MAYFLOWER WIND

Appendix X. Navigation Safety Risk Assessment

Document Revision	B
Issue Date	August 2021

MAYFLOWER WIND OFFSHORE WIND PROJECT

Navigation Safety Risk Assessment

Mayflower Wind Energy LLC

Document No.: 10205905-HOU-R-02
Issue: F**, Status:** DRAFT
Date: 27 August 2021

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Project name:	Mayflower Wind Offshore Wind Project	DNV Energy USA Inc.
Report title:	Navigation Safety Risk Assessment	101 Station Landing, Suite 520,
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Date of issue:	27 August 2021	
Project No.:	10205905	
Document No.:	10205905-HOU-R-02	
Issue/Status:	F/DRAFT	

Task and objective: This report presents the results of a navigation safety risk assessment conducted per USCG NVIC 01-19 by DNV GL on behalf of Mayflower Wind Energy LLC. It evaluates a 149-position layout.

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Keywords:
Mayflower Wind, Offshore Wind, Navigation safety risk, U.S., USCG, Construction and Operation Plan

Issue	Date	Reason for Issue	Prepared by	Verified by	Approved by
A	19 November 2020	Draft	C. Stahl V. Demay	J. Frye T. Fowler V. Demay C. Stahl	A. Duerr
B	24 November 2020	Draft	A. Roberts C. Stahl	C. Stahl A. Duerr	A. Duerr
C	3 February 2021	Draft	A. Roberts C. Stahl	C. Stahl A. Duerr	A. Duerr
D	15 February 2021	Draft	C. Stahl	A. Duerr	A. Duerr
E	17 August 2021	Draft	C. Stahl	J. Frye	J. Frye

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Abbreviation	Meaning
ADLS	Aircraft Detection Light System
AIS	Automatic Identification System
ALARP	As low as reasonably practicable
ATON	Aids to Navigation
BOEM	U.S. Bureau of Ocean Energy Management
CD	Current direction
CFR	Code of Federal Regulations
CIOSS	Cooperative Institute for Oceanographic Satellite Studies
COGOW	Climatology of Global Ocean Winds
COLREGs	International Regulations for Preventing Collisions at Sea
COP	Construction and Operations Plan
CPA	Closest Point of Approach
CS	Current speed
DSC	Digital Select Calling
DWT	Dead Weight Tonnage (units are tonnes)
ECA	Emission Control Area
ECC	Export Cable Corridor
ECDIS	Electronic Chart Display and Information System
EEZ	Exclusive Economic Zone
ETV	Emergency Towing Vessel
EU	European Union
FR	Federal Register
FSA	Formal Safety Assessment
GARFO	Greater Atlantic Regional Fisheries Office
GPS	Global Positioning System
HF	High Frequency
HFR	High Frequency Radar
HVAC	High-Voltage Alternating Current
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
LOA	Length Overall
LOS	Line of Sight
LPG	Liquified Petroleum Gas
MA/RI	Massachusetts/Rhode Island
MARCS	Marine Accident Risk Calculation System
MARIPARS	The Areas off Massachusetts and Rhode Island Port Access Route Study
MARPOL	International Convention for the Prevention of Pollution from Ships
MCA	UK Maritime & Coastguard Agency
MHHW	Mean Higher High Water
MSL	Mean Sea Level
NAIS	Nationwide Automatic Identification System
NEODP	Northeast Ocean Data Portal
NGDC	National Geophysical Data Center
NMFS	National Marine Fisheries Service
NOAA	U.S. National Oceanic and Atmospheric Administration
NROC	Northeast Regional Ocean Council
NSRA	Navigation Safety Risk Assessment
NVIC	Navigation and Vessel Inspection Circular

Abbreviation	Meaning
OCS	Outer Continental Shelf
OREI	Offshore Renewable Energy Installations
OSP	Offshore substation platform
PARS	Port Access Route Study
PATON	Private Aids to Navigation
PPU	Portable Pilot Unit
RODA	Responsible Offshore Development Alliance
SAR	Search and Rescue
SMC	Search and Rescue Mission Coordinator
SO_x	Sulfur oxides
TSS	Traffic Separation Scheme
U.S.	United States
UHF	Ultra-High Frequency
UK	United Kingdom
UKC	Under Keel Clearance
USCG	United States Coast Guard
UTM	Universal Transverse Mercator coordinate system
VHF	Very High Frequency
VMRS	Vessel Movement Reporting System
VMS	Vessel Monitoring System
VTR	Vessel Trip Report
WEA	Wind Energy Area
WGS84	World Geodetic System 1984 datum
WTG	Wind Turbine Generator

List of units

Unit	Meaning
ft	feet
km	kilometers
kt	knots
m	meters
mi	miles
MJ	megajoules
mt	metric tons
NM	nautical miles
m/s	meters per second

EXECUTIVE SUMMARY

This document presents the Navigation Safety Risk Assessment (NSRA) for the Mayflower Wind Offshore Wind Project (the Project). The Project will be located within 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

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

Figure ES-1 shows the boundaries of the NSRA Study Area and the Project. The layout used to assess risk from all potential structure locations has a minimum of 1 nautical miles (NM) (1.9 kilometers [km]) between Project structures in a uniform and aligned east-west/north-south pattern.

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 assure that any error is on the side of overestimating the risk.

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

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

The majority of the risk increase due to the Project lies within the Project Area and is due to the potential for a vessel to strike a Project structure (allision risk). Generally, most 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[1] (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.

Based on the modeling conducted for this assessment, the modeled risk increase from the Project is 0.4 accidents per year. Marine accidents involving fishing vessels represent 70 percent of the increase (Table ES-1). Cargo vessels, carriers, and tankers show a risk increase of 0.019 per year, equivalent to 1 additional accident every 52 years. Nearly all the deep draft allision risk lies in the southeast part of the Project Area. Note 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.

Table ES-1 Modeled Incremental Change in Accident Frequencies from the Project

Vessel type	Increase in frequency of any accident (number per year)	Percentage of Total
Cargo / Carrier	0.012	3.4%
Fishing	0.248	69.5%
Other / Undefined	0.057	16.0%
Passenger	0.003	0.9%
Pleasure	0.029	8.1%
Tanker	0.002	0.5%
Tanker - Oil	0.005	1.4%
Tug / Service	0.001	0.2%
Total	0.357	100%

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 by at least half. Conversely, if the actual number of transits were double, one would expect the risk to be somewhat more than double.

[1] 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.

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 Project 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.

Project 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.

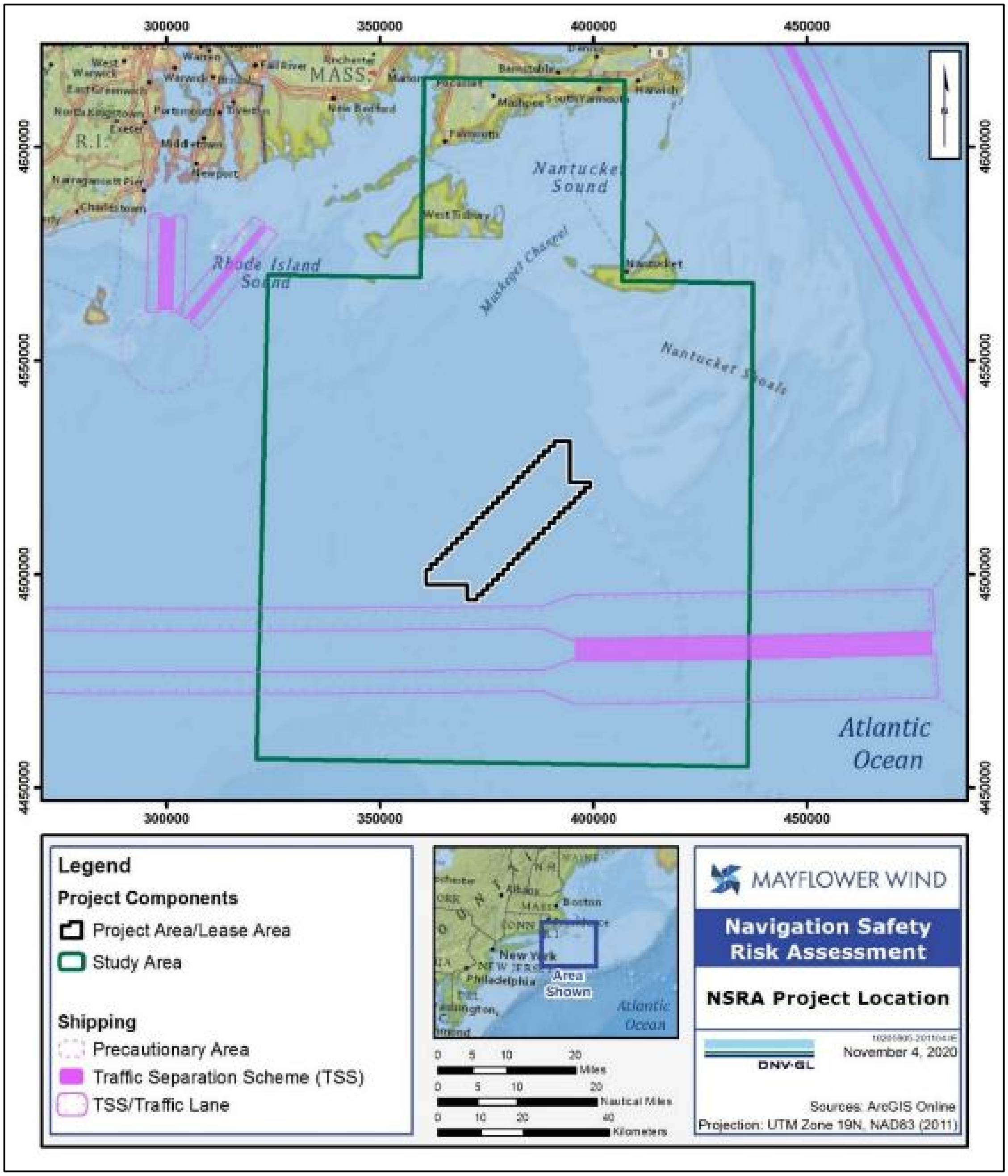


Figure ES-1 Project Location

1 INTRODUCTION AND PROJECT DESCRIPTION

Mayflower Wind Energy LLC retained DNV Energy USA Inc. (DNV GL) to conduct this independent Navigation Safety Risk Assessment (NSRA) of the proposed Mayflower Wind Offshore Wind Project (the Project). The Project's offshore structures will be located within the Commercial Lease of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf, OCS-A 0521.

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 was prepared by DNV GL and presents the results of the risk assessment. The objective of the NSRA is to address items in NVIC 01-19 that are pertinent to the Project. It is intended to be submitted to the Bureau of Ocean Energy Management (BOEM) as an appendix to the Project's Construction and Operations Plan (COP). DNV GL used its Marine Accident Risk Calculation System (MARCS) software to quantify the collision, allision, and grounding risks described in Section 11.

1.1 Evaluated Project components

Project wind turbine generators (WTG) and offshore substation platform(s) (OSP) comprise the offshore structures evaluated in this assessment. Several alternatives are being considered for the number of and sizes of offshore structures. Foundation types being considered by the Project include monopiles, piled jackets, suction-bucket jackets, and gravity-based structures.

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 described below. WTG foundation types not listed in the table fit in the below risk envelope if they are the same size or smaller than the risk envelope parameters. For the OSP(s), designs that result in vessel hazards that are the same size or smaller than the evaluated topsides dimensions also fit in this risk envelope. This assessment evaluated the Project maximum risk parameters shown in Table 1-1.

Table 1-1 Project Parameters Defining the NSRA Maximum Risk Envelope (Mayflower Wind, 2020)

Project-related parameter	Values evaluated in this NSRA	Parts of NSRA that used this parameter
Number of offshore structure locations (WTGs & OSPs)	149	Considered in all parts of the NSRA
Number of evaluated WTG locations*	144	Considered in all parts of the NSRA
Number of evaluated OSP locations	5	Considered in all parts of the NSRA

Project-related parameter	Values evaluated in this NSRA	Parts of NSRA that used this parameter
Maximum WTG foundation dimensions at mean sea level (MSL)	Monopile diameter: 16 meters (m) 53 feet (ft) Largest foundation (based on suction-bucket jacket): 60 m circular diameter 197 ft circular diameter	Visual obstruction Collision, allision, grounding risk modeling
Minimum WTG air gap from Mean Higher High Water (MHHW) based on monopile foundation	16.75 m 54.95 ft	Vessel clearances
Maximum WTG blade tip height from MSL	325 m 1,066 ft	Emergency response
Maximum OSP foundation dimensions from MSL	Monopile diameter: 16 m 53 ft Jacket footprint: 100 m x 70 m 328 ft x 230 ft	Visual obstruction Collision, allision, grounding risk modeling
Minimum OSP air gap from MHHW based on maximum size of OSP with a 10 m monopile foundation	18.8 m 61.7 ft Footprint of the hazard: 100 m x 70 m 328 ft x 230 ft	Vessel clearances

* Any of the five OSP locations could serve as WTG locations. This assessment evaluated the maximum number of OSPs; therefore, up to 5 WTGs could replace OSP positions for a total of 149 WTGs, and the assessment would still be valid.

In addition to the offshore structures listed above, Project cables will be buried and/or covered:

- Buried inter-array cables connecting the WTGs to the OSP(s)
- Up to five buried offshore export cables to convey power from the OSP(s) to shore

The evaluated locations of the structures and cable corridors are presented in Section 1.2. After submission of the NSRA with the COP in February 2021, the Brayton Point export cable corridor (ECC), was added to the Project Design Envelope (PDE), because a portion of the new ECC lies outside the Marine Traffic Study Area of the NSRA. Assessment of the Brayton Point ECC is provided in Appendix G. For the purposes of this NSRA, Project traffic listed in COP Section 3 (Table 3-20) is generalized as:

- Construction-phase round-trip vessel transits: current estimate is 2,184 per year (an average of 6.0 per day)
- Operations-phase round-trip averaging fewer than 1 vessel transit per day

The ports in use at any given time for Project purposes will depend on the vessels and equipment needed for the specific offshore activity. At this time, intended ports are anticipated to include the following (in alphabetical order):

- Arthur Kill Terminal, NY
- Brayton Point, MA
- New Bedford, MA
- Port of Salem, MA

1.2 Site location and installation coordinates

For the purpose of this NSRA, the “Project Area” is defined as the largest possible footprint of the offshore structures, and its boundaries align with the boundaries of offshore lease OCS-A 0521. The “Study Area,” which was discussed with the USCG at the NSRA kickoff meeting, consists of an area extending at least 20 NM (37 km) on all sides from the Project Area plus the export cable corridors. The Study Area and Project Area evaluated in this assessment are shown in Figure 1-1.

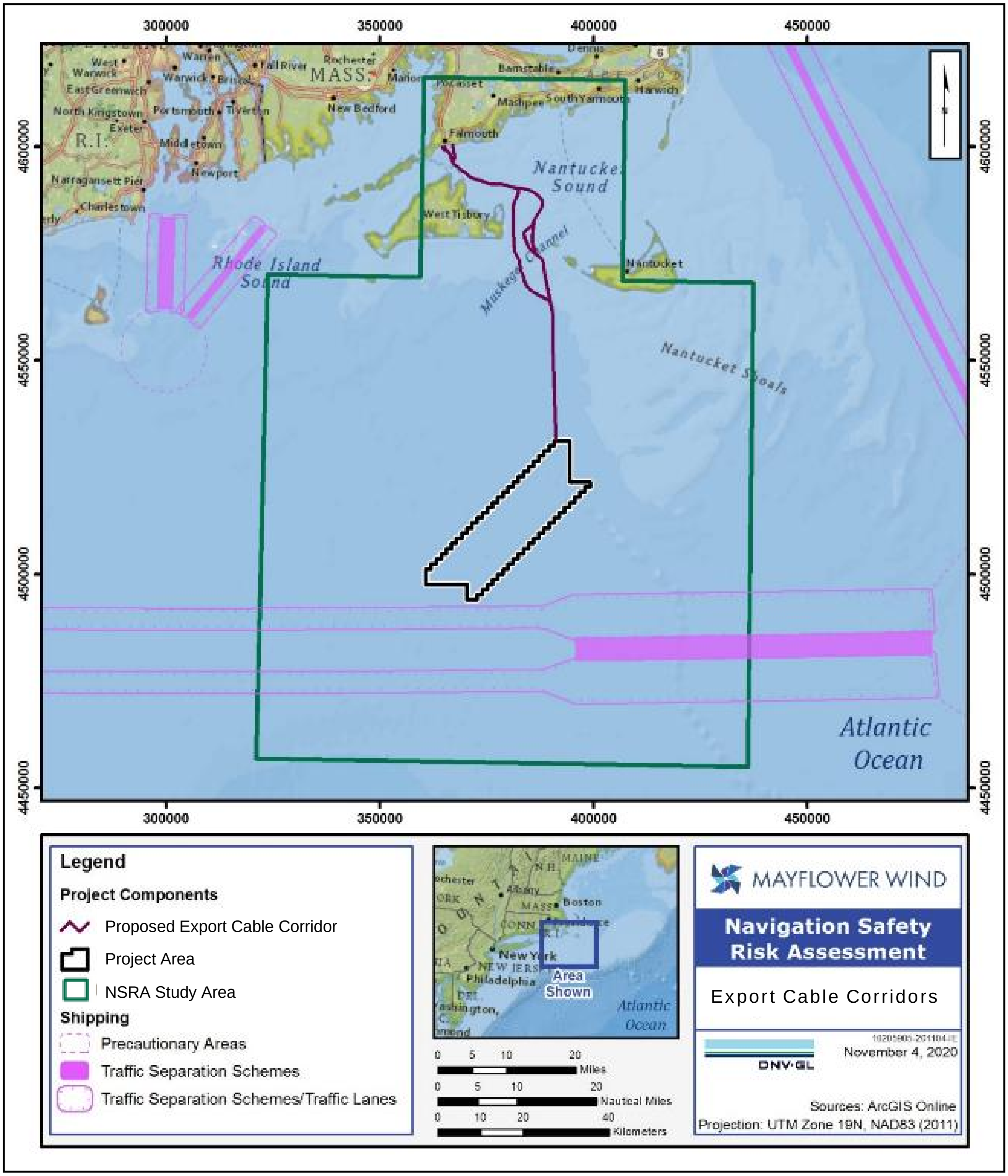


Figure 1-1 Project Area and Study Area[2]

[2] Since the submission of the NSRA in February 2021, Mayflower Wind has down-selected the Central and Eastern Options through Muskeget Channel from the export cable corridor PDE.

Figure 1-2 shows the layout[3] of offshore structures evaluated in this NSRA. Appendix A contains the coordinates of the evaluated Project structure locations.

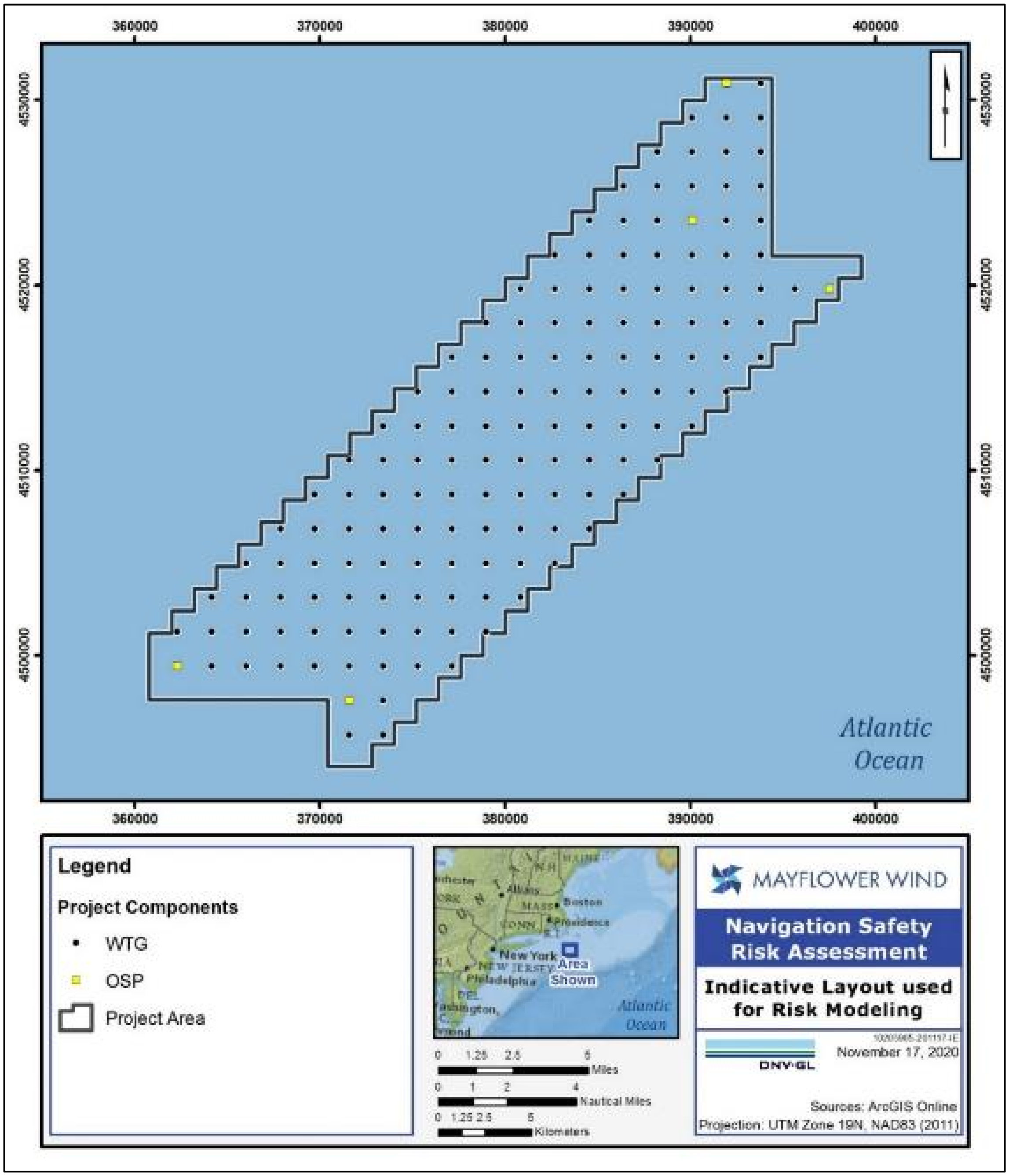


Figure 1-2 Indicative Layout Used for Risk Modeling

[3] The OSP locations selected for the modeling represent the worst-case locations at which Mayflower Wind will install OSPs. Mayflower Wind may choose alternate locations for OSPs that can be anticipated to have lower risk overall based on the NSRA risk model results.

2 TRAFFIC SURVEY

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

- Automatic Identification System (AIS) data for 2019 purchased from MarineTraffic (2020), which was discussed with the USCG at the NSRA kickoff meeting. The maps in Appendix B are based on this data set. The following vessels in the Study Area are required to carry AIS class A or class B equipment in conformance with 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):
    - Deep draft vessels (cargo vessels, carriers, tankers, large passenger vessels, and most commercial ships on international voyages, 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
    - Passenger vessels certificated to carry 150 or more passengers
- Marine transportation / traffic Nationwide Automatic Identification System (NAIS) data from USCG viewed as counts of vessel tracks in a 100 m by 100 m (328 ft x 328 ft) grid (Northeast Regional Ocean Council [NROC], 2020).
- Relative commercial fishing density from Vessel Monitoring System (VMS) data from the National Marine Fisheries Service (NMFS). The data set through the year 2016 was used. VMS data are collected by National Oceanic and Atmospheric Administration (NOAA) NMFS via type-approved transmitters that automatically transmit a vessel's position for relay to NMFS.
- 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.
- The Port Access Route Study report published by the USCG for The Areas off Massachusetts and Rhode Island, referred to as MARIPARS (USCG, 2020a).
- Consultations with recreational boating, fishing, and towing industry organizations (i.e., the Responsible Offshore Development Alliance [RODA]), Massachusetts Lobstermen's Association, agencies, and other stakeholders). See Appendix C and COP Appendix W, the Fisheries Communications Plan, for details.

Per NVIC 01-19, the following aspects of marine traffic in the Study 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 definition of the Study Area and plan to purchase AIS data for the NSRA were presented to the USCG during a dialogue on 6 May 2020, early in the NSRA assessment process. The Study Area (Figure 2-1) encompasses the Project Area and offshore waters for more than 20 NM (37 km) in any direction. The southern portion of the Study Area was modeled using DNV GL's Marine Accident Risk Calculation Software (MARCS). It was agreed that the 2019 AIS data were more appropriate for purposes of the NSRA than 2020 data because of potential effects from COVID-19 on shipping.

