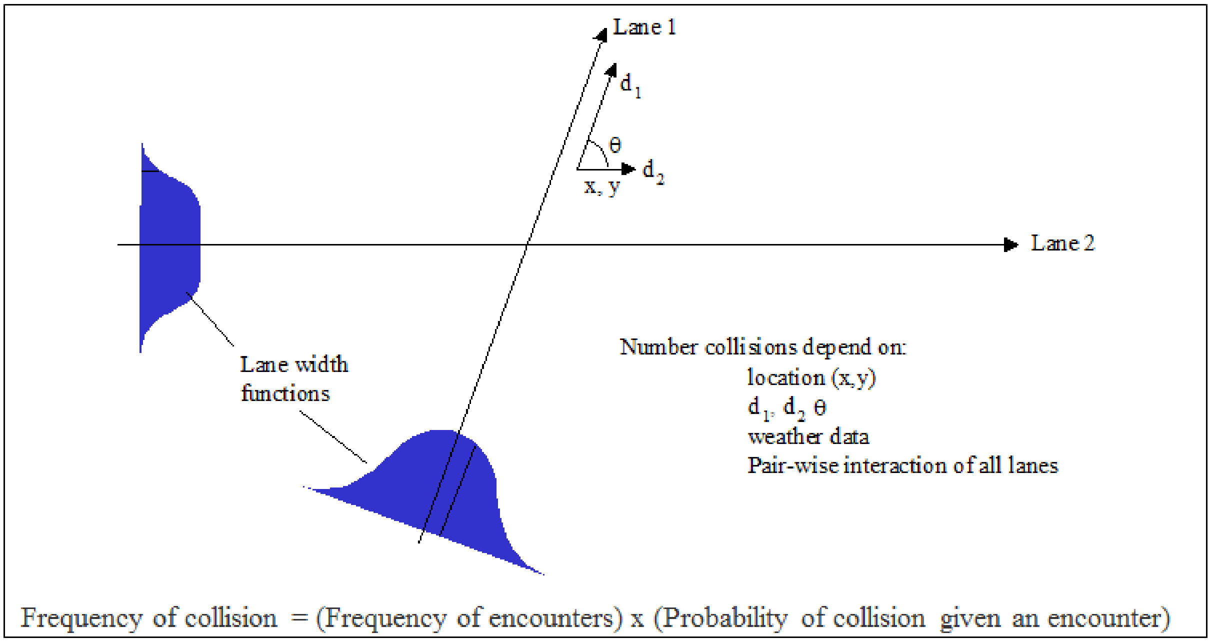

Figure D-8 Graphical Representation of the Collision Model

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 ships 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.

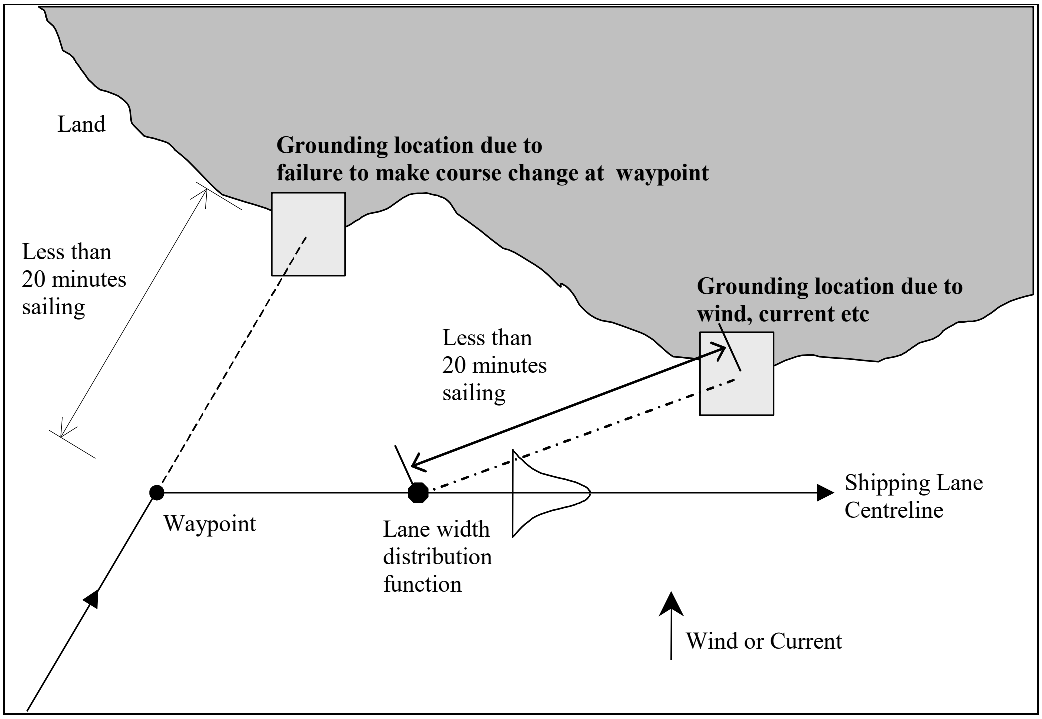

Figure D-9 Graphical Representation of the powered grounding model

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, control of drifting ships can be recovered 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.

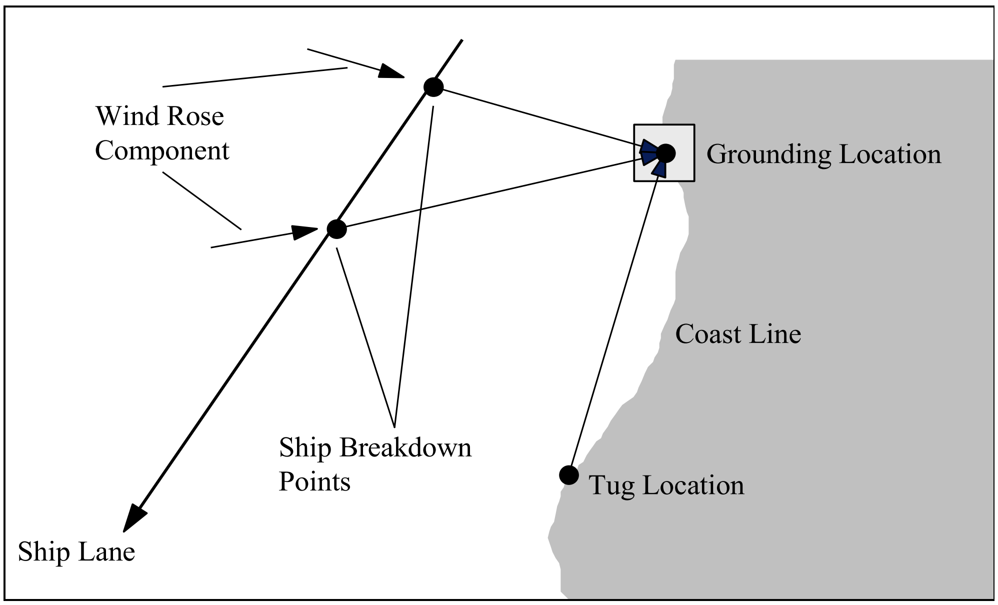

Figure D-10 Graphical Representation of the Drift Grounding Model

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.

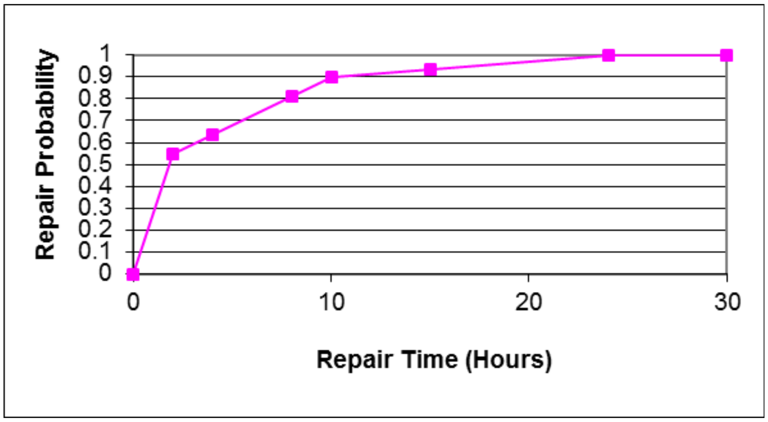

Figure D-11 Graphical representation of the self-repair save mechanism

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 sea bed + 300 m to stop the ship + 300 m for the length of ship + 100 m for clearance = 800 m, or 0.5 NM (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 sea beds consist predominantly of sands, silts, and muds). If the anchor holds, then an anchor save is made.

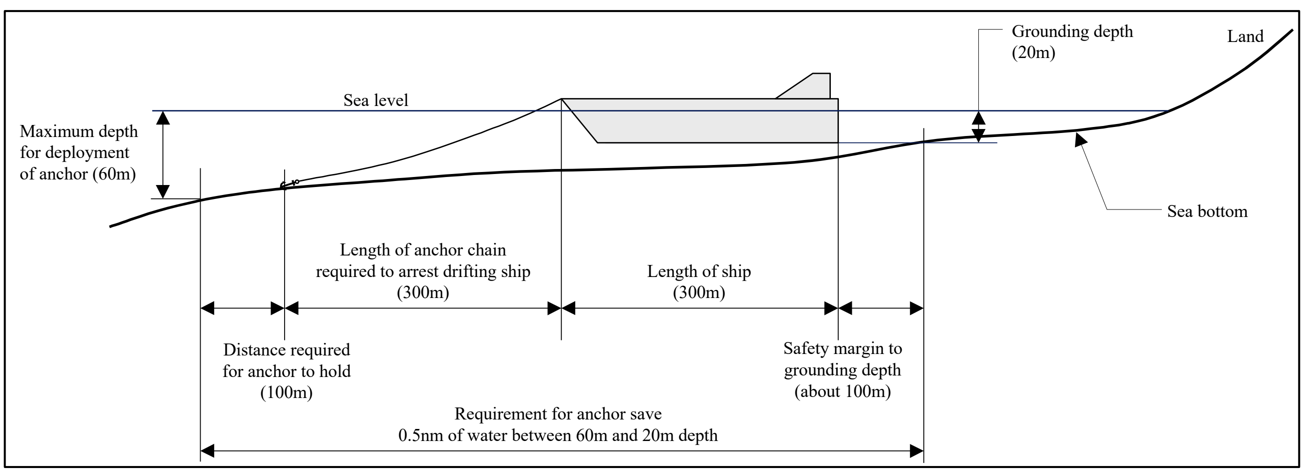

Figure D-12 Graphical Representation of the Anchor-Save Mechanism

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.

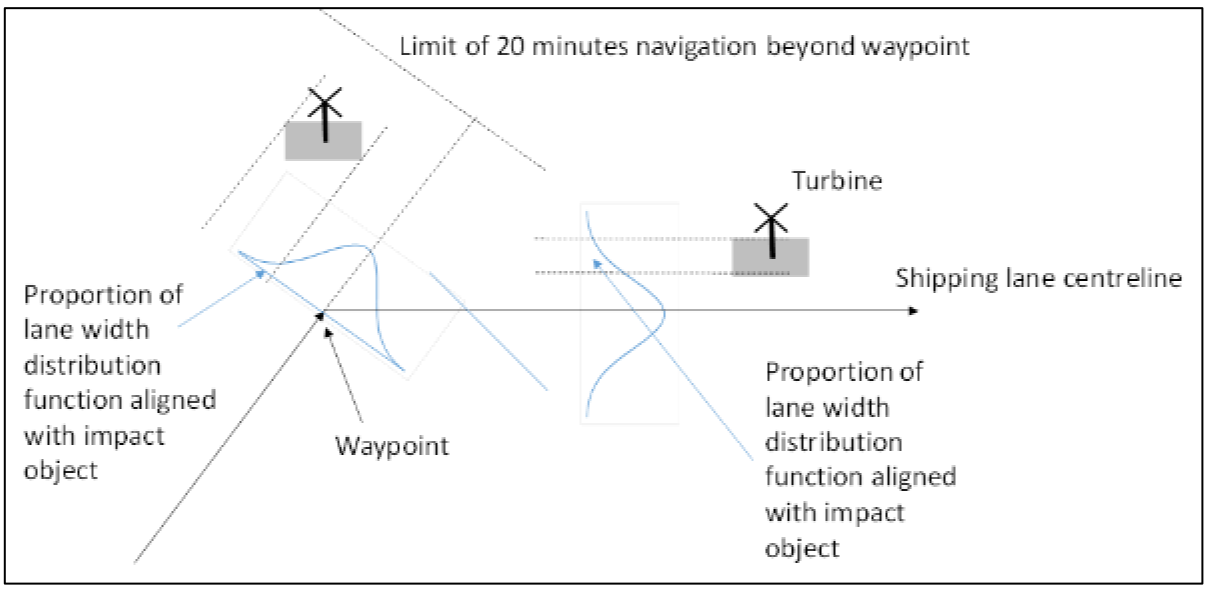

Figure D-13 Graphical Representation of Powered-Impact Model

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[26] 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 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."

[26] "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.

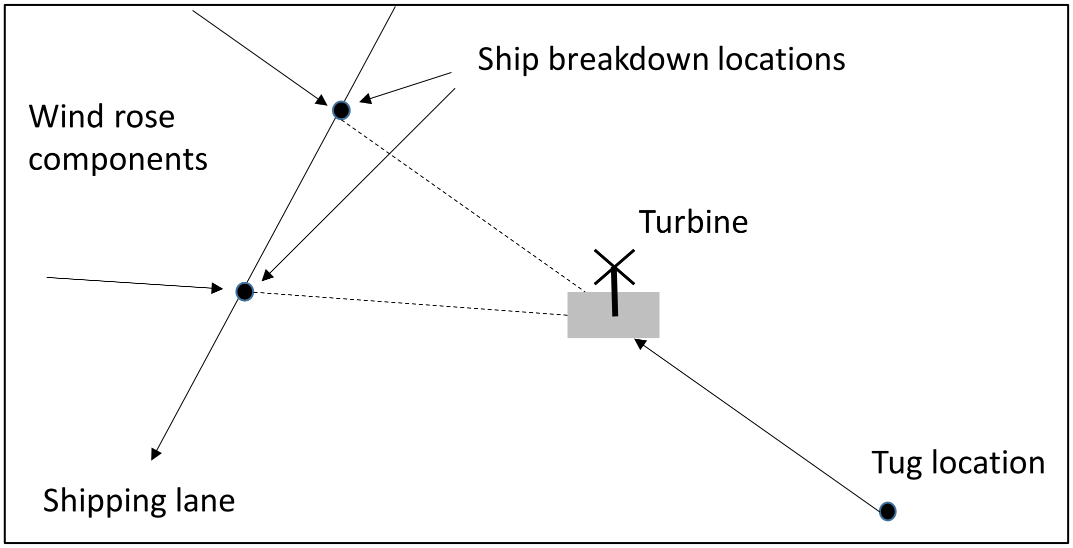

Figure D-14 Graphical representation of the drift impact model

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%, 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 gives an overall relative risk of 0.8 (i.e., a 20%

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, 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%. 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% 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%. 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 aids to navigation (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% 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%, which is justified by these 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.5.3.3 Port State Control

Port State Control is the inspection of foreign ships in national ports to verify that the condition of the ship and its equipment comply with the requirements of international regulations and that the ship is manned and operated in compliance with these rules. In this report, the term Port State Control is also used to include other general shipping industry initiatives with similar goals, such as: new IMO regulations; improved class rules; enhanced surveys; improved design; International Safety Management and improved bunker fuel oil quality testing.

The effects of Port State Control are generally considered to be increased compliance with international regulations, including rest periods, and a reduction in sub-standard ships. This is expected to affect ship safety for all accident types. The effect of Port State Control is represented in the model by:

Applying a relative risk factor of 0.88 for all the technical failure rates in the risk model. This directly affects the frequency of drift grounding, fire/explosion and structural failure/foundering. It also has a very minor impact on collision and powered grounding (which are dominated by human error and human incapacitation).

Applying a human error and human incapacitation relative risk factor of 0.88 in the collision and powered grounding accident models. This represents the emphasis placed on international safety management issues by Port State Control inspections and should help ensure reductions in the likelihood of excessively fatigued navigating officers.

It should be noted that Port State Control is one of several risk controls which the shipping industry has implemented to improve reliability and safety. Improved fuel quality monitoring by shipping companies is another. MARCS assumes that all these risk controls are represented by Port State Control.

D.6 Additional background on MARCS

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 navigation risk projects

North East Shipping Risk Assessment, PP042653, 2012-2013

The Australian Maritime Safety Agency (AMSA) is the Australian government agency with primary 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 northeast area of Australia. The results were used to guide AMSA's decision making processes.

Aleutian Islands Marine Risk Assessment, EP007543, 2009-2011

The Aleutian Island chain to the southwest 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 USCG. A team from Environmental Resources Management (ERM) and DNV 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 MARCS model 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 six 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.6.2 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 program by a consortium of 10 European organizations 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 program 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 program. 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 eight risk reduction measures via three case studies (English Channel, North Sea and Rotterdam Port Approach).

D.6.3 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 MARYLAND OFFSHORE WIND PROJECT 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 and for each ship type.

MARCS was used to calculate the frequency of collision, grounding, and allision for each cell defined by a grid covering the MARCS Study Area. The model estimates 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. Note, this appendix only reports accident frequency results. The possible consequence of accidents, and hence the accident risk, is discussed in the main report. Nevertheless, in this appendix “risk” is sometimes used as shorthand for accident frequency.

The modelling is reported in terms of specified scenarios. Each scenario consists of a set of inputs, normally focused on the number of allision objects (WTGs, offshore sub-stations, Met tower) included in the scenario.

Three cases are reported for each scenario:

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 ship types will navigate around the wind farm once it is installed.

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

Each scenario is described at the start of the relevant scenario results section below.

E.2 Model inputs

E.2.1 Study area

This is a quantitative assessment of collision, allision, and grounding in the modeled MARCS Study Area during operation of the Project. The MARCS Study Area utilized in the MARCS modelling of the new Maryland Offshore Wind Farm (the Project) is shown in Figure E-1. Note the distinctions between the Project Area, MARCS Study Area, and NSRA Study Area (Study Area).

The modeled data are in the MARCS Study Area, bounded by:

- Latitude 38.75 to the north
- Latitude 38.00 to the south
- Longitude -75.25 to the west
- Longitude -74.25 to the east

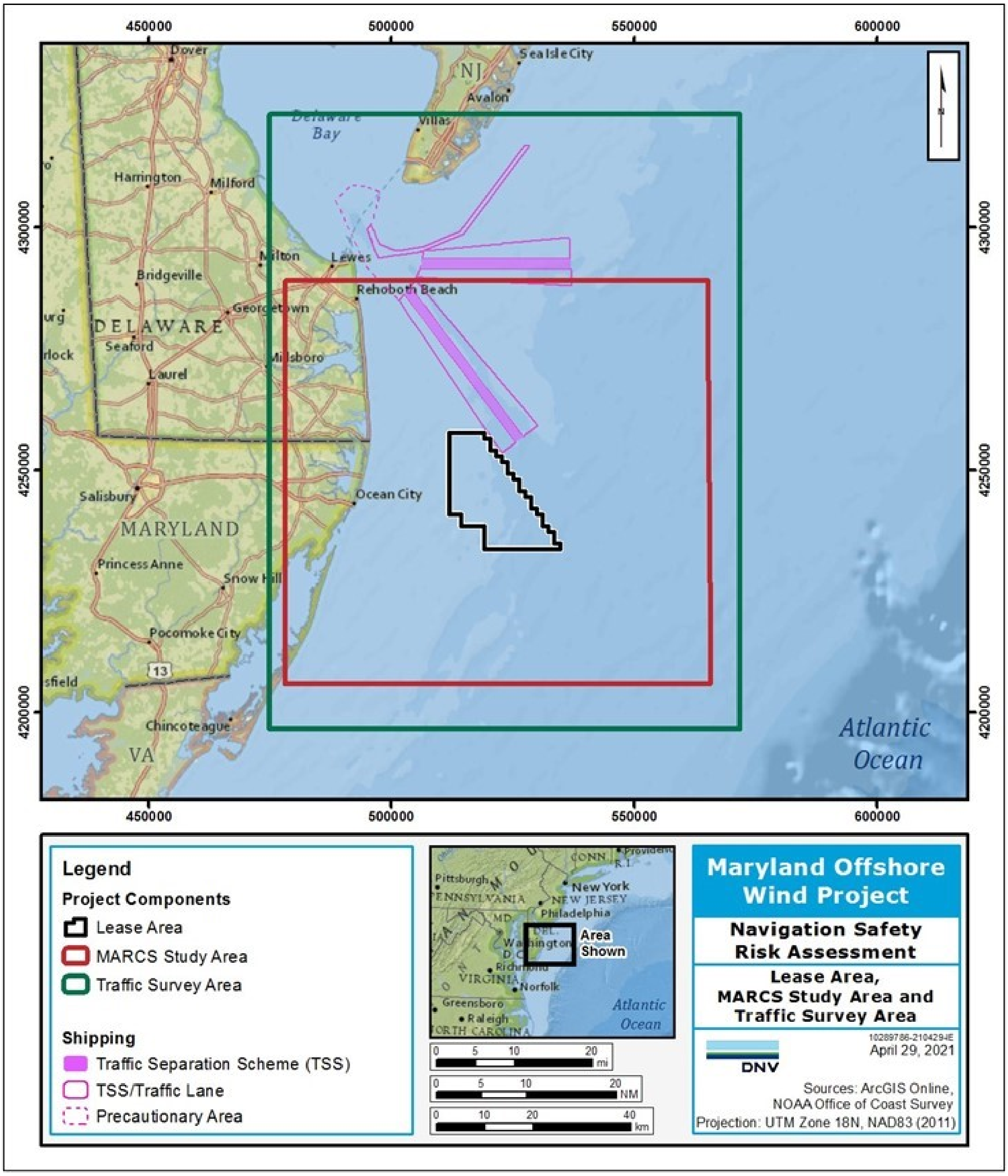

Figure E-1 Quantified Risk MARCS Study Area

Accident frequency result areas (or sub-areas) are presented in Figure E-2.

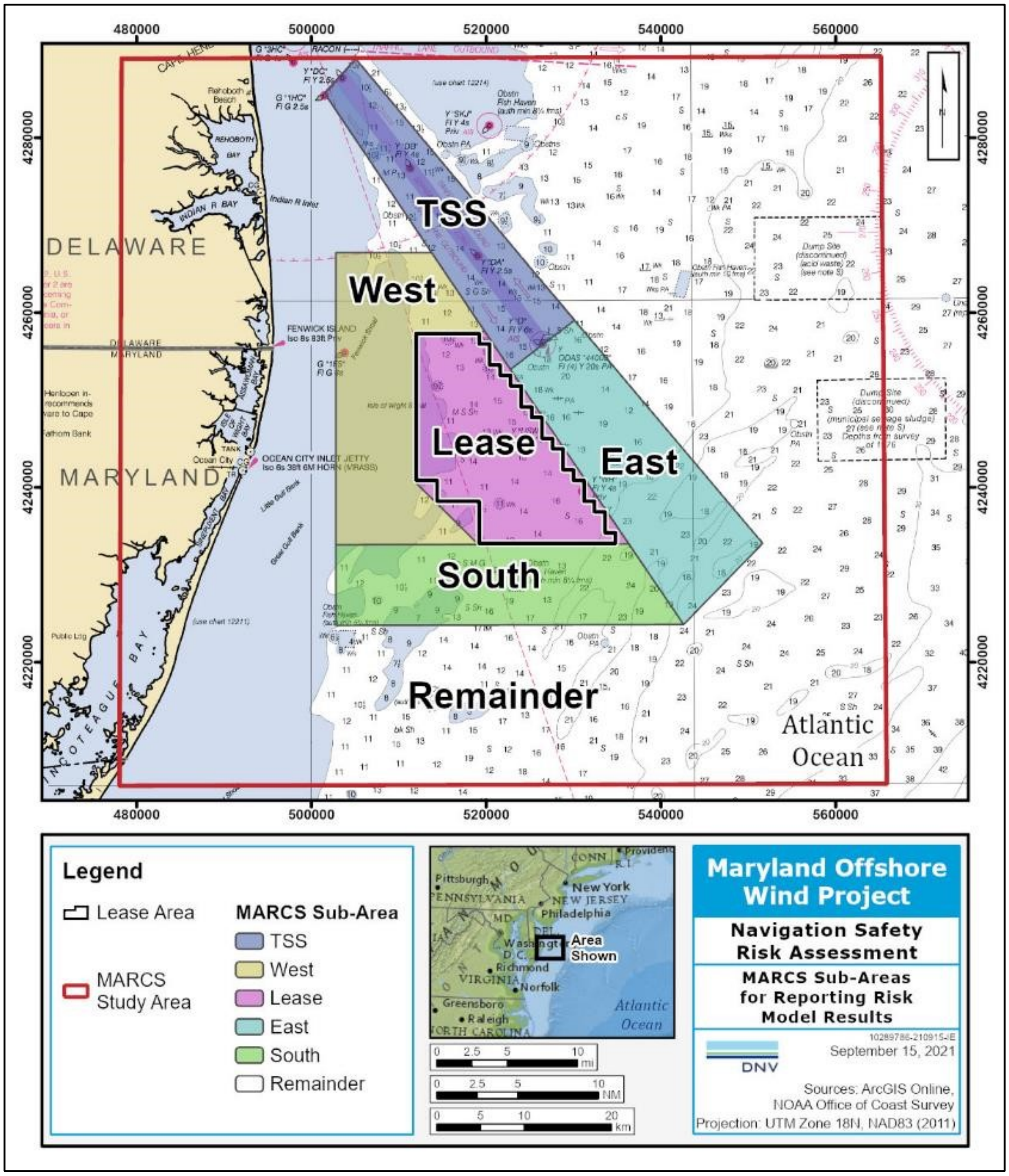

Figure E-2 Defined Sub-Areas within the MARCS Study Area

E.2.2 Wind farm

The Project is modeled as a maximum of 126 Project structures, consisting of 121 WTGs, 4 offshore substations (OSSs) and 1 Meteorological (Met) tower, see Figure E-3. The sea level footprint (collision cross-section) of all the WTGs is 12 m, the footprint of all the OSSs is 92 m (2 structures) and 52 m (2 structures) and the footprint of the Met tower is 21 m. Project OSS and WTGs are separated by a minimum distance of 0.767 NM. The locations and sizes (collision cross-sections) of the structures are presented in Section 1 of the main report.

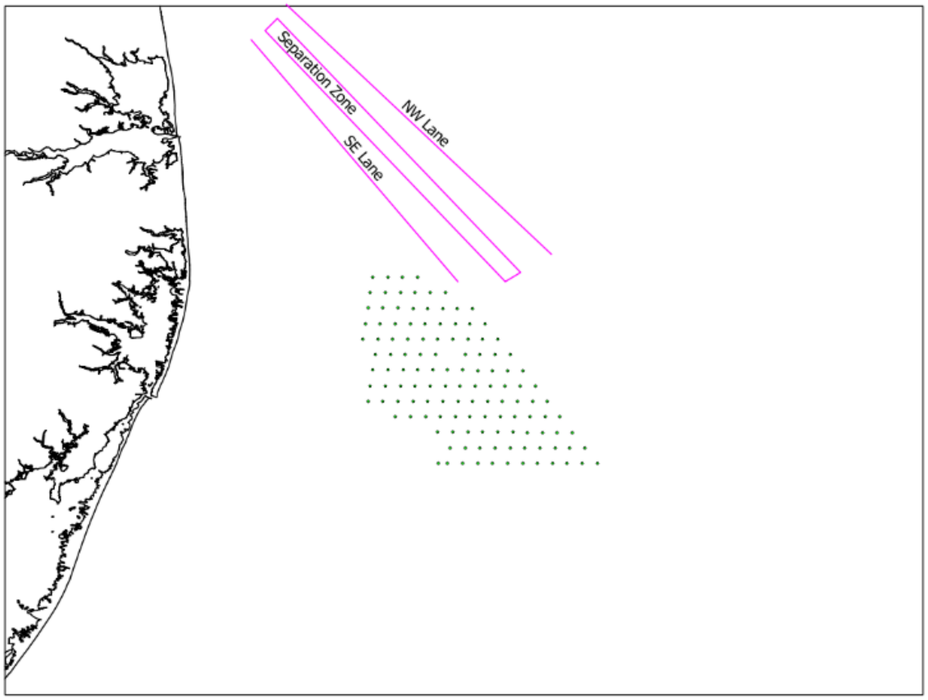

Figure E-3 Location of the Project Structures in the MARCS Study Area

E.2.3 Metocean inputs

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

Wind

MARCS uses the wind speed and direction as a modelling 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 the Climatology of Global Ocean Winds (COGOW) (2009) (1 January 2000 through 31 December 2008) were obtained from the Climatology of Global Ocean Winds (COGOW) website (2009).

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)	5.14%	4.92%	4.13%	3.95%	4.16%	4.54%	5.21%	5.62%	37.66%
20 – 30 (Fresh)	9.06%	9.13%	8.75%	0.00%	8.30%	8.63%	8.83%	8.89%	61.58%
30 – 45 (Gale)	0.24%	0.25%	0.00%	0.00%	0.00%	0.00%	0.00%	0.25%	0.74%
> 45 (Storm)	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.02%
Total	14.44%	14.30%	12.88%	3.95%	12.45%	13.17%	14.04%	14.76%	100.00%

Visibility

The Journal of Navigation's information regarding marine traffic studies[27] defines poor visibility as beginning at 2.2 NM (4.0 km). 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.

Table E-2 Visibility (NOAA, 2020c)

Visibility in NM	Frequency	Modeled visibility
< 1	3.5%	Bad visibility = 7.60% of an average year
1 – 2*	4.1%	
2 – 3	4.2%	Good visibility = 92.4% of an average year
3 – 4	3.3%	
4 – 5	2.9%	
5 - 6	2.8%	
6 - 7	2.7%	
7 - 8	2.9%	
8+	73.6%	
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 MARCS Study Area was modeled as an "open water" area because the MARCS Project Area is located at least 9 NM (16.7 km) from the nearest shoreline and is in the Atlantic Ocean.

[27] G.R.G. Lewison, "The Estimation of Collision Risk for Marine Traffic in UK Waters," Journal of Navigation, September 1980.

Shoreline

Figure E-1 illustrates the shoreline used in MARCS. The defined shoreline identifies possible grounding locations for the model.

E.2.4 Traffic data

Traffic data was derived by analysis of 1.77 million lines of Automatic Identification System (AIS) data for the time period between 1 January 2019 and 31 December 2019 for the MARCS Study Area. MARCS uses a statistical representation of aggregated ship tracks (Appendix D) and up to eight distinct traffic types. The AIS data was initially allocated to 7 traffic types as shown in IDs 1 to 7 in Table E-3. Subsequent to this initial allocation, traffic type 7 (Tugs) was allocated to Tug-ATB (traffic type 7) and Tug-Towline (traffic type 8) on a 50:50 basis, see this section below.

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 in Table E-3.

Table E-3 Traffic types used for MARCS analysis

ID	Traffic type name	Average Speed (knots)
1	Cargo Tanker	10.2
2	Cruise Ferries	16.5
3	Fishing	6.3
4	Other	7.7
5	Passenger	11.3
6	Pleasure	13.1
7	Tug-ATB	8.1
8	Tug - Towline	8.1

The AIS data initially allocated to type Tug was subsequently re-allocated into 2 tug types as follows:

- 50% of the tugs in the AIS data were assigned to traffic type 7 (Tug-ATB). These are Articulated Tank Barges (ATB) and similar tug configurations. ATBs are typically 450 ft LOA (139 m), but sometimes 475 ft (146 m) and up to 750 ft (230 m).
- 50% of the tugs in the AIS data were assigned to traffic type 8 (Tug-Towline). These are tugs towing a barge on a long line. These will be represented with lengths of 927 m and widths of 463 m to account for the barge and the long line.

The AIS dataset was analyzed in the following stages:

- Dirty 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.

The Base Case route structure derived from the above analysis of the AIS data is shown in Figure E-4.

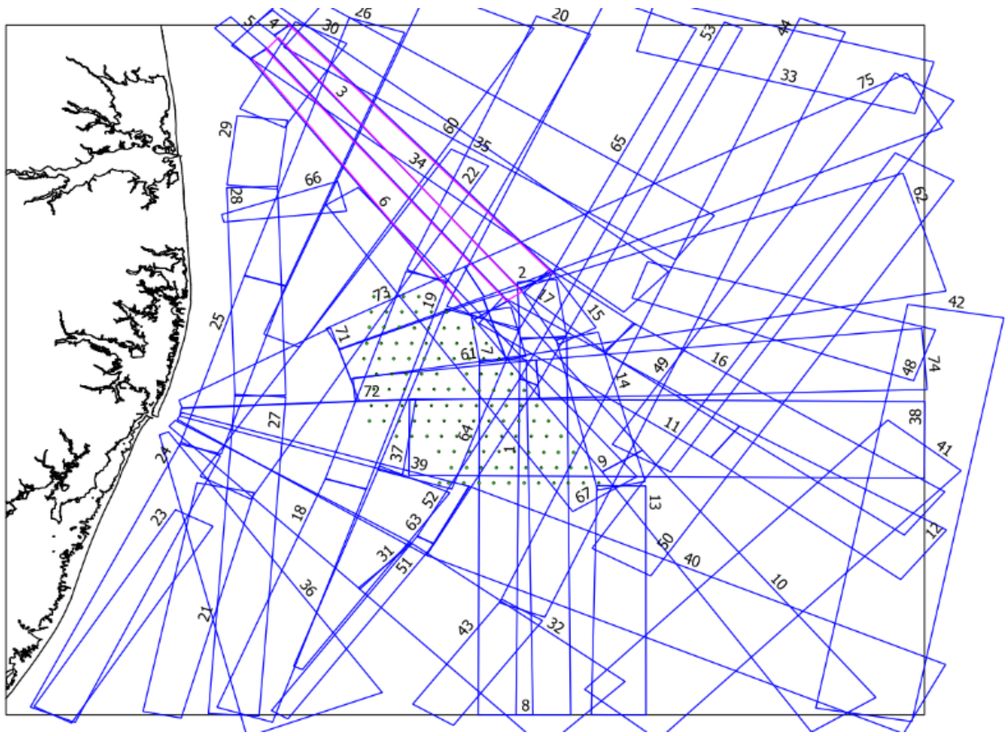

Figure E-4 Base Case Route Structure Derived from Analysis of AIS Data

The decision concerning whether and how to account for nearby wind leases involves a trade-off. If the other leases are ignored for purposes of the model, the risk estimate accounts for the Project in isolation. If instead, it is assumed that all of the leases are built upon, the risk estimate would represent the extreme of future 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 area structures are built upon.

Figure E-5 shows the additional wind farm leases which were avoided when re-routing the future traffic.

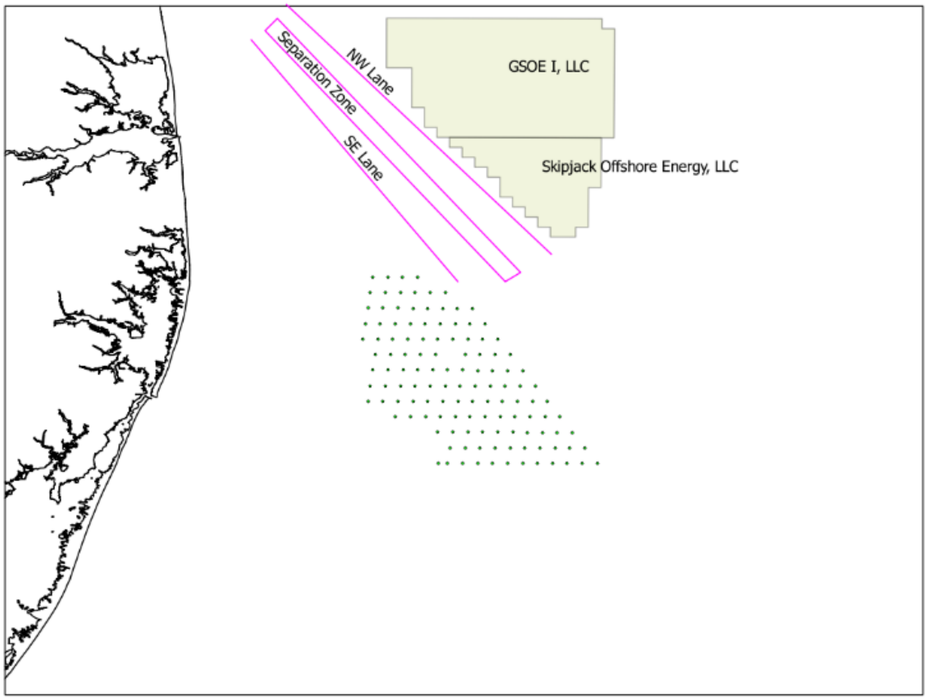

Figure E-5 Wind farm lease areas which were avoided when re-routing Future Traffic

E.2.5 Traffic data adjustments

The traffic data derived from AIS data analysis were adjusted to correctly represent the data required for each calculation. 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 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 MARCS Study Area, special care was placed on estimating additional traffic, such as recreational and commercial fishing vessel traffic, in the vicinity of the Project that may not have been captured in the AIS dataset.

- The frequency of non-AIS transmitting fishing vessels is equal to 50% of the frequency of AIS transmitting fishing vessels. These non-AIS fishing vessels use the same routes as the AIS-transmitting fishing vessels. These non-transmitting fishing vessels will be smaller than those fishing vessels that transmit AIS. The extra manually added fishing vessels were allocated equally to the two smallest size categories (0-10 m LOA and 10-20 m LOA). This is DNV expert judgment based on input from USCG Navigation Center of Excellence that their statistical evaluation of

The USCG Navigation Center of Excellence provided its conclusion to use a 12.5% increase in commercial fishing vessel populations (on the basis of AIS data) to better represent the total population of commercial fishing vessels in the area(USCG, 2021j).

- In addition, 1220 transits per year outbound (plus the same inbound) of Pleasure ships were assumed to transit from Ocean City to the center of the wind farm on 3 routes, see Figure E-6. All these ships are also allocated to the two smallest size categories for pleasure ships (0-10 m LOA, 10-20 m LOA). This is based on expert judgment of DNV together with SeaRisk Solutions who developed the following estimates of current recreational fishing in the vicinity of the Lease Area:
  - December through March – 2 trips to/from the Lease Area per day
  - April – 3 trips to/from the Lease Area per day
  - May through August – 5 trips to/from the Lease Area per day
  - September through November – 3 trips to/from the Lease Area per day

This traffic is added to the Base Case, to Base Case Plus and to the Future Case.

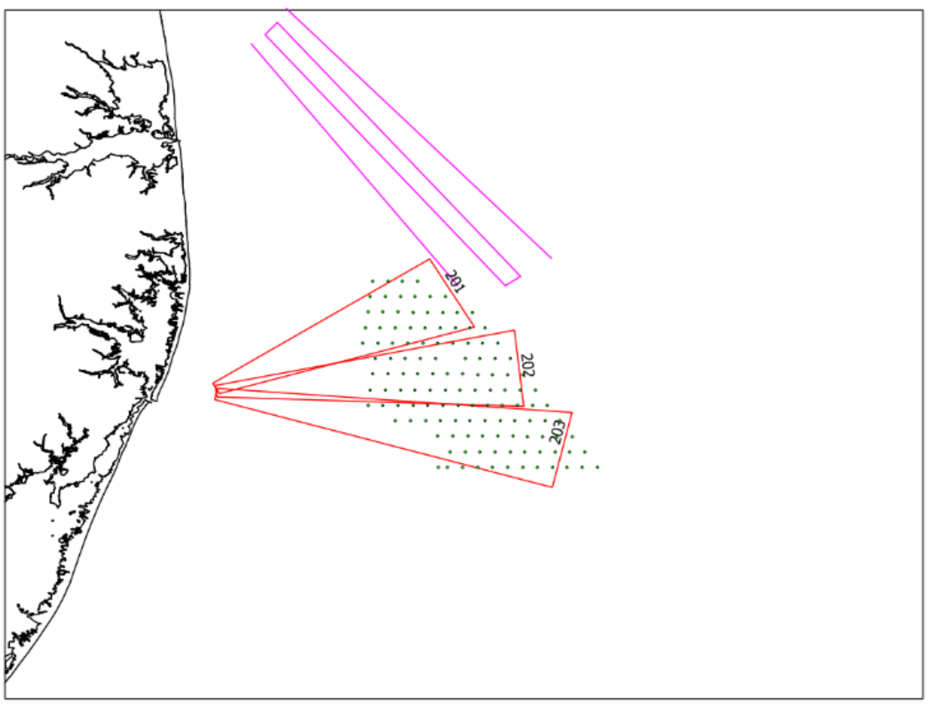

Figure E-6 Route for Additional Traffic from Ocean City to Centre of Maryland Wind

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.

- In the Future Case, tour, recreation and similar boats were assumed to have an annual frequency of 2034/year (just over 5.6 per day) outbound (plus the same inbound). These Pleasure transits were allocated to the 3 routes from Ocean City to the center of the wind farm, see Figure E-6 (1822 outbound and 1822 inbound) and to 1 route from Indian River to the center of the wind farm (212 outbound and 212 inbound). For all routes, these ships were added to the Pleasure category and were allocated equally to the two smallest size categories (0-10 m LOA and 10-20 m LOA). This is based on expert judgment of DNV together with SeaRisk Solutions who developed the following estimates of current pleasure boat activity in the vicinity of the Lease Area:
    - May through September – 15 trips to/from the Lease Area per day
    - April, October, and November – 7 trips to/from the Lease Area per day
    - June through September – 1 trip to/from the Lease Area per day
- In addition, 600 transits per year outbound (plus the same inbound) of Crew Transfer Vessels (CTVs) were assumed to transit from Ocean City to the center of the wind farm. These Passenger ships were allocated to the third ship size category (20-30 m LOA). This is based on US Wind's estimate of CTV trips to/from the Lease Area. Typical CTVs can navigate at 20 to 24 kt, and were modeled as such. Their crews are selected and trained to be familiar with the local conditions and hence they were assigned human performance characteristics similar to that of local pilots.

This traffic is added to the Future Case in addition to the traffic added to the Base Case and Base Case Plus.

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 developed alternative routes for vessels to avoid the Project Area and to minimize the additional navigation while taking account of the existing TSSs and the two additional wind farm that will be constructed. Only the following ship types were re-routed in the Future Case: Cargo Tanker (type 1), Cruise Ferries (type 2), Tug-ATB (type 7) and Tug-Towline (type 8).

Figure E-7 shows an example of how this modification was performed for two of the routes that needed modification.

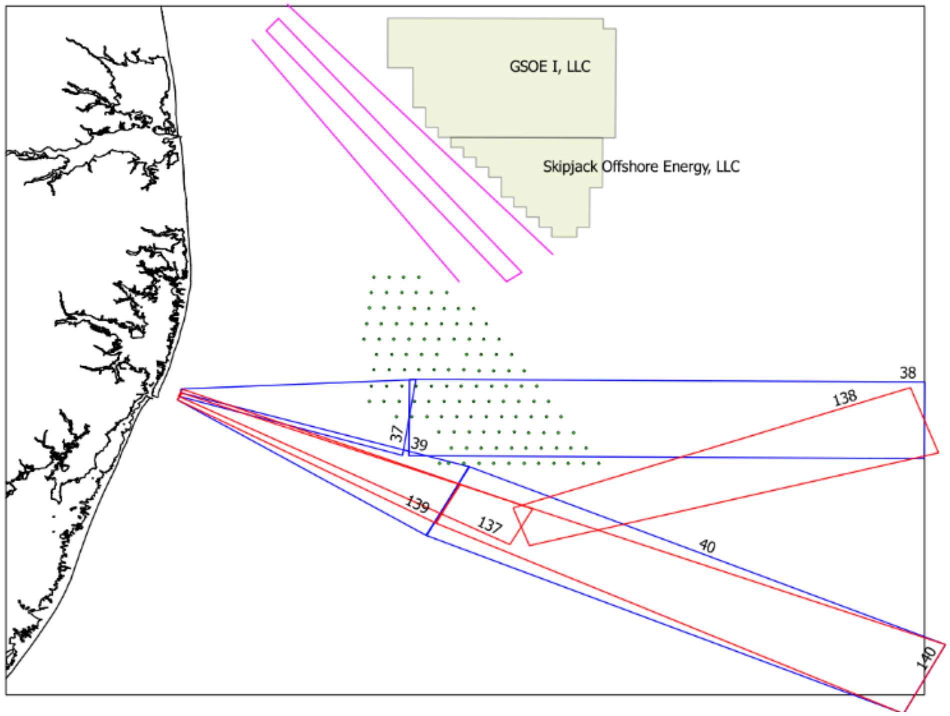

Figure E-7 Re-Routing of Routes going through Project Area (Dark Blue are the Base Case Routes, Red are the Future Case Re-Routes and Light Blue shows the approximate location of the Extended Outbound TSS Lane)

E.2.6 Operational inputs

The MARCS model can apply different risk reduction options to a specific type of traffic and/or to a specified area. For this study, the risk controls applied do not depend on the location of ships within the MARCS Study Area. The risk controls applied to vessels transiting are described in Table E-4 as a function of ship type Id (see Table E-3).