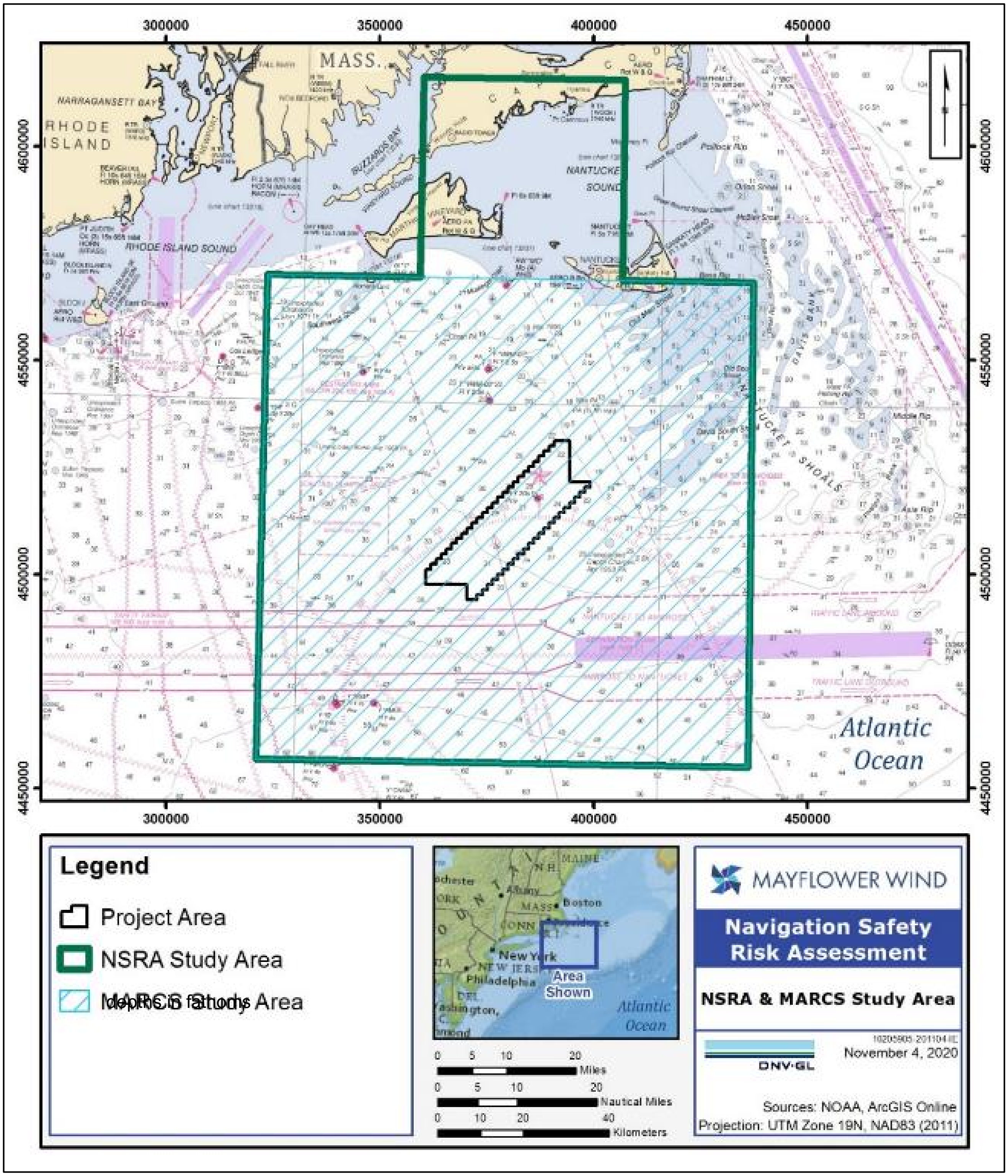


Figure 2-1 NSRA Study Area and MARCS, South Study Area

The navigation features in the Project Area are shown in Figure 2-2. Of note are shoals northeast of the Project and the Nantucket to Ambrose Shipping Safety Fairway to the south, which connects to the New York Eastern Approach Traffic Separation Schemes (TSS).

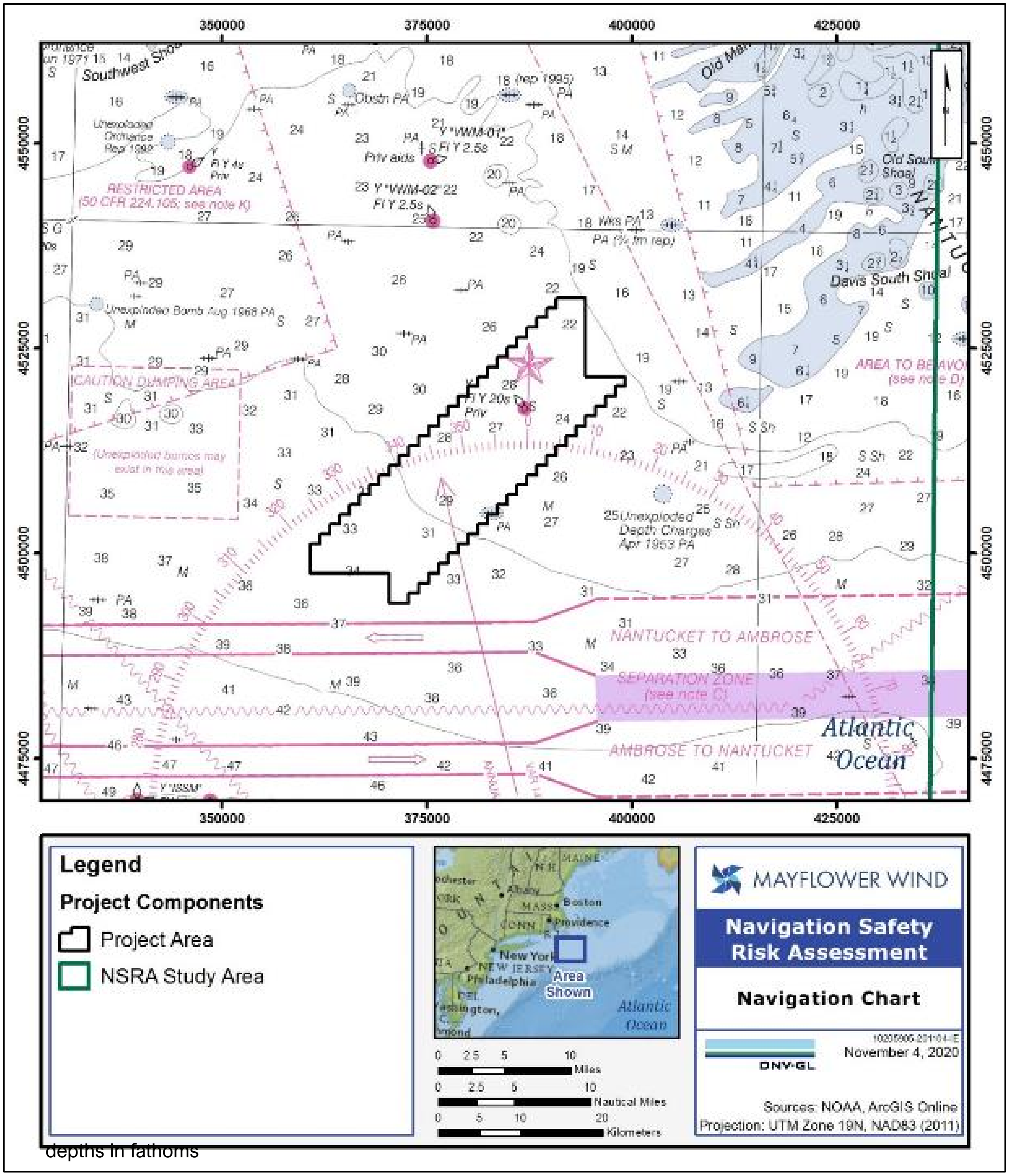


Figure 2-2 Navigation Chart in the Project Area

2.1 Traffic Patterns, Density, and Statistics

There is wide variance in traffic density, vessel types, and vessel sizes within the Study Area. Based on the information in the traffic survey, vessel traffic in the North Study Area comprises smaller vessels with a high seasonal influence, most of which do not transit into the South Study Area. The vessel traffic in the South Study Area is more complex because there is a mixture of deep draft vessels and commercial fishing vessels engaged in fishing or transiting to fishing grounds outside the Project Area. The majority of deep draft vessel transits occur in the traffic lanes along the southern edge of the Study Area.

Figure 2-3 presents tracks for vessels transmitting AIS signals in the Study Area.

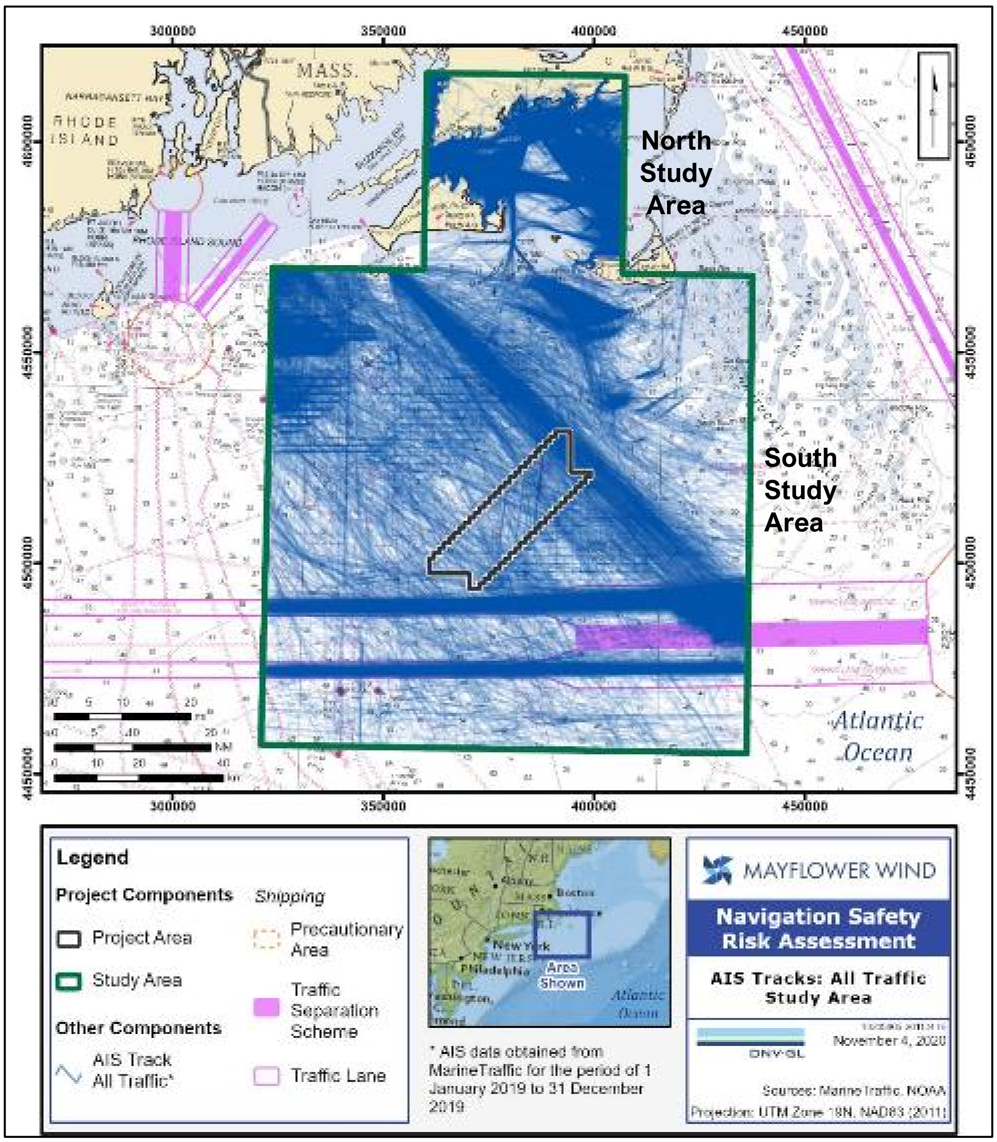


Figure 2-3 All AIS Tracks in the Study Area[4]

[4] Based on AIS data for 2019 (MarineTraffic, 2020)

Figure 2-4 provides a more detailed view of the traffic patterns within the Project Area. The densest traffic is in the northeastern portion of the Project Area, which consists primarily of transiting fishing vessels (see Section 2.1.1.2).

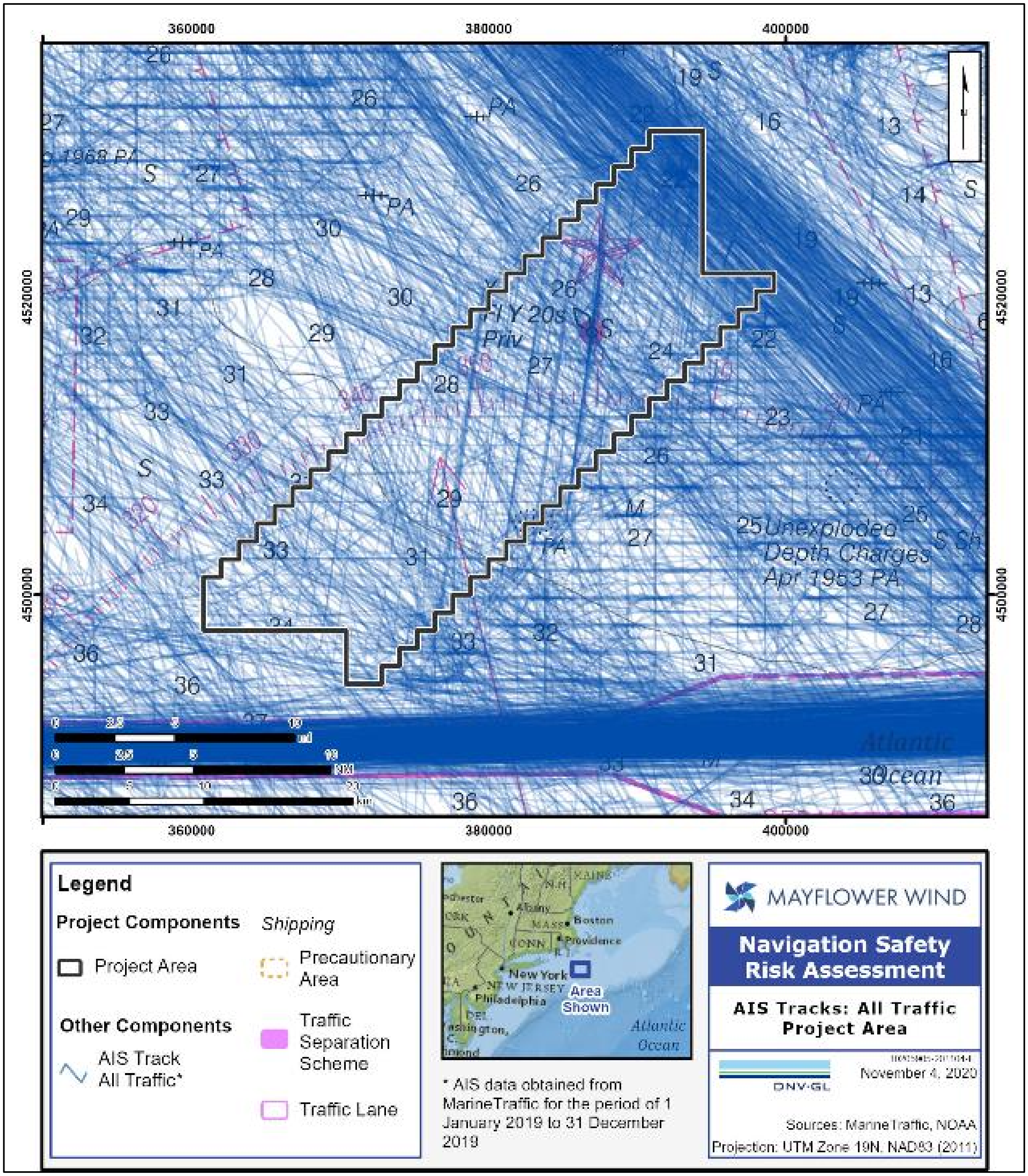


Figure 2-4 All AIS Tracks in the Project Area[4]

AIS data contains detailed vessel type information. The AIS vessel types were grouped as shown in Table 2-1 for purposes of the NSRA.

Table 2-1 Groupings of AIS Vessel Types for the NSRA[4]

NSRA Vessel Type	Vessel Type in Raw AIS Data[4]
Cargo/Carrier	Bulk Carrier
	Cargo
	Cargo/Containership
	Cement Carrier
	Container Ship
	Fish Carrier
	General Cargo
	Heavy Load Carrier
	Ro-Ro Cargo
	Ro-Ro/Container Carrier
	Self-discharging Bulk Carrier
	Vehicles Carrier
Fishing (commercial)	Fishing
	Fishing Vessel
	Trawler
Other/Undefined	Buoy-Laying Vessel
	Dive Vessel
	Dredger
	Fishery Patrol Vessel
	Fishery Research Vessel
	High Speed Craft
	Inland - Maintenance Craft - Cableship - Dredger
	Inland - Unknown
	Law Enforce
	Local Vessel
	Military Ops
	Multi-purpose Offshore Vessel
	Offshore Supply Ship
	Other
	Patrol Vessel
	Pilot Vessel
	Port Tender
	Research/Survey Vessel
	Reserved
	Search and Rescue (SAR)
	Special Craft
	Special Vessel
	Supply Vessel
	Training Ship
	Unspecified
	Utility Vessel
Passenger	Passenger
	Passenger Ship
	Ro-Ro/Passenger Ship
Pleasure	Pleasure Craft
	Sailing Vessel
	Yacht
Tanker (no oil or chemical cargoes)	Asphalt/Bitumen Tanker
	Chemical Tanker
	Liquified Petroleum Gas (LPG) Tanker
	Tanker
Tanker – Oil (carrying oil or chemical cargoes)	Crude Oil Tanker
	Oil Products Tanker
	Oil/Chemical Tanker
Tug/Service	Pusher Tug
	Towing Vessel
	Tug

The sections below present traffic patterns (2.1.1), density of vessel traffic (2.1.2), summary traffic statistics (2.1.3), and types of cargo (2.1.4).

2.1.1 Traffic patterns

Traffic patterns are presented for each of the NSRA vessel types listed in Table 2-1:

- Cargo/carrier and tanker vessels (Section 2.1.1.1)
- Fishing vessels (Section 2.1.1.2)
- Passenger vessels (Section 2.1.1.3)
- Pleasure, including recreational vessels (Section 2.1.1.4)
- Tugs (Section 2.1.1.5)
- Other vessels (Section 2.1.1.6)

Full-page maps of AIS vessel tracks, point densities, and speeds for each vessel type are provided in Appendix B.

2.1.1.1 Cargo/carrier and tanker vessel traffic

Figure 2-5 and Figure 2-6 show views of the AIS data obtained for this NSRA for cargo vessels, carriers, and tankers. Note there are only a few of these vessel tracks in the North Study Area, but there are more in the South Study Area. Cargo vessels, carriers, and tankers make use of the TSS in the region on approach to and departure from ports. A Traffic Separation System "is an internationally recognized measure that minimizes the risk of collision by separating vessels into opposing streams of traffic through establishment of traffic lanes" (IMO, 2019a). Vessel use of TSS is voluntary (USCG, 2004).

Two TSS are very influential on deep draft vessel routes in the Study Area:

- The Nantucket / Ambrose Shipping Safety Fairway ("Nantucket Ambrose Fairway" hereinafter) in the South Study Area
- The Narragansett Bay TSS in Rhode Island Sound northwest of the Study Area

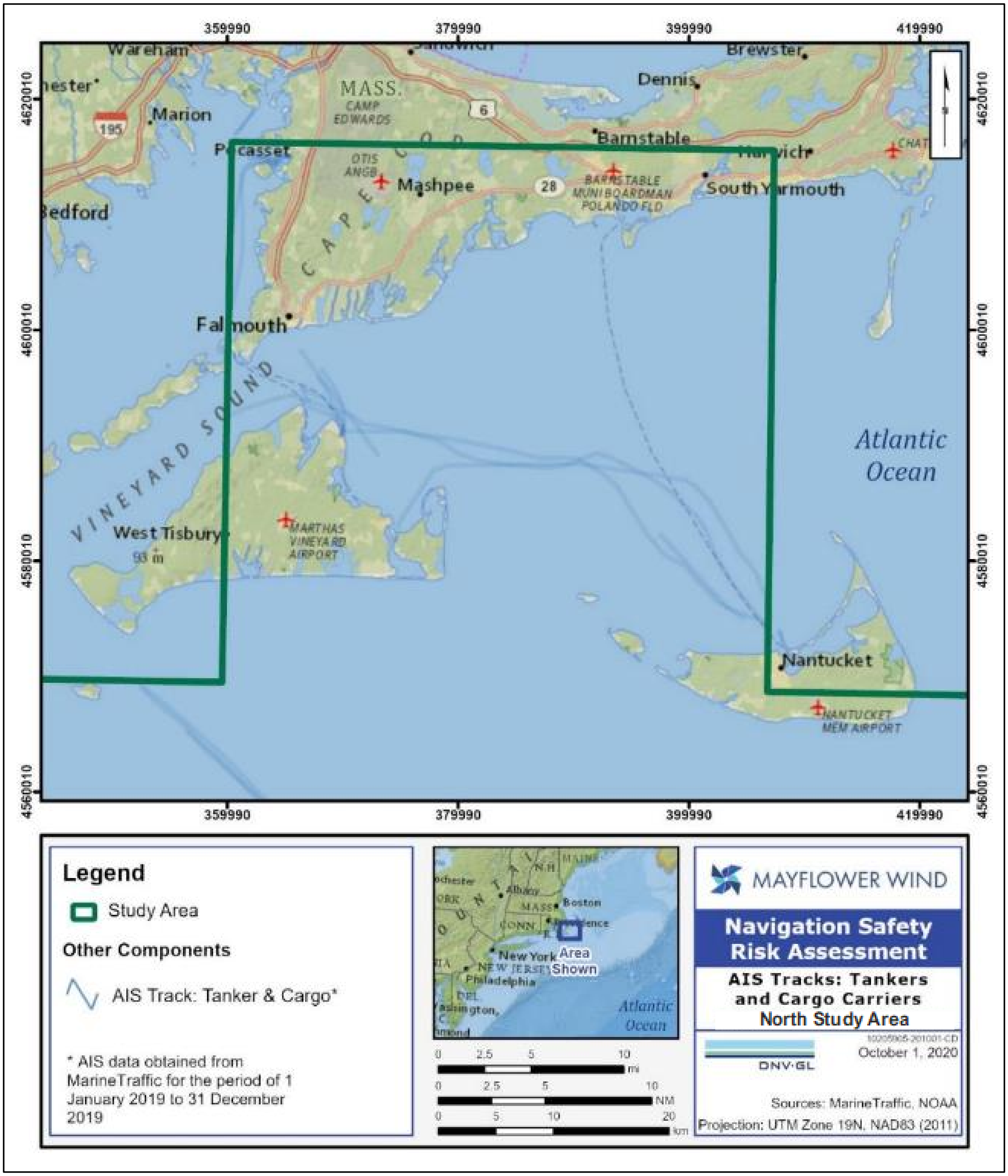


Figure 2-5 AIS Tracks for Cargo/Carrier Vessels and Tankers – North Study Area[4]

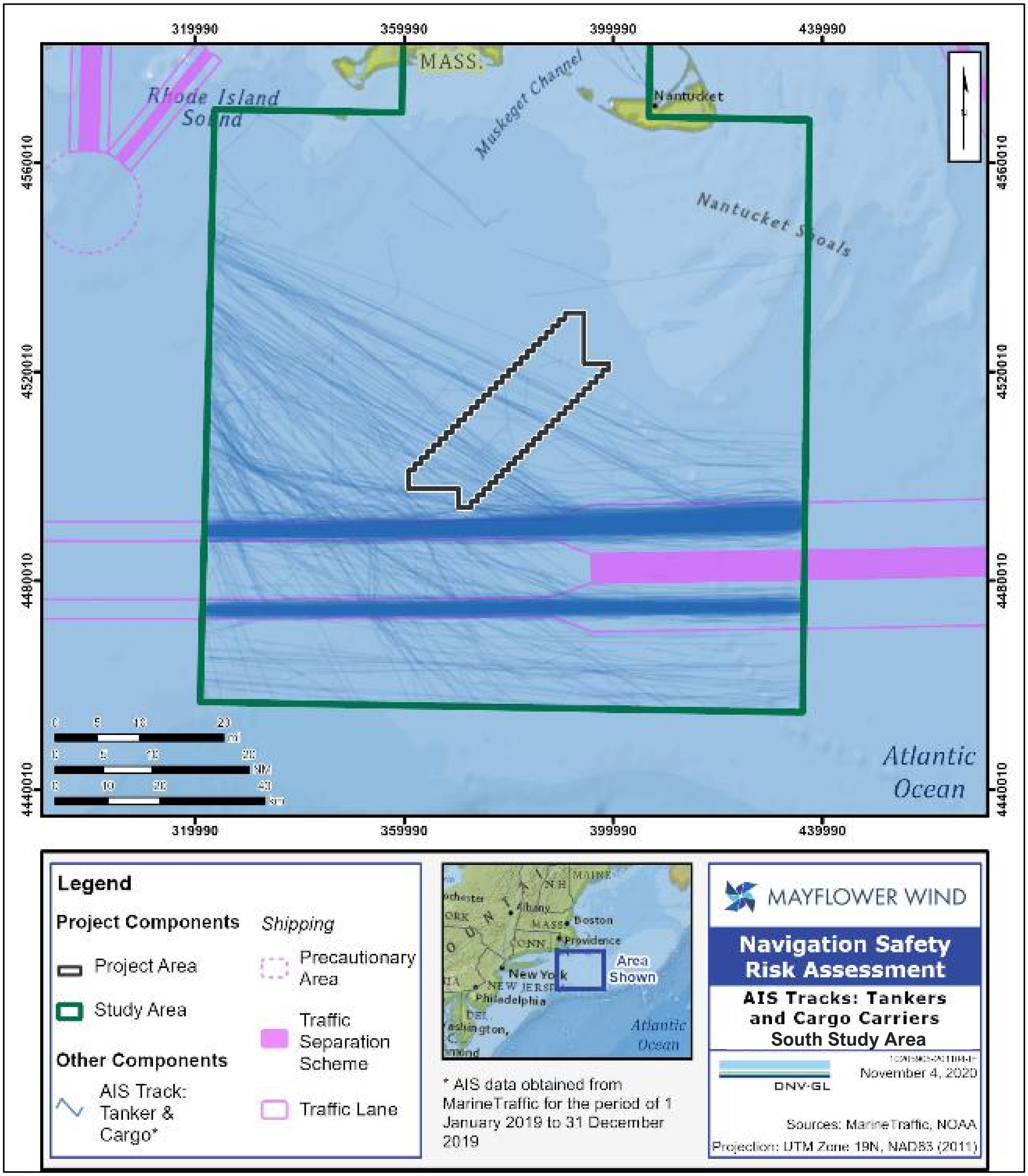


Figure 2-6 AIS Tracks for Cargo / Carrier Vessels and Tankers – South Study Area[4]

The Nantucket Ambrose Fairway resembles a divided highway. Westbound traffic transits the northern lane and eastbound traffic transits the southern lane. The width of the northern lane is 5 NM (9.3 km) at its eastern terminus outside the Study Area, where westbound traffic enters the Nantucket to Ambrose Inbound Lane. It narrows to 3 NM (5.6 km) immediately south of the Project Area.

A 3 NM (5.6 km) wide Separation Zone lies between the inbound and outbound lanes at the eastern terminus; it is 6 NM (11.1 km) wide where the traffic lanes are narrower. The Ambrose to Nantucket Outbound Lane begins at the New York Precautionary Area west of the Study Area. Similar to the Inbound Lane, it has a width of 3 NM (5.6 km) closer to New York and it widens to 6 NM (11.1 km) immediately south of the Project Area.