Table E-4 Risk controls applied in MARCS modelling for the MARCS Study Area

Risk Control \ Ship Type Id	1	2	3	4	5	6	7	8
Differential global positioning systems	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Electronic chart display and information system	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Port State Control	Yes	Yes	No	No	No	No	No	No
Vessel traffic services	No	No	No	No	No	No	No	No
Pilotage	No	No	No	No	No	No	No	No
Portable pilotage unit	No	No	No	No	No	No	No	No
Underkeel clearance management	No	No	No	No	No	No	No	No

Note, if a risk control is not applied to all ships of the specified ship 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.2.7 Detailed lane lateral distribution function analysis

The new Maryland Offshore Wind Farm is to be located immediately south-west of the outbound TSS lane from Delaware Bay, see Figure E-8.

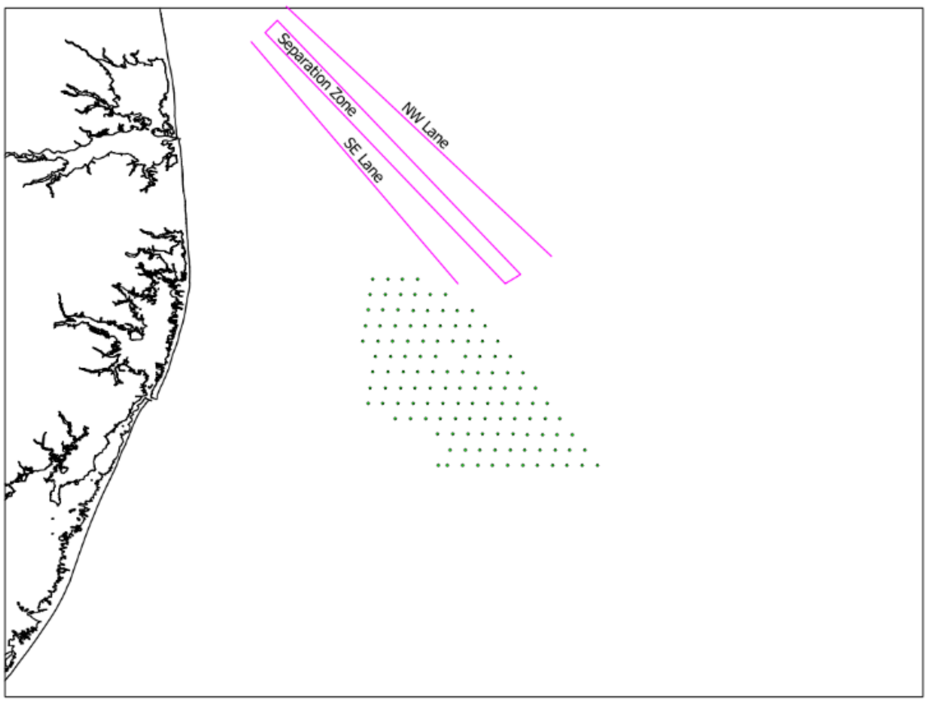

Figure E-8 Location of the Proposed New Maryland Offshore Wind Farm and the Existing Traffic Separation Scheme

The proximity of the outbound lane to the proposed WTGs means that the allision risk will depend significantly on the traffic lateral distribution function. This function can be quantified by detailed analysis of the AIS data. This is described in this section.

Ten gates or transects, each 10km wide, were defined perpendicular to the outbound TSS lane centerline as shown in Figure E-9 (note the map projection used in Figure E-9 is not square, so 90º angles may not look like they are 90º).

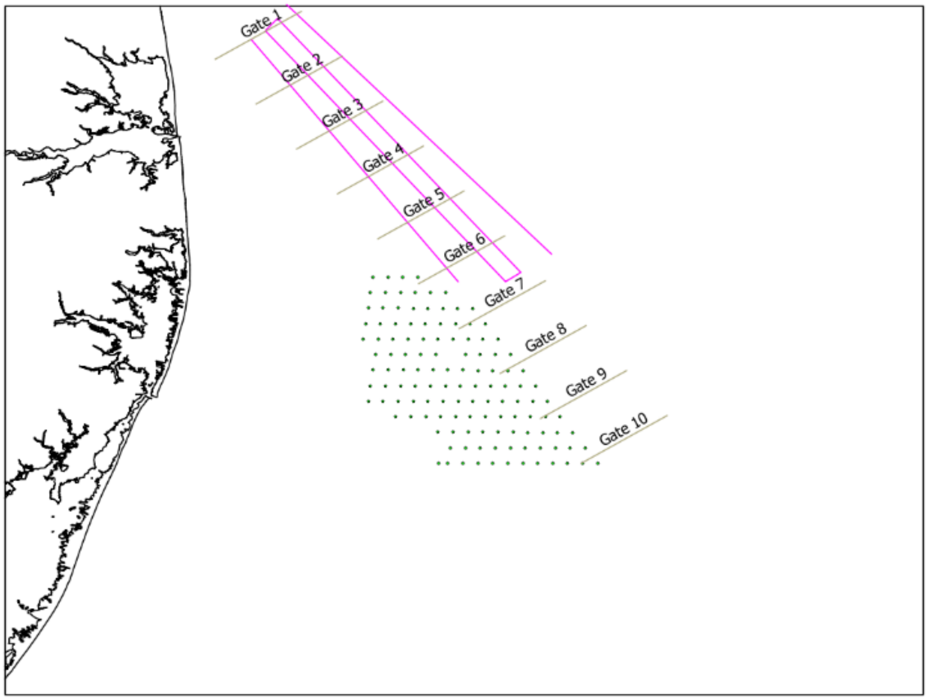

Figure E-9 Definition of Gates or Transects for the Detailed Lane Lateral Distribution Function Analysis

Each track link in the AIS track file was read and the point of intersection of the link with each gate was calculated. If the point of intersection was within the 10km width of the gate, then the point was added to the appropriate bin of the histogram for that gate. Histograms were calculated for all traffic and for traffic with headings within 25º of the bearing of the outbound lane centerline (145°), for all traffic and for each traffic type. The results for Gates 1 to 10 are shown in Figure E-10 to Figure E-19. These figures also show the limits of the defined TSS (outbound on the right, inbound on the left).

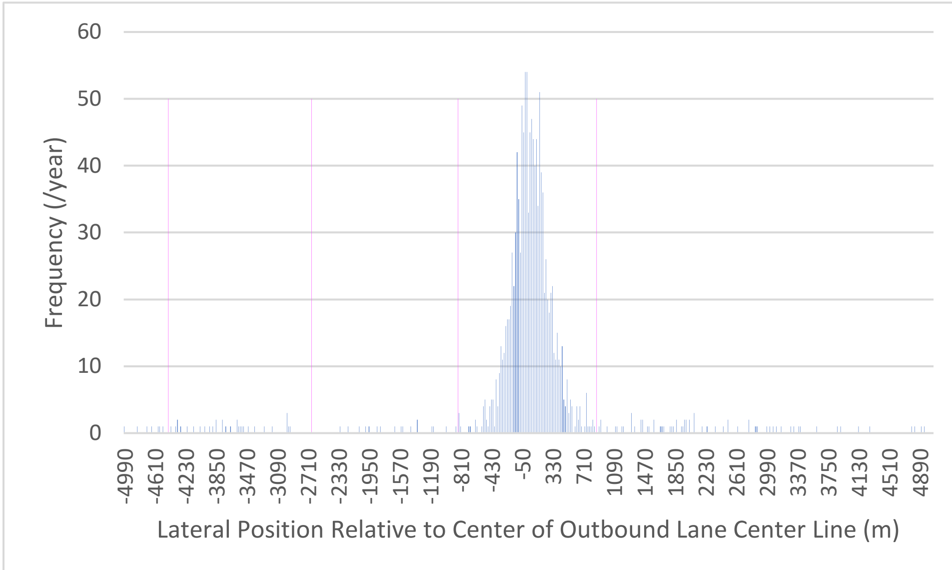

Figure E-10 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 1

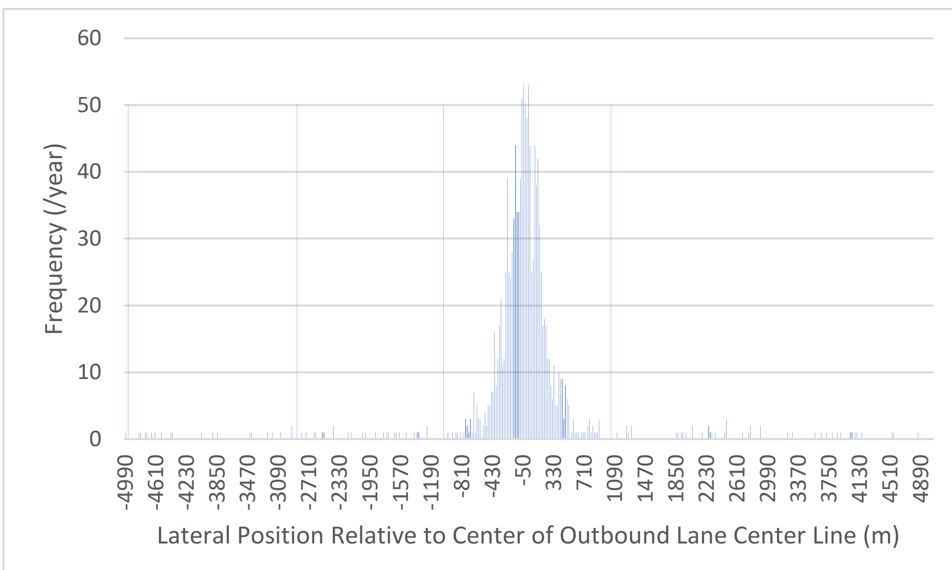

Figure E-11 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 2

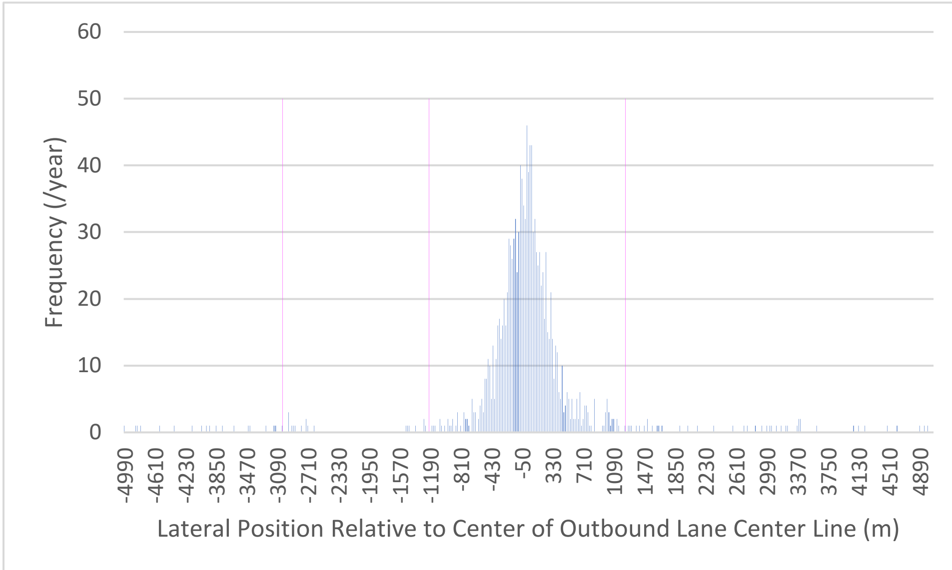

Figure E-12 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 3

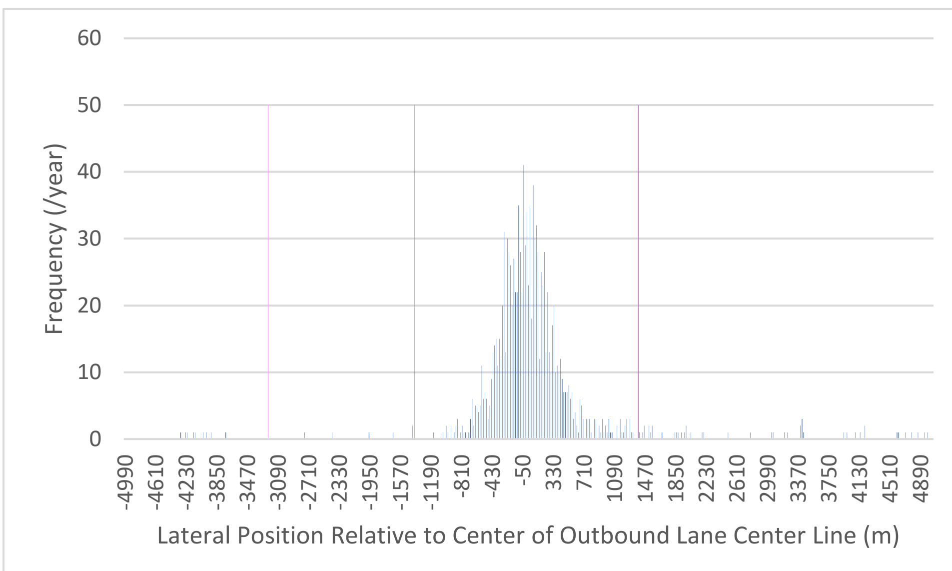

Figure E-13 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 4

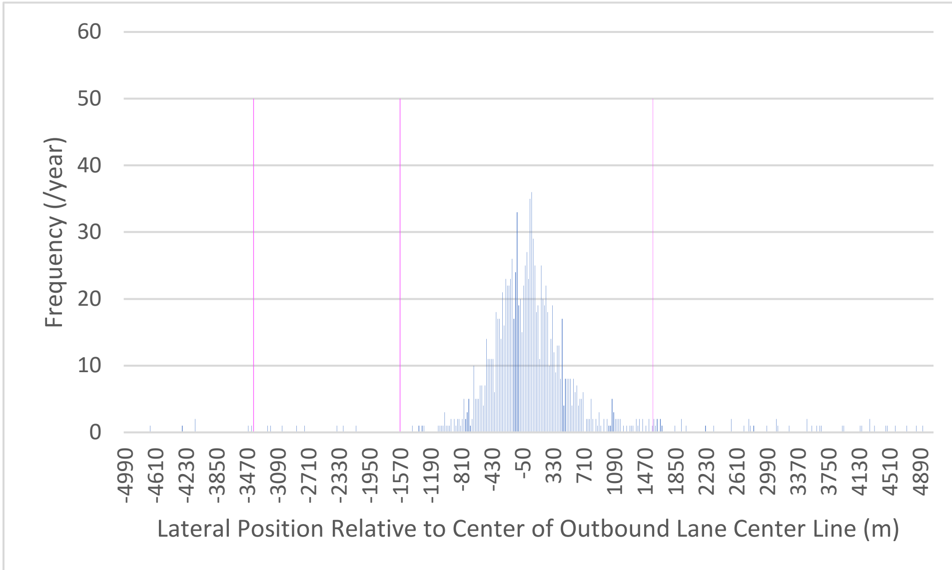

Figure E-14 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 5

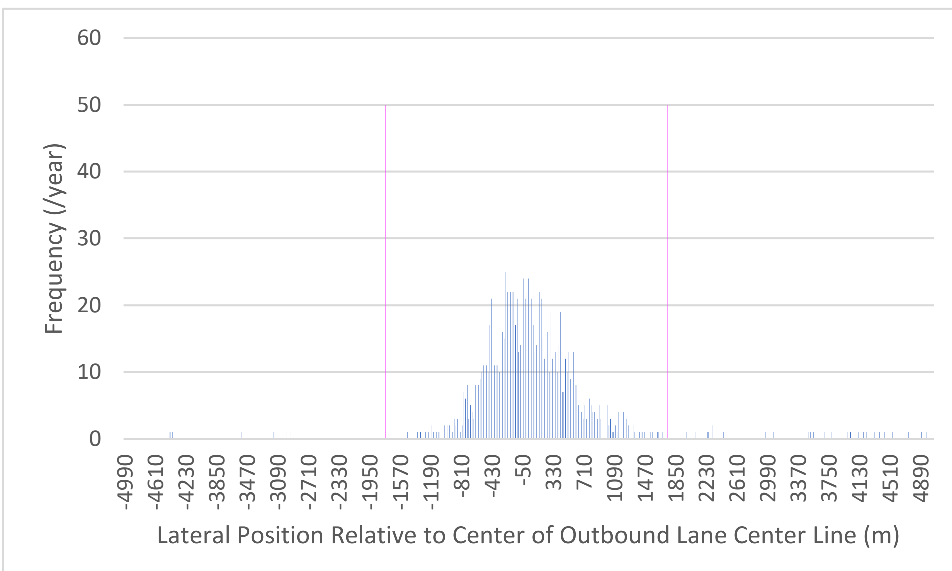

Figure E-15 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 6

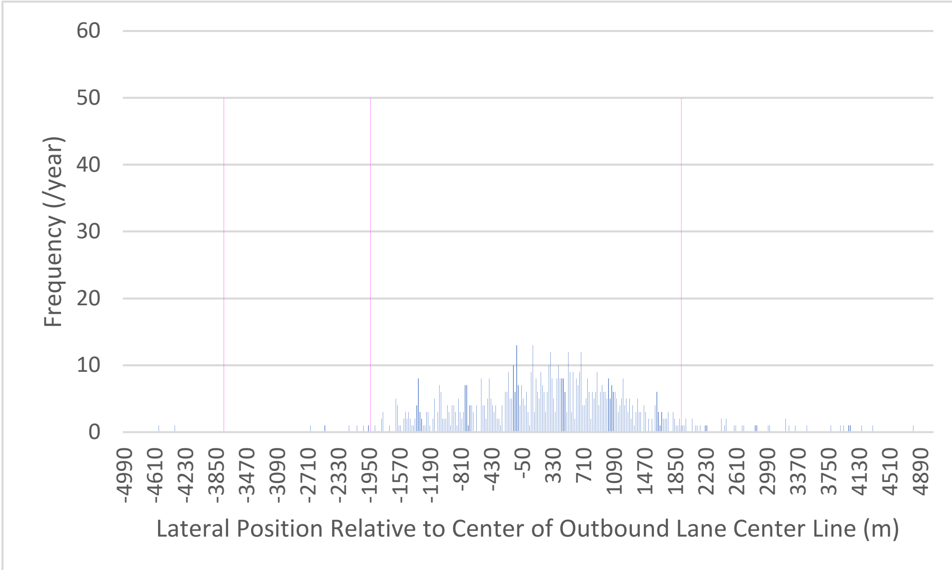

Figure E-16 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 7

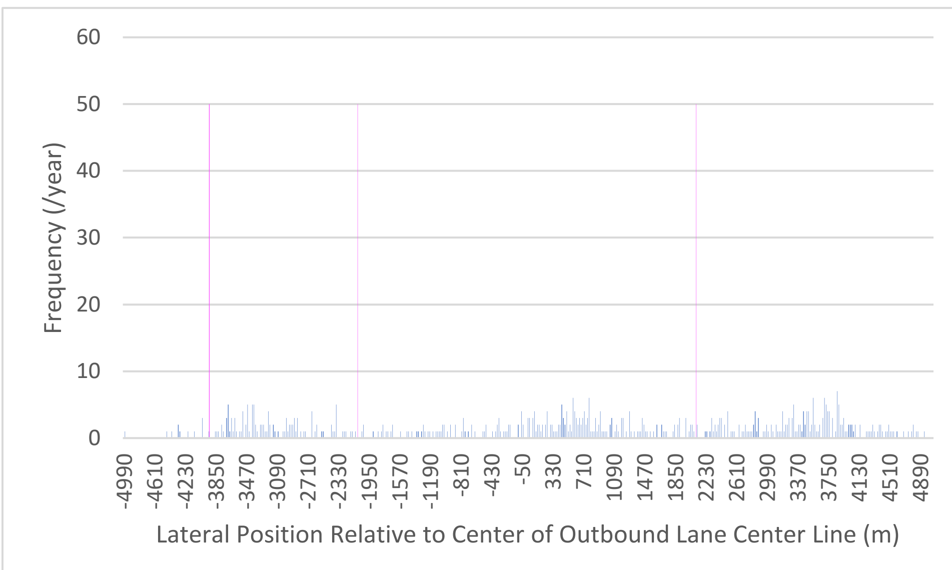

Figure E-17 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 8

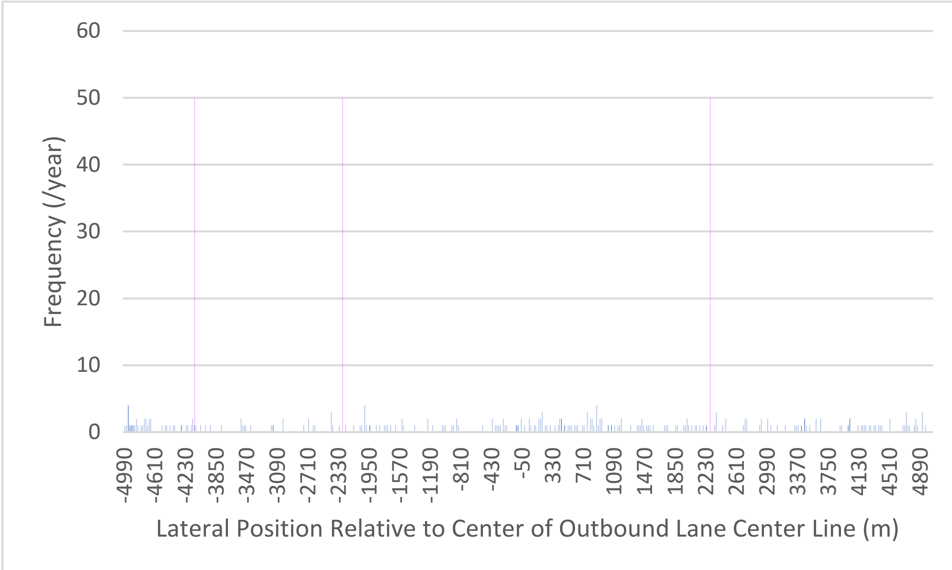

Figure E-18 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 9

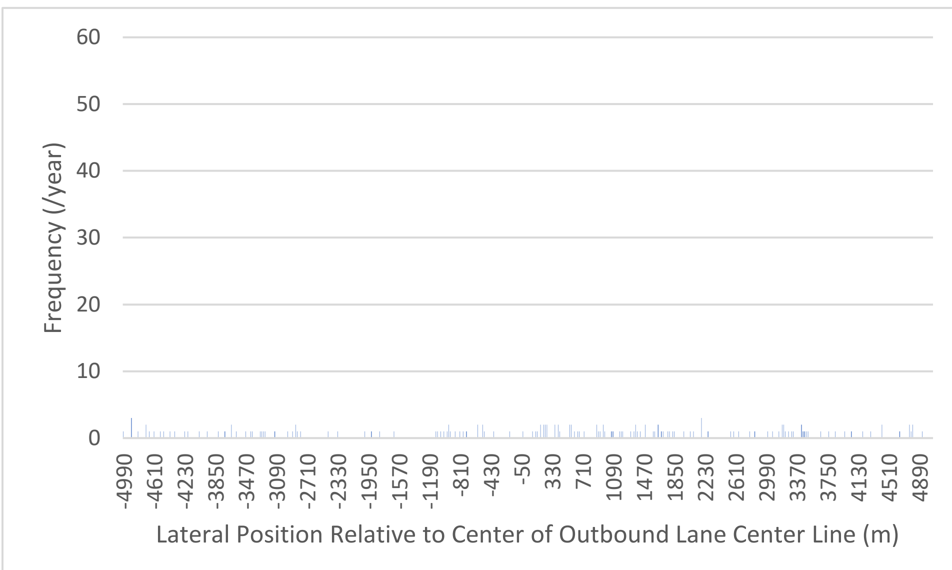

Figure E-19 Histogram of the Outbound Lane Lateral Traffic Distribution Function for Gate 10

These histograms show the coherence (degree of bunching) of the outbound traffic is rapidly lost as the traffic exits the TSS at and soon after Gate 6.

The results shown for Gates 1 to 8 in Figure E-10 to Figure E-17 are summarized in Figure E-20.

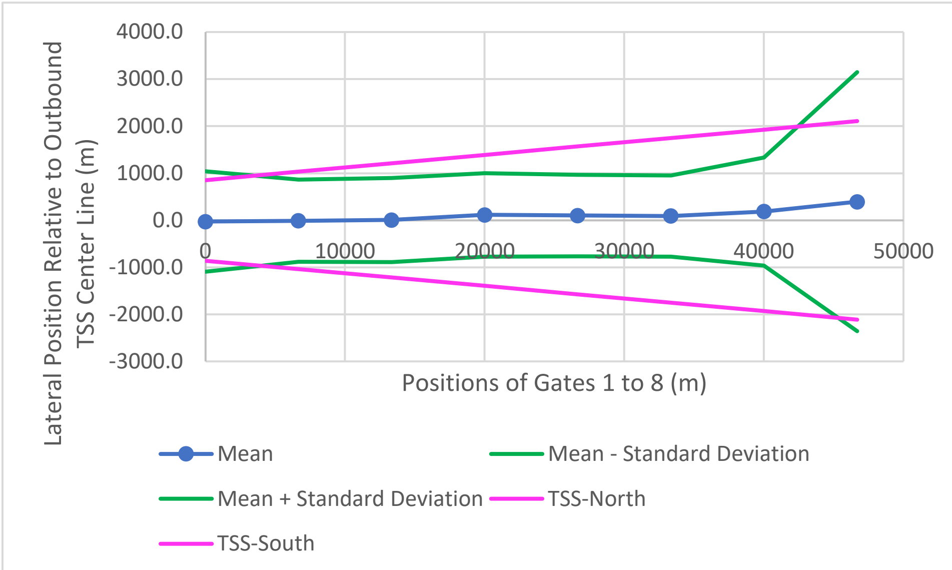

Figure E-20 Summary of Analysis of Outbound Lane Lateral Distribution Function

Figure E-20 shows:

- For Gates 1 to 6, the mean of the lateral distribution function is very close to the centerline of the defined outbound TSS lane.
- The standard deviation of the lateral distribution function is approximately constant for Gates 2 to 6. There is a slight spread at Gate 1 as ships move into alignment as they enter the TSS. The standard deviation is calculated as 876 m and hence the lane width (2 x standard deviation) is calculated as 0.945 NM.
- The degree to which the traffic utilizes the full width of the outbound TSS decreases as the gate number increases.

Examination of the lane width distribution function histograms as a function of ship type shows that ship types Cargo/ Tanker (vessel type 1), Other (vessel type 4) and Tugs (vessel types 7 and 8) follow the outbound TSS lane more exactly than others, see Figure E-21 to Figure E-27. Note for these figures the histograms are plotted for all traffic of the specified type, independent of heading. This is why both the inbound (on the left) and outbound (on the right) lanes are shown in the figures.

The lane width (0.945 NM), derived from the detailed analysis of AIS data, was applied only to vessel types 1, 4, 7, and 8.

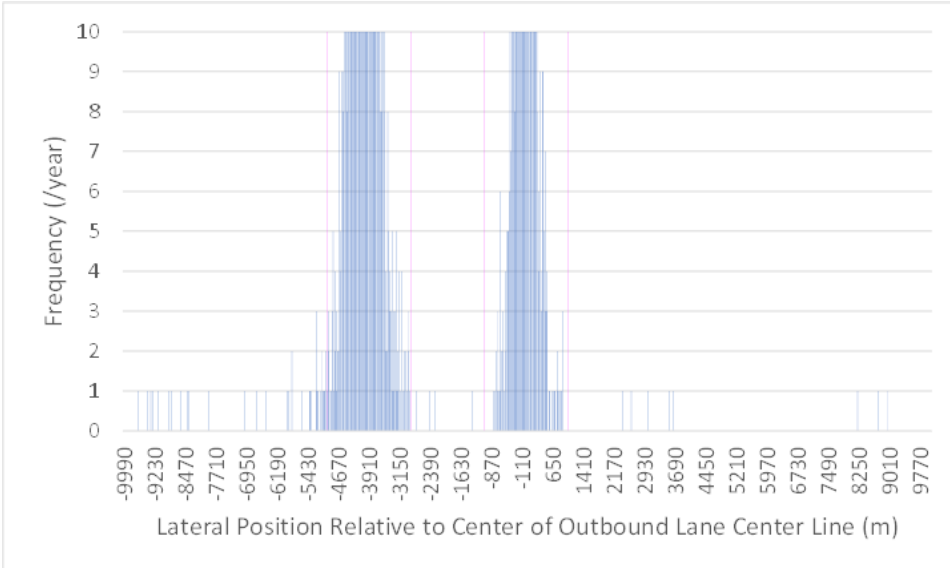

Figure E-21 Histogram of the Lane Lateral Traffic Distribution Function for Cargo/ Tanker (type 1)

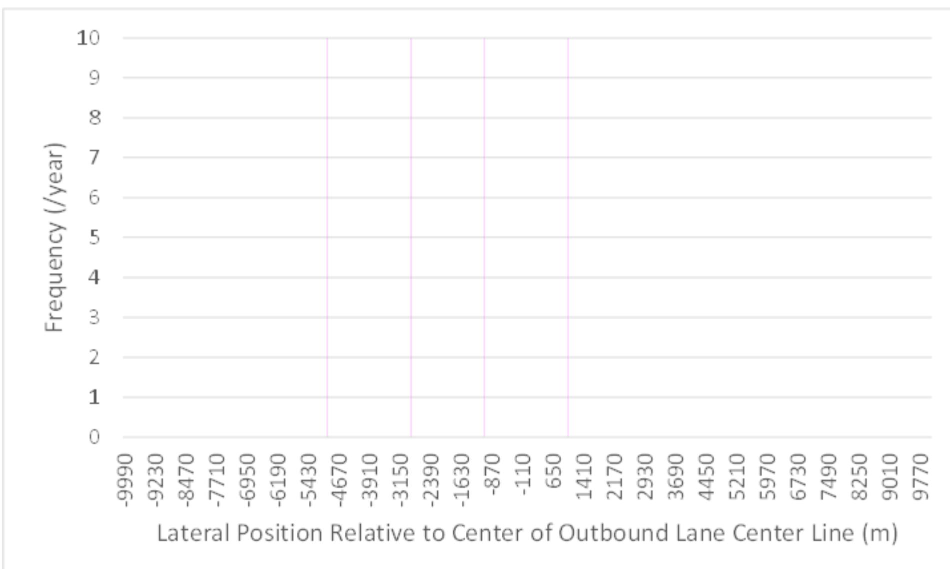

Figure E-22 Histogram of the Lane Lateral Traffic Distribution Function for Cruise/ Ferry (type 2)

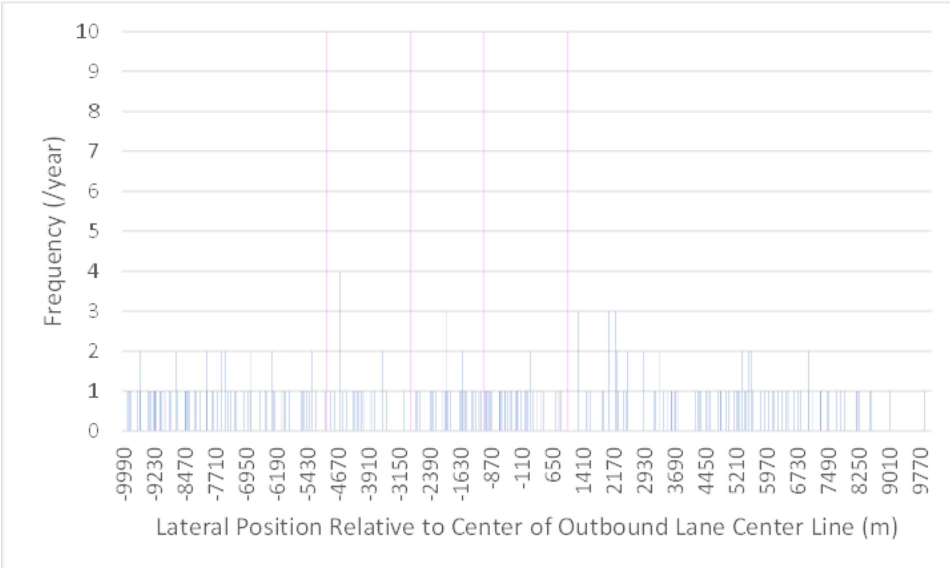

Figure E-23 Histogram of the Lane Lateral Traffic Distribution Function for Fishing (type 3)

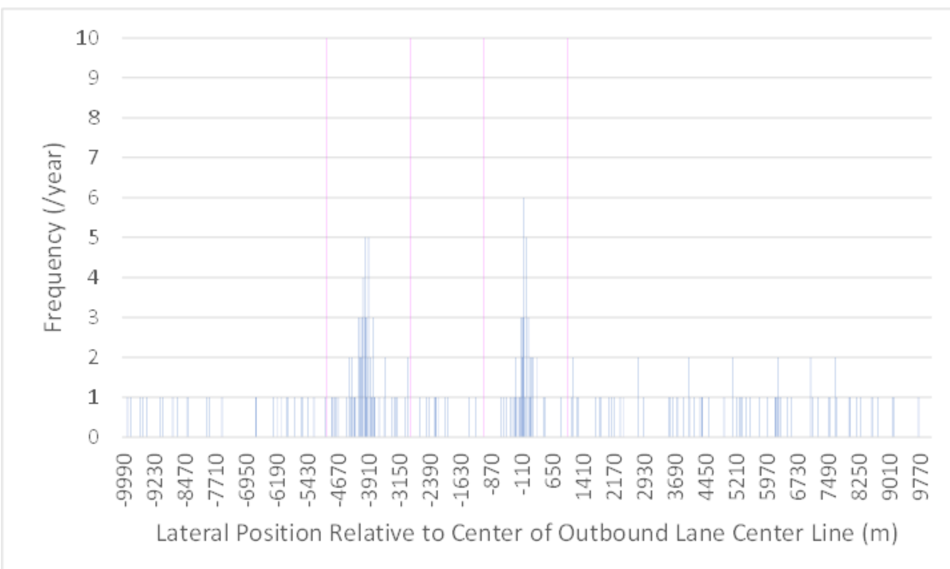

Figure E-24 Histogram of the Lane Lateral Traffic Distribution Function for Other (type 4)

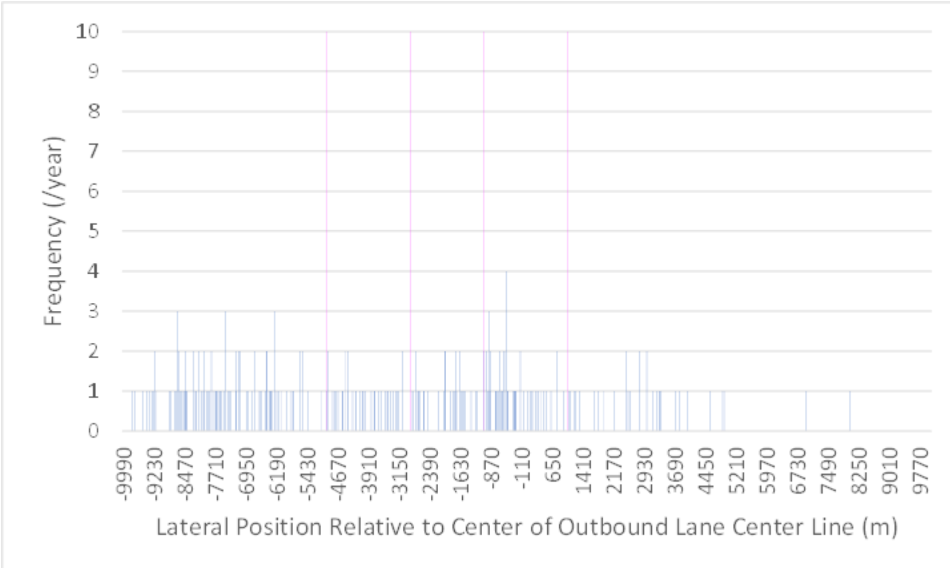

Figure E-25 Histogram of the Lane Lateral Traffic Distribution Function for Passenger (type 5)

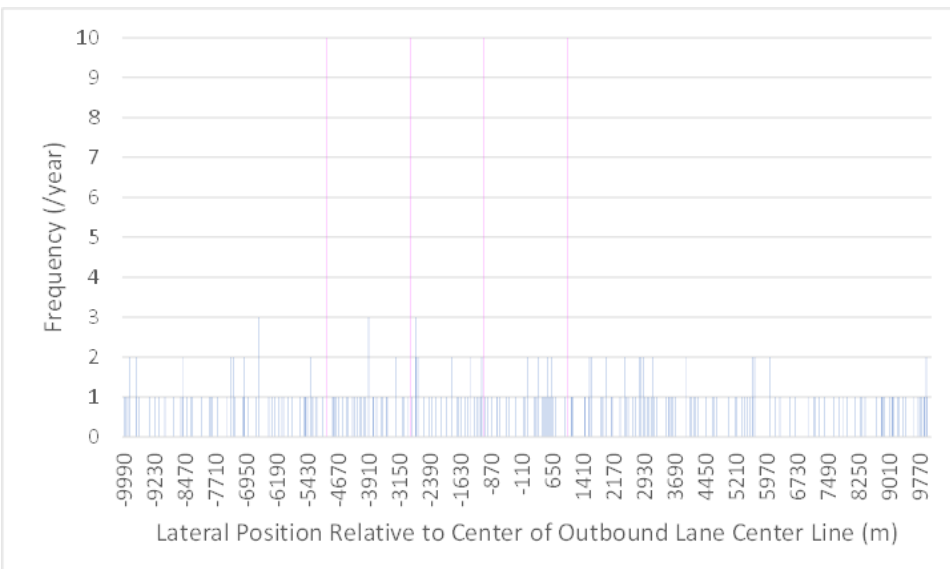

Figure E-26 Histogram of the Lane Lateral Traffic Distribution Function for Pleasure (type 6)

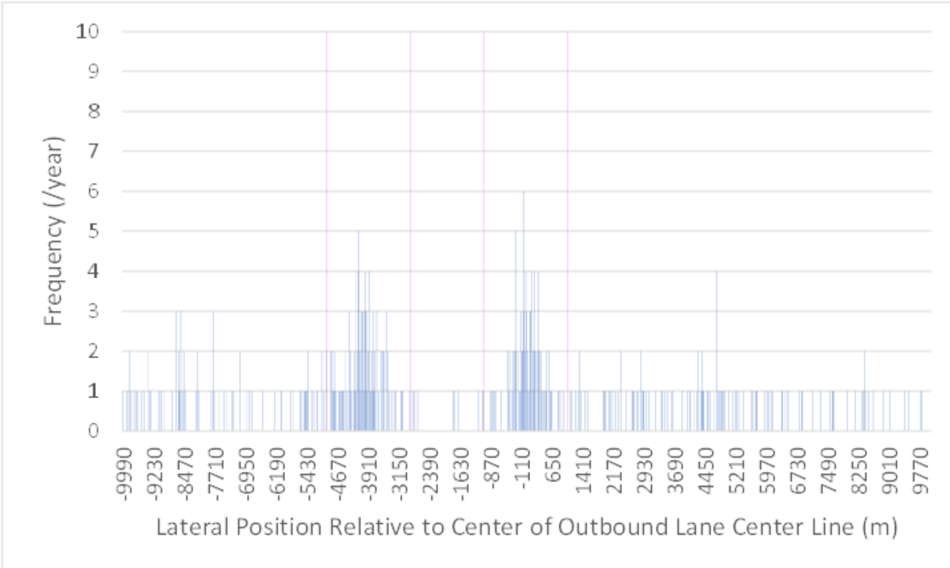

Figure E-27 Histogram of the Lane Lateral Traffic Distribution Function for Tugs (types 7 and 8)

E.3 Scenario i - 126 structures: Collision, allision, and grounding frequency results

Scenario i evaluates the risks from 126 allision objects (WTGs, OSS, Met tower). The allision objects are summarized in Table E-5 and shown in Figure E-28.

Table E-5 Summary of Allision Objects Modelled in Scenario i (126 Structures)

	Number	Circular Collision Cross Section (m)	Color in Figure E-28
WTG	121	12	Green
OSS1	2	92	Red
OSS2	2	52	Blue
Met tower	1	21	Magenta
Total	**126**		

Figure E-28 shows the Scenario i allision objects.

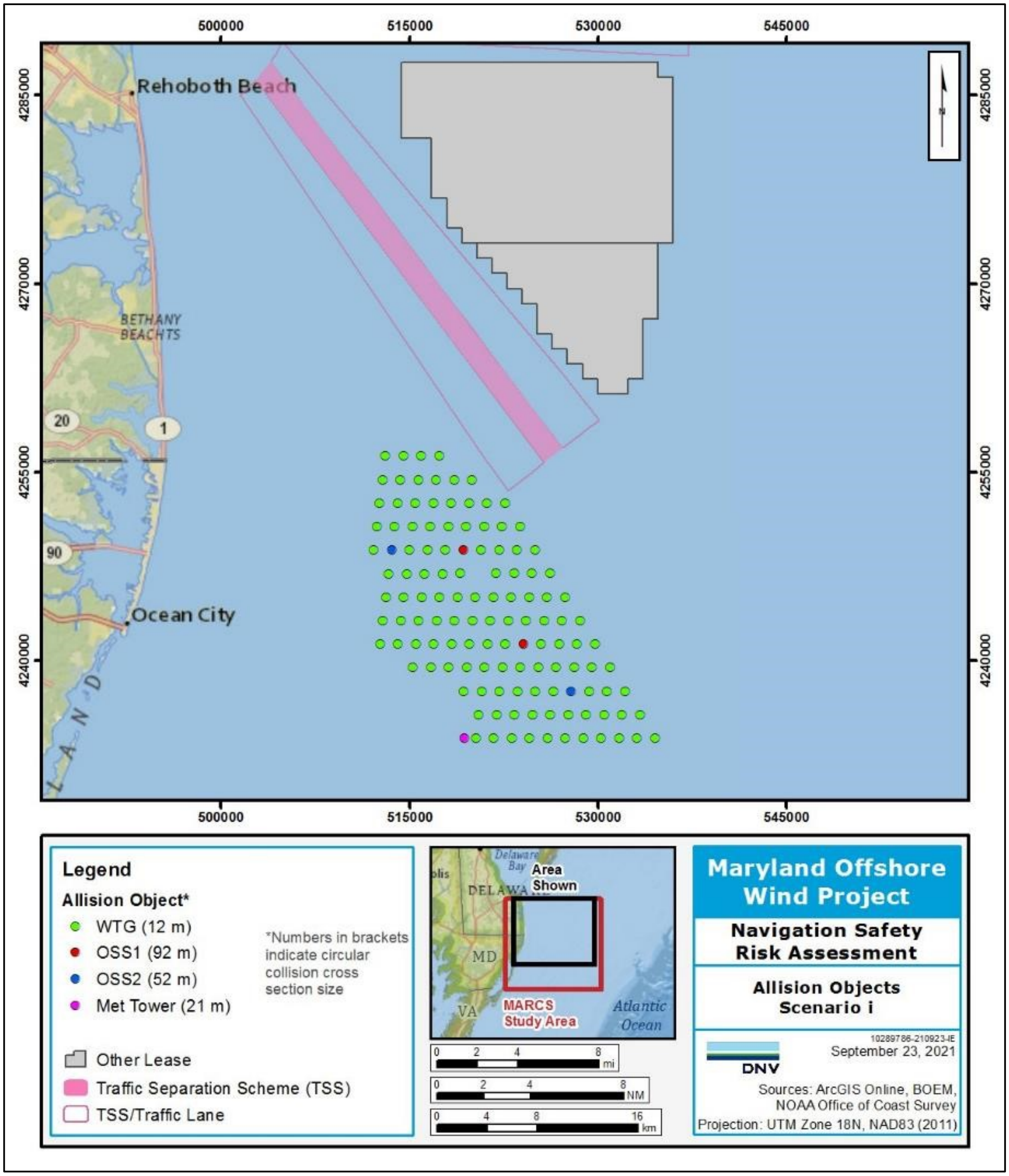

Figure E-28 Allision Objects evaluated in Scenario i (126 Structures) (magenta = Met tower, red = OSS1, blue = OSS2)

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 MARCS 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 MARCS 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 from the Base Case. The Base Case Plus estimates the frequency of a collision, grounding, and allision with Project structures.
- A Future Case with the Project (Case 2). 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-6 summarizes these cases which are run for each scenario.