Another important feature in the Study Area is Nantucket Shoals, to the northeast and east of the Project. These are a potentially significant hazard, particularly to deep draft vessels (for this study, cargo/carrier, tanker, and cruise passenger vessels).As a result, the International Maritime Organization (IMO) has designated an Area to be Avoided along the western edge of the shoals (see previous Figure 2-2). The AIS tracks for cargo/carrier and tanker vessels bear out that these deep draft vessels do not transit near the shoals.

Cargo vessel, carrier, and tanker traffic is most concentrated within the Nantucket Ambrose Fairway. Vessel tracks in Figure 2-6 show that some deep draft vessels in the Nantucket Ambrose Fairway take short excursions from it, generally staying within 1 NM (1.9 km) of the TSS.

Outside the Nantucket Ambrose Fairway, the AIS data show that the cargo/carriers and tankers transit to/from the Precautionary Area for Narragansett and Buzzards Bay, at the seaward end of the Narragansett Bay TSS. A few of these vessel tracks cross the Project Area en route between the Precautionary Area and the Nantucket Ambrose Fairway. Section 2.1.3.1 provides track counts for traffic of interest to the NSRA.

Based on the AIS data, there is no evidence that cargo/carrier vessels or tankers anchor in the Project Area.

Traffic added to AIS for the purpose of risk modeling

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

Table 2-2 Cargo/Carrier and Tanker Vessel Transits Added to the AIS Tracks for Risk Modeling

Vessel type & activity	Adjusted number of tracks	Routes	Model Case
Carrier, LPG cargo and others	50 trips each way to allow for potential growth MARIPARS identified an additional 6-8 LPG trips to Providence, Rhode Island (USCG, 2020a)	Nantucket Ambrose Fairway toward Rhode Island Sound and vice-versa	Base Case and Future Case

2.1.1.2 Fishing vessel traffic

Commercial fishing vessels do not follow specified routes in the same manner that cargo vessels do. In addition, because of their smaller size, the great majority of the fishing vessels in the Study Area are subject to fewer navigational requirements, including use of AIS. A study of AIS-based fishing activity by the Food and Agriculture Organization of the United Nations (Taconet et. al., 2019) concluded that in the Atlantic waters off the United States (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." As a result, the traffic model built to estimate risk included more fishing vessel traffic than is represented in the AIS data.

The fishing locations chosen by commercial fishing vessels, and hence their routes, are closely guarded. The locations of fish populations and management areas that dictate where fishing can and cannot occur change both within and between years, and therefore, fishing vessel routes and level of fishing activity in a given location vary over time as well.

This assessment identified fishing traffic patterns using additional information sources, including:

- Nationwide Automatic Identification System (NAIS) data – 2019 trackline density is viewable via the Northeast Ocean Data Portal (NEODP, 2020). USCG NAIS data are preferred over the AIS data obtained from Marine Traffic for review of fishing routes because they contain a larger number of tracks for this vessel type, which typically uses AIS-B. Presumably, the USCG has more robust coverage /bandwidth than MarineTraffic.
- Fishing activity by catch – VMS data that indicate which types of fish were caught in the Study 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 gear – Combined permit / VTR data that indicate where specific fishing gear was used in the Marine Traffic Study Area. VTR data are collated from vessel reports provided to NOAA's Northeast Fisheries Science Center.
- USCG Port Access Route Study (PARS) - Fishing vessel information provided in the MARIPARS report (USCG, 2020a) shows significant fishing activity that is not represented in the available AIS data.

NAIS data

Figure 2-7 presents the NAIS track densities for commercial fishing vessels in the Study Area. NAIS appears to contain significantly more fishing and pleasure vessel data than the data obtained from MarineTraffic.

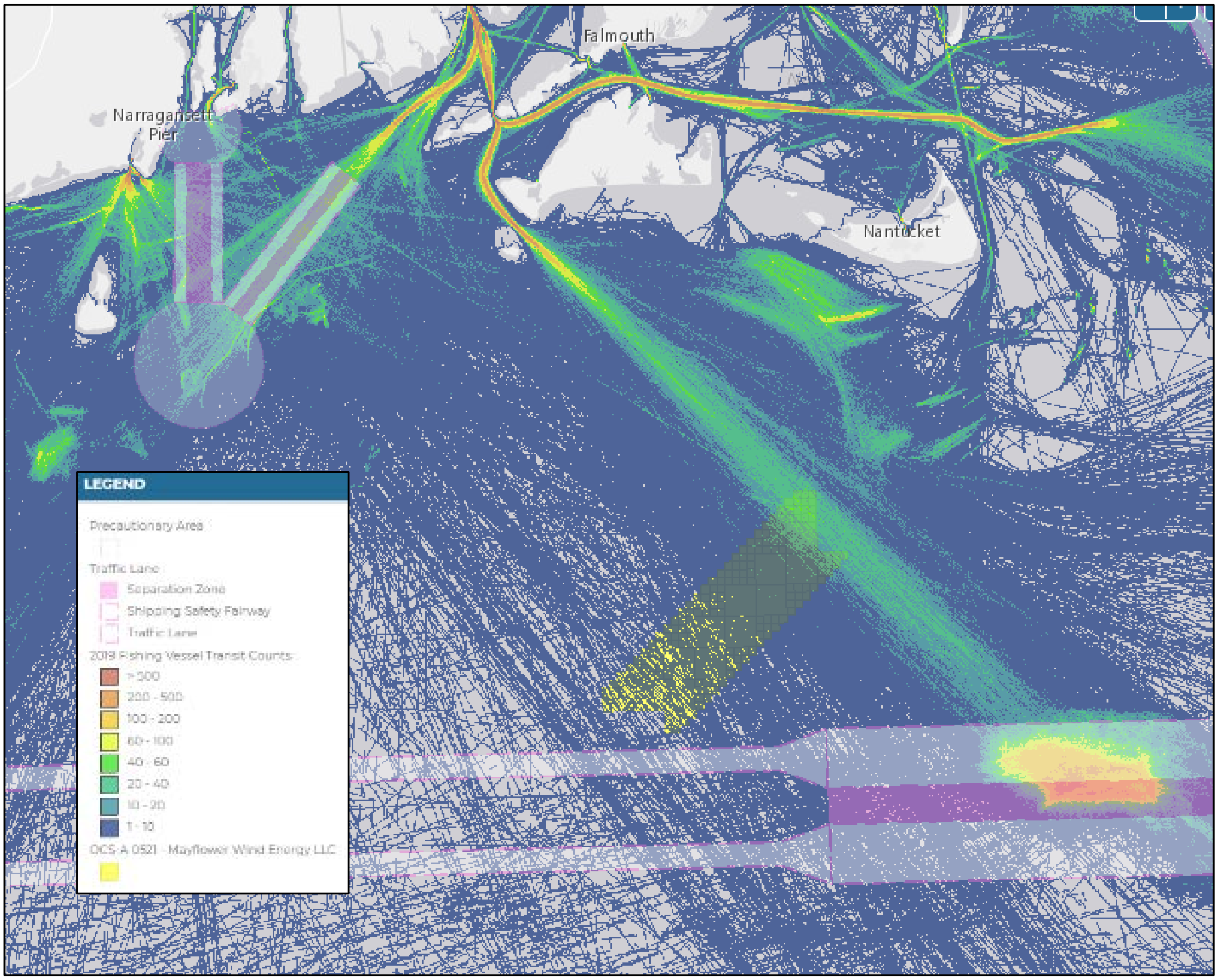


Figure 2-7 NAIS Trackline Density for Fishing Vessels (NEODP, 2020)

The densest fishing vessel transit route is aligned in a northwest - southeast direction, crossing the northeastern boundary of the Project Area. The yellow and red patches in Figure 2-7 near Nantucket to the north and the larger yellow/orange/red area within the Nantucket Ambrose Fairway appear to be fishing grounds. These conclusions are in line with findings in the recent USCG MARIPARS report (2020a). The figure indicates significagnt fishing vessel track density through Nantucket Shoals in the Study Area and apparent fishing activity in the slues between the shoals.

Fishing activity by catch (VMS data)

Figure 2-8 provides views of commercial fishing activity in the Study Area based on VMS data provided by NMFS through the year 2016. The data are subject to 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 in this assessment.

The color scale in the figure is based on relative values rather than absolute values. The categories are “Low,” “Med-Low,” “Med-Hi,” “High,” and “Very High.” An area defined as “High” indicates higher than average fishing activity compared within the Mid-Atlantic region (approximately Virginia to Maine).

The VMS data indicate medium levels of fishing in the northern portion of the Project Area, spotty medium and med-low fishing elsewhere in the Project Area, and high levels of fishing north and west of the Project.

The polar histograms of VMS activity shown in Figure 2-9 represent the courses of fishing vessels passing through Mayflower Lease OCS-A 0521 between January 2014 and August 2019 (NMFS, 2020). The courses indicated in Figure 2-9 correlate well with the AIS and VMS tracks discussed above, and provide the following insights relevant to vessel traffic:

- The fishing vessels predominantly crossed the Lease Area in a southeast-northwest direction, between coastal ports and the fishing grounds southeast of the Project.
- Vessels that were actively fishing (defined as those having speeds less than 5 knots (kt) transited in nearly all directions, but the most heavily transited directions were east-west; north-south, with significant contributions from courses that were aligned southeast-southwest.
- About 50 percent more vessels were transiting through the Lease Area than were fishing in the Lease Area.

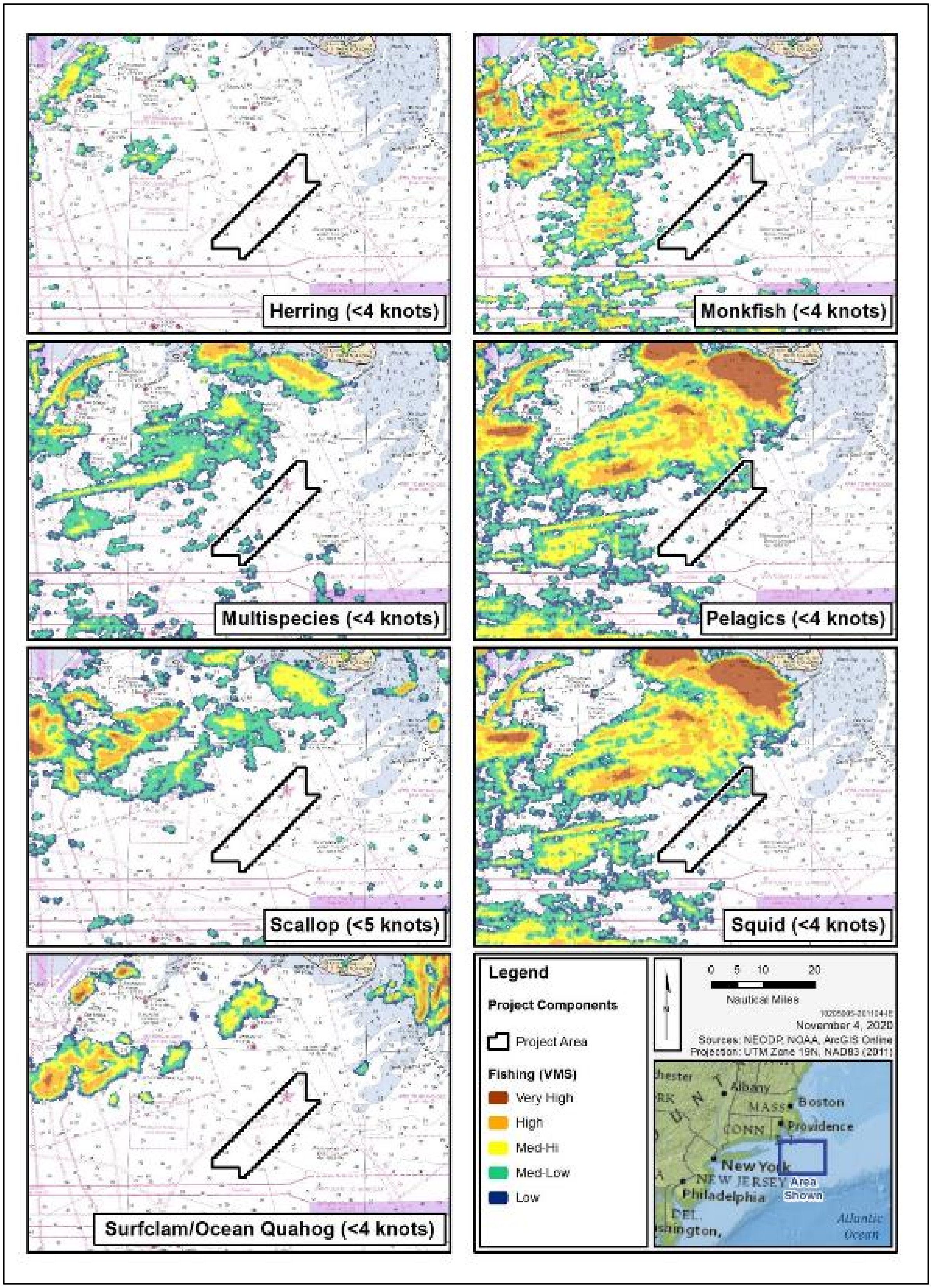


Figure 2-8 Commercial Fishing Vessel Density While Fishing, 2015/2016 (VMS) (NROC, 2018)

Figure 2-9 VMS Activity by Course in the Lease Area – Jan 2014 to Aug 2019 (NMFS, 2020)

Fishing activity by permitted gear (VTR data)

Publicly available VTR data were obtained for fishing gear use in the Study Area. The data through the year 2015 were obtained from Communities at Sea (Figure 2-10) (NOAA, 2016). The VTR and VMS data indicate similar levels of activity in the Project Area:

- Medium-low levels of pelagics and squid fishing in the northern Project Area
- Low levels of gillnet fishing in the southern Project Area
- Sparse low levels of fishing elsewhere in the Project Area
- Higher levels of fishing outside and in some cases, adjacent to, the Project Area

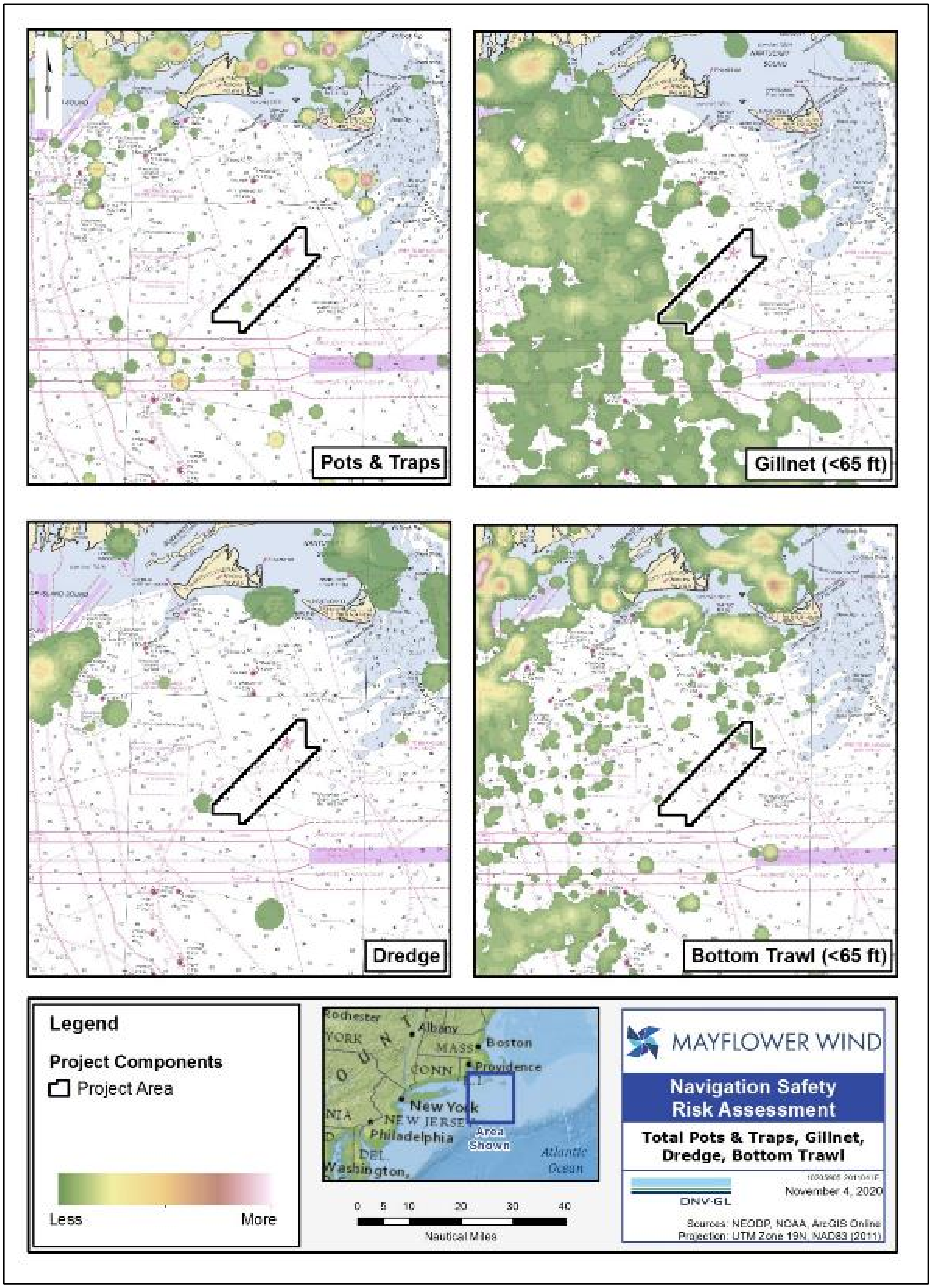


Figure 2-10 Fishing Activity by Gear Types, 2011 – 2015 (NOAA, 2016)

NMFS has provided commercial fisheries landings data specific to each lease area in the Atlantic OCS by combining VTRs and dealer reports into modeled fishing intensity raster data sets (NOAA, 2020f). For the years 2008 through 2018, data for the Mayflower Wind Lease Area (OCS-A 0521) indicate that the gear types of bottom and midwater trawls, pots and traps, and gillnets represent more than 95% of the commercial fishing activity in the Lease Area represented by this data set. Additional discussion on this data and its limitations is provided in COP Section 6 and Appendix V, Commercial and Recreational Technical Report.

MARIPARS

The MARIPARS report (USCG, 2020a) generally aligns with the above descriptions and provides more information about fishing activity. The report provides an additional view of a specific pattern of fishing vessel traffic less than 19.8 m (65 ft) in length and not included in NAIS. Fishing vessel tracks indicate a predominant east-west fishing pattern, consistent with a "gentlemen's agreement" between mobile and fixed gear fishermen to prevent gear entanglement (USCG, 2020a). Fishing activity in the MA/RI WEA, including the Lease Area, is highest in August and September and fishing activity and transit patterns exhibit high seasonal and annual variability, in response to variations in fisheries resource distributions (USCG, 2020a).

Traffic added to AIS for the purpose of risk modeling

A key input to the risk modeling conducted to estimate collision, allision, and grounding risk, described in Section 11, is transits assigned to specific routes created in the model. AIS data is a reliable source of transit and route data for most vessel types. However, based on the information reviewed above, a significant proportion of fishing vessel transits are not represented in the AIS data. Any estimate of fishing vessel transits in a specific area will have uncertainties due to the lack of a comprehensive available data set and the variability in fishing locations. To align the risk model more closely with reality in the Project Area, additional vessel transits were estimated based on DNV GL's expert judgment and added to the AIS traffic (Table 2-3).

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

Vessel type & activity	Adjusted number of tracks	Routes	Model Case
Fishing	Increase by 100%. Reason: Fishing vessels may not transmit AIS en route to fishing grounds.	All fishing vessel tracks in the Study Area.	Base Case and Future Case
Fishing – new fishing in the Project Area	Increase by 20% Reason: Possible increase in fishing activity due to presence of Project structures, seems reasonable for lobster. Most fishing occurs in the northern portion of the Project Area.	All fishing vessel tracks in AIS that touch the Project Area.	Future Case

2.1.1.3 Passenger vessel traffic

Figure 2-11 and Figure 2-12 show passenger vessel track densities in the Study Area. In the northern portion of the Study Area, passenger vessel traffic includes roll-on/roll-off (Ro-Ro) vessel traffic primarily between Cape Cod, Nantucket, and Martha's Vineyard. The traffic in this area includes smaller passenger vessels, with the great majority transiting within Nantucket Sound.

In the vicinity of the Project Area, the passenger vessels are primarily cruise ships, corroborated by a review of vessel names and average vessel size (see Section 2.1.3.2). The overwhelming majority of cruise ship tracks lie within the Nantucket Ambrose Fairway; there are a few tracks with a northwest-southeast direction indicating transit between the Nantucket Ambrose Fairway and the Precautionary Area for Narragansett and Buzzards Bays.

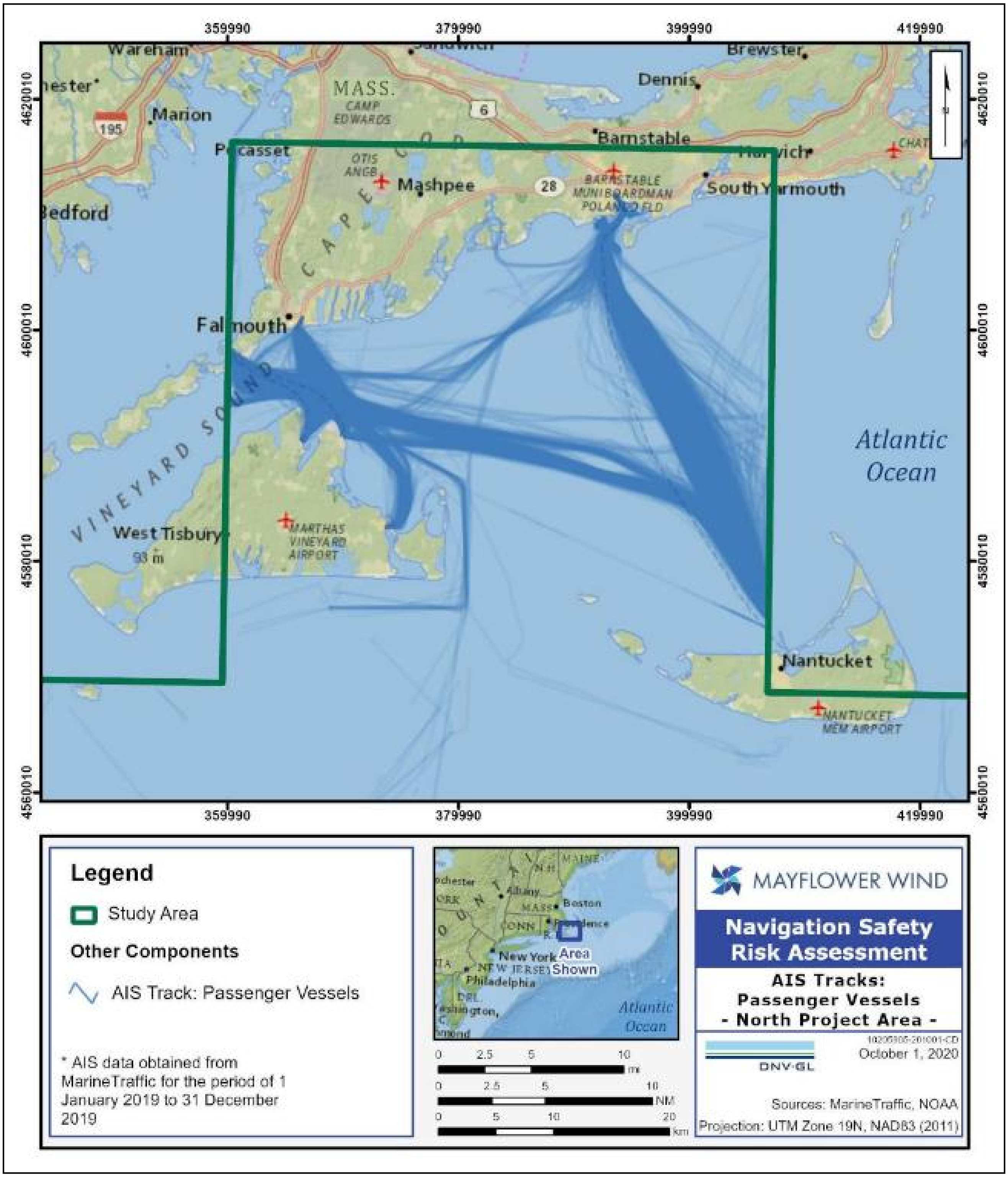


Figure 2-11 AIS Tracks for Passenger Vessels – North Study Area[4]

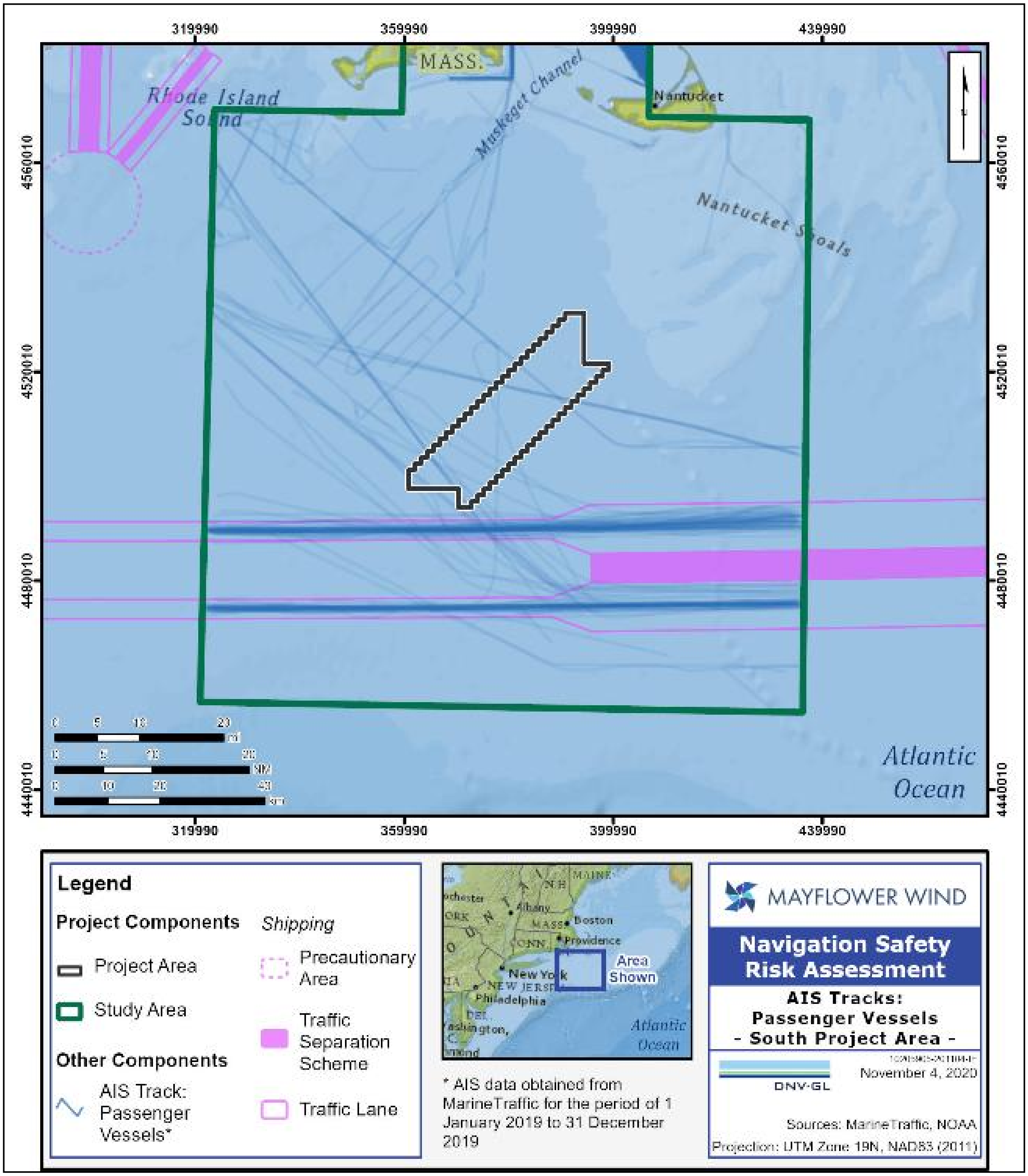


Figure 2-12 AIS Tracks for Passenger Vessels – South Study Area[4]

Traffic added to AIS for the purpose of risk modeling

The USCG identified an anticipated future increase in port calls for cruise ships in the MARIPARS report (USCG, 2020a). To align the risk model more closely with reality , these were added to the traffic in the model for collision, allision and grounding risk in Section 11 (Table 2-4).