Table E-6 Summary of modeled cases for each Scenario Evaluated

Case	Considerations
Base Case (Case 0)	• AIS data • Traffic adjustments to some specific vessels not in the AIS data
Base Case Plus (Case 1)	• AIS data • Traffic adjustments to some specific vessels not in the AIS data • Implementation of the Project structures
Future Case with the Project (Case 2)	• AIS data • Traffic adjustments to some specific vessels not in the AIS data • Implementation of Project structures • Re-distribution of traffic lanes for ship types Cargo/ Tanker, Cruise/ Ferry, Tugs-ATB and Tug-Towline (Types 1, 2, 7 and 8). • Additional traffic projected to be generated by the presence of the wind farm

Cases 0, 1, and 2 are modeled in MARCS. The MARCS model is detailed further in Appendix D to this NSRA. It has been utilized globally by DNV to determine the navigation risk of more than 20 wind farms.

All results are reported for the MARCS Study Area and for each of the defined sub-areas (Figure E-2)

E.3.1 Base Case (Case 0) Scenario i - 126 Structures

The Base Case results define the baseline average annual frequencies of marine accidents. The Base Case utilized AIS data for 2019 plus the additional transits described above in Section E.2.5.

Table E-7 presents the Base Case accident frequencies for each ship type and for each accident type for the sub-area Lease. Cells shaded grey denote frequencies less than 0.00005/year (1 in 20,000 per year) (in this table and all subsequent similar tables). Note these frequencies are for all accidents irrespective of whether the accident has significant consequences.

Table E-7 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area Lease[28]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000378	0.000000	0.000000	0.000000	0.000000	0.000378
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000315	0.000000	0.000000	0.000000	0.000000	0.000315
Other	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Passenger	0.000005	0.000000	0.000000	0.000000	0.000000	0.000005
Pleasure	0.000940	0.000000	0.000000	0.000000	0.000000	0.000940
Tug-ATB	0.000080	0.000000	0.000000	0.000000	0.000000	0.000080
Tug-Towline	0.000080	0.000000	0.000000	0.000000	0.000000	0.000080
Total	0.001829	0.000000	0.000000	0.000000	0.000000	0.001829

Table E-8 to Table E-13 show similar results for the remaining sub-areas and for the entire MARCS Study Area.

Table E-8 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area TSS

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001609	0.000000	0.000000	0.000000	0.000000	0.001608
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000474	0.000000	0.000000	0.000000	0.000000	0.000474
Other	0.000158	0.000000	0.000000	0.000000	0.000000	0.000158
Passenger	0.000082	0.000000	0.000000	0.000000	0.000000	0.000082
Pleasure	0.000249	0.000000	0.000000	0.000000	0.000000	0.000249
Tug-ATB	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Tug-Towline	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Total	0.002911	0.000000	0.000000	0.000000	0.000000	0.002911

[28] 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-9 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area East

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000976	0.000000	0.000000	0.000000	0.000000	0.000976
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000386	0.000000	0.000000	0.000000	0.000000	0.000386
Other	0.000041	0.000000	0.000000	0.000000	0.000000	0.000041
Passenger	0.000001	0.000000	0.000000	0.000000	0.000000	0.000001
Pleasure	0.000135	0.000000	0.000000	0.000000	0.000000	0.000135
Tug-ATB	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Tug-Towline	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Total	0.001607	0.000000	0.000000	0.000000	0.000000	0.001607

Table E-10 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area West

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000024	0.000000	0.000000	0.000000	0.000000	0.000024
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000477	0.000000	0.000000	0.000000	0.000000	0.000477
Other	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Passenger	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Pleasure	0.001227	0.000000	0.000000	0.000000	0.000000	0.001227
Tug-ATB	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Tug-Towline	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Total	0.001914	0.000000	0.000000	0.000000	0.000000	0.001914

Table E-11 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area South

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000123	0.000000	0.000000	0.000000	0.000000	0.000123
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000101	0.000000	0.000000	0.000000	0.000000	0.000101
Other	0.000009	0.000000	0.000000	0.000000	0.000000	0.000009
Passenger	0.000013	0.000000	0.000000	0.000000	0.000000	0.000013
Pleasure	0.000092	0.000000	0.000000	0.000000	0.000000	0.000092
Tug-ATB	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Tug-Towline	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Total	0.000374	0.000000	0.000000	0.000000	0.000000	0.000374

Table E-12 Case 0 Accident frequencies (per year) without the Wind Farm in the Remainder of the MARCS Study Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001413	0.001047	0.069840	0.000000	0.000000	0.072301
Cruise Ferries	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
Fishing	0.002380	0.082740	0.124900	0.000000	0.000000	0.210020
Other	0.000213	0.006787	0.021260	0.000000	0.000000	0.028260
Passenger	0.000167	0.015190	0.009783	0.000000	0.000000	0.025140
Pleasure	0.002160	0.206500	0.103000	0.000000	0.000000	0.311660
Tug-ATB	0.000257	0.006340	0.027380	0.000000	0.000000	0.033977
Tug-Towline	0.000257	0.006340	0.027380	0.000000	0.000000	0.033977
Total	0.006848	0.324944	0.383544	0.000000	0.000000	0.715336

Table E-13 Case 0 Accident frequencies (per year) without the Wind Farm in the Entire MARCS Study Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.004523	0.001047	0.069840	0.000000	0.000000	0.075410
Cruise Ferries	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
Fishing	0.004133	0.082740	0.124900	0.000000	0.000000	0.211773
Other	0.000479	0.006787	0.021260	0.000000	0.000000	0.028526
Passenger	0.000299	0.015190	0.009783	0.000000	0.000000	0.025272
Pleasure	0.004803	0.206500	0.103000	0.000000	0.000000	0.314303
Tug-ATB	0.000623	0.006340	0.027380	0.000000	0.000000	0.034343
Tug-Towline	0.000623	0.006340	0.027380	0.000000	0.000000	0.034343
Total	0.015483	0.324944	0.383544	0.000000	0.000000	0.723971

E.3.2 Base Case Plus the Project (Case 1) Scenario i - 126 Structures

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 mainly used to verify the modeling. The results tables are shown in the same sequence as that used in Section E.3.1 above for the Base Case (Case 0).

The results for Case 1 are compared with the other case results and discussed in Section E.7.

Table E-14 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area Lease

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000378	0.000000	0.000000	0.054430	0.066710	0.121519
Cruise Ferries	0.000000	0.000000	0.000000	0.000034	0.000029	0.000063
Fishing	0.000315	0.000000	0.000000	0.013270	0.013850	0.027435
Other	0.000031	0.000000	0.000000	0.003146	0.003906	0.007083
Passenger	0.000005	0.000000	0.000000	0.001000	0.000547	0.001552
Pleasure	0.000940	0.000000	0.000000	0.046470	0.044520	0.091930
Tug-ATB	0.000080	0.000000	0.000000	0.010150	0.017840	0.028070
Tug-Towline	0.000080	0.000000	0.000000	0.095130	0.075520	0.170734
Total	0.001829	0.000000	0.000000	0.223630	0.222922	0.448381

Table E-15 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area TSS

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001609	0.000000	0.000000	0.000000	0.000000	0.001608
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000474	0.000000	0.000000	0.000000	0.000000	0.000474
Other	0.000158	0.000000	0.000000	0.000000	0.000000	0.000158
Passenger	0.000082	0.000000	0.000000	0.000000	0.000000	0.000082
Pleasure	0.000249	0.000000	0.000000	0.000000	0.000000	0.000249
Tug-ATB	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Tug-Towline	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Total	0.002911	0.000000	0.000000	0.000000	0.000000	0.002911

Table E-16 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area East

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000976	0.000000	0.000000	0.000000	0.000000	0.000976
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000386	0.000000	0.000000	0.000000	0.000000	0.000386
Other	0.000041	0.000000	0.000000	0.000000	0.000000	0.000041
Passenger	0.000001	0.000000	0.000000	0.000000	0.000000	0.000001
Pleasure	0.000135	0.000000	0.000000	0.000000	0.000000	0.000135
Tug-ATB	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Tug-Towline	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Total	0.001607	0.000000	0.000000	0.000000	0.000000	0.001607

Table E-17 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area West

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000024	0.000000	0.000000	0.000000	0.000000	0.000024
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000477	0.000000	0.000000	0.000000	0.000000	0.000477
Other	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Passenger	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Pleasure	0.001227	0.000000	0.000000	0.000000	0.000000	0.001227
Tug-ATB	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Tug-Towline	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Total	0.001914	0.000000	0.000000	0.000000	0.000000	0.001914

Table E-18 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area South

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000123	0.000000	0.000000	0.000000	0.000000	0.000123
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000101	0.000000	0.000000	0.000000	0.000000	0.000101
Other	0.000009	0.000000	0.000000	0.000000	0.000000	0.000009
Passenger	0.000013	0.000000	0.000000	0.000000	0.000000	0.000013
Pleasure	0.000092	0.000000	0.000000	0.000000	0.000000	0.000092
Tug-ATB	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Tug-Towline	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Total	0.000374	0.000000	0.000000	0.000000	0.000000	0.000374

Table E-19 Case 1 Accident frequencies (per year) without the Wind Farm in the Remainder of the MARCS Study Area

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001413	0.001047	0.069840	0.000000	0.000000	0.072300
Cruise Ferries	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
Fishing	0.002380	0.082740	0.124900	0.000000	0.000000	0.210020
Other	0.000213	0.006787	0.021260	0.000000	0.000000	0.028260
Passenger	0.000167	0.015190	0.009783	0.000000	0.000000	0.025140
Pleasure	0.002160	0.206500	0.103000	0.000000	0.000000	0.311660
Tug-ATB	0.000257	0.006340	0.027380	0.000000	0.000000	0.033977
Tug-Towline	0.000257	0.006340	0.027380	0.000000	0.000000	0.033973
Total	0.006848	0.324944	0.383544	0.000000	0.000000	0.715336

Table E-20 Case 1 Accident frequencies (per year) without the Wind Farm in the Entire MARCS Study Area

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.004523	0.001047	0.069840	0.054430	0.066710	0.196550
Cruise Ferries	0.000000	0.000000	0.000001	0.000034	0.000029	0.000064
Fishing	0.004133	0.082740	0.124900	0.013270	0.013850	0.238893
Other	0.000479	0.006787	0.021260	0.003146	0.003906	0.035578
Passenger	0.000299	0.015190	0.009783	0.001000	0.000547	0.026819
Pleasure	0.004803	0.206500	0.103000	0.046470	0.044520	0.405293
Tug-ATB	0.000623	0.006340	0.027380	0.010150	0.017840	0.062333
Tug-Towline	0.000623	0.006340	0.027380	0.095130	0.075520	0.204993
Total	0.015483	0.324944	0.383544	0.223630	0.222922	1.170523

E.3.3 Future Case with the Project (Case 2) Scenario i - 126 Structures

The Case 2 results show the average annual frequencies of marine accidents using modified Base Case traffic data and incorporating the Project structures. The results tables are shown in the same sequence as that used in Section E.3.1 and Section E.3.2 above.

The results for Case 2 are compared with the other case results and discussed in Section E.7 herein.

Table E-21 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area Lease

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000016	0.000000	0.000000	0.002285	0.008548	0.010849
Cruise Ferries	0.000000	0.000000	0.000000	0.000001	0.000002	0.000003
Fishing	0.000653	0.000000	0.000000	0.013270	0.013850	0.027773
Other	0.000058	0.000000	0.000000	0.003141	0.003906	0.007105
Passenger	0.001318	0.000000	0.000000	0.011130	0.008095	0.020543
Pleasure	0.004662	0.000000	0.000000	0.115700	0.114300	0.234662
Tug-ATB	0.000000	0.000000	0.000000	0.000211	0.001063	0.001274
Tug-Towline	0.000000	0.000000	0.000000	0.001058	0.004780	0.005838
Total	0.006707	0.000000	0.000000	0.146796	0.154544	0.308047

Table E-22 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area TSS

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.002005	0.000000	0.000000	0.000000	0.000000	0.002003
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000570	0.000000	0.000000	0.000000	0.000000	0.000570
Other	0.000181	0.000000	0.000000	0.000000	0.000000	0.000181
Passenger	0.000104	0.000000	0.000000	0.000000	0.000000	0.000104
Pleasure	0.000303	0.000000	0.000000	0.000000	0.000000	0.000303
Tug-ATB	0.000230	0.000000	0.000000	0.000000	0.000000	0.000230
Tug-Towline	0.000230	0.000000	0.000000	0.000000	0.000000	0.000230
Total	0.003621	0.000000	0.000000	0.000000	0.000000	0.003621

Table E-23 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area East

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001744	0.000000	0.000000	0.000000	0.000000	0.001744
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000558	0.000000	0.000000	0.000000	0.000000	0.000558
Other	0.000052	0.000000	0.000000	0.000000	0.000000	0.000052
Passenger	0.000022	0.000000	0.000000	0.000000	0.000000	0.000022
Pleasure	0.000243	0.000000	0.000000	0.000000	0.000000	0.000243
Tug-ATB	0.000111	0.000000	0.000000	0.000000	0.000000	0.000111
Tug-Towline	0.000111	0.000000	0.000000	0.000000	0.000000	0.000111
Total	0.002841	0.000000	0.000000	0.000000	0.000000	0.002841

Table E-24 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area West

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000009	0.000000	0.000000	0.000000	0.000000	0.000009
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.001071	0.000000	0.000000	0.000000	0.000000	0.001071
Other	0.000052	0.000000	0.000000	0.000000	0.000000	0.000052
Passenger	0.001961	0.000000	0.000000	0.000000	0.000000	0.001961
Pleasure	0.006481	0.000000	0.000000	0.000000	0.000000	0.006481
Tug-ATB	0.000173	0.000000	0.000000	0.000000	0.000000	0.000173
Tug-Towline	0.000173	0.000000	0.000000	0.000000	0.000000	0.000173
Total	0.009920	0.000000	0.000000	0.000000	0.000000	0.009920

Table E-25 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area South

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000184	0.000000	0.000000	0.000000	0.000000	0.000184
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000119	0.000000	0.000000	0.000000	0.000000	0.000119
Other	0.000010	0.000000	0.000000	0.000000	0.000000	0.000010
Passenger	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Pleasure	0.000140	0.000000	0.000000	0.000000	0.000000	0.000140
Tug-ATB	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Tug-Towline	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Total	0.000538	0.000000	0.000000	0.000000	0.000000	0.000538

Table E-26 Case 2 Accident frequencies (per year) without the Wind Farm in the Remainder of the MARCS Study Area

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001269	0.001023	0.072760	0.000000	0.000000	0.075054
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.002984	0.082740	0.124900	0.000000	0.000000	0.210624
Other	0.000238	0.006787	0.021260	0.000000	0.000000	0.028285
Passenger	0.002507	0.069620	0.021260	0.000000	0.000000	0.093387
Pleasure	0.008391	0.422100	0.174900	0.000000	0.000000	0.605391
Tug-ATB	0.000348	0.006306	0.030400	0.000000	0.000000	0.037054
Tug-Towline	0.000348	0.006306	0.030400	0.000000	0.000000	0.037054
Total	0.016087	0.594882	0.475880	0.000000	0.000000	1.086849

Table E-27 Case 2 Accident frequencies (per year) without the Wind Farm in the Entire MARCS Study Area

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.005227	0.001023	0.072760	0.002285	0.008548	0.089843
Cruise Ferries	0.000000	0.000000	0.000000	0.000001	0.000002	0.000003
Fishing	0.005955	0.082740	0.124900	0.013270	0.013850	0.240715
Other	0.000591	0.006787	0.021260	0.003141	0.003906	0.035685
Passenger	0.005943	0.069620	0.021260	0.011130	0.008095	0.116048
Pleasure	0.020220	0.422100	0.174900	0.115700	0.114300	0.847220
Tug-ATB	0.000889	0.006306	0.030400	0.000211	0.001063	0.038869
Tug-Towline	0.000889	0.006306	0.030400	0.001058	0.004780	0.043433
Total	0.039714	0.594882	0.475880	0.146796	0.154544	1.411816

E.4 Scenario ii - 119 structures: Collision, allision, and grounding frequency results

Scenario ii evaluates the risks from 119 allision objects (WTGs, OSS, Met tower). This arises by removing all allision objects within 1NM of the south-west boundary of the outbound TSS lane. The allision objects are summarized in Table E-28 and shown in Figure E-29.

Results are presented in tables similar to those presented for Scenario i.

Table E-28 Summary of Allision Objects Modelled in Scenario ii

	Number	Circular Collision Cross Section (m)	Color in Figure E-29
WTG	114	12	Green
OSS1	2	92	Red
OSS2	2	52	Blue
Met tower	1	21	Magenta
Total	**119**		

Figure E-29 shows the Scenario ii allision objects.

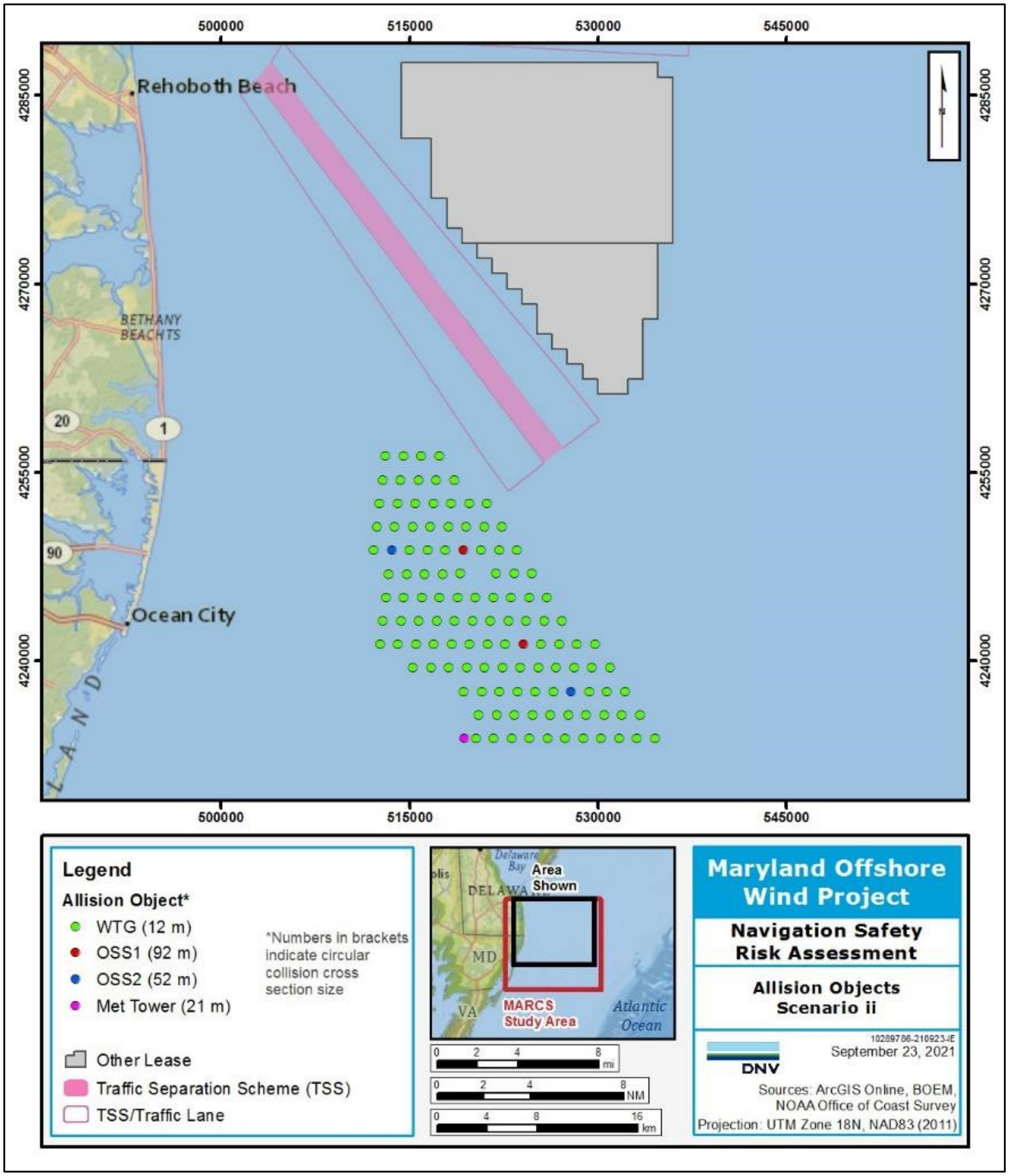

Figure E-29 Allision Objects evaluated in Scenario ii (119 Structures) (magenta = Met tower, red = OSS1, blue = OSS2)

E.4.1 Base Case (Case 0) Scenario ii - 119 Structures

The Base Case results define the baseline average annual frequencies of marine accidents. The Base Case utilized AIS data for 2019 plus the additional transits described above in Section E.2.5.

Table E-29 to Table E-35 presents the Base Case accident frequencies in each sub-area for each ship type and each accident type. As in Scenario I, cells shaded grey denote frequencies less than 0.00005/year (1 in 20,000 per year). Note these frequencies are for all accidents irrespective of whether the accident has significant consequences.

Table E-29 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area Lease[29]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000378	0.000000	0.000000	0.000000	0.000000	0.000378
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000315	0.000000	0.000000	0.000000	0.000000	0.000315
Other	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Passenger	0.000005	0.000000	0.000000	0.000000	0.000000	0.000005
Pleasure	0.000940	0.000000	0.000000	0.000000	0.000000	0.000940
Tug-ATB	0.000080	0.000000	0.000000	0.000000	0.000000	0.000080
Tug-Towline	0.000080	0.000000	0.000000	0.000000	0.000000	0.000080
Total	0.001829	0.000000	0.000000	0.000000	0.000000	0.001829

Table E-30 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area TSS

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001609	0.000000	0.000000	0.000000	0.000000	0.001608
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000474	0.000000	0.000000	0.000000	0.000000	0.000474
Other	0.000158	0.000000	0.000000	0.000000	0.000000	0.000158
Passenger	0.000082	0.000000	0.000000	0.000000	0.000000	0.000082
Pleasure	0.000249	0.000000	0.000000	0.000000	0.000000	0.000249
Tug-ATB	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Tug-Towline	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Total	0.002911	0.000000	0.000000	0.000000	0.000000	0.002911

[29] 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-31 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area East

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000976	0.000000	0.000000	0.000000	0.000000	0.000976
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000386	0.000000	0.000000	0.000000	0.000000	0.000386
Other	0.000041	0.000000	0.000000	0.000000	0.000000	0.000041
Passenger	0.000001	0.000000	0.000000	0.000000	0.000000	0.000001
Pleasure	0.000135	0.000000	0.000000	0.000000	0.000000	0.000135
Tug-ATB	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Tug-Towline	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Total	0.001607	0.000000	0.000000	0.000000	0.000000	0.001607

Table E-32 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area West

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000024	0.000000	0.000000	0.000000	0.000000	0.000024
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000477	0.000000	0.000000	0.000000	0.000000	0.000477
Other	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Passenger	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Pleasure	0.001227	0.000000	0.000000	0.000000	0.000000	0.001227
Tug-ATB	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Tug-Towline	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Total	0.001914	0.000000	0.000000	0.000000	0.000000	0.001914

Table E-33 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area South

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000123	0.000000	0.000000	0.000000	0.000000	0.000123
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000101	0.000000	0.000000	0.000000	0.000000	0.000101
Other	0.000009	0.000000	0.000000	0.000000	0.000000	0.000009
Passenger	0.000013	0.000000	0.000000	0.000000	0.000000	0.000013
Pleasure	0.000092	0.000000	0.000000	0.000000	0.000000	0.000092
Tug-ATB	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Tug-Towline	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Total	0.000374	0.000000	0.000000	0.000000	0.000000	0.000374

Table E-34 Case 0 Accident frequencies (per year) without the Wind Farm in the Remainder of the MARCS Study Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001413	0.001047	0.069840	0.000000	0.000000	0.072301
Cruise Ferries	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
Fishing	0.002380	0.082740	0.124900	0.000000	0.000000	0.210020
Other	0.000213	0.006787	0.021260	0.000000	0.000000	0.028260
Passenger	0.000167	0.015190	0.009783	0.000000	0.000000	0.025140
Pleasure	0.002160	0.206500	0.103000	0.000000	0.000000	0.311660
Tug-ATB	0.000257	0.006340	0.027380	0.000000	0.000000	0.033977
Tug-Towline	0.000257	0.006340	0.027380	0.000000	0.000000	0.033977
Total	0.006848	0.324944	0.383544	0.000000	0.000000	0.715336

Table E-35 Case 0 Accident frequencies (per year) without the Wind Farm in the Entire MARCS Study Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.004523	0.001047	0.069840	0.000000	0.000000	0.075410
Cruise Ferries	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
Fishing	0.004133	0.082740	0.124900	0.000000	0.000000	0.211773
Other	0.000479	0.006787	0.021260	0.000000	0.000000	0.028526
Passenger	0.000299	0.015190	0.009783	0.000000	0.000000	0.025272
Pleasure	0.004803	0.206500	0.103000	0.000000	0.000000	0.314303
Tug-ATB	0.000623	0.006340	0.027380	0.000000	0.000000	0.034343
Tug-Towline	0.000623	0.006340	0.027380	0.000000	0.000000	0.034343
Total	0.015483	0.324944	0.383544	0.000000	0.000000	0.723971

E.4.2 Base Case Plus the Project (Case 1) Scenario ii - 119 Structures

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 mainly used to verify the modeling. The results tables are shown in the same sequence as that used in Section E.3.1 above for the Base Case (Case 0).

The results for Case 1 are compared with the other case results and discussed in Section E.7.

Table E-36 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area Lease

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000378	0.000000	0.000000	0.048880	0.062790	0.112049
Cruise Ferries	0.000000	0.000000	0.000000	0.000034	0.000027	0.000061
Fishing	0.000315	0.000000	0.000000	0.012470	0.013240	0.026025
Other	0.000031	0.000000	0.000000	0.002865	0.003691	0.006587
Passenger	0.000005	0.000000	0.000000	0.000954	0.000524	0.001483
Pleasure	0.000940	0.000000	0.000000	0.045030	0.042310	0.088280
Tug-ATB	0.000080	0.000000	0.000000	0.009480	0.016800	0.026360
Tug-Towline	0.000080	0.000000	0.000000	0.089180	0.071390	0.160654
Total	0.001829	0.000000	0.000000	0.208893	0.210772	0.421494

Table E-37 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area TSS

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001609	0.000000	0.000000	0.000000	0.000000	0.001608
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000474	0.000000	0.000000	0.000000	0.000000	0.000474
Other	0.000158	0.000000	0.000000	0.000000	0.000000	0.000158
Passenger	0.000082	0.000000	0.000000	0.000000	0.000000	0.000082
Pleasure	0.000249	0.000000	0.000000	0.000000	0.000000	0.000249
Tug-ATB	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Tug-Towline	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Total	0.002911	0.000000	0.000000	0.000000	0.000000	0.002911

Table E-38 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area East

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000976	0.000000	0.000000	0.000000	0.000000	0.000976
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000386	0.000000	0.000000	0.000000	0.000000	0.000386
Other	0.000041	0.000000	0.000000	0.000000	0.000000	0.000041
Passenger	0.000001	0.000000	0.000000	0.000000	0.000000	0.000001
Pleasure	0.000135	0.000000	0.000000	0.000000	0.000000	0.000135
Tug-ATB	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Tug-Towline	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Total	0.001607	0.000000	0.000000	0.000000	0.000000	0.001607

Table E-39 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area West

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000024	0.000000	0.000000	0.000000	0.000000	0.000024
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000477	0.000000	0.000000	0.000000	0.000000	0.000477
Other	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Passenger	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Pleasure	0.001227	0.000000	0.000000	0.000000	0.000000	0.001227
Tug-ATB	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Tug-Towline	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Total	0.001914	0.000000	0.000000	0.000000	0.000000	0.001914

Table E-40 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area South

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000123	0.000000	0.000000	0.000000	0.000000	0.000123
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000101	0.000000	0.000000	0.000000	0.000000	0.000101
Other	0.000009	0.000000	0.000000	0.000000	0.000000	0.000009
Passenger	0.000013	0.000000	0.000000	0.000000	0.000000	0.000013
Pleasure	0.000092	0.000000	0.000000	0.000000	0.000000	0.000092
Tug-ATB	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Tug-Towline	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Total	0.000374	0.000000	0.000000	0.000000	0.000000	0.000374

Table E-41 Case 1 Accident frequencies (per year) without the Wind Farm in the Remainder of the MARCS Study Area

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001413	0.001047	0.069840	0.000000	0.000000	0.072300
Cruise Ferries	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
Fishing	0.002380	0.082740	0.124900	0.000000	0.000000	0.210020
Other	0.000213	0.006787	0.021260	0.000000	0.000000	0.028260
Passenger	0.000167	0.015190	0.009783	0.000000	0.000000	0.025140
Pleasure	0.002160	0.206500	0.103000	0.000000	0.000000	0.311660
Tug-ATB	0.000257	0.006340	0.027380	0.000000	0.000000	0.033977
Tug-Towline	0.000257	0.006340	0.027380	0.000000	0.000000	0.033973
Total	0.006848	0.324944	0.383544	0.000000	0.000000	0.715336

Table E-42 Case 1 Accident frequencies (per year) without the Wind Farm in the Entire MARCS Study Area

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.004523	0.001047	0.069840	0.048880	0.062790	0.187080
Cruise Ferries	0.000000	0.000000	0.000001	0.000034	0.000027	0.000062
Fishing	0.004133	0.082740	0.124900	0.012470	0.013240	0.237483
Other	0.000479	0.006787	0.021260	0.002865	0.003691	0.035082
Passenger	0.000299	0.015190	0.009783	0.000954	0.000524	0.026750
Pleasure	0.004803	0.206500	0.103000	0.045030	0.042310	0.401643
Tug-ATB	0.000623	0.006340	0.027380	0.009480	0.016800	0.060623
Tug-Towline	0.000623	0.006340	0.027380	0.089180	0.071390	0.194913
Total	0.015483	0.324944	0.383544	0.208893	0.210772	1.143636

E.4.3 Future Case with the Project (Case 2) Scenario ii – 119 Structures

The Case 2 results show the average annual frequencies of marine accidents using modified Base Case traffic data and incorporating the Project structures. The results tables are shown in the same sequence as that used in Section E.3.1 and Section E.3.2 above.

The results for Case 2 are compared with the other case results and discussed in Section E.7 herein.

Table E-43 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area Lease

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000016	0.000000	0.000000	0.001635	0.007993	0.009644
Cruise Ferries	0.000000	0.000000	0.000000	0.000001	0.000002	0.000003
Fishing	0.000653	0.000000	0.000000	0.012470	0.013240	0.026363
Other	0.000058	0.000000	0.000000	0.002838	0.003691	0.006587
Passenger	0.001318	0.000000	0.000000	0.010730	0.007687	0.019735
Pleasure	0.004662	0.000000	0.000000	0.112400	0.108800	0.225862
Tug-ATB	0.000000	0.000000	0.000000	0.000176	0.001013	0.001189
Tug-Towline	0.000000	0.000000	0.000000	0.000908	0.004555	0.005463
Total	0.006707	0.000000	0.000000	0.141158	0.146981	0.294846

Table E-44 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area TSS

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.002005	0.000000	0.000000	0.000000	0.000000	0.002003
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000570	0.000000	0.000000	0.000000	0.000000	0.000570
Other	0.000181	0.000000	0.000000	0.000000	0.000000	0.000181
Passenger	0.000104	0.000000	0.000000	0.000000	0.000000	0.000104
Pleasure	0.000303	0.000000	0.000000	0.000000	0.000000	0.000303
Tug-ATB	0.000230	0.000000	0.000000	0.000000	0.000000	0.000230
Tug-Towline	0.000230	0.000000	0.000000	0.000000	0.000000	0.000230
Total	0.003621	0.000000	0.000000	0.000000	0.000000	0.003621

Table E-45 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area East

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001744	0.000000	0.000000	0.000000	0.000000	0.001744
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000558	0.000000	0.000000	0.000000	0.000000	0.000558
Other	0.000052	0.000000	0.000000	0.000000	0.000000	0.000052
Passenger	0.000022	0.000000	0.000000	0.000000	0.000000	0.000022
Pleasure	0.000243	0.000000	0.000000	0.000000	0.000000	0.000243
Tug-ATB	0.000111	0.000000	0.000000	0.000000	0.000000	0.000111
Tug-Towline	0.000111	0.000000	0.000000	0.000000	0.000000	0.000111
Total	0.002841	0.000000	0.000000	0.000000	0.000000	0.002841

Table E-46 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area West

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000009	0.000000	0.000000	0.000000	0.000000	0.000009
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.001071	0.000000	0.000000	0.000000	0.000000	0.001071
Other	0.000052	0.000000	0.000000	0.000000	0.000000	0.000052
Passenger	0.001961	0.000000	0.000000	0.000000	0.000000	0.001961
Pleasure	0.006481	0.000000	0.000000	0.000000	0.000000	0.006481
Tug-ATB	0.000173	0.000000	0.000000	0.000000	0.000000	0.000173
Tug-Towline	0.000173	0.000000	0.000000	0.000000	0.000000	0.000173
Total	0.009920	0.000000	0.000000	0.000000	0.000000	0.009920

Table E-47 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area South

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000184	0.000000	0.000000	0.000000	0.000000	0.000184
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000119	0.000000	0.000000	0.000000	0.000000	0.000119
Other	0.000010	0.000000	0.000000	0.000000	0.000000	0.000010
Passenger	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Pleasure	0.000140	0.000000	0.000000	0.000000	0.000000	0.000140
Tug-ATB	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Tug-Towline	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Total	0.000538	0.000000	0.000000	0.000000	0.000000	0.000538

Table E-48 Case 2 Accident frequencies (per year) without the Wind Farm in the Remainder of the MARCS Study Area

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001269	0.001023	0.072760	0.000000	0.000000	0.075054
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.002984	0.082740	0.124900	0.000000	0.000000	0.210624
Other	0.000238	0.006787	0.021260	0.000000	0.000000	0.028285
Passenger	0.002507	0.069620	0.021260	0.000000	0.000000	0.093387
Pleasure	0.008391	0.422100	0.174900	0.000000	0.000000	0.605391
Tug-ATB	0.000348	0.006306	0.030400	0.000000	0.000000	0.037054
Tug-Towline	0.000348	0.006306	0.030400	0.000000	0.000000	0.037054
Total	0.016087	0.594882	0.475880	0.000000	0.000000	1.086849

Table E-49 Case 2 Accident frequencies (per year) without the Wind Farm in the Entire MARCS Study Area

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.005227	0.001023	0.072760	0.001635	0.007993	0.088638
Cruise Ferries	0.000000	0.000000	0.000000	0.000001	0.000002	0.000003
Fishing	0.005955	0.082740	0.124900	0.012470	0.013240	0.239305
Other	0.000591	0.006787	0.021260	0.002838	0.003691	0.035167
Passenger	0.005943	0.069620	0.021260	0.010730	0.007687	0.115240
Pleasure	0.020220	0.422100	0.174900	0.112400	0.108800	0.838420
Tug-ATB	0.000889	0.006306	0.030400	0.000176	0.001013	0.038784
Tug-Towline	0.000889	0.006306	0.030400	0.000908	0.004555	0.043058
Total	0.039714	0.594882	0.475880	0.141158	0.146981	1.398615

E.5 Scenario iii – 98 structures: Collision, allision, and grounding frequency results

Scenario iii evaluates the risks from 98 allision objects (WTGs, OSS, Met tower). This arises by removing all allision objects within 2 NM of the south-west boundary of the outbound TSS lane. The allision objects are summarized in Table E-50 and shown in Figure E-30.

Results are presented in tables similar to those presented for Scenario I and Scenario ii.

Table E-50 Summary of Allision Objects Modelled in Scenario iii

	Number	Circular Collision Cross Section (m)	Color in Figure E-30
WTG	93	12	Green
OSS1	2	92	Red
OSS2	2	52	Blue
Met tower	1	21	Magenta
Total	**98**		

Figure E-30 shows the Scenario iii allision objects.

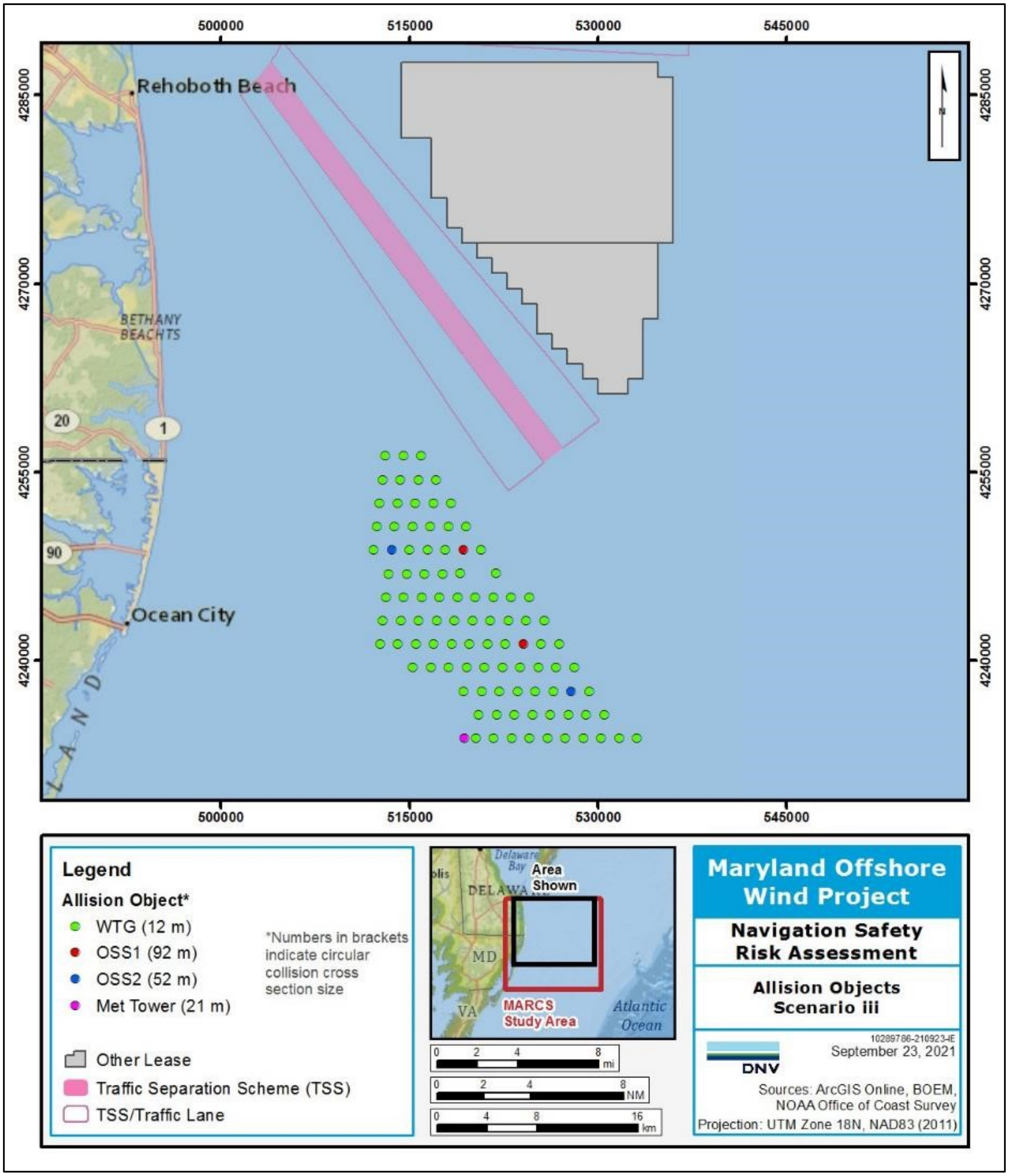

Figure E-30 Allision Objects evaluated in Scenario iii (98 Structures) (magenta = Met tower, red = OSS1, blue = OSS2)

E.5.1 Base Case (Case 0) Scenario iii – 98 Structures

The Base Case results define the baseline average annual frequencies of marine accidents. The Base Case utilized AIS data for 2019 plus the additional transits described above in Section E.2.5.

Table E-51 to Table E-57 presents the Base Case accident frequencies in each sub-area for each ship type and each accident type. As in Scenario I and Scenario ii, cells shaded grey denote frequencies less than 0.00005/year (1 in 20,000 per year). Note these frequencies are for all accidents irrespective of whether the accident has significant consequences.

Table E-51 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area Lease[30]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000378	0.000000	0.000000	0.000000	0.000000	0.000378
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000315	0.000000	0.000000	0.000000	0.000000	0.000315
Other	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Passenger	0.000005	0.000000	0.000000	0.000000	0.000000	0.000005
Pleasure	0.000940	0.000000	0.000000	0.000000	0.000000	0.000940
Tug-ATB	0.000080	0.000000	0.000000	0.000000	0.000000	0.000080
Tug-Towline	0.000080	0.000000	0.000000	0.000000	0.000000	0.000080
Total	0.001829	0.000000	0.000000	0.000000	0.000000	0.001829

Table E-52 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area TSS

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001609	0.000000	0.000000	0.000000	0.000000	0.001608
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000474	0.000000	0.000000	0.000000	0.000000	0.000474
Other	0.000158	0.000000	0.000000	0.000000	0.000000	0.000158
Passenger	0.000082	0.000000	0.000000	0.000000	0.000000	0.000082
Pleasure	0.000249	0.000000	0.000000	0.000000	0.000000	0.000249
Tug-ATB	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Tug-Towline	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Total	0.002911	0.000000	0.000000	0.000000	0.000000	0.002911

[30] 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-53 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area East

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000976	0.000000	0.000000	0.000000	0.000000	0.000976
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000386	0.000000	0.000000	0.000000	0.000000	0.000386
Other	0.000041	0.000000	0.000000	0.000000	0.000000	0.000041
Passenger	0.000001	0.000000	0.000000	0.000000	0.000000	0.000001
Pleasure	0.000135	0.000000	0.000000	0.000000	0.000000	0.000135
Tug-ATB	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Tug-Towline	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Total	0.001607	0.000000	0.000000	0.000000	0.000000	0.001607

Table E-54 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area West

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000024	0.000000	0.000000	0.000000	0.000000	0.000024
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000477	0.000000	0.000000	0.000000	0.000000	0.000477
Other	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Passenger	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Pleasure	0.001227	0.000000	0.000000	0.000000	0.000000	0.001227
Tug-ATB	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Tug-Towline	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Total	0.001914	0.000000	0.000000	0.000000	0.000000	0.001914

Table E-55 Case 0 Accident frequencies (per year) without the Wind Farm in the Sub-Area South

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000123	0.000000	0.000000	0.000000	0.000000	0.000123
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000101	0.000000	0.000000	0.000000	0.000000	0.000101
Other	0.000009	0.000000	0.000000	0.000000	0.000000	0.000009
Passenger	0.000013	0.000000	0.000000	0.000000	0.000000	0.000013
Pleasure	0.000092	0.000000	0.000000	0.000000	0.000000	0.000092
Tug-ATB	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Tug-Towline	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Total	0.000374	0.000000	0.000000	0.000000	0.000000	0.000374

Table E-56 Case 0 Accident frequencies (per year) without the Wind Farm in the Remainder of the MARCS Study Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001413	0.001047	0.069840	0.000000	0.000000	0.072301
Cruise Ferries	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
Fishing	0.002380	0.082740	0.124900	0.000000	0.000000	0.210020
Other	0.000213	0.006787	0.021260	0.000000	0.000000	0.028260
Passenger	0.000167	0.015190	0.009783	0.000000	0.000000	0.025140
Pleasure	0.002160	0.206500	0.103000	0.000000	0.000000	0.311660
Tug-ATB	0.000257	0.006340	0.027380	0.000000	0.000000	0.033977
Tug-Towline	0.000257	0.006340	0.027380	0.000000	0.000000	0.033977
Total	0.006848	0.324944	0.383544	0.000000	0.000000	0.715336

Table E-57 Case 0 Accident frequencies (per year) without the Wind Farm in the Entire MARCS Study Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.004523	0.001047	0.069840	0.000000	0.000000	0.075410
Cruise Ferries	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
Fishing	0.004133	0.082740	0.124900	0.000000	0.000000	0.211773
Other	0.000479	0.006787	0.021260	0.000000	0.000000	0.028526
Passenger	0.000299	0.015190	0.009783	0.000000	0.000000	0.025272
Pleasure	0.004803	0.206500	0.103000	0.000000	0.000000	0.314303
Tug-ATB	0.000623	0.006340	0.027380	0.000000	0.000000	0.034343
Tug-Towline	0.000623	0.006340	0.027380	0.000000	0.000000	0.034343
Total	0.015483	0.324944	0.383544	0.000000	0.000000	0.723971

E.5.2 Base Case Plus the Project (Case 1) Scenario iii – 98 Structures

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 mainly used to verify the modeling. The results tables are shown in the same sequence as that used in Section E.3.1 above for the Base Case (Case 0).