Table 2-4 Passenger Vessel Transits Added to the AIS Data for Risk Modeling

Vessel type & activity	Adjusted number of tracks	Routes	Model Case
Passenger (cruise ships)	50 trips each way. The MARIPARS report (USCG, 2020a) identified an additional 50 cruise ship visits to Newport, Rhode Island, approximately doubling its current cruise traffic.	Nantucket Ambrose Fairway toward Rhode Island Sound from the west and vice-versa	Base Case and Future Case

2.1.1.4 Pleasure vessel traffic

Figure 2-13 and Figure 2-14 show pleasure vessel track densities in the Study Area. The overwhelming majority of pleasure vessel transits occur within Nantucket Sound. Comparatively fewer pleasure AIS tracks crossed into the Project Area in 2019 versus fishing vessel tracks in previous Figure 2-7.

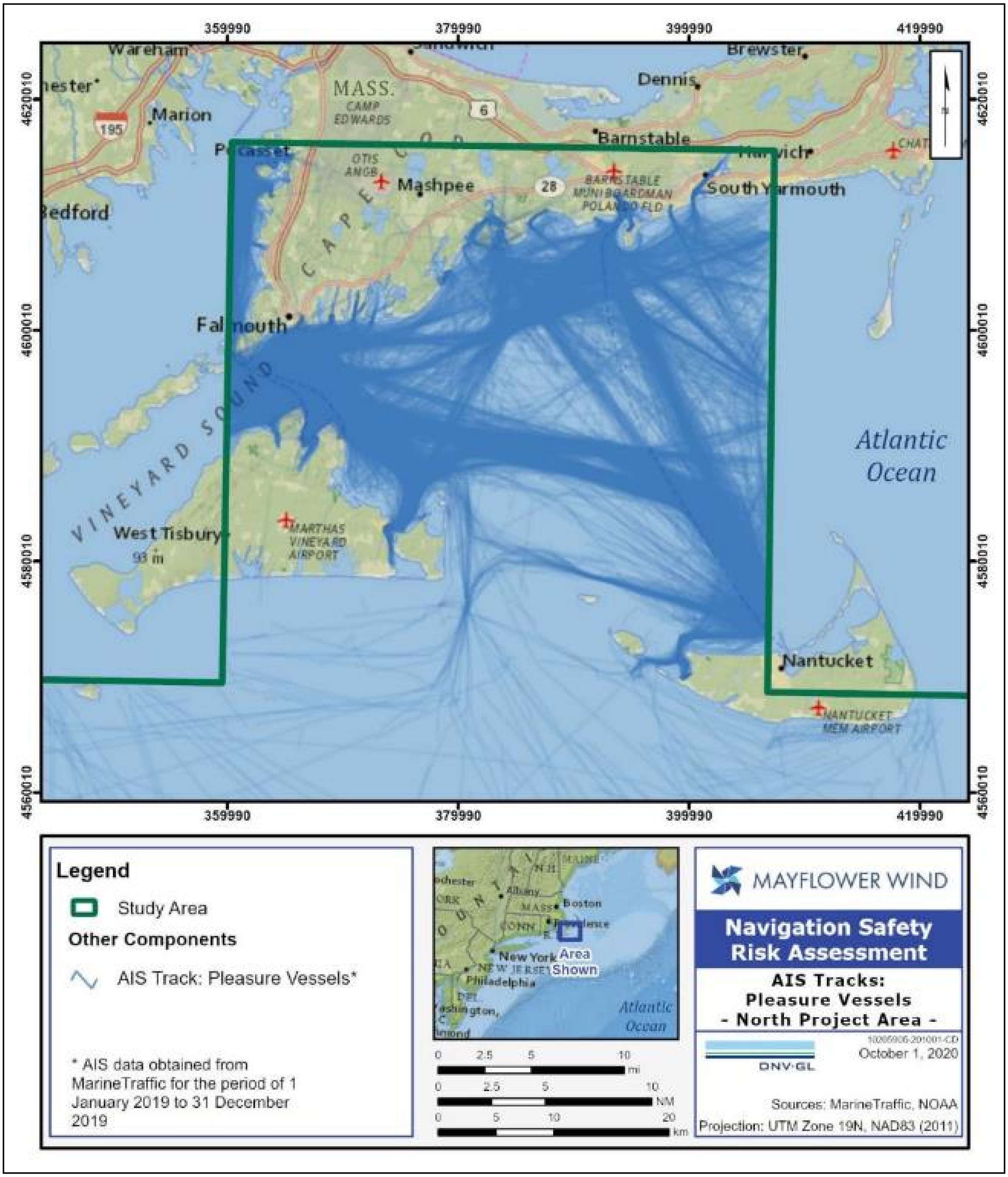


Figure 2-13 AIS Tracks for Pleasure Vessels – North Study Area[4]

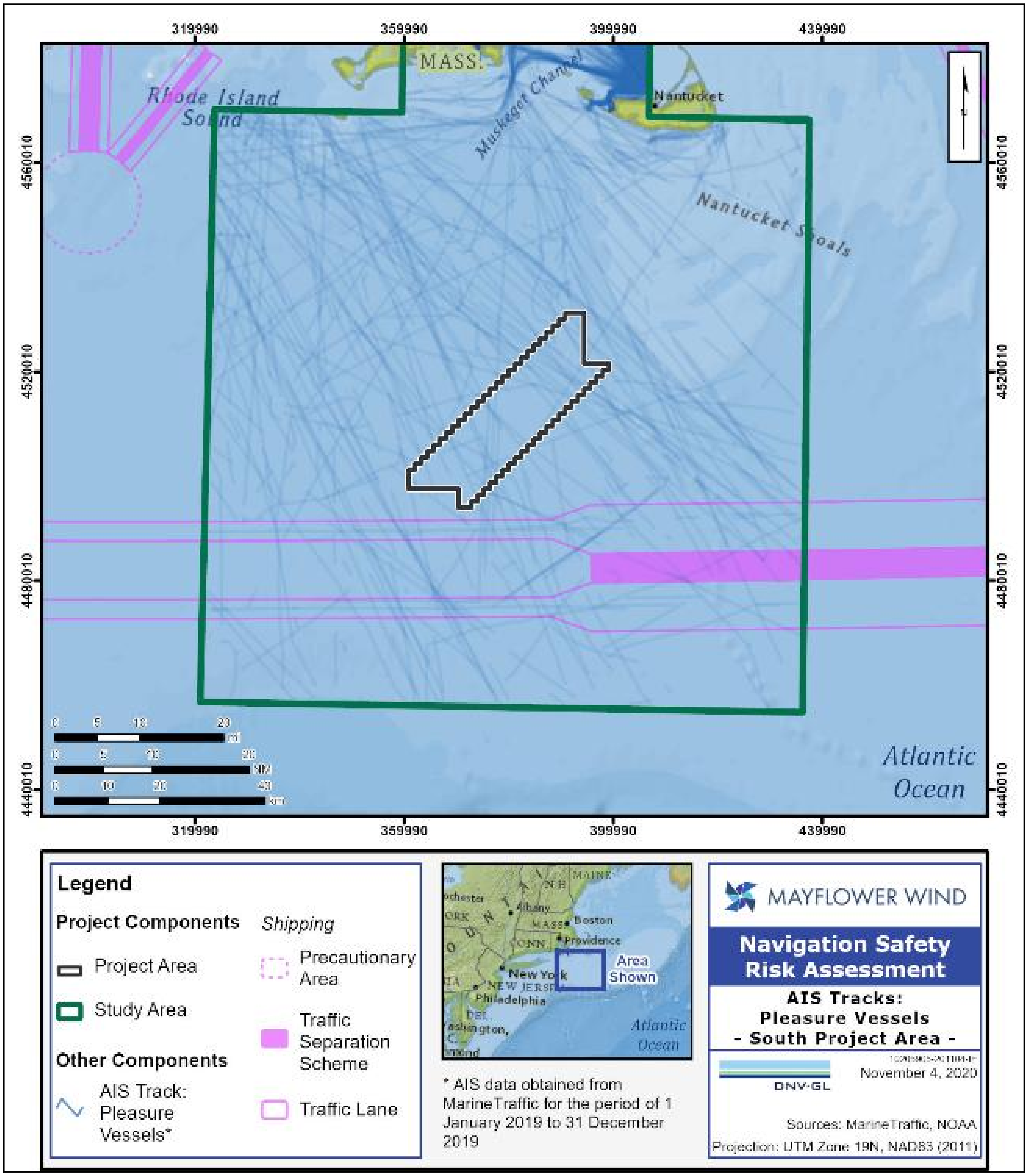


Figure 2-14 AIS Tracks for Pleasure Vessels – South Study Area[4]

In addition to reviewing AIS data for pleasure vessels, recreational boating data were obtained from the 2012 Northeast Recreational Boater survey, conducted by SeaPlan (2013), the NROC, states' coastal agencies, marine trade association of industry representatives, and the First USCG District. The data are from a randomly selected survey of registered boaters in the 2012 boating season. Figure 2-11 shows the recreational boating density from the SeaPlan survey. The data contain four registered activities in the southern (MARCS) portion of the NSRA Study Area. Figure 2-14 shows that more pleasure vessel transits occur near the coast and their density falls off closer to the Nantucket Ambrose Fairway Section 2.1.3.1 presents vessel transit counts in the area.

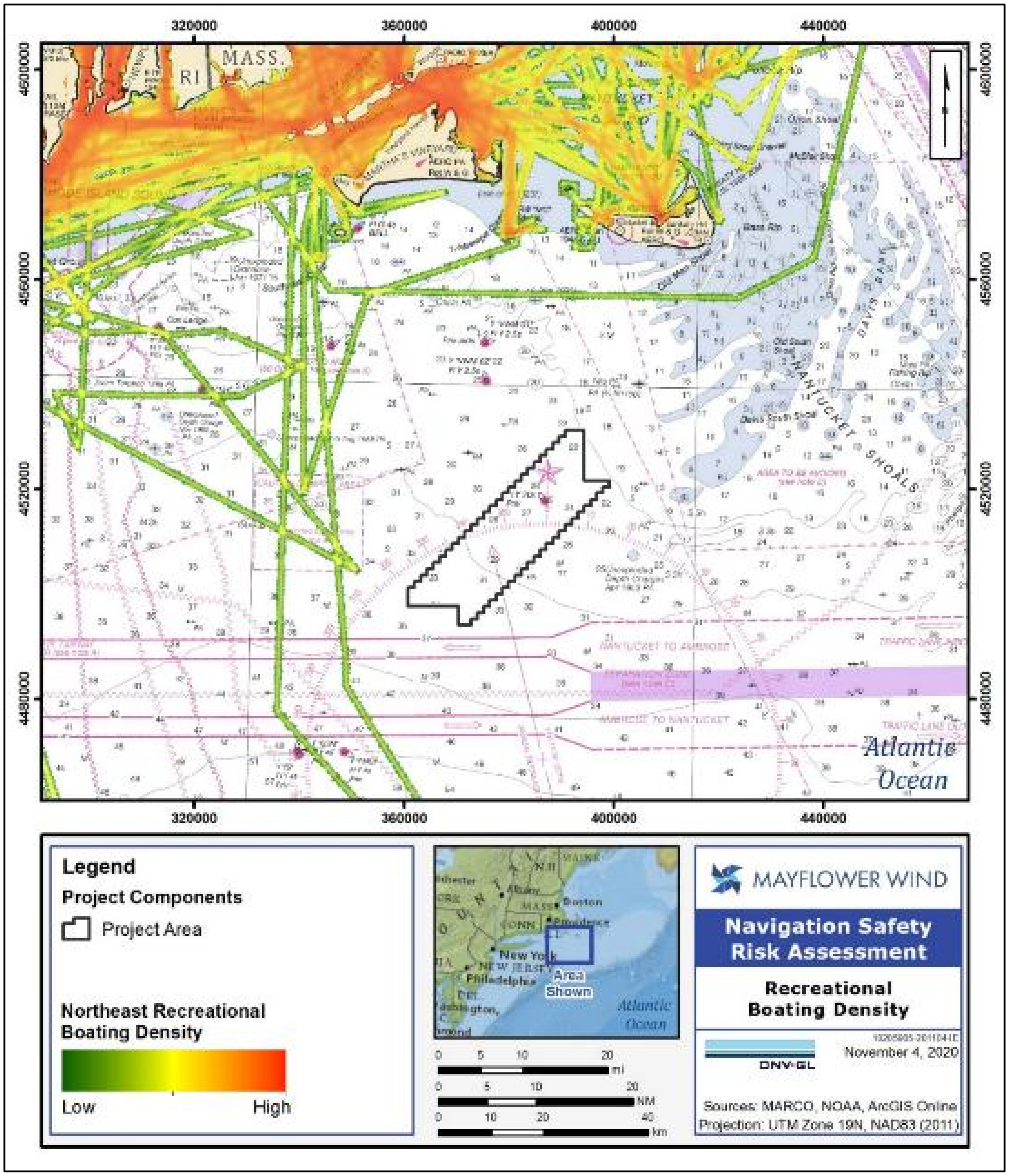


Figure 2-15 Recreational Boating Density (SeaPlan, 2013)

Traffic added to AIS for the purpose of risk modeling

Approximately 15 percent of the pleasure vessel tracks in AIS were from vessels self-identified as longer than 20 m (65 ft), indicating that a lot of pleasure vessels use AIS even though there is no requirement for them to do so. Given that pleasure vessels are likely underrepresented in the AIS data and a lack of information on the percentage of passenger vessels that do not transmit AIS, a potential range was identified by a DNV GL navigation risk expert. A low estimate could be 10 percent of all passenger vessels transmit AIS near the Project Area - a high estimate could be 90 percent. Given the location of the Project Area, distance from local ports and near a TSS, the average of 50 percent was selected for purposes of modeling. Therefore, the number of pleasure vessel tracks near the Project Area in the AIS data was doubled in the risk model (Table 2-3). It would have been possible to double the number of passenger vessel tracks in all routes in the model; however, the undesired effect would have been to increase the Base Case risk, causing the risk increase from the Project to be a smaller percentage of the Base Case.

In addition to the above correction to align the risk model more closely with reality, the Project could attract additional vessel traffic, mostly likely for recreational fishing. To account for this effect, three routes were equally assigned a portion of 100 additional pleasure transits to the Project and 100 return transits.

Table 2-5 Pleasure Vessel Transits Added to AIS Transits for Modeling

Vessel type & activity	Adjusted number of tracks	Routes	Model Case
Pleasure	Increase the AIS tracks by 100%	All routes within 1 NM (1.9 km) of the Project Area	Base Case and Future Case
Pleasure	100 additional tracks each way	Equally assigned to three routes ending along a centerline in the Project Area. Two routes begin in Nantucket Bay and one begins on the southwest side of the Study Area.	Future Case

2.1.1.5 Tug/Service traffic

The AIS tracks for tugs and service vessels are shown in Figure 2-16 and Figure 2-17. The majority of this traffic is in the southern portion of Nantucket Sound.

Significantly more tugs and service transits occur in Nantucket Sound than near the Project Area. In the MARIPARS report, the USCG similarly concluded that tug vessel transits have low frequency in the area.

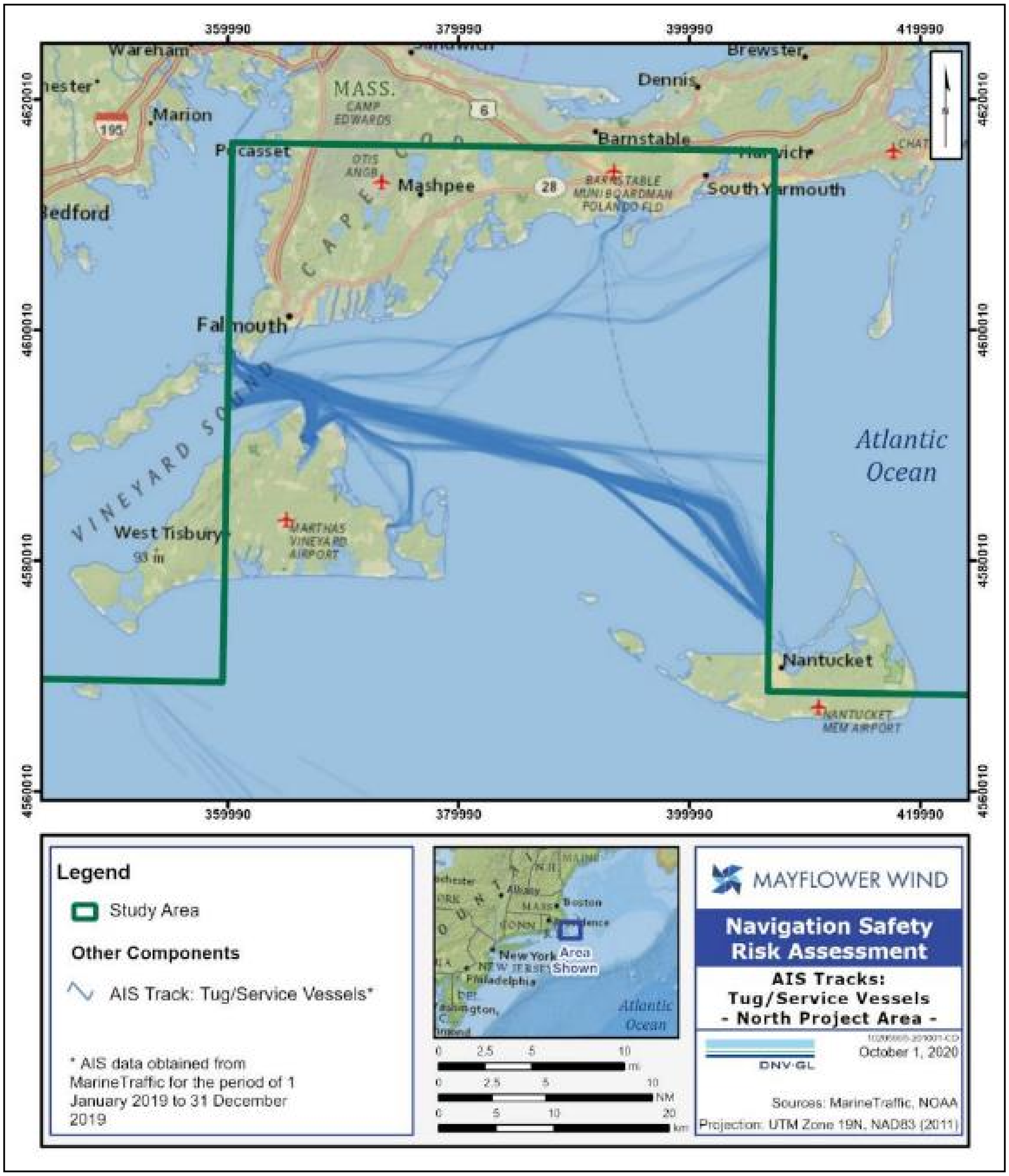


Figure 2-16 AIS Tracks for Tugs and Service Vessels – North Study Area[4]

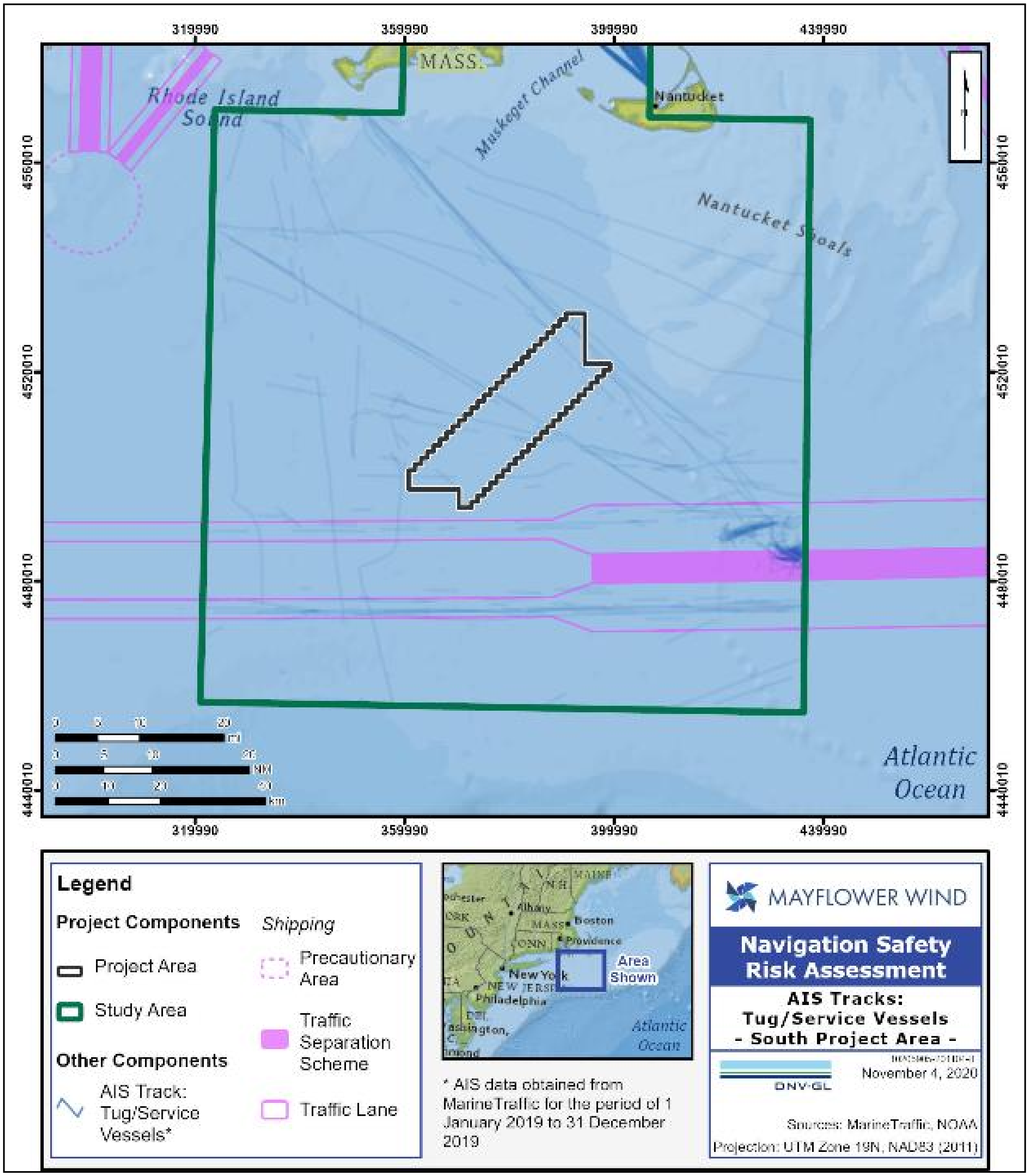


Figure 2-17 AIS Tracks for Tugs and Service Vessels – South Study Area[4]

2.1.1.6 Other vessel traffic

AIS tracks for "other" vessel types are presented in Figure 2-18 and Figure 2-19. 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 in previous Table 2-1. In the North Study Area, vessels of this type take nearly direct routes between the ports in the area.