The results for Case 1 are compared with the other case results and discussed in Section E.7.

Table E-58 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area Lease

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000378	0.000000	0.000000	0.033430	0.048260	0.082069
Cruise Ferries	0.000000	0.000000	0.000000	0.000023	0.000021	0.000044
Fishing	0.000315	0.000000	0.000000	0.010390	0.011250	0.021955
Other	0.000031	0.000000	0.000000	0.002143	0.002882	0.005056
Passenger	0.000005	0.000000	0.000000	0.000836	0.000443	0.001284
Pleasure	0.000940	0.000000	0.000000	0.040720	0.037340	0.079000
Tug-ATB	0.000080	0.000000	0.000000	0.007967	0.013980	0.022027
Tug-Towline	0.000080	0.000000	0.000000	0.075860	0.059860	0.135804
Total	0.001829	0.000000	0.000000	0.171369	0.174036	0.347234

Table E-59 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area TSS

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001609	0.000000	0.000000	0.000000	0.000000	0.001608
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000474	0.000000	0.000000	0.000000	0.000000	0.000474
Other	0.000158	0.000000	0.000000	0.000000	0.000000	0.000158
Passenger	0.000082	0.000000	0.000000	0.000000	0.000000	0.000082
Pleasure	0.000249	0.000000	0.000000	0.000000	0.000000	0.000249
Tug-ATB	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Tug-Towline	0.000170	0.000000	0.000000	0.000000	0.000000	0.000170
Total	0.002911	0.000000	0.000000	0.000000	0.000000	0.002911

Table E-60 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area East

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000976	0.000000	0.000000	0.000000	0.000000	0.000976
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000386	0.000000	0.000000	0.000000	0.000000	0.000386
Other	0.000041	0.000000	0.000000	0.000000	0.000000	0.000041
Passenger	0.000001	0.000000	0.000000	0.000000	0.000000	0.000001
Pleasure	0.000135	0.000000	0.000000	0.000000	0.000000	0.000135
Tug-ATB	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Tug-Towline	0.000034	0.000000	0.000000	0.000000	0.000000	0.000034
Total	0.001607	0.000000	0.000000	0.000000	0.000000	0.001607

Table E-61 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area West

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000024	0.000000	0.000000	0.000000	0.000000	0.000024
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000477	0.000000	0.000000	0.000000	0.000000	0.000477
Other	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Passenger	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Pleasure	0.001227	0.000000	0.000000	0.000000	0.000000	0.001227
Tug-ATB	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Tug-Towline	0.000064	0.000000	0.000000	0.000000	0.000000	0.000064
Total	0.001914	0.000000	0.000000	0.000000	0.000000	0.001914

Table E-62 Case 1 Accident frequencies (per year) without the Wind Farm in the Sub-Area South

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000123	0.000000	0.000000	0.000000	0.000000	0.000123
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000101	0.000000	0.000000	0.000000	0.000000	0.000101
Other	0.000009	0.000000	0.000000	0.000000	0.000000	0.000009
Passenger	0.000013	0.000000	0.000000	0.000000	0.000000	0.000013
Pleasure	0.000092	0.000000	0.000000	0.000000	0.000000	0.000092
Tug-ATB	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Tug-Towline	0.000018	0.000000	0.000000	0.000000	0.000000	0.000018
Total	0.000374	0.000000	0.000000	0.000000	0.000000	0.000374

Table E-63 Case 1 Accident frequencies (per year) without the Wind Farm in the Remainder of the MARCS Study Area

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001413	0.001047	0.069840	0.000000	0.000000	0.072300
Cruise Ferries	0.000000	0.000000	0.000001	0.000000	0.000000	0.000001
Fishing	0.002380	0.082740	0.124900	0.000000	0.000000	0.210020
Other	0.000213	0.006787	0.021260	0.000000	0.000000	0.028260
Passenger	0.000167	0.015190	0.009783	0.000000	0.000000	0.025140
Pleasure	0.002160	0.206500	0.103000	0.000000	0.000000	0.311660
Tug-ATB	0.000257	0.006340	0.027380	0.000000	0.000000	0.033977
Tug-Towline	0.000257	0.006340	0.027380	0.000000	0.000000	0.033973
Total	0.006848	0.324944	0.383544	0.000000	0.000000	0.715336

Table E-64 Case 1 Accident frequencies (per year) without the Wind Farm in the Entire MARCS Study Area

Base Case Plus	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.004523	0.001047	0.069840	0.033430	0.048260	0.157100
Cruise Ferries	0.000000	0.000000	0.000001	0.000023	0.000021	0.000045
Fishing	0.004133	0.082740	0.124900	0.010390	0.011250	0.233413
Other	0.000479	0.006787	0.021260	0.002143	0.002882	0.033551
Passenger	0.000299	0.015190	0.009783	0.000836	0.000443	0.026551
Pleasure	0.004803	0.206500	0.103000	0.040720	0.037340	0.392363
Tug-ATB	0.000623	0.006340	0.027380	0.007967	0.013980	0.056290
Tug-Towline	0.000623	0.006340	0.027380	0.075860	0.059860	0.170063
Total	0.015483	0.324944	0.383544	0.171369	0.174036	1.069376

E.5.3 Future Case with the Project (Case 2) Scenario iii – 98 Structures

The Case 2 results show the average annual frequencies of marine accidents using modified Base Case traffic data and incorporating the Project structures. The results tables are shown in the same sequence as that used in Section E.3.1 and Section E.3.2 above.

The results for Case 2 are compared with the other case results and discussed in Section E.7 below.

Table E-65 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area Lease

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000016	0.000000	0.000000	0.000409	0.006342	0.006767
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000002	0.000002
Fishing	0.000653	0.000000	0.000000	0.010390	0.011250	0.022293
Other	0.000058	0.000000	0.000000	0.002124	0.002882	0.005064
Passenger	0.001318	0.000000	0.000000	0.009534	0.006802	0.017654
Pleasure	0.004662	0.000000	0.000000	0.102500	0.096780	0.203942
Tug-ATB	0.000000	0.000000	0.000000	0.000105	0.000855	0.000960
Tug-Towline	0.000000	0.000000	0.000000	0.000366	0.003846	0.004212
Total	0.006707	0.000000	0.000000	0.125428	0.128759	0.260894

Table E-66 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area TSS

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.002005	0.000000	0.000000	0.000000	0.000000	0.002003
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000570	0.000000	0.000000	0.000000	0.000000	0.000570
Other	0.000181	0.000000	0.000000	0.000000	0.000000	0.000181
Passenger	0.000104	0.000000	0.000000	0.000000	0.000000	0.000104
Pleasure	0.000303	0.000000	0.000000	0.000000	0.000000	0.000303
Tug-ATB	0.000230	0.000000	0.000000	0.000000	0.000000	0.000230
Tug-Towline	0.000230	0.000000	0.000000	0.000000	0.000000	0.000230
Total	0.003621	0.000000	0.000000	0.000000	0.000000	0.003621

Table E-67 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area East

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001744	0.000000	0.000000	0.000000	0.000000	0.001744
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000558	0.000000	0.000000	0.000000	0.000000	0.000558
Other	0.000052	0.000000	0.000000	0.000000	0.000000	0.000052
Passenger	0.000022	0.000000	0.000000	0.000000	0.000000	0.000022
Pleasure	0.000243	0.000000	0.000000	0.000000	0.000000	0.000243
Tug-ATB	0.000111	0.000000	0.000000	0.000000	0.000000	0.000111
Tug-Towline	0.000111	0.000000	0.000000	0.000000	0.000000	0.000111
Total	0.002841	0.000000	0.000000	0.000000	0.000000	0.002841

Table E-68 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area West

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000009	0.000000	0.000000	0.000000	0.000000	0.000009
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.001071	0.000000	0.000000	0.000000	0.000000	0.001071
Other	0.000052	0.000000	0.000000	0.000000	0.000000	0.000052
Passenger	0.001961	0.000000	0.000000	0.000000	0.000000	0.001961
Pleasure	0.006481	0.000000	0.000000	0.000000	0.000000	0.006481
Tug-ATB	0.000173	0.000000	0.000000	0.000000	0.000000	0.000173
Tug-Towline	0.000173	0.000000	0.000000	0.000000	0.000000	0.000173
Total	0.009920	0.000000	0.000000	0.000000	0.000000	0.009920

Table E-69 Case 2 Accident frequencies (per year) without the Wind Farm in the Sub-Area South

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000184	0.000000	0.000000	0.000000	0.000000	0.000184
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.000119	0.000000	0.000000	0.000000	0.000000	0.000119
Other	0.000010	0.000000	0.000000	0.000000	0.000000	0.000010
Passenger	0.000031	0.000000	0.000000	0.000000	0.000000	0.000031
Pleasure	0.000140	0.000000	0.000000	0.000000	0.000000	0.000140
Tug-ATB	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Tug-Towline	0.000027	0.000000	0.000000	0.000000	0.000000	0.000027
Total	0.000538	0.000000	0.000000	0.000000	0.000000	0.000538

Table E-70 Case 2 Accident frequencies (per year) without the Wind Farm in the Remainder of the MARCS Study Area

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.001269	0.001023	0.072760	0.000000	0.000000	0.075054
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Fishing	0.002984	0.082740	0.124900	0.000000	0.000000	0.210624
Other	0.000238	0.006787	0.021260	0.000000	0.000000	0.028285
Passenger	0.002507	0.069620	0.021260	0.000000	0.000000	0.093387
Pleasure	0.008391	0.422100	0.174900	0.000000	0.000000	0.605391
Tug-ATB	0.000348	0.006306	0.030400	0.000000	0.000000	0.037054
Tug-Towline	0.000348	0.006306	0.030400	0.000000	0.000000	0.037054
Total	0.016087	0.594882	0.475880	0.000000	0.000000	1.086849

Table E-71 Case 2 Accident frequencies (per year) without the Wind Farm in the Entire MARCS Study Area

Future Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.005227	0.001023	0.072760	0.000409	0.006342	0.085761
Cruise Ferries	0.000000	0.000000	0.000000	0.000000	0.000002	0.000002
Fishing	0.005955	0.082740	0.124900	0.010390	0.011250	0.235235
Other	0.000591	0.006787	0.021260	0.002124	0.002882	0.033644
Passenger	0.005943	0.069620	0.021260	0.009534	0.006802	0.113159
Pleasure	0.020220	0.422100	0.174900	0.102500	0.096780	0.816500
Tug-ATB	0.000889	0.006306	0.030400	0.000105	0.000855	0.038555
Tug-Towline	0.000889	0.006306	0.030400	0.000366	0.003846	0.041807
Total	0.039714	0.594882	0.475880	0.125428	0.128759	1.364663

E.6 Model verification

Several checks and cross-checks were conducted to assure the model is self-consistent, and provides valid, credible results.

The difference between Scenario i, Scenario ii, and Scenario iii is only the number of Project structures. All other model input variables are unchanged. Thus, the detailed model verification discussed here refers only to Scenario ii.

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.

E.6.1 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 MARCS Study Area shows that the total accident frequency increases by 0.420 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 0.209 and 0.211 for powered and drift allision respectively. The sum of the allision frequencies represent the difference in the total accident frequency between Case 1 and Case 0. Approximately 50% 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.6.2 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 MARCS Study Area. The main differences were:

- Powered allision is reduced for Cargo/ Tanker, Cruise/ Ferry, Tug-ATB and Tug-Towline. This is because these ship types are re-routed around the wind farm in the Future Case.
- Powered allision is increased for Pleasure vessels and, to a lesser extent, Passenger vessels. This is because of the additional traffic of these types included in the Future Case.
- Similar trends with ship type are seen for drift allision for similar reasons.
- Powered grounding is increased for Pleasure vessels and to a lesser extent for Passenger vessels. This is because of the increased traffic of these ship types in the Future Case.
- Drift grounding is increased for Pleasure vessels and to a lesser extent for Passenger vessels, but also by a very small degree for most other ship types (not Fishing or Other). The Pleasure and Passenger increase is due to the additional traffic. The changes for other ship types are due to re-routing some traffic closer to the shoreline.

- Collision frequency increases because there is significantly more ship-miles in the MARCS Study Area in the Future Case.

E.7 Results and discussion

This section presents and discusses the accident frequency differences due to the Project.

E.7.1 Discussion of project risk difference

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-72 and Figure E-31 show the predicted effect of the Project on accident frequency, that is, the difference between Case 2 and Case 0 for the MARCS Study Area.

Table E-72 Case 2 minus Case 0 Accident frequencies (per year) in the Entire MARCS Study Area for Scenario ii (119 structures)

Project Risk	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	0.000704	-0.000024	0.002920	0.001635	0.007993	0.013228
Cruise Ferries	0.000000	0.000000	-0.000001	0.000001	0.000002	0.000002
Fishing	0.001822	0.000000	0.000000	0.012470	0.013240	0.027532
Other	0.000112	0.000000	0.000000	0.002838	0.003691	0.006641
Passenger	0.005644	0.054430	0.011477	0.010730	0.007687	0.089968
Pleasure	0.015417	0.215600	0.071900	0.112400	0.108800	0.524117
Tug-ATB	0.000266	-0.000034	0.003020	0.000176	0.001013	0.004441
Tug-Towline	0.000266	-0.000034	0.003020	0.000908	0.004555	0.008715
Total	0.024231	0.269938	0.092336	0.141158	0.146981	0.674644

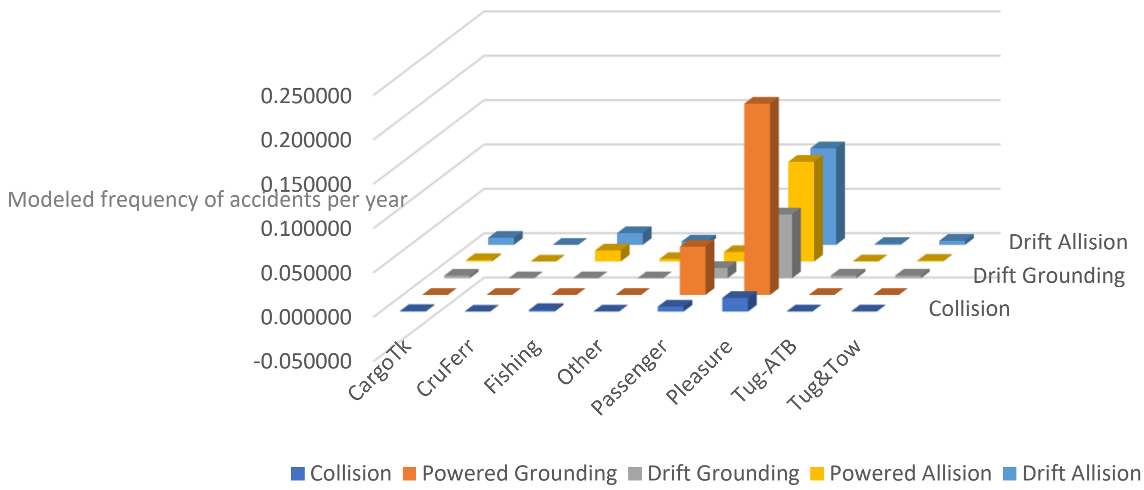

Figure E-31 Case 2 minus Case 0 Accident frequencies (per year) in the Entire MARCS Study Area for Scenario ii (119 structures)

Table E-72 shows that the main difference due to the Project is due to Pleasure ships (78% of the total). This is because of the significant increase (by a factor of 1.74) in ship-miles for Pleasure vessels assumed in the Future Case. Passenger vessel ship-miles also increase in the Future Case significantly (a factor of 2.74) but the accident frequency increase is only 13%. These additional Passenger vessels are CTVs operated by the Project. The Project has undertaken to ensure high standards of crew selection, training and management on their CTVs. These undertakings underlie the reduced accident conditional probabilities used for CTVs (assumed equivalent to pilot human performance) and this is reflected in the relatively modest increase in accident frequency seen.

The main accident type contributing to the increased accident frequency seen in Table E-72 is powered grounding (40%), mainly due to Pleasure vessels. This powered grounding risk arises as Pleasure vessels return to port after a trip to the wind farm. The Project cannot be deemed responsible for the safety of third-party traffic generated by interest in the wind farm and, as a result, this risk model has not been fully optimized to assess these powered grounding risks.

Drift and powered allision are the next most significant accident types (21% and 22% of the total respectively). The main vessel type contributor is again Pleasure vessels. For non-Pleasure vessels the accident frequencies are low, with accident return periods of 80 years to greater than 1000 years depending on the ship type.

E.7.2 Discussion of the sub-area results

Arguably, the accident frequency difference (Case 2 – Case 0) that is most directly attributable to the Project is that in Sub-Area Lease. These results are shown in Table E-73.

Table E-73 Case 2 minus Case 0 Accident frequencies (per year) in Sub-Area Lease for Scenario ii

Project Risk	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo Tanker	-0.000362	0.000000	0.000000	0.001635	0.007993	0.009266
Cruise Ferries	0.000000	0.000000	0.000000	0.000001	0.000002	0.000003
Fishing	0.000338	0.000000	0.000000	0.012470	0.013240	0.026048
Other	0.000027	0.000000	0.000000	0.002838	0.003691	0.006556
Passenger	0.001313	0.000000	0.000000	0.010730	0.007687	0.019730
Pleasure	0.003722	0.000000	0.000000	0.112400	0.108800	0.224922
Tug-ATB	-0.000080	0.000000	0.000000	0.000176	0.001013	0.001109
Tug-Towline	-0.000080	0.000000	0.000000	0.000908	0.004555	0.005383
Total	0.004878	0.000000	0.000000	0.141158	0.146981	0.293017

As expected, the dominant accident types that contribute to the Project risk in sub-area Lease are powered and drift allision (48% and 50% respectively). Also as expected from the discussion above, the Pleasure vessels contribute most of the total accident difference (77%).

Only the collision frequencies change for the sub-areas TSS, East, West, and South, as these sub-areas do not include either allision objects or coastline. The absolute changes in collision frequencies are all small (0.008/year or lower) and are not discussed further.

E.7.3 Discussion of scenario results

The difference between the 3 scenarios is only the number of allision objects in the wind farms (126 for Scenario I, 119 for Scenario ii and 98 for Scenario iii). Hence, the accident frequencies for collision, powered grounding are identical for each scenario for a given case.

The powered and drift allision accident frequencies as a function of ship type and scenario are shown for the Future Case (Case 2) in Figure E-32 and Figure E-33, respectively.

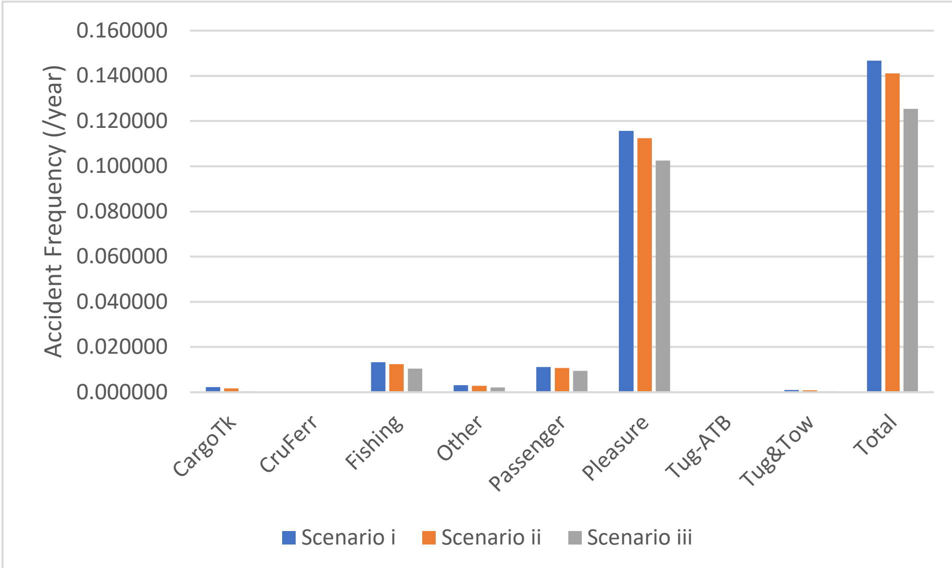

Figure E-32 Future Case Powered Allision Frequency (/year) as a function of Scenario and Ship Type

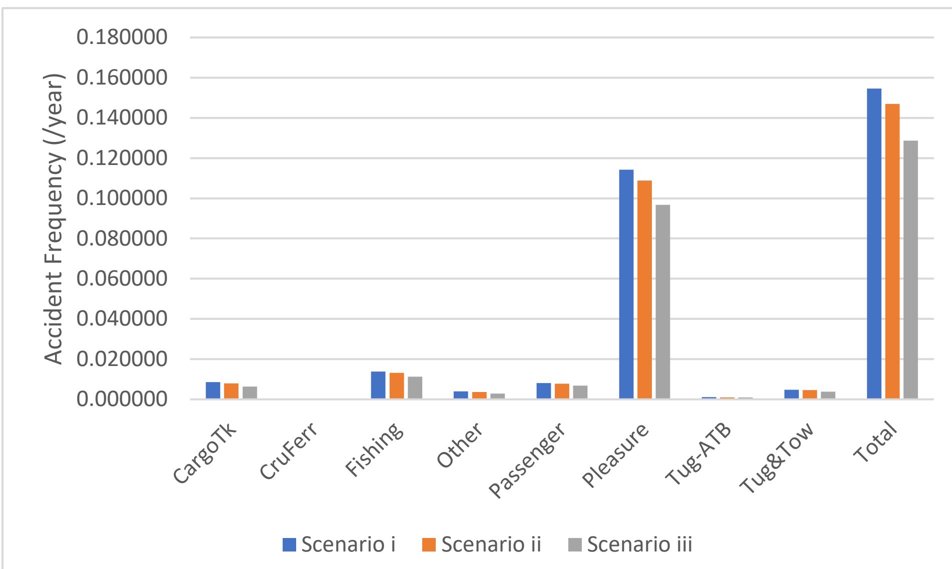

Figure E-33 Future Case Drift Allision Frequency (/year) as a function of Scenario and Ship Type

As expected, the allision frequency decreases as the number of allision objects decreases (since in the limit of zero objects the allision frequency is exactly 0.0). As discussed previously, Pleasure ships contribute most of the allision accident frequency.