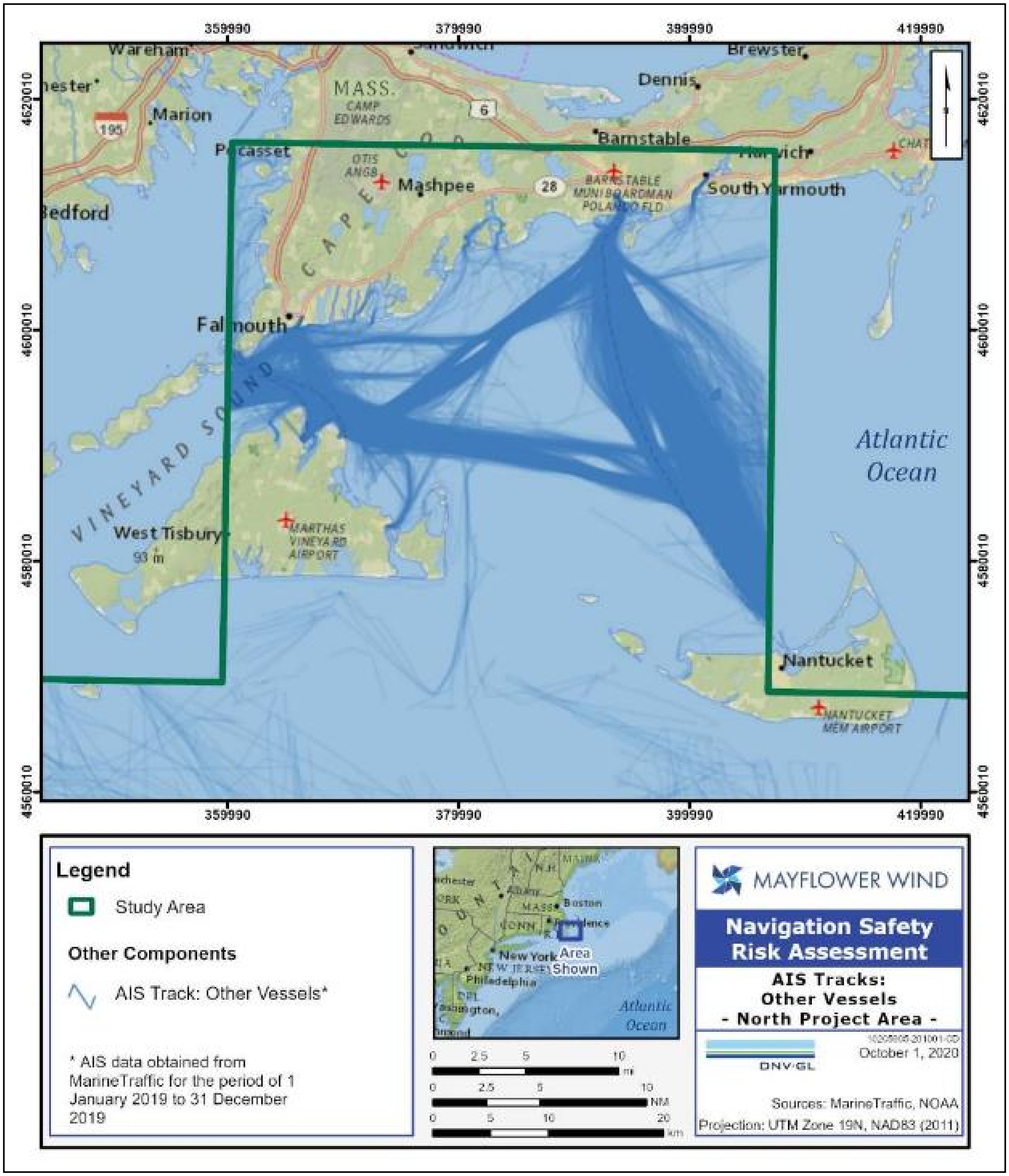


Figure 2-18 AIS Tracks for Other Vessels – North Study Area[4]

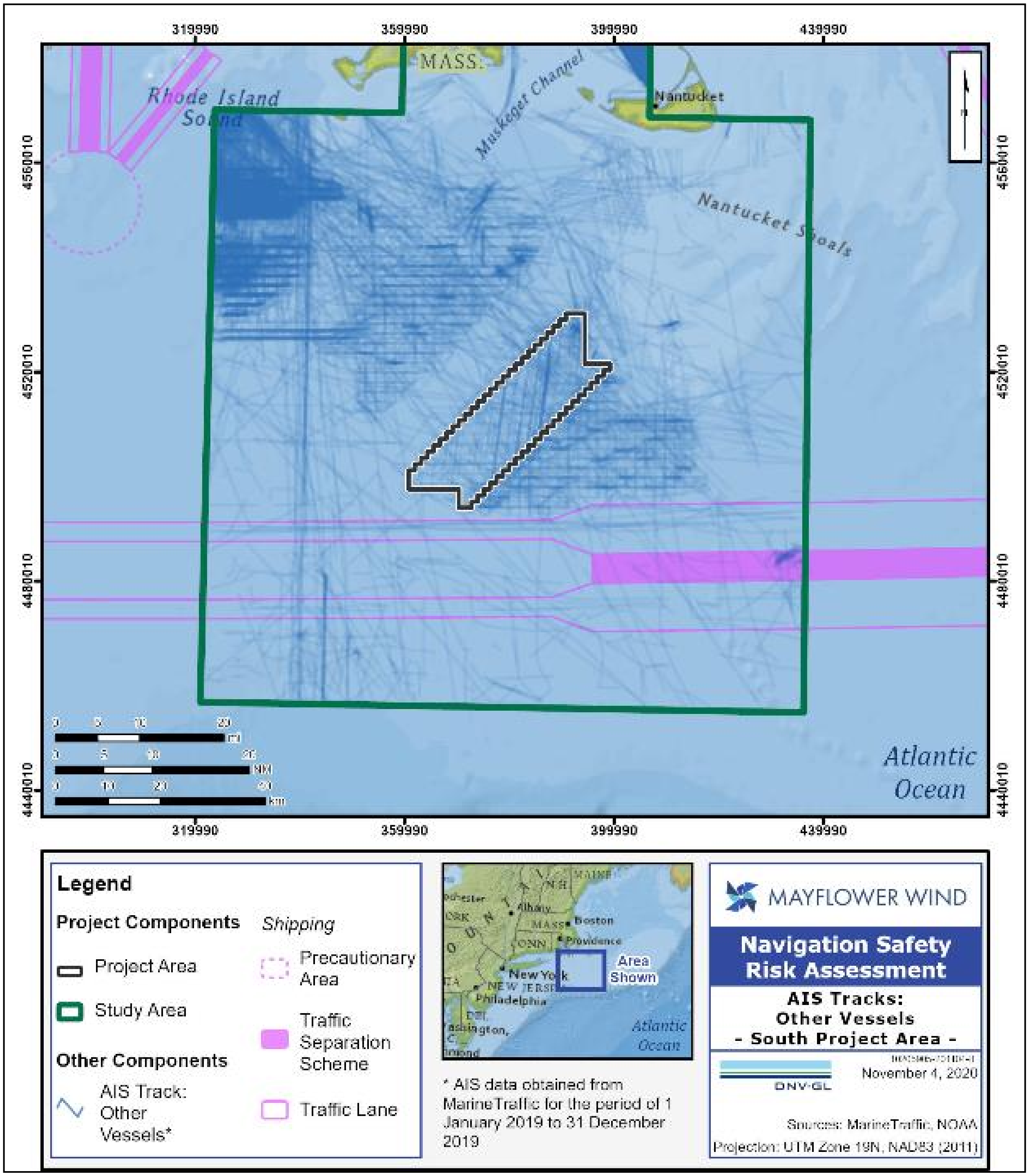


Figure 2-19 AIS Tracks for Other Vessels – South Study Area[4]

Within and adjacent to the Project Area, a significant portion of the tracks from the “other” vessel types are from research/survey vessels (Figure 2-20). Such vessels typically conduct gridded data collection activities for offshore wind Projects.

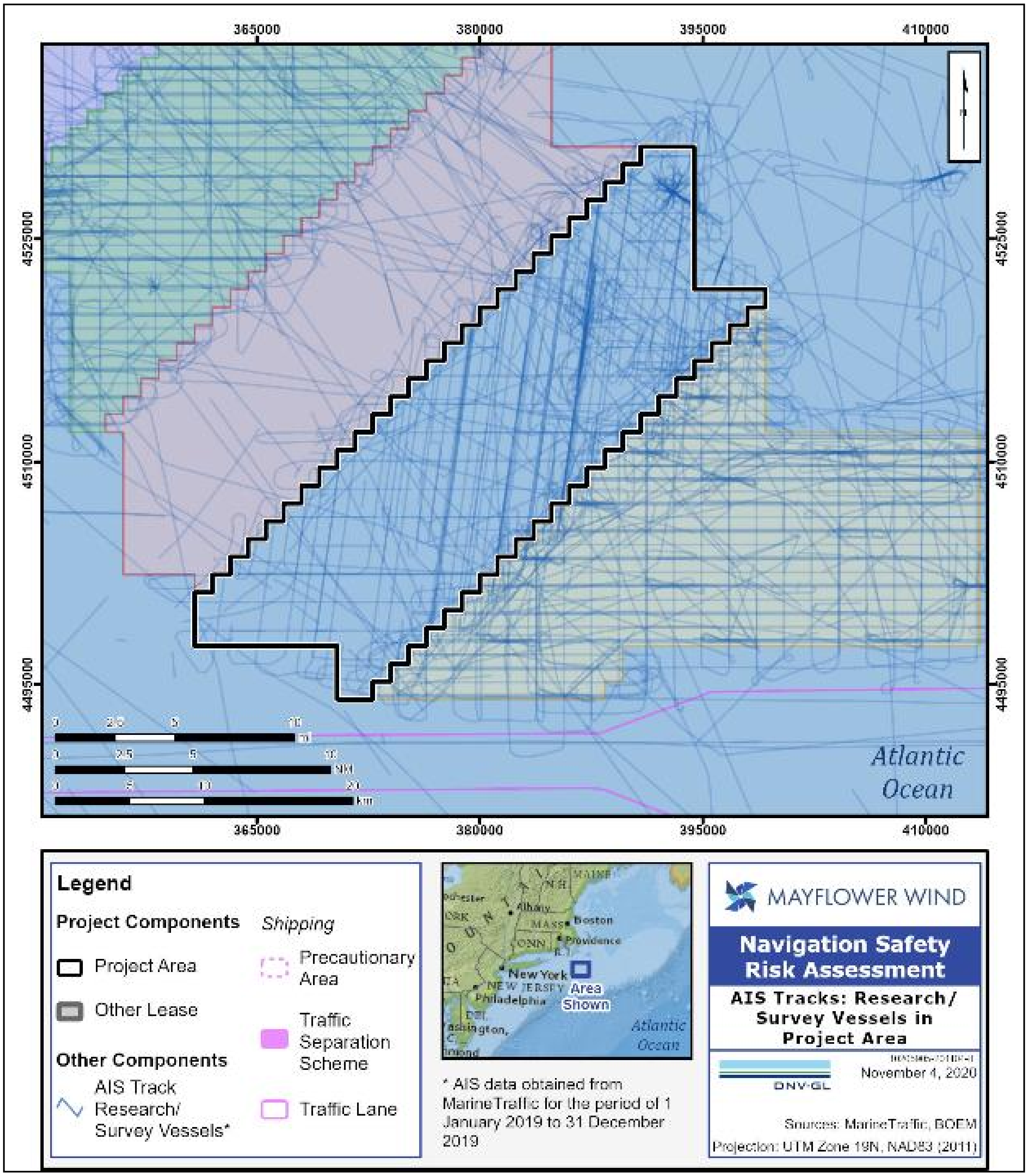


Figure 2-20 AIS Tracks for Research/Survey Vessels[4]

2.1.2 Traffic density

Figure 2-21 presents a density heat map for all AIS points in the Study Area. Point density maps for each ship type are provided in Appendix B.

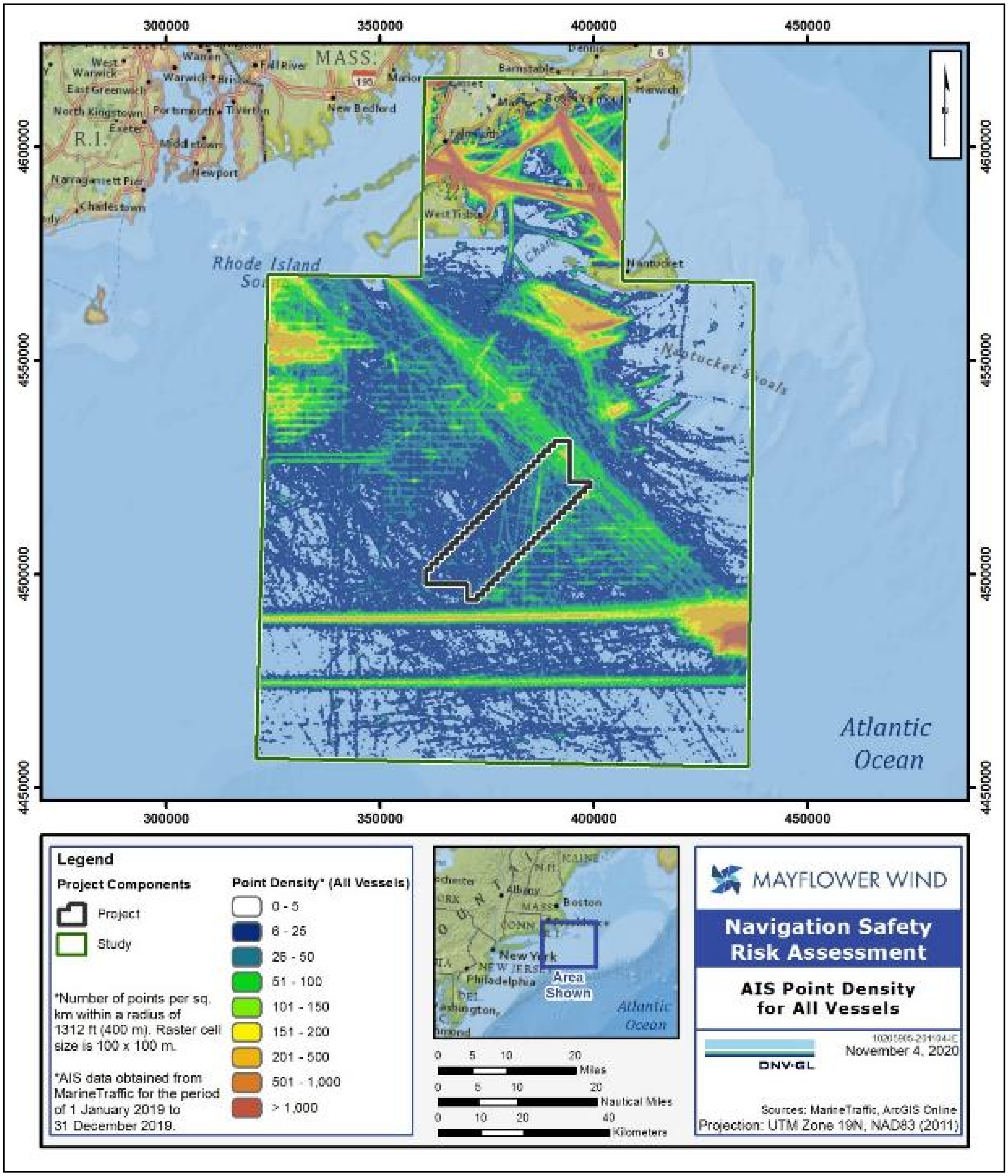


Figure 2-21 AIS Point Density[4]

2.1.3 Traffic statistics

This section presents the traffic statistics for the Study Area. The statistics provide insight into how many transits occur and which vessel types transit in specific locations.

2.1.3.1 Transit counts

Transit counts per transect

Figure 2-22 and Figure 2-23 show the transects defined for this NSRA. The transect locations were selected to evaluate traffic composition for the major traffic routes and the Project Area. The number of vessel tracks crossing each transect provides insight into the amount and types of marine traffic among the routes indicated in the 2019 AIS data.

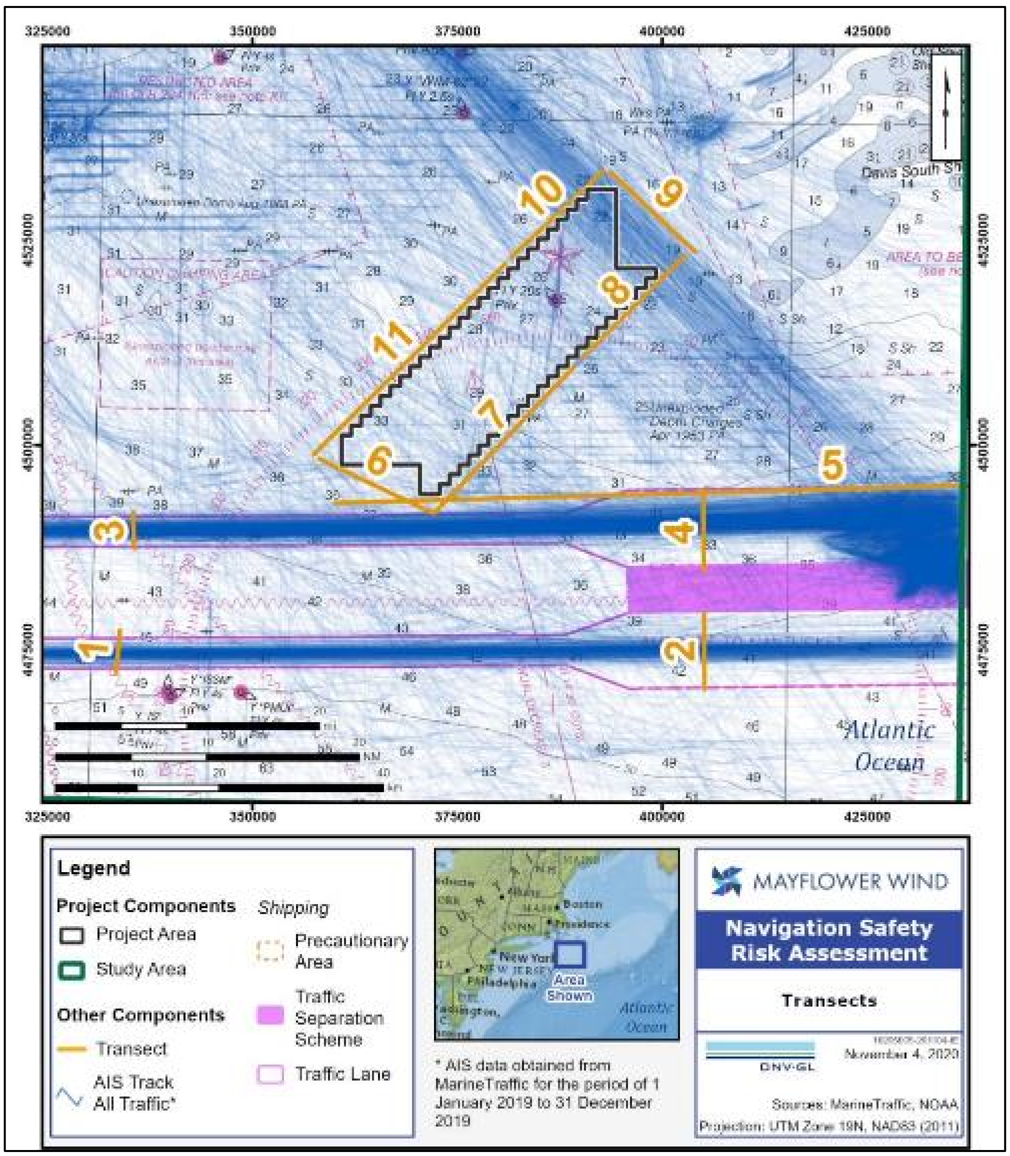


Figure 2-22 Transects Used for Statistical Analysis of Traffic in South Study Area[4]

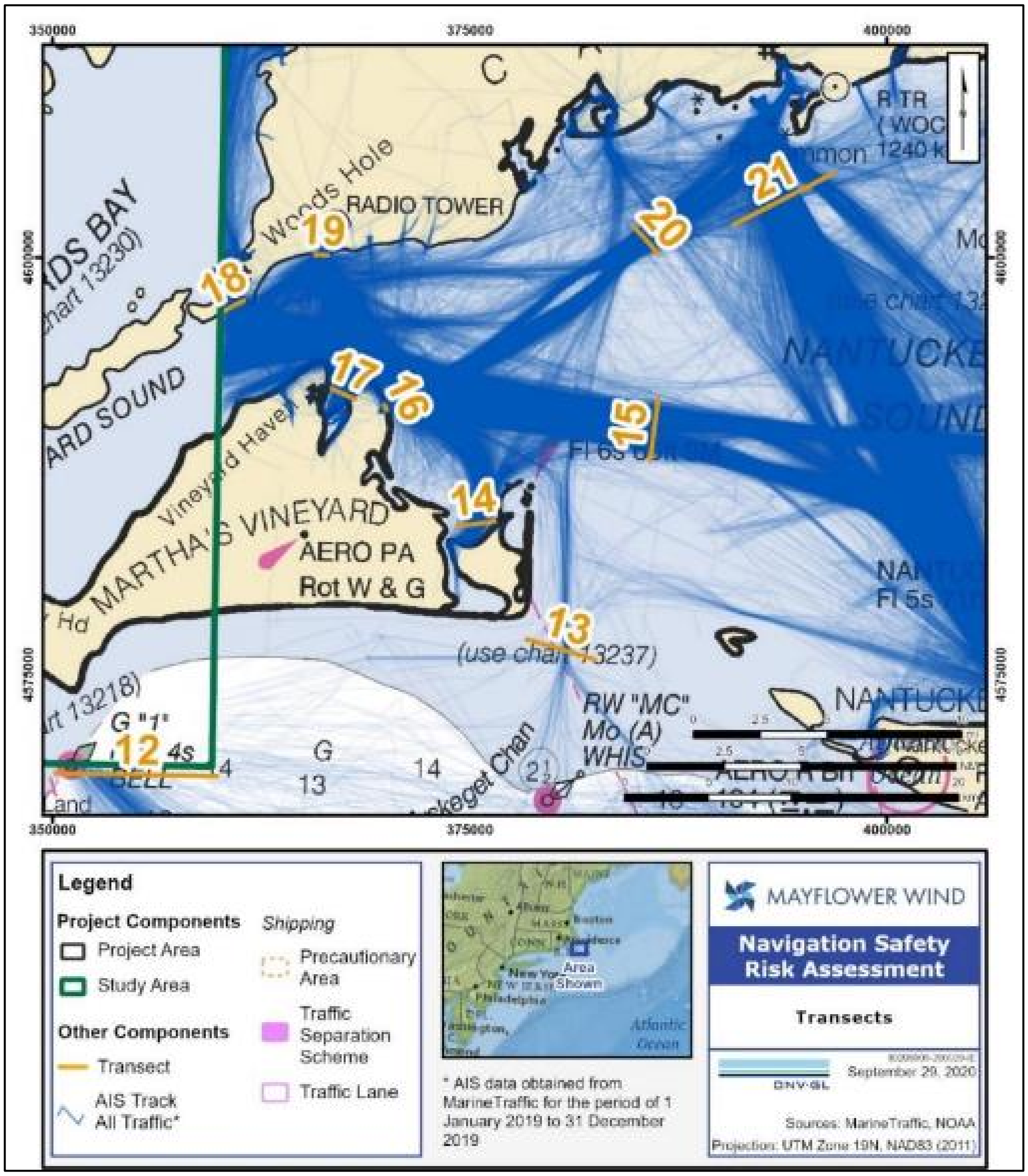


Figure 2-23 Transects Used for Statistical Analysis of Traffic in North Study Area[4]

Figure 2-24 presents the vessel transits (AIS track counts) for the numbered transects near the Project Area. The counts are based on 2019 AIS data (MarineTraffic, 2020).

Deep draft traffic in the outbound lane of the Nantucket Ambrose Fairway is represented in transects 1 and 2. Cargo, tanker, and to a lesser extent, passenger (cruise) ships transit this lane and the northern, inbound lane (transects 3 and 4). There was about 50 percent more inbound traffic to NY than outbound traffic.

Transect 5 shows almost the same number of tracks crossed the Nantucket Ambrose Fairway as transited in it. Most of the crossing vessels are fishing vessels, some of which fish within the Nantucket Ambrose Fairway.

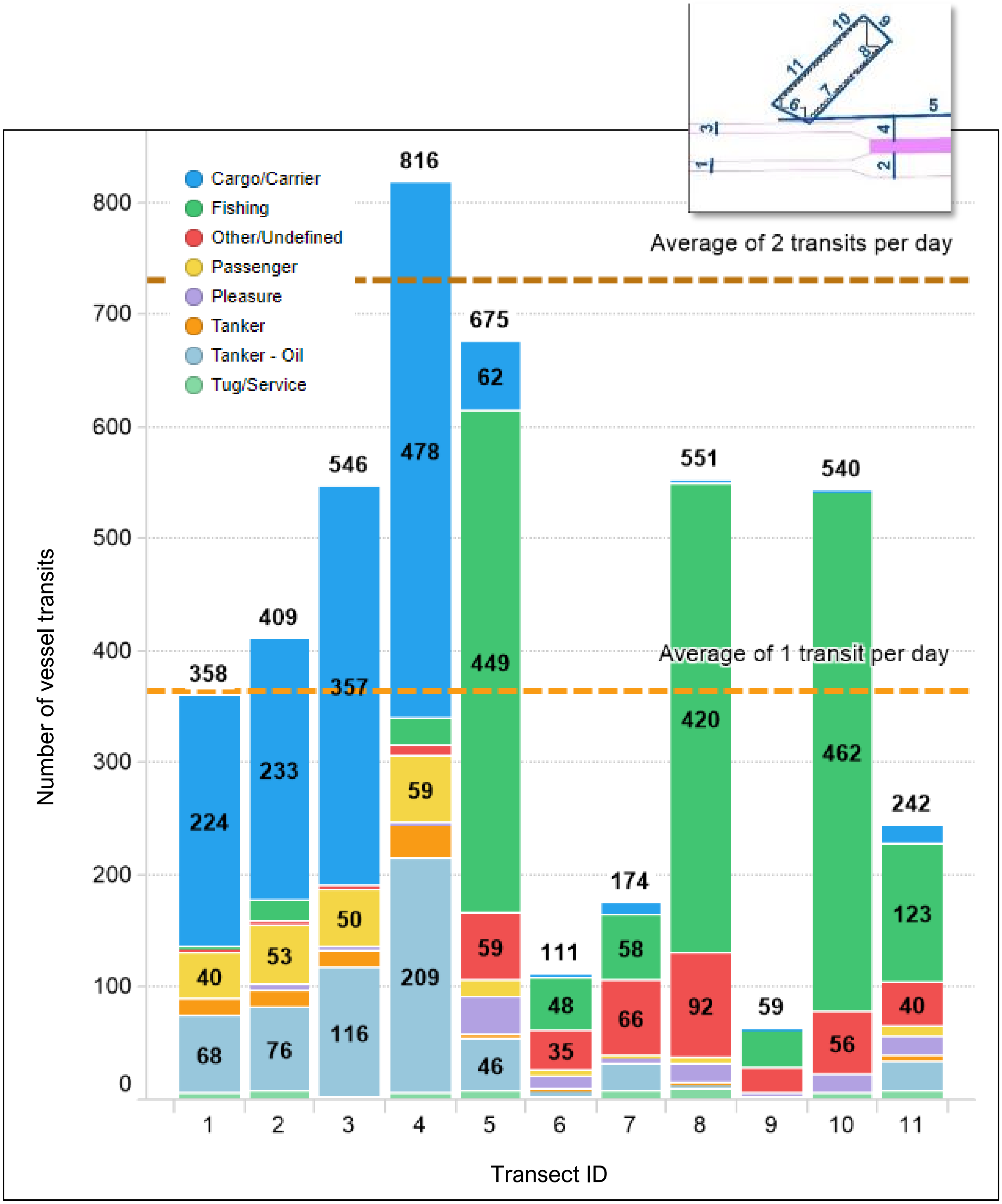


Figure 2-24 Annual Number of Vessel Transits for Transects 1 to 11[4]

The Project Area is bounded to the northwest by transects 10 and 11, which show just under 800 tracks crossed into and out of the Project Area in 2019. About 70 percent of this traffic occurs from May through September. If all 2019 transits occurred during these four months, there would have been an average of 6.5 vessels per day crossing into and out of the Project Area.