It is Federal Government policy to promote offshore wind power. The policy goal is to reduce emissions of carbon dioxide per unit of electrical power consumed and hence mitigate climate change. Implicit in this Federal policy is an acceptance of increased allision risk. Thus, it can be argued that the purpose of the NSRA is not to minimize allision risk, but to ensure allision risk does not increase disproportionately or unacceptably compared to other benefits.

Assuming wind turbines are centered in less densely trafficked sea areas, then the allision risk per structure should be roughly constant as the wind farm increases in size. Eventually, as the wind farm size increases, the outer structures will start to encroach into more densely trafficked sea areas and the allision risk per structure will then start to increase.

Table E-74 shows the allision frequencies normalized by the number of structures

Table E-74 Allision Frequency per Structure

	Scenario i	Scenario ii	Scenario iii
Structures	126	119	98
Powered Allision	0.001165	0.001186	0.00128
Drift Allision	0.001227	0.001235	0.001314
Total	**0.002392**	**0.002421**	**0.002594**

In Table E-74 the trend is actually increasing accident frequency per structure as the number of structures reduces. This is because the large structures (OSSs and Met tower) are the same for each scenario, thus they make a proportionately larger allision frequency contribution to Scenario iii (which has only 98 structures).

Table E-74 also shows that the accident frequency per structure does not increase as the number of structures increases. This implies that even for Scenario i, the wind farm is not yet encroaching into more densely trafficked sea areas.

E.7.4 Conclusions

The following conclusions can be drawn from the modeling results:

- Collision risk increases (mainly due to the assumed increase in traffic generated by the wind farm) but from a low base and the predicted future collision risk is a total of 0.04/year, or 1 accident every 25 years. This is not a big number in a global context.
- Grounding risk increases mainly due to the assumed/ predicted traffic increase due to the wind farm. The developer is not responsible for groundings of 3rd party traffic which puts to sea in order to see or fish around the wind farm (the majority of the increase) and the risk model has not been optimized to assess these grounding risks. The developer is responsible for CTV groundings. This risk may be mitigated by crew selection and training (reduced human error probabilities) and transit rules (e.g., no transits during poor visibility or strong wind).
- Allision risk increases. This is an inevitable consequence of the federal policy (is it Fed policy?) of promoting offshore wind energy to reduce CO_2 emissions. About 90% of this allision frequency is due to smaller ships navigating within the wind farm footprint. The consequence of these allisions is likely to be low for both ship and WTG. Risk is mitigated by not installing WTGs in close proximity to the outbound TSS. The frequency of higher consequence allisions (powered allision of ships with LOA > 100m) is 0.0095/year or 1 deep draft powered allision in 105 years, which is 4 times the design lifetime of the wind farm.

E.8 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) and for the Future Case with the addition of the Project (and additional vessel traffic caused by the presence of the wind farm and assumed modified traffic routes). The difference between Case 2 and Case 0 is our best estimate of the increase in accident frequency caused by the presence of Maryland wind farm.

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 2 and Case 0 is 0.68 accidents per year across the entire Study Area (an increase of 93%). The majority of this accident frequency increase is attributed to estimated increases in Pleasure vessel traffic and a significant portion of this is due to Pleasure traffic grounding. The Project cannot be deemed responsible for accidents to 3rd party vessels several miles away from the wind farm. Our best estimate of the extra accident frequency that results directly from the presence of the Project using plausible but conservative estimates is 0.29/year (from project sub-area Lease), which is an increase of 40% compared to the Base Case.

The quantified risk assessment of the navigational risk for the Project concludes there is a small risk increase due to the Project in light of comparative global risk profiles. 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 a checklist for review and development of an NSRA. Table F-1 is the checklist that was completed by DNV during development of this NSRA.

Table F-1 Completed NSRA Checklist

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	Coordinates of the structures in the Lease Area as evaluated in the NSRA are provided in separate communication from US Wind. The precise locations of the structures export cable will be provided to relevant agencies when they are finalized, which is anticipated to occur after approval of the COP.
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	GIS data and accompanying metadata for relevant Project components will be provided to the USCG will be provided in separate communication from US Wind..
2. TRAFFIC SURVEY		
Was the traffic survey conducted within 12 months of the NSRA?	Yes	One year of AIS data (2019) was assessed in the traffic survey presented in Section 2 of the NSRA report. Potential use of 2020 and 2021 AIS data was considered but not recommended by DNV as representative of marine traffic relevant to future Project operational phase risk because of relatively temporary effects on traffic patterns and densities resulting from the effects of COVID-19.
Does the survey include all vessel types?	Yes	All vessel types in the AIS data and other identified vessel traffic/patterns were included in the traffic survey. See details per vessel type in Section 2.1.

ISSUE	Covered in the NSRA?	COMMENTS
Is the time period of the survey at least 28 days duration?	Yes	AIS data for 2019 (365 days) was assessed in the Traffic Survey. See Section 2
Does the survey include consultation with recreational vessel organizations?	Yes	Consultation with recreational organizations was undertaken and is summarized in Appendix II-L2 of the US Wind COP. See the NSRA, Appendices B and C for the list of organizations and discussed concerns.
Does the survey include consultation with fishing vessel organizations?	Yes	Consultation with fishing organizations was undertaken and is summarized in Appendix II-F1 and Appendix II-L2 of the US Wind COP. See the NSRA, Appendices B and C for the list of organizations and discussed concerns.
Does the survey include consultation with pilot organizations?	Yes	Consultation with pilots was undertaken and is included in COP Appendix II-L2. See the NSRA, Appendices B and C for the list of organizations and discussed concerns.
Does the survey include consultation with commercial vessel organizations?	Yes	Consultation with commercial vessel organizations was undertaken and is summarized in Appendix II-L2 of the US Wind COP. See the NSRA, Appendices B and C for the list of organizations and discussed concerns.
Does the survey include consultation with port authorities?	Yes	Consultation with MAC members was undertaken and is summarized in Appendix II-L2 of the US Wind COP. See the NSRA, Appendices B and C for the list of organizations and discussed concerns.
Does the survey include proposed structure location relative to areas used by any type of vessel?	Yes	Vessel routes and pattens, including relative to the Lease Area, are provided in Section 2.1. The locations of structures relative to vessel uses for any vessel type are described in Section 2.2.1 for non-transit uses and Section 2.2.2 for transit-related uses.
Does the survey include numbers, types, sizes and other characteristics of vessels presently using such areas?	Yes	The numbers of vessels, types, sizes and characteristics of vessels are described in 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	Section 2.1.4 contains a summary of the primary cargoes in the Traffic Survey Area..
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	Non-transit uses of waters in the Traffic Survey Area are assessed in 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	Transit routes used by coastal or deep draft vessels and ferries are presented Sections 2.1.1.6 (tugs), 2.1.1.1 (cargo/tanker vessels), and 2.1.1.4 (passenger vessels). Fishing vessel routes are presented in Section 2.2.2.2 (which also refers to Section 2.1.1.2).
Does the survey include alignment and proximity of the site relative to adjacent shipping routes	Yes	Proximity to shipping routes is described in Section 2.2.2.3, and the risk related to the shipping routes is included in the accident assessment in Section 11.
Does the survey include whether the nearby area contains prescribed or recommended routing measures or precautionary areas?	Yes	Section 2.2.3.1 describes routing measures, precautionary areas, separation zones, and TSS in the Traffic Survey Area.
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	Separation zones in the Traffic Survey Area are discussed in Section 2.2.3.1.
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	Anchorages, safe havens, port approaches and pilot areas in the Traffic Survey Area are presented in Section 2.2.3. Current anchoring practices are discussed in Section 2.2.3.2. Project impacts on anchorages is discussed in Sections 2.2.3.5 and 5.4.
Does the survey include the feasibility of allowing vessels to anchor within the vicinity of the structure field?	Yes	Anchoring in the Lease Area is discussed in Section 2.2.3.5.

ISSUE	Covered in the NSRA?	COMMENTS
Does the survey include the proximity of the site to existing fishing grounds, or to routes used by fishing vessels to such grounds?	Yes	Section 2.1.1.2 describes fishing vessel activity and fishing areas. A summary of fishing transit routes is provided in Section 2.2.2.2.
Does the survey include whether the site lies within the limits of jurisdiction of a port and/or navigation authority?	Yes	Ports and navigation authorities are presented in Section 2.2.4.1.
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	Offshore military uses are presented in Section 2.2.4.2.
Does the survey include the proximity of the site to existing or proposed offshore OREI/gas platform or marine aggregate mining?	Yes	OREI, gas platforms, and marine mining are presented in Section 2.2.4.3. Cumulative effects are described in Section 11.4.
Does the survey include the proximity of the site to existing or proposed structure developments?	Yes	Existing and proposed offshore developments are presented in Sections 2.2.4.3.
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	Ocean disposal sites are presented in Section 2.2.4.5.
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	ATON and VTS are described in Section 2.2.4.4.
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	Section 2.3 and Appendix E describe anticipated changes in traffic from the Project. Temporary changes in traffic are anticipated during installation/removal of the export cable. The effects from changes in traffic during the operational phase of the Project were assessed quantitatively using computer simulation techniques described in Appendices D and E. A summary of risk results is presented in Section 11.

ISSUE	Covered in the NSRA?	COMMENTS
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	The potential effects from vessel emission requirements are presented in Section 2.4.
Does the survey include seasonal variations in traffic?	Yes	Seasonal variations in traffic are presented in 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	The hazards posed by above water Project components to vessels and vessel activities are assessed in Section 3.
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	Vessel clearances from Project structures are assessed in 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	The Project's potential effects on emergency rescue are described in 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	The Project's plan to control operations during emergencies is presented in Section 14 and plans to be developed in the future related to emergency response are presented in Section 16.
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	Noise and other potential hazards to navigation safety or USCG missions from the Project are assessed in Section 3.
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	An analysis of the consequences from a vessel impact with a Project structure is presented in Section 3.4.

ISSUE	Covered in the NSRA?	COMMENTS
4. OFFSHORE UNDER WATER STRUCTURES		
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?	Yes	No underwater devices are planned other than subsea cables. The hazards posed by the cables to vessels and vessel activities are assessed in Section 4.
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?	NA	Underkeel clearance hazards were evaluated and determined not to be relevant to the Project. No Project components will rise above the sea bed to pose a hazard to passing vessels. Charted water depths are a minimum of 12.3 m (40 ft) where Project structures will be located (Section 6.3), which is more than sufficient for vessels transiting the area. See Section 4 for assessment of hazards related to buried Project components.
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 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.	NA	Not applicable. No underwater components are planned other than subsea cables and foundations of above-water structures.. See Section 4 for assessment of hazards related to Project components buried in the sea bed.
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:		
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?	Yes	Navigation hazards in the site for all relevant vessel types, directions, and conditions is summarized in Section 5 for construction, operations, and decommissioning Project phases. Additional information on each hazard type is summarized in Section 3.1.

ISSUE	Covered in the NSRA?	COMMENTS
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?	Yes	The NSRA contains information for the USCG to determine whether or not exclusion from the site could cause navigation, safety or transiting problems for vessels operating in the area. Section 5 assesses the safety of navigation close to structures during for construction, operations, and decommissioning of the Project. Additional information on each hazard type is summarized in Section 3.1.
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?	Yes	The NSRA contains information for the USCG to determine whether or not exclusion from the site could cause navigation, safety or transiting problems for vessels operating in the area. Section 5 assesses the safety of navigation close to structures during for construction, operations, and decommissioning of the Project. Information on each hazard type is summarized in Section 3. Supporting information is provided in Section 2 and Section 11.
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	Based on the water depths, tides, historical routes, and historical accident data, keel clearance is not an anticipated hazard to vessels in the vicinity of the Project. Tides and bathymetry are described in Section 6.1 and 6.3, respectively.
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	Section 6.2 describes tidal streams and currents, which are not anticipated to significantly affect navigation risk in proximity to the Project.
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	Sections 6.1 and 6.2 describe tidal streams and ocean currents, which are not anticipated to significantly affect navigation risk in proximity to the Project.
Current directions/velocities might aggravate or mitigate the likelihood of allision with the structure?	Yes	Section 6.2 describes currents, which are not anticipated to significantly affect navigation risk in proximity to the Project.

ISSUE	Covered in the NSRA?	COMMENTS
The maximum rate tidal stream runs parallel to the major axis of the proposed site layout, and, if so, its effect?	Yes	Section 6.2 describes tidal streams and currents, which are not anticipated to significantly affect navigation risk in proximity to the Project.
The set is across the major axis of the layout at any time, and, if so, at what rate?	Yes	Section 6.2 describes tidal streams and currents, which are not anticipated to significantly affect navigation risk in proximity to the Project.
In general, whether engine failure or other circumstance could cause vessels to be set into danger by the tidal stream or currents?	Yes	Section 6.2 describes tidal streams and currents. Relevant aspects, including the frequency of engine failure, were included in the risk modeling described in Appendix E and the quantified risk results summarized in Section 11.
Structures themselves could cause changes in the set and rate of the tidal stream or direction and rate of the currents?	Yes	No impacts to tides and currents streams are anticipated as noted in 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	Section 4 mentions a future scour study and Section 6.2 describes the relative low level of tidal influence in the Lease Area.
Structures would cause danger and/or severely affect the air column, water column, sea bed and sub-sea bed in the general vicinity of the structure?	Yes	No danger or severe effects are anticipated at this time to navigation safety regarding the air column, water column, sea bed and sub-sea bed in the general vicinity based on the available data. See Section 6 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	Visibility, weather, and sea state are considered in the collision, allision, and grounding risk modeling. Section 7 describes weather conditions and Section 11 summarizes the risk results.
The structures could create problems in the area for vessels under sail, such as wind masking, turbulence, or sheer?	Yes	Risk to vessels under sail is assessed in 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	Visibility, weather, and sea state are considered in the collision, allision, and grounding risk modeling, as well as potential failure modes such as engine failure and rudder failure. Section 6 described tidal conditions, Section 7 describes weather conditions, and Section 11 summarizes the 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	Effects related to ice are assessed in Section 7.4
An analysis of the ability for structures to withstand anticipated ice flows should be conducted by the applicant?	Yes	Effects related to ice are assessed in 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	Effects related to icing are assessed in Section 7.4, as well as planned measures to prevent adverse consequences.
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	The factors evaluated during selection of offshore wind layout are described in Section 8. Section 10 describes the potential effects of the Project on communications, radar, and positioning systems. Section 12 describes the potential demands on emergency response capability. Section 16 describes development of Project operational procedures in the future that will detail how the Project will cooperate with USCG in the event of an emergency situation and that will be discussed and agreed with the USCG.

ISSUE	Covered in the NSRA?	COMMENTS
Each OREI layout design will be assessed on a case-by-case basis.	Yes	Three layouts were considered in this NSRA. The modeled frequency of accidents documented in Appendix E was used by US Wind to arrive at a preferred proposed layout.
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	The factors evaluated during selection of offshore wind layout are described in Section 8. The structure layout more than 1 NM from a TSS is a risk control identified in early phase work. The NSRA presents information supporting how the risks are reduced to ALARP. Sections 11.1 and 11.2 summarize the collision, allision, and grounding risk results; other risks are assessed as indicated in topical sections of the NSRA. Section 11.3 provides lists of risk control measures that are (1) already implemented by other parties (2) included in the Project plan (3) evaluated on a cost-benefit and other bases per ALARP criteria. Project mitigation commitments informed by risk benefit are listed in Section 17.
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	Section 1.2 presents the proposed structure layout, in straight rows and columns except for the Met tower. Section 5.2 assesses lines of orientation and distances between structures. Section 8 describes current USCG capabilities and high-level processes. Section 12 presents an assessment of Project effects on emergency response.
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	The Project does not share a boundary with any other existing or proposed OREI lease. The Project is likely to be developed in stages; therefore, the ATON requirements will change. For example, structures that are exterior in one phase may become interior structure when another phase is constructed.

ISSUE	Covered in the NSRA?	COMMENTS
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	Section 9 assesses the potential for a structure to block the view of a vessel underway.
Structures could block or hinder the view of the coastline or of any other navigational feature such as aids to navigation, landmarks, promontories?	Yes	Section 9 assesses the potential for a structure to block the view of navigational features.
Structures and locations could limit the ability of vessels to maneuver in order to avoid collisions?	Yes	Section 3.1, and Section 11 assess risks related to Project effects on vessel maneuverability.
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	Sections 10.1 through 10.4 present potential effects on VHF Rescue 21, DSC, and AIS), UHF, marine radar, land-based radar, and GPS. Section 10.4 discusses potential risk control measures for marine radar effects.
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	Yes	Marine radar effects are assessed in Section 10.2.
Structures, in general, would comply with current recommendations concerning electromagnetic interference?	Yes	The Project structures will comply with regulations and requirements (US Wind, 2022).
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	Noise from Project WTGs is assessed in Section 3.1 and its effects on communications in Section 10.1.
Structures, generators, and the sea bed cabling within the site and onshore might produce electro-magnetic fields affecting compasses and other navigation systems?	Yes	Effects of the Project on specific navigation systems are discussed in 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	No non-contact physical risks from the Project are identified in the NSRA. Noise from Project WTGs is assessed in Sections 3.1 and 3.4.

ISSUE	Covered in the NSRA?	COMMENTS
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	The quantified frequencies of collision, allision, and grounding accidents are summarized in Section 11.2. Consequences of potential of collision, allision, and grounding accidents are described in Section 11.1. The results include location, type of accident, and type of vessel.

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	The provided SAR data is summarized and discussed in Section 12, which also presents the additional estimated SAR cases from the Project.
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	The MEP data from MISLE is assessed in Section 12, together with an estimate of additional pollution cases from the Project.

ISSUE	Covered in the NSRA?	COMMENTS
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	Section 13 outlines the current requirements for marine lighting and marking of structures.
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	Section 13 outlines the current requirements for marine lighting and marking of structures. The Project's lighting and marking scheme for each Project phase will be agreed in consultation with USCG and BOEM.
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	Section 13 outlines the current requirements for marine lighting and marking of structures. The Project's lighting and marking scheme for each Project phase will be agreed in consultation with USCG and BOEM.
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	Section 13 addresses this topic to the extent practical at this project stage. An optimized set of navigation aids will be selected in consultation and coordination with USCG.
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	Section 13 addresses this topic to the extent practical at this project stage. An optimized set of navigation aids will be selected in consultation and coordination with USCG.
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	Section 13 addresses this topic to the extent practical at this project stage. An optimized set of navigation aids and aviation lighting will be selected in consultation and coordination with USCG and BOEM.
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	Section 13 outlines the current requirements for marine lighting and marking of structures. The Project intends to comply with PATON permits issues by the USCG for Project structures.
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	Section 13 addresses this topic to the extent practical at this project stage. An optimized set of navigation aids will be selected in consultation and coordination with USCG, particularly Fifth District. The requirements for the availability of ATON will be incorporated into each ATON permit issued to the Project.

ISSUE	Covered in the NSRA?	COMMENTS
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	Section 13 addresses this topic to the extent practical at this project stage. An optimized set of navigation aids will be selected in consultation and coordination with USCG, particularly Fifth District. The requirements for the availability of ATON will be incorporated into each ATON permit issued to the Project.
How the marking of the structure will impact existing Federal aids to navigation in the vicinity of the structure?	Yes	Existing ATON are presented in Section 2.2.4.4. Potential Project effects on the use of existing ATON are assessed in Section 9.
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	Section 13 outlines the current requirements for marine lighting and marking of structures. The Project's final lighting and marking will be agreed in consultation with USCG and BOEM.
All generators and transmission systems should be equipped with control mechanisms that can be operated from an operations center of the installation.	Yes	Section 14 describes controls and shutdown capabilities from the Project's shore-based operations center.

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	Section 14 describes controls and shutdown capabilities from the Project's shore-based operations center. Section 15 refers to the Project Safety Management System and Emergency Response Plan. Emergency procedures will be developed and implemented in coordination with the relevant agencies, including USCG.
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	Section 14 describes that controls and shutdown capabilities from the Project's shore-based operations center. The Project Emergency Response Plan (the Oil Spill Response Plan is outlined in COP Appendix I-A . Emergency procedures will be developed and implemented in coordination with the relevant agencies, including USCG. Consultation with USCG will include the topic of structure access during an emergency.
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, as appropriate at an early design phase.	Section 15 refers to the Project Emergency Response Plan. Emergency procedures will be developed and implemented in coordination with the relevant agencies, including USCG. Consultation with USCG will include the topic of structure access during an emergency. The design details of the access and egress for offshore structures will be developed and ultimately verified by the Certified Verification Agent, as part of the Facility Design Report and Fabrication and Installation Report process.
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	The operations center will be manned 24 hours per day, as described in Section 15.

ISSUE	Covered in the NSRA?	COMMENTS
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	The operations center will have charts with indication of the GPS location and identifiers for each structure, as described in Section 15.
All applicable Coast Guard command centers (District and Sector) will be advised of the contact telephone number of the operations center?	Yes	Section 15 refers to the Project Emergency Response Plan and procedures which will be developed and implemented in coordination with the relevant agencies, including USCG. All applicable USCG command centers will be advised of the emergency contact number for the Project operations center.
All applicable Coast Guard command centers will have a chart indicating the position and unique identification number of each of the structures?	Yes	Section 15 refers to the Project Emergency Response Plan and procedures which will be developed and implemented in coordination with the relevant agencies, including USCG. The precise locations of the structures and the export cable will be provided to relevant agencies when they are finalized, which is anticipated to occur after approval of the COP.
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	Emergency procedures will be developed and implemented in coordination with the relevant agencies, including USCG.
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	Detailed emergency shutdown and restart procedures will be outlined in the Project's Emergency Response Plan and Safety Management System. Project emergency procedures will be developed in coordination with USCG.
Communication and shutdown procedures should be tested satisfactorily at least twice each year.	Yes	Section 16 describes anticipated aspects to be included in the Project's Emergency Response Plan and Safety Management System, including testing of procedures.

ISSUE	Covered in the NSRA?	COMMENTS
After an allision, the applicant should submit documentation that verifies the structural integrity of the structure.	Yes	Section 16 describes anticipated aspects to be incorporated in the Project's Emergency Response Plan and Safety Management System, including verification of structural integrity after an allision.

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