Figure 2-25 presents the transits north of the Project, including Nantucket Sound.

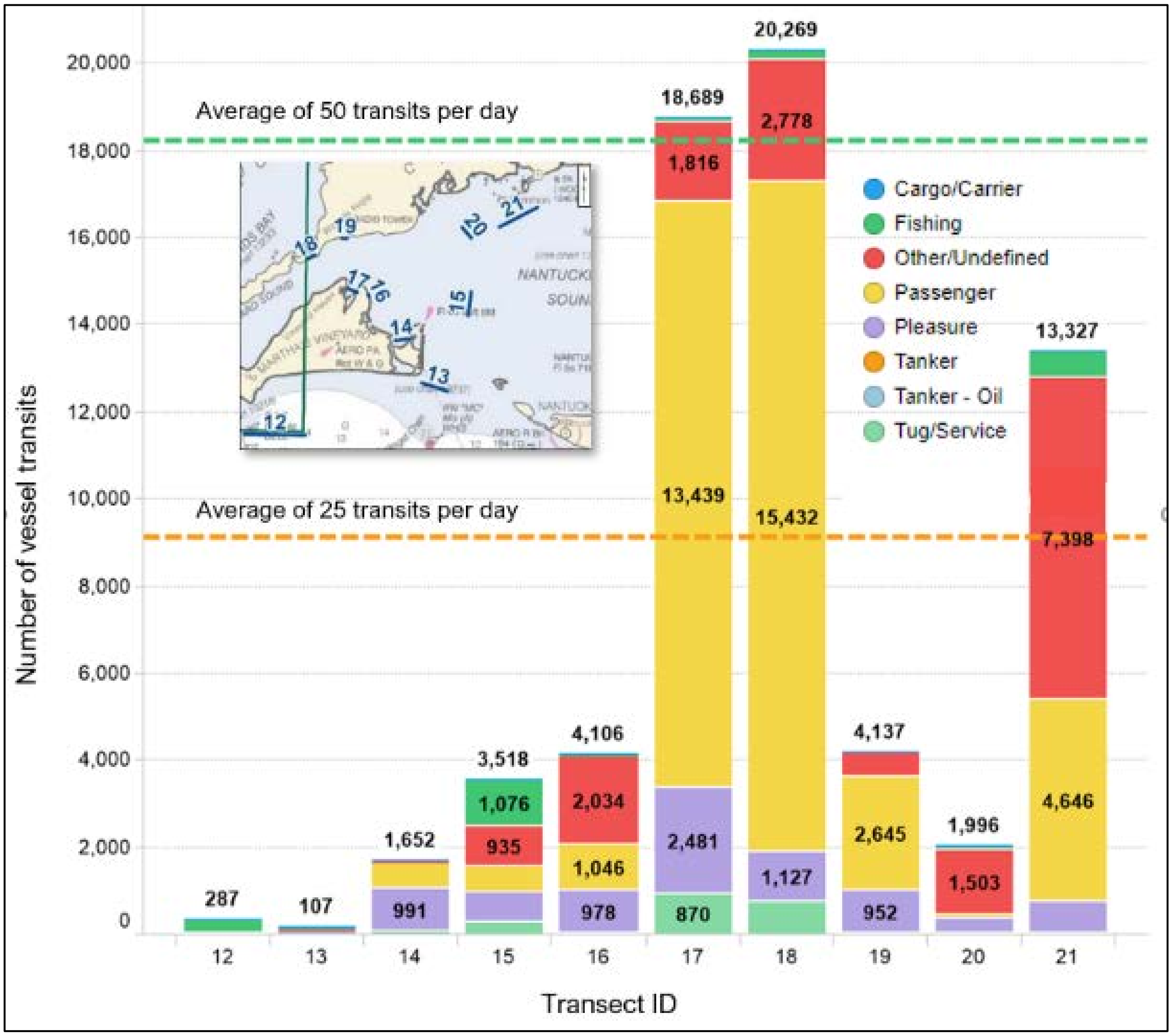


Figure 2-25 Annual Number of Vessel Transits for Transects 12 to 21[4]

In the North Study Area, two routes averaged more than 50 transits per day over 2019. The transits double in the summer months compared to the winter months because of the highly seasonal passenger traffic, visible in:

- The entrance to Vineyard Haven (transect 17)
- The entrance to Oak Bluffs Harbor (transect 18)

The next most utilized route is indicated by vessel tracks between Cape Cod and Nantucket Harbor (transect 21), which averaged about 37 transits per day.

2.1.3.2 Vessel size

Vessel sizes were evaluated within the Study Area and within the more limited area used for risk modeling, the southern part of the Study Area.

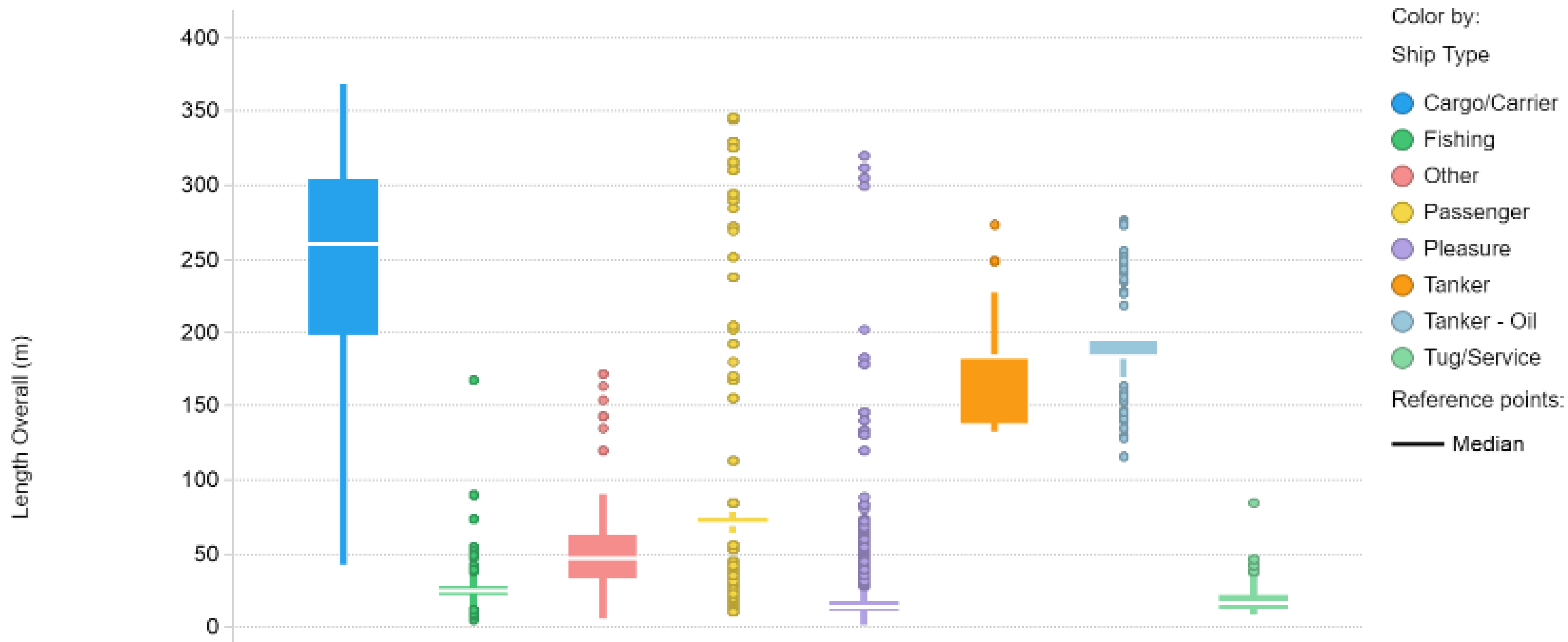
There are three primary uses of the ship size data and statistics:

- The data provide a general sense of the range of vessel sizes in the vicinity of the Project Area.
- The ship's breadth and length are used in the powered and drift allision models, respectively.
- The average dead weight tonnage (DWT) is used in the analysis described in Section 11.3 to estimate allision energies. Any over-estimation of vessel size adds a margin of conservatism, over-estimates the potential allision energy, and therefore, over-estimates the potential consequences.

Size distributions for length overall (LOA), beam, and DWT for vessels in the Study Area are provided in Figure 2-26 through Figure 2-28 based on the unadjusted AIS data[5]. Vessel size statistics presented in this section are based on each vessel user entering the inputs into the AIS. It is notable that in this data set, no fishing vessels entered a DWT. Where a DWT value was needed for modeling or energy calculations, an average of 500 DWT was assumed for fishing vessels to assure over-estimation of the accident frequency in the judgment of DNV GL experts in quantifying navigation safety risk.

Figure 2-26 shows that the average cargo/carrier vessel is 251 m (823 ft) LOA. Oil tankers and other tankers average 193 m (633 ft) and 172 m (564 ft) LOA, respectively. Fishing, pleasure, and tugs all average less than 25 m (82 ft) LOA. Beam and DWT data show similar patterns, but less data was entered in the AIS.

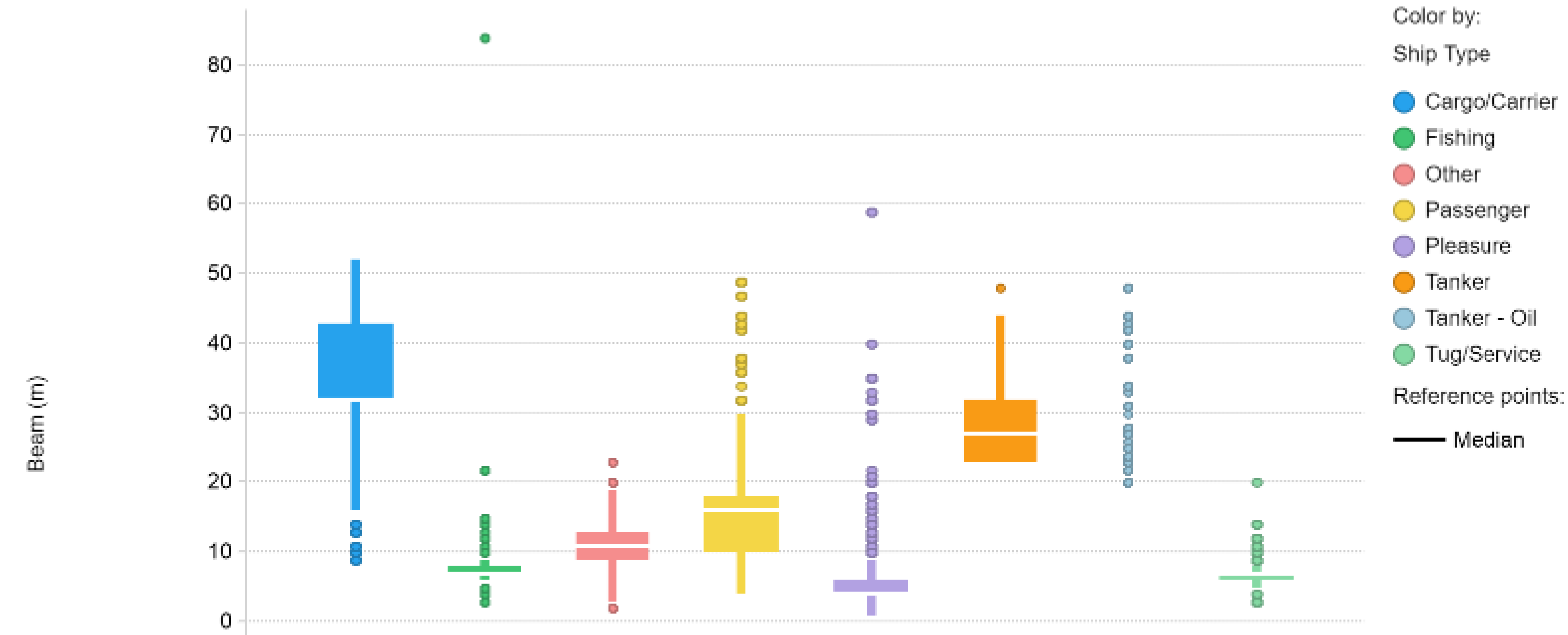
[5] Zeros values removed.



	Cargo/Carrier	Fishing	Other	Passenger	Pleasure	Tanker	Tanker -...	Tug/Service
UniqueCount	108	44	62	52	89	14	46	23
Min	43	6	6	11	1	133	117	8
Median	260	24	47	70	14	183	183	17
Avg	251	25	46	64	18	172	193	19
Max	368	168	172	347	855	274	277	85

Ship Type

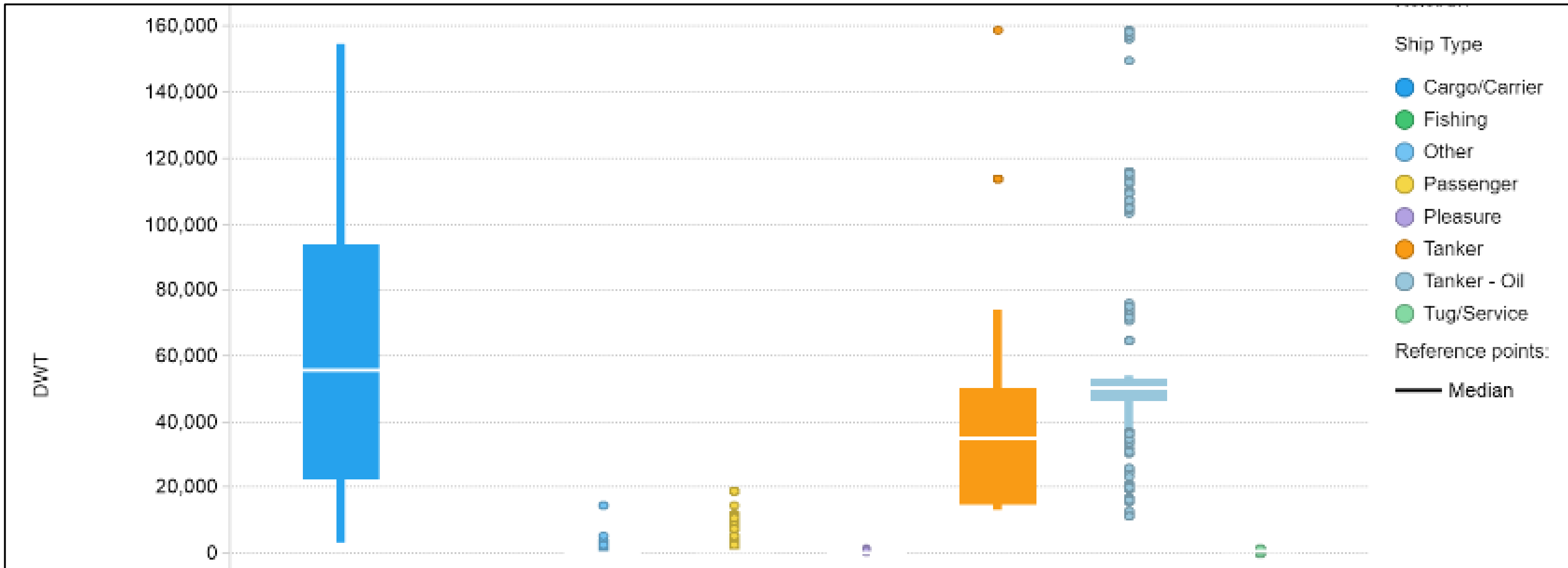
Figure 2-26 LOA Distribution in Study Area[4]



	Cargo/Carrier	Fishing	Other	Passenger	Pleasure	Tanker	Tanker -...	Tug/Service
UniqueCount	37	15	20	29	28	9	19	12
Min	9	3	2	4	1	23	20	3
Median	32	7	11	16	4	27	32	7
Avg	35	7	11	14	5	28	33	6
Max	52	84	23	49	59	48	48	20

Ship Type

Figure 2-27 Beam Distribution in Study Area[4]



	Cargo/Carrier	Fishing	Other	Passenger	Pleasure	Tanker	Tanker - Oil	Tug/Service
UniqueCount	454	0	38	37	48	26	277	16
Min	3,414	(Empty)	20	100	1	12,972	11,316	73
Median	55,828	(Empty)	120	533	117	34,930	49,999	433
Avg	59,862	(Empty)	495	731	167	36,919	57,556	522
Max	155,000	(Empty)	14,620	19,189	1,650	159,152	158,933	1,445

Ship Type

Figure 2-28 Dead Weight Tonnage Distribution in Study Area[4]

Vessel sizes and even some vessel types were present only in the northern (Nantucket Sound) or southern Atlantic Ocean) portions of the Study Area. Figure 2-29 shows the average LOA of each vessel type depending on the area transited.

Cargo and carrier vessels transited both in the North and South Study Areas, but no cargo/carrier vessel tracks crossed from one area into the other (designated as “Both”). Cargo/carrier vessels in the North Study Area had an average LOA of 90 m (295 ft), while vessels in the South Study Area were more than twice as large, averaging 252 m (827 ft) LOA.

Fishing, other, pleasure vessels, and tugs transited in the North Study Area, South Study Area, and between, and had fairly consistent LOA across the Study Area.

There were no tanker tracks in the North Study Area. Passenger vessels in the South Study Area were nearly four times as long as their counterparts in the North Study Area. This is because the ferries crossing Nantucket Sound and the cruise ships transiting in the Nantucket Ambrose Fairway are both categorized as passenger vessels.

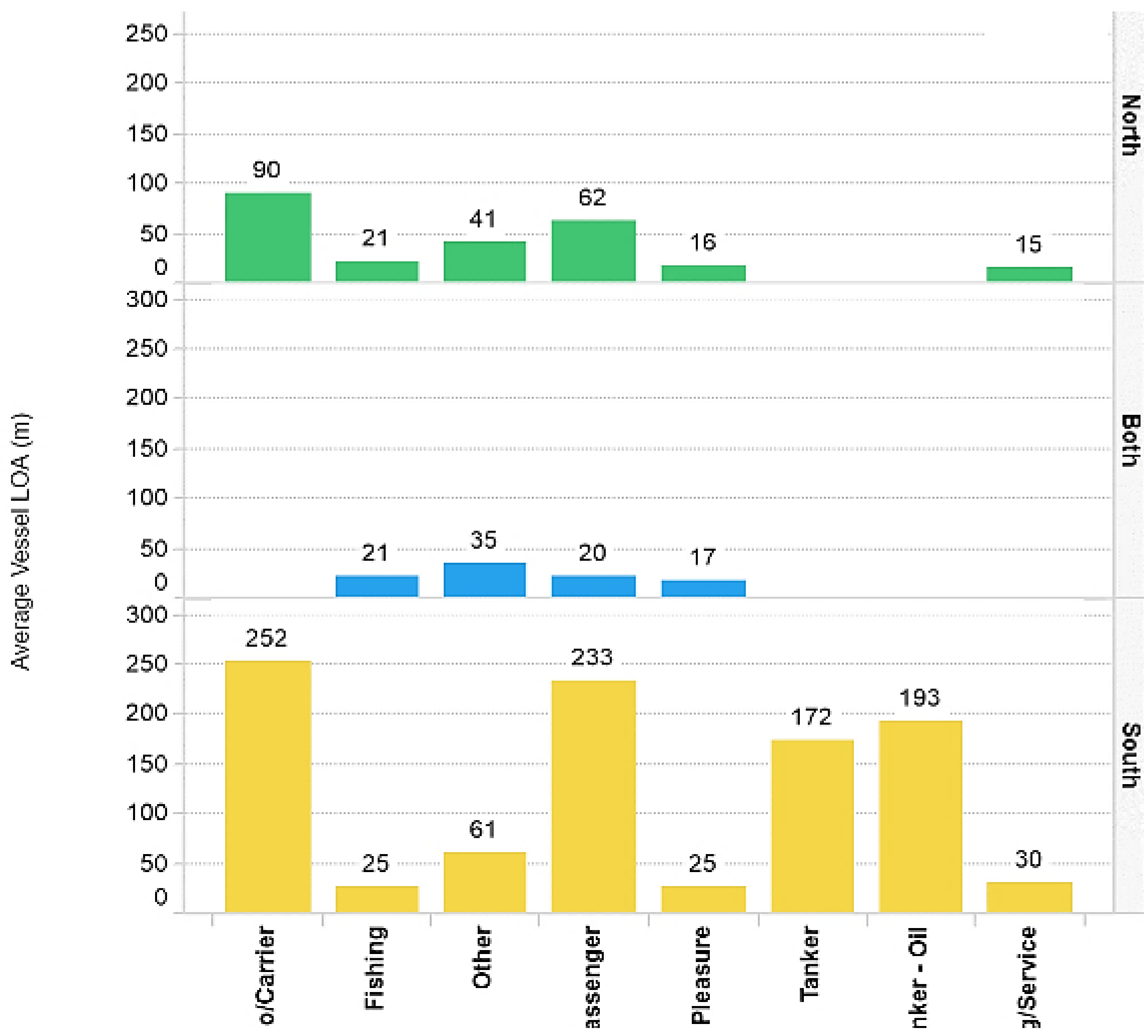


Figure 2-29 LOA in North Versus South Portions of the Study Area[4]

For the evaluation of potential impact energies presented in Section 3.4, the DWT of vessels in the model was determined from the unadjusted AIS data for the South Study Area and assumptions for fishing vessels as described above. Table 2-6 shows the average sizes of vessels within the South (MARCS) Study Area.

Table 2-6 Average DWT per Vessel Type in the MARCS, South Study Area[4]

Vessel type	Average DWT (metric tonnes [mt])
Cargo/Carrier	62,520
Fishing	500
Other/Undefined	1,512
Passenger	7,341
Pleasure	121
Tanker	46,341
Tanker - Oil	56,526
Tug/Service	666

2.1.3.3 Vessel speed

This section characterizes vessel speeds in the Study Area. Figure 2-30 presents speeds reported in the AIS data. The highest speeds are in Nantucket Sound, including ferries, and in the Nantucket Ambrose Fairway, consisting of deep draft vessels. There is considerable area covered by low-speed traffic between the inbound and outbound lanes of the Nantucket Ambrose Fairway.

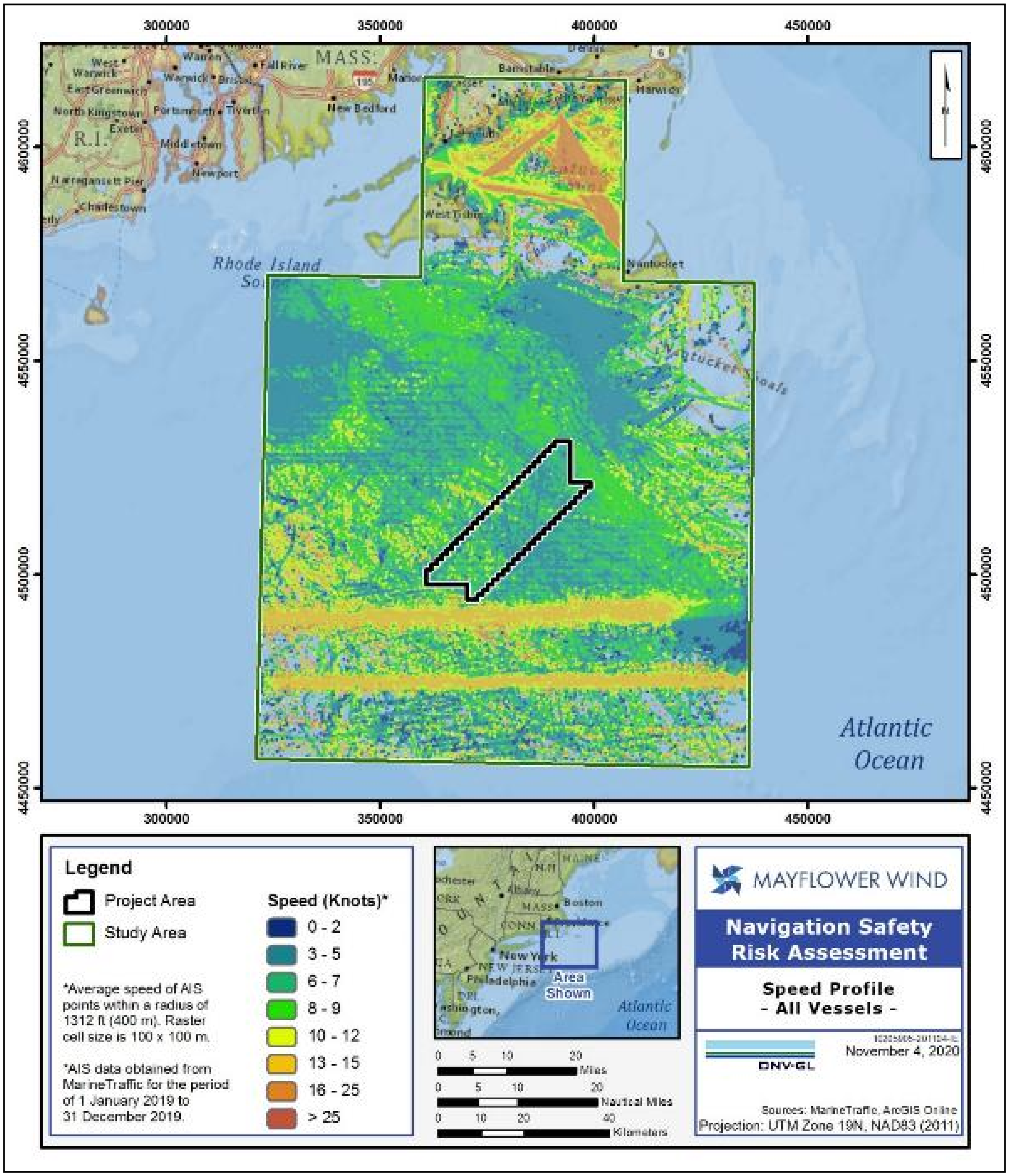


Figure 2-30 Speed Profile of all Vessels in the AIS Data[4]

The average speed of vessels transiting at more than 2 kt[6] in the southern part of the Study Area is 6.3 kt with a standard deviation of 4.9 kt, indicating a wide range of speed. Table 2-7 shows the average vessel speed per vessel type.

Table 2-7 Average Vessel Speed in South Study Area

Vessel type	Average speed (kt)
Cargo/Carrier	13.7
Fishing	4.7
Other/Undefined	4.1
Passenger	15.0
Pleasure	10.4
Tanker	11.8
Tanker - Oil	11.7
Tug/Service	4.9

2.1.4 Types of cargo

The cargoes being carried by vessels near the Project Area include:

- Containerized cargo
- Vehicles
- Break bulk and bulk cargoes (i.e., equipment, steel, wood pulp, and petroleum products)
- Refrigerated cargo
- Cruise vessels (New York Shipping Association, 2020)

[6] This cutoff was selected to provide a more representative set of "moving vessel" speeds for the Project Area for the purposes of the energy calculation in Section 3.4.1. Note that fishing activity is generally identified by speeds less than 4 kt.

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 2-31 shows the navigation chart near the Project and Figure 2-32 shows the export cable corridors. Analysis of hazards related to the export cable is provided in Section 3.1 and Section 4.

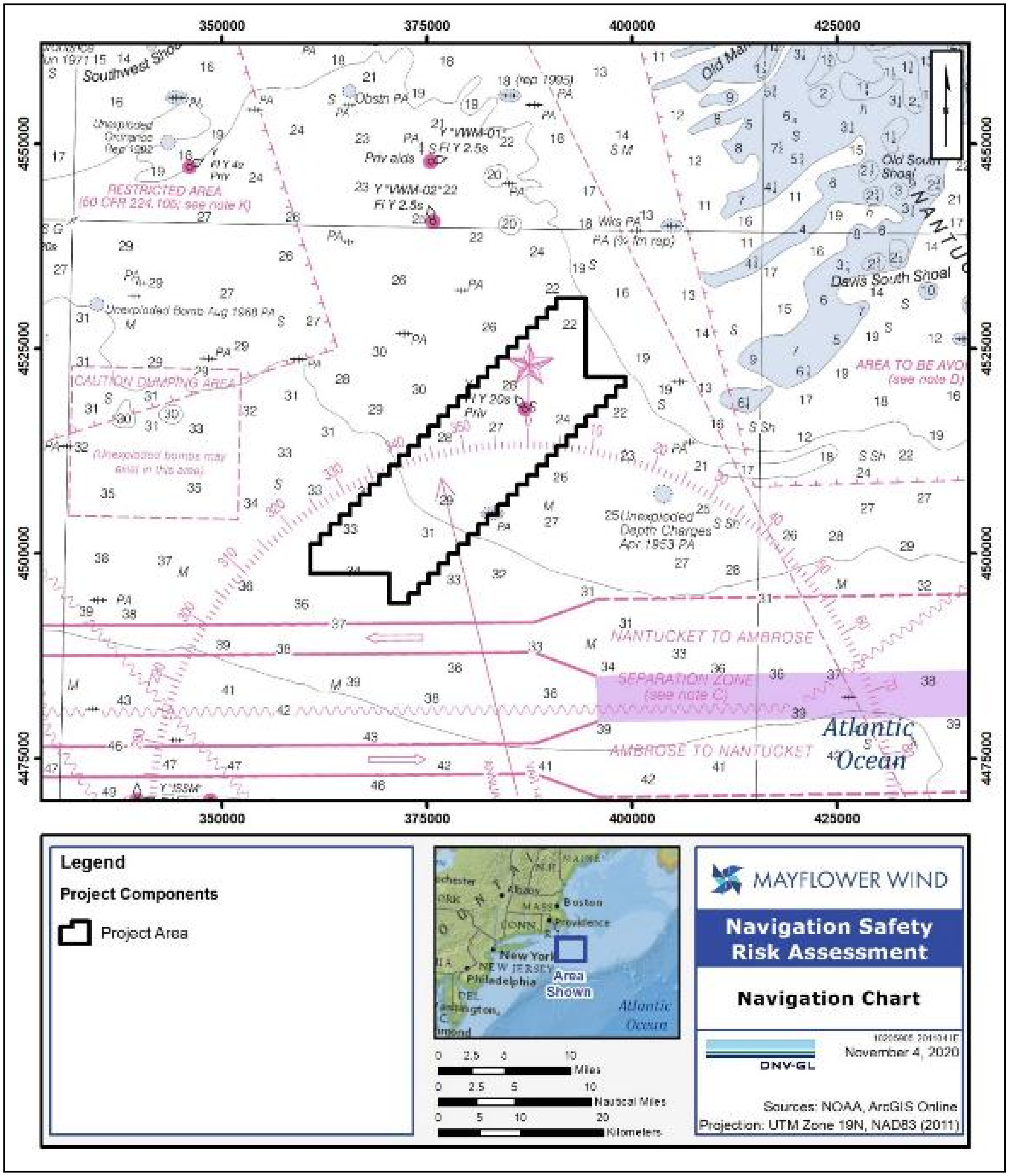


Figure 2-31 Navigation Chart Near the Project

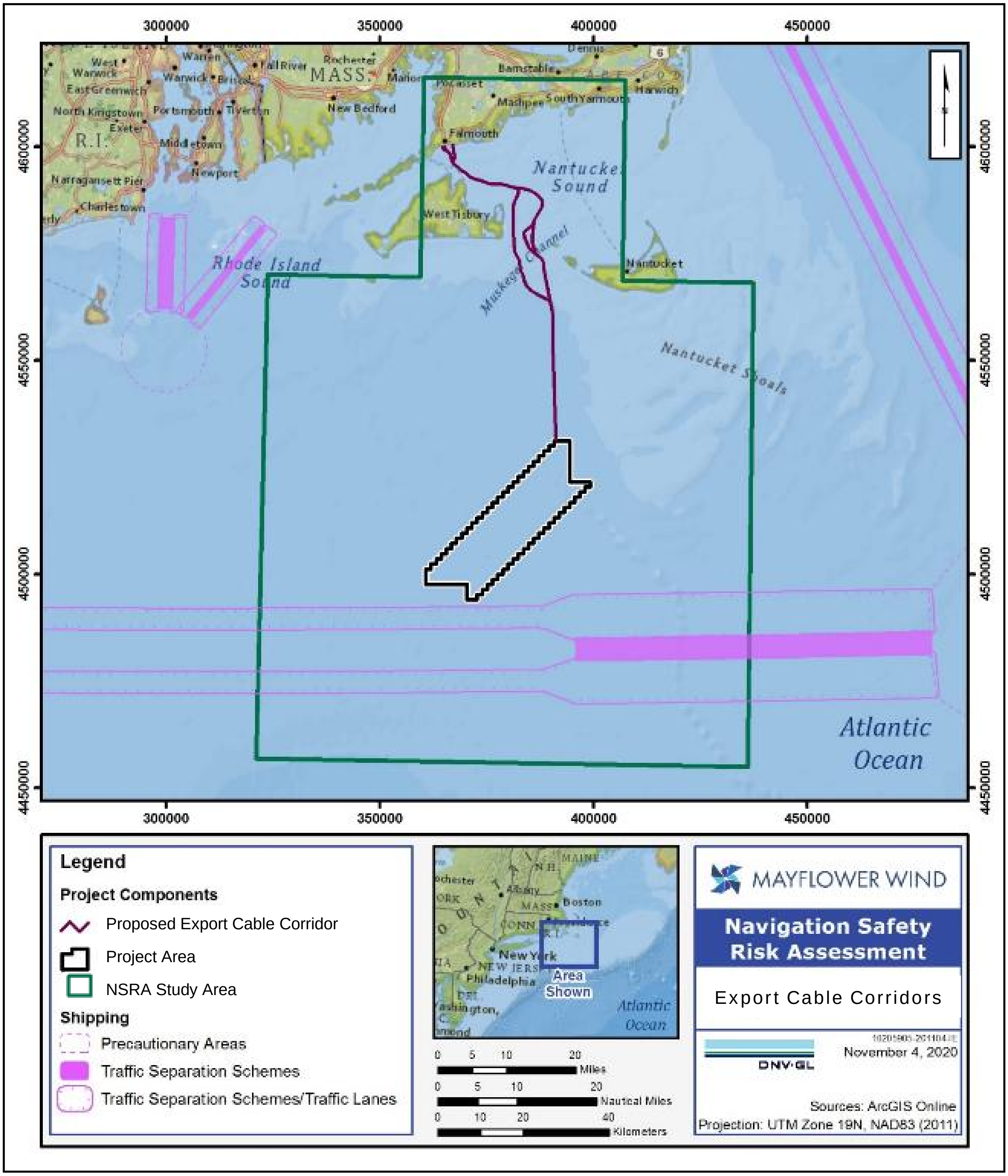


Figure 2-32 Export Cable Corridor (Mayflower Wind, 2020)

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
  - Day cruising of leisure craft (pleasure and passenger)
  - Sailing and racing courses
  - Wildlife viewing transits
- Section 2.2.2 Transit uses
  - Routes used by coastal or deep-draft vessels, ferry routes
  - Transit routes used by fishing vessels
  - Shipping routes
  - Routing measures, precautionary areas, separation zones, TSS
- Section 2.2.3 Transit-related safety measures
  - Anchorage grounds
  - Safe havens
  - Port approaches
  - Pilot boarding or landing areas
  - Anchoring in the wind farm
- 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 Day cruises

Commercial day trips and tours are common to/from ports in Rhode Island and Massachusetts. Commercial day cruises in the North Study Area include sightseeing cruises and 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 the closer ports in Nantucket Sound, most likely to fish. Additional transits were added to the Future Case risk model to account for this possibility (see Section 2.1.1.3).

2.2.1.2 Sailing and racing courses

Figure 2-33 illustrates typical routes of distance sailing races, some of which have historically transited through the Project Area (SeaPlan et. al., 2015). Future races will most likely route around the Project Area because these events are held in open water by design.

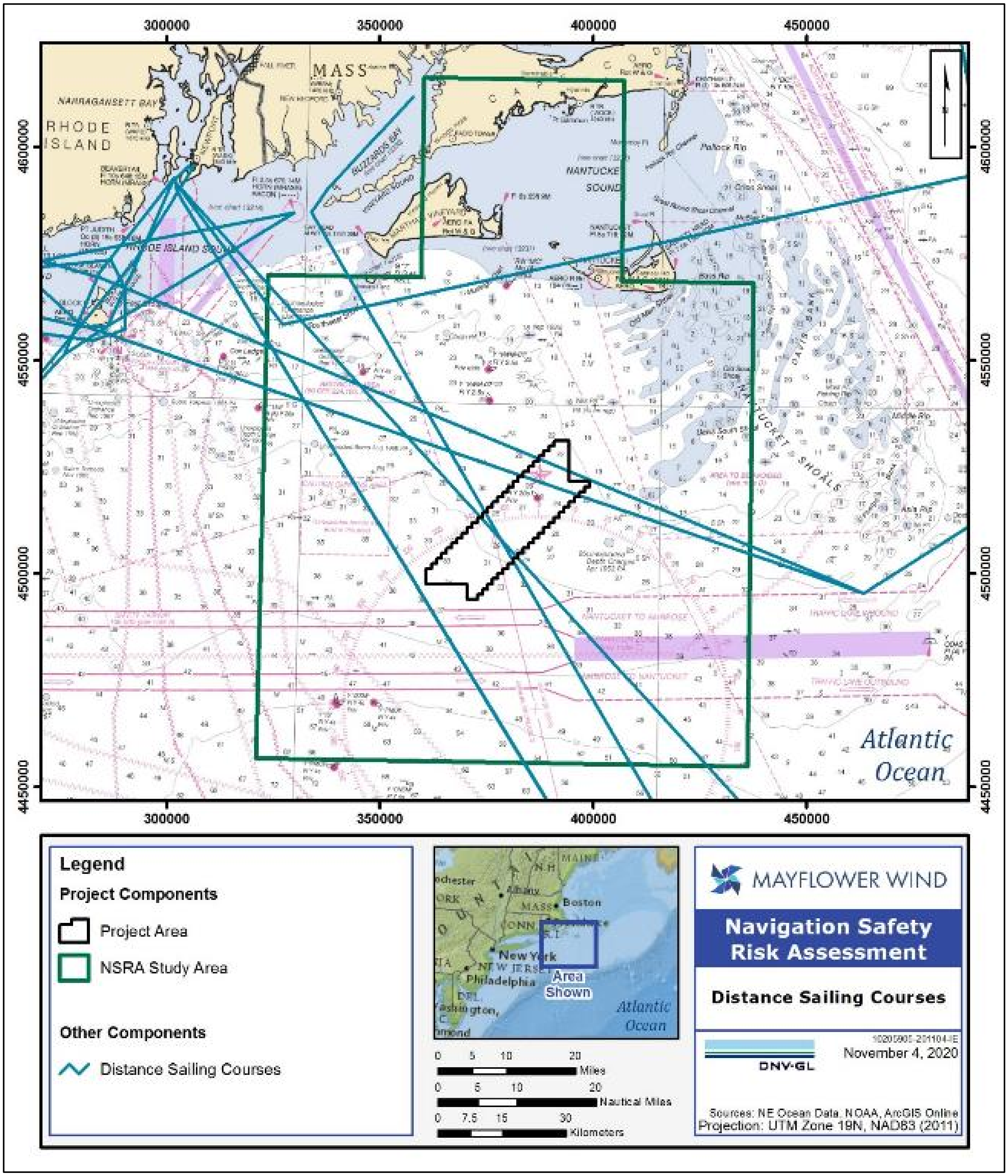


Figure 2-33 Distance Sailing Races (SeaPlan et. al., 2015)

2.2.1.3 Wildlife viewing

Figure 2-34 illustrates the offshore wildlife viewing areas in the Study Area, including wildlife and sightseeing, and commercial whale watching areas (NROC, 2015). Vessels transiting to offshore wildlife viewing areas could take routes through the Project Area.

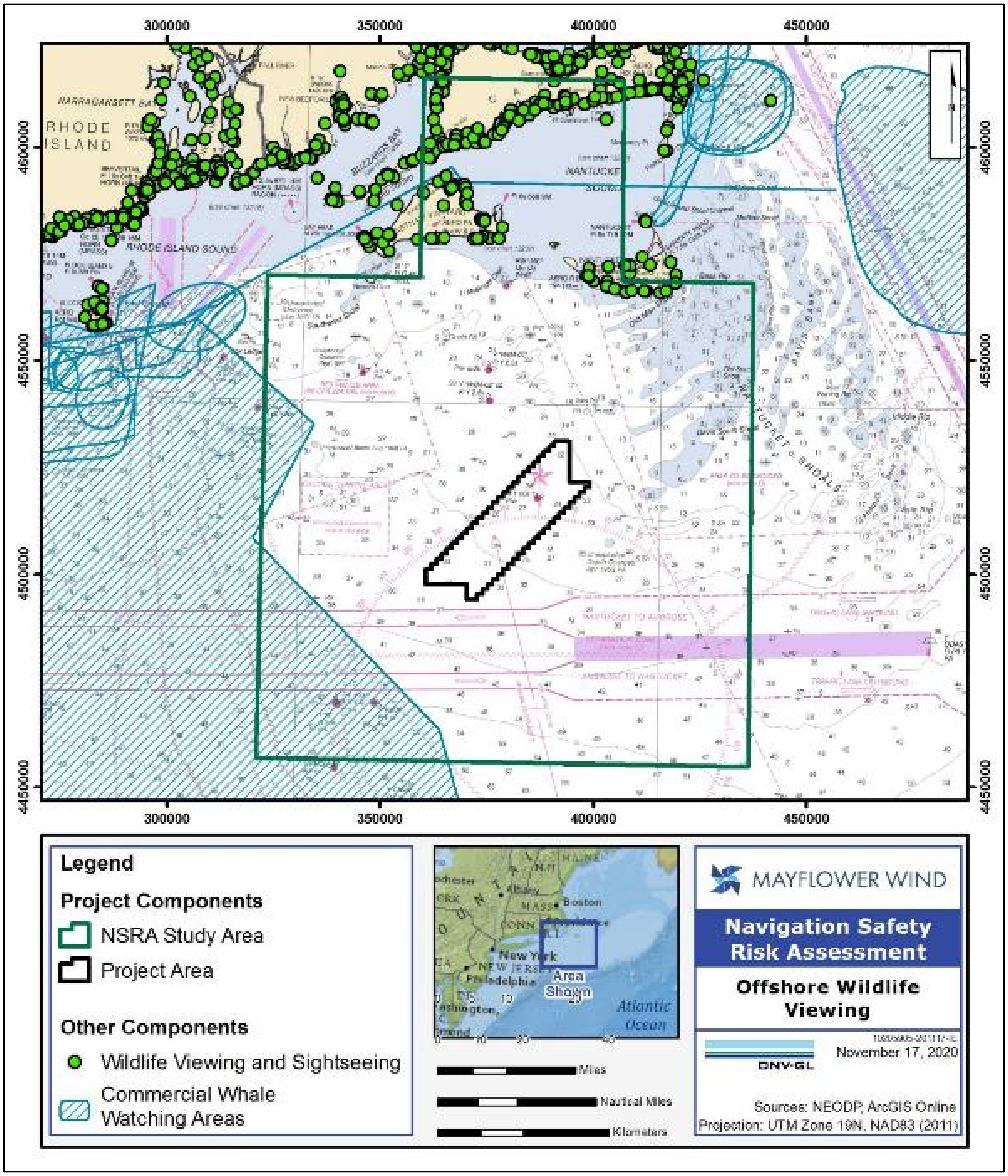
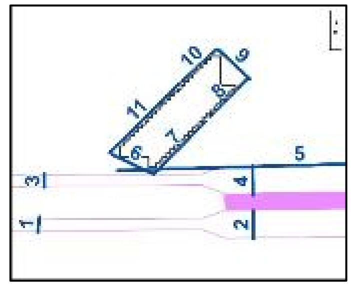


Figure 2-34 Offshore Wildlife Viewing Areas (NROC, 2015)

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 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, tanker, and passenger vessels), and ferries (passenger vessels) are described in Sections 2.1.1.5 (tugs), 2.1.1.1 (cargo/tanker vessels), and 2.1.1.3 (passenger vessels).

The influence of Project structures on these vessels is limited to those with tracks passing through or near (within 1 NM of) the Project Area. Forty-nine tracks of these vessel types passed through transects 10 or 11. Because of the traffic in the Nantucket Ambrose Fairway south of the Project, 1019 deep draft vessel tracks came within 4.3 NM (8 km) of the Project Area.

For risk modeling of the Future Case, after the Project is constructed, the tracks that came within 1 NM were re-assigned to a nearly parallel route located west of the Project.

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.

The major fishing traffic route transits from Gay Head, Martha's Vineyard along a northwest-southeast course to/from fishing areas southeast of the Project Area. Nantucket Shoals bounds the route on the east, although many tracks appear to cross the shoals. The closest shallows to the Project Area is Davis South Shoal, with a charted depth of 6.25 fathoms (11.4 m, 37.5 ft) about 5 NM (9.3 km) east of the Project.

It is possible that fishing vessels will not modify the overall direction of their route because of the Project structures.

Discussion on modeling fishing vessels in the vicinity of Nantucket Shoals

Because fishing vessels could transit through the Project Area, no modifications were made to the fishing vessel routes in the Future Case; namely, fishing vessel routes are unchanged and pass through the Project Area after the Project is constructed. If instead, they were routed around the Project, the risk of allision with Project structures would be significantly lower than indicated by the modeling, and the risk of collision elsewhere would be higher than indicated by the modeling.

Grounding risk at Nantucket Shoals is a significant consideration to mariners in the area; however, the Project Area is more than 5 NM (9.3 km) from the nearest shoal, and the traffic density in that area is the same in the modeled Base Case (as things are) and in the Future Case (after the Project is constructed). Because risk change is being estimated, an important consideration evaluated here is the extent to which the Project will increase grounding risk. The collision, allision, and grounding model did not account for the risk of grounding on the shoals.

The NSRA team evaluated the possibility of modeling the shoals as potential grounding locations. The model results would then account for all the tracks crossing the shoals as groundings in both the Base Case and

Future Case. The AIS data do not include underkeel clearance for each vessel and since this is an important variable for vessels transiting the shoals, substantial complexity would need to be added to the modeling effort in order to account for the shoals in a realistic way.

A general principle of risk modeling is that additional complexity should be added to a risk model only when it would provide additional insights that can be used to inform decision making. Several key factors influenced the decision to not account for Nantucket Shoals in the model:

- Vessel tracks crossing the shoals are evident in the AIS data (see Figure 2-3)
- No deep draft vessels transit the route near the shoals (see discussion in Section 2.1.1.1)
- Fishing vessels will likely choose to transit through the Project Area, despite increased allision risk, because taking an eastern route would increase transit time. Since there is more than 5 NM (9.3 km) between the Project Area and the nearest shoal, no significant increase in grounding risk is anticipated in the modeling if vessels were to take an eastern route; however, the modeling might show a small increase in collision risk along the route.
- No additional transits are added to this route in the Future Case compared to the Base Case.

In DNV GL's expert judgment, the most informative estimate of risk from the Project is to assume the same near-shoal route for all AIS tracks in the Base Case and the Future Case, without including grounding locations at the shoals. This approach underestimates both the Base Case grounding risk and the Future Case grounding risk by the same amount (because the number of vessel transits on this route and their distributions are the same for both cases). However, it provides a reasonable conservative representation of the allision and collision risk posed by the introduction of Project structures and a realistic representation of any additional grounding risk resulting from the Project.

2.2.2.3 Shipping routes

The Project Area does not lie in international or coastwise shipping routes; however, the inbound lane of the Nantucket Ambrose Fairway, which has an average between 10 and 20 deep draft transits per day, is located about 2.2 NM (4.1 km) to the south. Deep draft vessels in international trade use this and other routes in the Study Area, described in Section 2.1.1.1. Section 2.1.1.5 describes coastwise traffic in greater detail; however, coastwise traffic does not frequent the Project Area.

Project structures pose a potential hazard to vessels in shipping routes that intend to transit a safe route around the Project Area but depart the intended route because of human error or an onboard failure. This hazard is quantified in the risk modeling presented in Section 11.1 and Appendix E.

2.2.2.4 Routing measures, precautionary areas, separation zones, TSS

This section provides a review of safe 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 higher resolution analysis in an NSRA to support decision making.

A comparison of the recommended navigation safe distances for planning in the Marine Planning Guidelines and Project location are provided in Table 2-8.

Table 2-8 Marine Planning Guidelines

Marine Planning Guideline	Project characteristic
2 NM from the parallel outer or seaward boundary of a traffic lane.	2.2 NM (4.1 km) from the parallel outer or seaward boundary of the Nantucket Ambrose Fairway, which conforms to the guideline.
5 NM from the entry/exit (terminations) of a TSS.	More than 20 NM (37 km) from the entry of a TSS, which conforms to the guideline (all TSS entries are outside the NSRA Study Area).

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
- Currents
- Mixing of vessel types
- Complex vessel interactions
- Undersized routing measures

Large distances along a route is listed as a consideration in the NVIC. It was accounted for in the model generically as part of the underlying fault trees in the model. The underlying assumption is that the Study Area is adequately 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 between fatigue levels on the vessel types in the Study Area; however, taken on the whole, the risk controls and traffic in the Study Area are expected to be at least as good as other coastal waters around the globe in the view of DNV GL expert judgment.

NVIC 01-19 also provides a list of potential risk mitigation measures. These and the risk control measures listed in Section 11.3 are included here for potential consideration in the USCG's As Low As Reasonably Practicable (ALARP) review:

(a) "Mitigating factors include aids to navigation, pilotage, vessel traffic services, precautionary areas, areas to be avoided, anchorages, limited access areas, and other routing measures…. 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." The factors specified in NVIC 01-19 are discussed in relevant sections of this NSRA.

(b) “Low traffic density. Low traffic density will decrease vessel interactions and allow for more space for transiting vessels to maneuver.” The density of traffic is accounted for in the risk modeling described in Section 11 and Appendix E. Reduced traffic density in the Project Area is included in the model, specifically, deep draft and tug vessels are assumed to route around the Project Area. The counter-effect of increased traffic density in the new routes is also included in the model.

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

(d) “Distance from ports, shoals, and other obstructions. If there are large distances to other hazards vessels will be able to adjust their route to ensure safe transits.” Distances from traffic and other hazards is accounted for in the design of the risk model for this NSRA.

(e) “Aids to Navigation. Enhanced Aids to Navigation may assist vessels in more accurately determining their position as well as identifying potential hazards.” The potential benefit from any Project-specific Private Aids to Navigation (PATON) and coordinated numbering/marking of structures across contiguous lease areas is not accounted for in the risk modeling conducted for this NSRA. However, it is anticipated that the Project will request PATON permits from the USCG, and this NSRA will provide input to that review.

2.2.3 Transit-related safety measures

This section presents anchorages, safe havens, approaches, and pilot areas in the Marine Traffic Study Area.

2.2.3.1 Anchorages and safe havens

Figure 2-35 shows the designated anchorages in the area. The closest anchorage is Anchorage G, located 13 NM (24 km) from the Project Area; therefore, no measurable effects on navigation safety are anticipated related to anchorages. No significant anchorage activity is indicated by the AIS data in the vicinity of the Project Area.

Concerning the potential for emergency anchorage in an offshore wind farm, in an emergency situation, the captain of the vessel will identify the safest course of action available at the time. Based on conversations with members of the maritime industry, captains of vessels in international trade would choose another course of action rather than anchor between structures in an offshore wind farm.

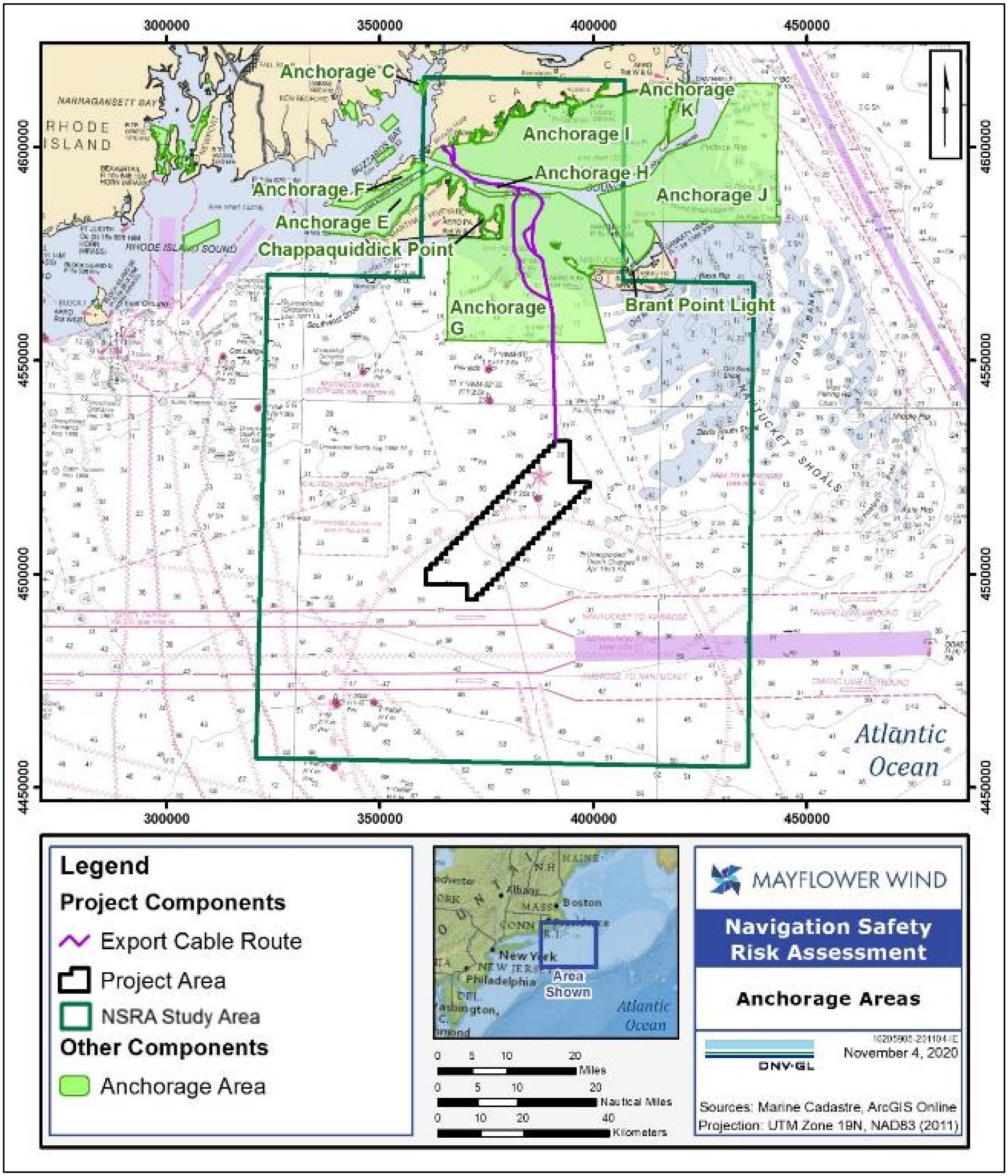


Figure 2-35 Anchorage Areas (NOAA, 2010a)

2.2.3.2 Port approaches

There are no deep draft ports in the southern portion of the Study Area, and no direct, long-term effects from the Project on port access are anticipated. All traffic in the southern portion of the Study Area was included in the risk model developed for this NSRA, and therefore the results account for traffic crossings and other route-related aspects associated with transit to and from ports.

The export cable will cross significant seasonal traffic in Nantucket Sound, including port approaches (Figure 2-36). During normal Project operation, no effects on marine traffic are anticipated from the presence of the export cables. During construction, the timing of cable lay will influence the level of effect on local port traffic. This is mentioned in Section 5.1 and discussed further in the COP Section 13.1.2.1.

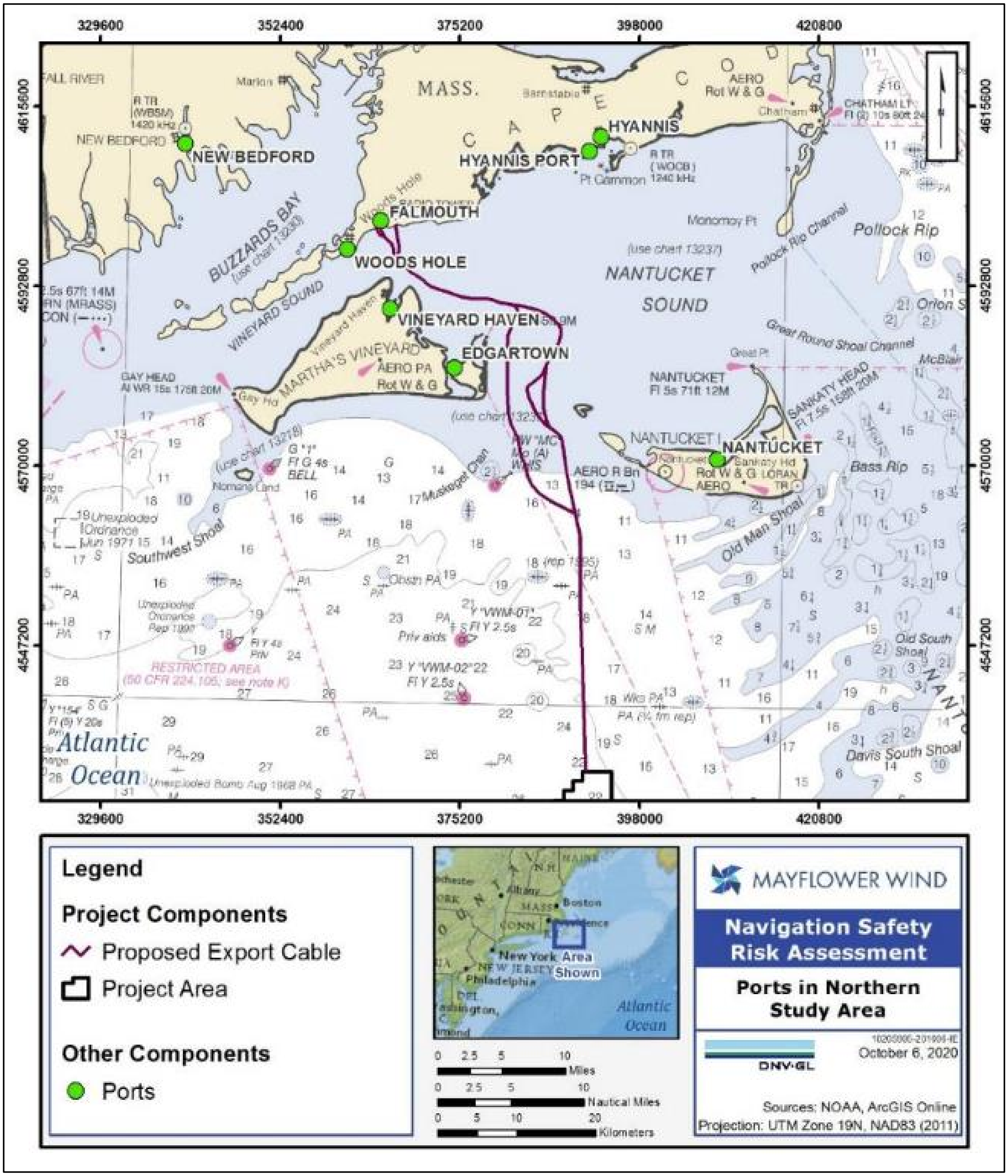


Figure 2-36 Ports in the North Study Area

2.2.3.3 Pilot boarding / landing areas

There are no pilot boarding or landing areas in the Study Area.

2.2.3.4 Anchoring in an offshore wind farm

Anchoring activity is not apparent in the vicinity of the Project based on a detailed review of the 2019 AIS data and NAIS vessel track densities.

Emergency anchorage that catches a cable in the Project Area has the potential to threaten the stability of a smaller vessel, endanger the crew, and damage the inter-array cable should an anchor penetrate the seabed to the cable burial depth and penetrate cable protection. Standard industry practice is that anchoring in an offshore wind farm is a potentially hazardous activity and should be undertaken only by Project-related vessels or in emergency situations. Cable risk is discussed in Section 4.

2.2.4 Other aspects

2.2.4.1 Within the jurisdiction of a port or navigation authority

The Study Area is within USCG Captain of the Port Zone: Southeastern New England. No part of the South Study Area is under the jurisdiction of a port authority. Smaller port/harbor authorities exist in Nantucket Sound in the northern portion of the Study Area. The export cable permitting process will involve authorities that are relevant to the specific final cable corridor.

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

The Project Area is within Warning Area 105 (W-105) in the Narragansett Military Operations Area (Figure 2-37). Area W-105 is a special-use airspace for exercises over portions of Narragansett Bay (NAFAC, 2016).

In addition, a Danger Zone (an area used for target practice, bombing, rocket firing, etc.) has been designated around Nomans Land in the northwestern portion of the Study Area. Between November 1 and April 30, no vessel is allowed enter or remain in the Danger Zone (33 CFR 334.80).

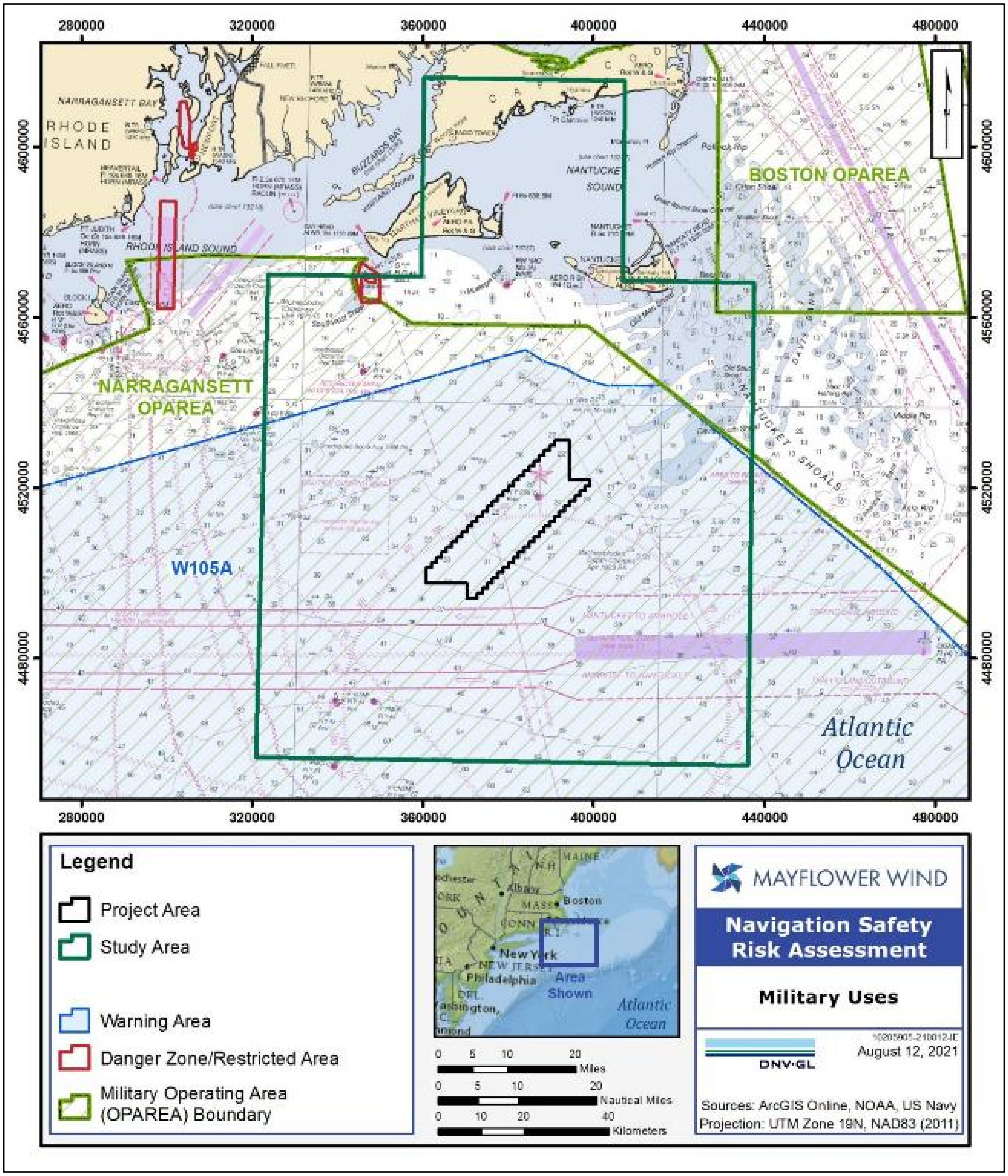


Figure 2-37 Military Uses in the Vicinity of the Project (NAFAC, 2016)

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 Study Area.

Proposed energy-related facilities in the Study Area are shown in Figure 2-38. The potential cumulative effects from the adjacent proposed offshore wind farms is discussed in Section 11.4.

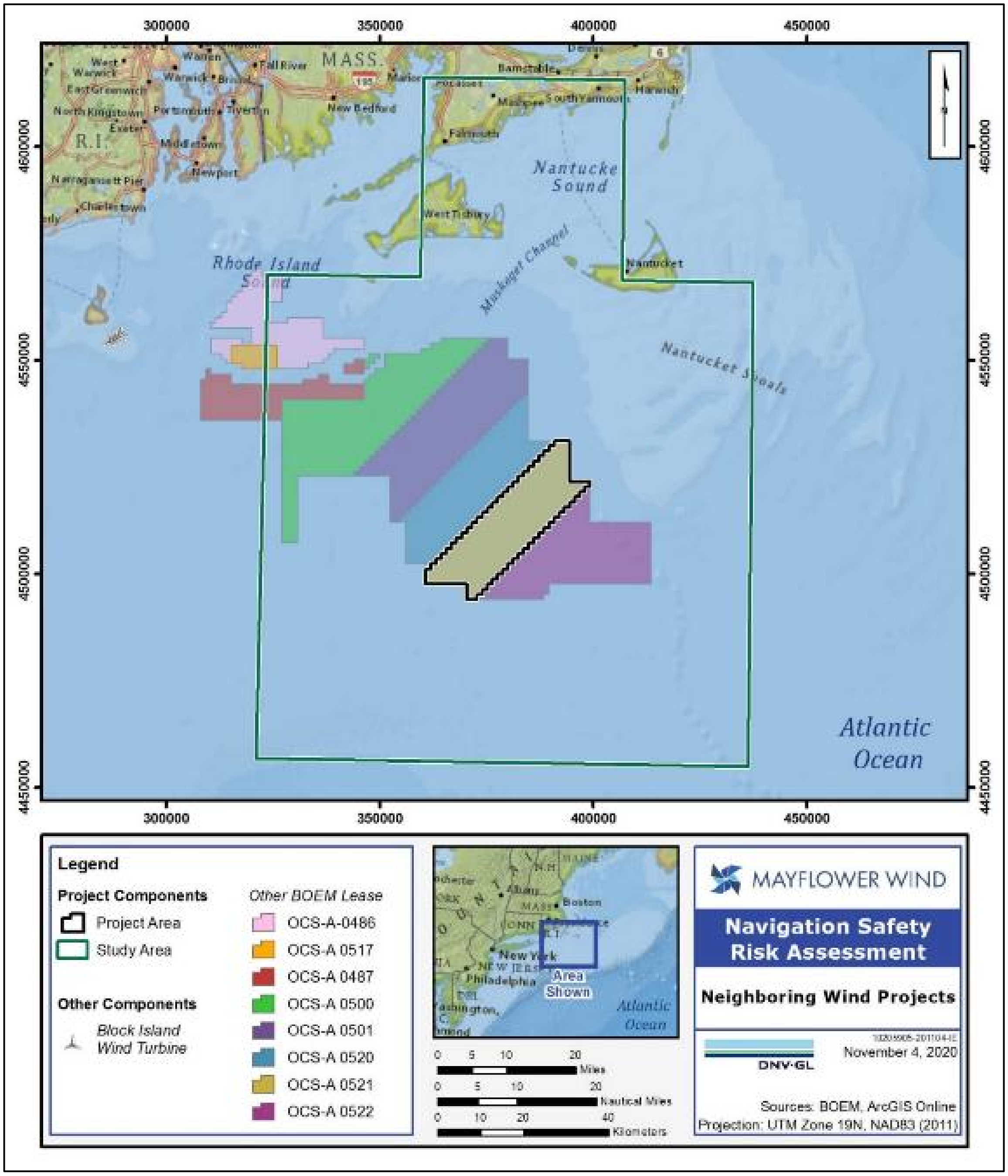


Figure 2-38 Proposed Neighboring Wind Energy Projects

2.2.4.4 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 Study Area.

Ocean disposal sites are shown in Figure 2-39 – there are a few in the North Study Area and none in the South Study Area. Vessel activity from Project construction and operation is not anticipated to affect these sites. Sites indicated as unknown have an unknown use status according to NOAA Office of Coastal Management (2010b).

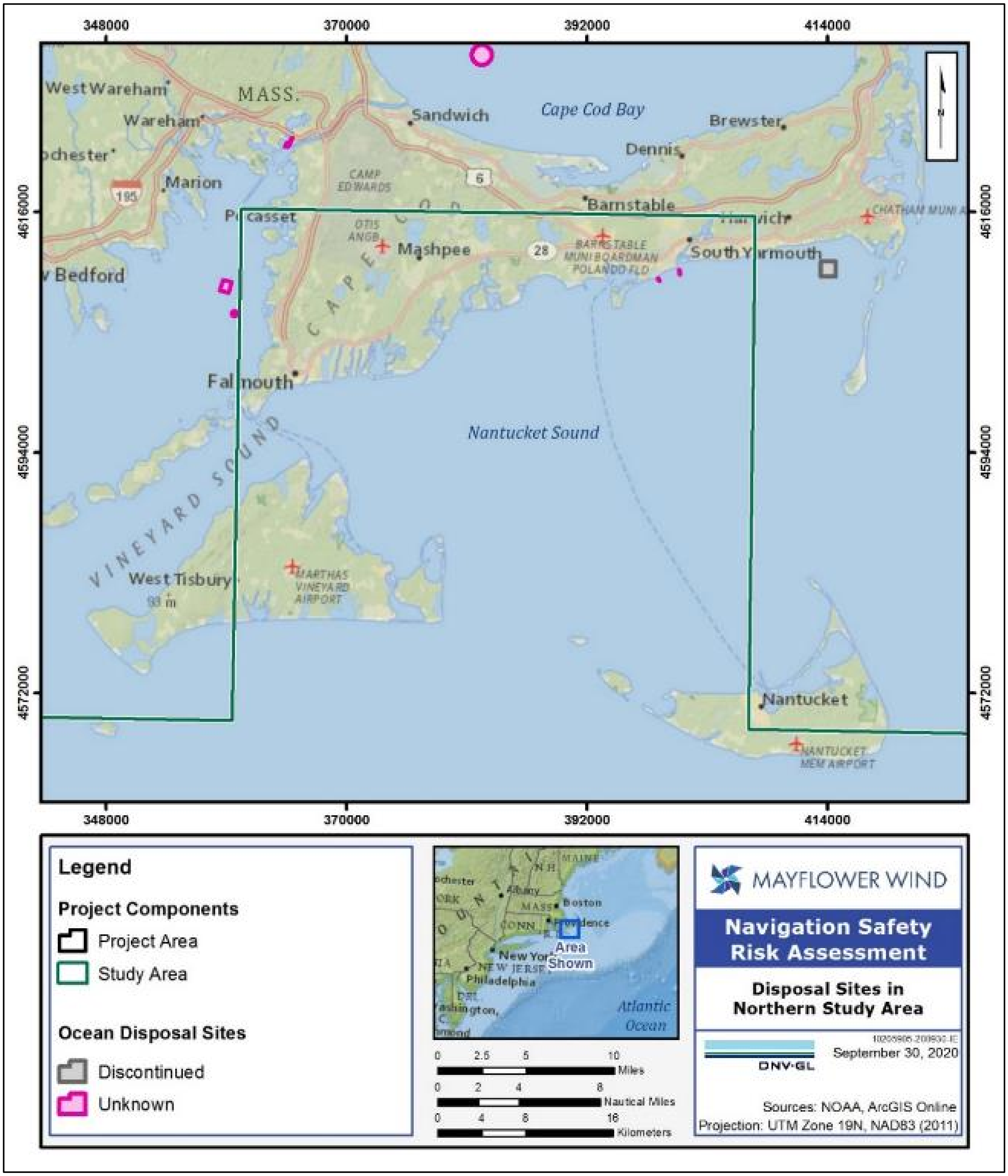


Figure 2-39 Disposal Sites (NOAA, 2010b)

2.2.4.5 Aids to navigation and/or Vessel Traffic Services

The closest federal ATON is approximately 21 NM (39 km) from the Project Area (NOAA, 2010c); the Muskeget Channel "MC" buoy marks the southern entrance to the channel. No negative effects from the Project are anticipated on existing ATON. Section 9 provides additional discussion about ATON.

The closest USCG operated Vessel Traffic Services is VTS New York. There is a Vessel Movement Reporting System (VMRS) Buzzards Bay, which also covers Cape Cod Canal. Both are outside the NSRA Study Area.

2.3 Anticipated changes in traffic from the Project

Compared to the traffic indicated in the 2019 AIS data, Project-related construction, operations and maintenance, and inspections traffic will increase the number of vessel transits to/from the Project Area and is anticipated to cause changes to current traffic patterns for some vessel types.

The risk model built for this assessment includes a representation of the South Study Area marine traffic in a Base Case, before the construction of the Project, and in a Future Case, after the Project is constructed.

The following reasonably foreseeable changes in marine traffic volume and routes are accounted for in the Future Case:

1. Additional non-Project traffic that might be generated by the presence of the offshore wind Project.
2. Alternative traffic routes anticipated to be used once the Project is constructed instead of the current (Base Case) routes. The following vessel types are anticipated to choose routes around the Project Area:
    - Cargo/carrier
    - Tanker including oil tanker
    - Passenger (primarily cruise ships as confirmed by the average passenger vessel LOA of 233 m (764 ft), shown in previous Figure 2-29
    - Tug

Each is described below.

<u>Traffic added to AIS tracks</u>

The adjustments to transits described in this section are implemented in the Future Case MARCS model, including Project structures.

It is anticipated that there could be public interest in the Project resulting in pleasure tours of the offshore wind Project and an increase of recreational traffic (likely recreational fishing). To incorporate the potential tours, excursions, and recreational (including recreational fishing) traffic surrounding the Project, a hypothetical estimate was made of the number of vessels per year that will be added to existing local traffic patterns: 100 trips per year. This is a conservative upper estimate for the first operational year of the Project. This additional traffic in the Future Case is included in the Pleasure vessel category and is allocated a new route from Narragansett Bay to the Project Area.

The MARIPARS report (2020a) reviewed the characteristics of potential future traffic not related to offshore wind development and concluded that the best available way to predict future vessel traffic and density was to review port development plans. The potential additional traffic identified in the MARIPARS report comprised:

- Six to eight new LPG tanker transits to and from Providence: this NSRA assumes that an additional 50 LPG vessels per year enter the Study Area from the Nantucket Ambrose Fairway, take the Narragansett TSS to the Port of Providence, and take a reverse route on departure from the port.
- An additional 50 cruise ship visits to Newport: some cruise ships in the AIS data enter the Study Area from both the southwest and the southeast and transit north toward the Narragansett TSS on approach to Newport. The additional 100 transits are assumed to be divided equally between the two approach routes. In addition, the southeastern route across the Project Area is modified to a more north-south direction in the Future Case, as deep draft vessels will modify their routes to navigate around the Project. A reverse route is assumed on departure from the port.
- New vessels and activity related to construction and maintenance of proposed offshore wind farms: the construction traffic will be relatively short-lived in terms of the risk being assessed in this study. The Project-related vessel traffic for maintenance and operations will have different characteristics than the other types of non-wind farm traffic and is not included in new Future Case baseline traffic being modeled in this assessment. The Project-related vessels will transit to take personnel to structures, have very few other vessel movements, and are likely to spend most of the time offshore adjacent to Project structures.

  During Project offshore construction activities, additional/re-routed marine traffic may cause increases in safety risk in/near ports, which could be partially or wholly offset by mitigation measures identified by maritime entities before and/or during construction (see discussion in Section 5.1).

  During Projection operation, less than 100 Project-related vessel trips per year are anticipated. A reduction in 2019 AIS traffic will occur from cessation of Project survey vessel transits, vessel type “Other,” discussed in Section 2.3.

Modification of traffic routes in the future case

The model built to assess collision, allision, and grounding risk after the Project is constructed contains routes that differ from the Base Case (current situation) model. According to the AIS data, some deep draft vessels traverse the area where the Project structures are to be constructed. Many deep draft vessels (cargo, tanker, tanker oil products, and cruise ships) as well as tug/service vessels are expected to choose not to navigate through the Project Area 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 the Project Area by 1 NM (1.9 km), (2) minimizing the additional distance transited, and (3) accounting for existing routing measures.

For the Future Case model, 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 Project Area in the Base Case. All remaining vessel types (fishing, other, and pleasure) were modeled as continuing to navigate through the Project Area in the Future Case.

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 ships in international trade. Such ships using fuel oil in an ECA must have a maximum of 0.50 percent (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 [EEZ]) is below a level that is reasonably quantifiable in this Project risk model.

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 2-40 shows the number of transits per month per vessel type in the Study Area.

The number of vessel tracks in the Study Area is highest in the summer with a peak in July of over 21,000 tracks. The low is in January with less than 3,500 tracks. In the year of data, summer increases were the greatest for pleasure, fishing, passenger, and other vessel types.

For purposes of comparison, Figure 2-41 shows the same presentation for the southern portion of the Study Area. Notably, the vast majority of the seasonal increase is from fishing vessels in the summer.

Non-fishing vessels show seasonal effects, albeit to a much lower extent:

- Summer is a peak for other, passenger, pleasure, and perhaps tug/service
- Fall is a peak for tankers with non-oil cargoes
- Spring and fall are peaks for cargo/carrier and tankers with oil cargoes

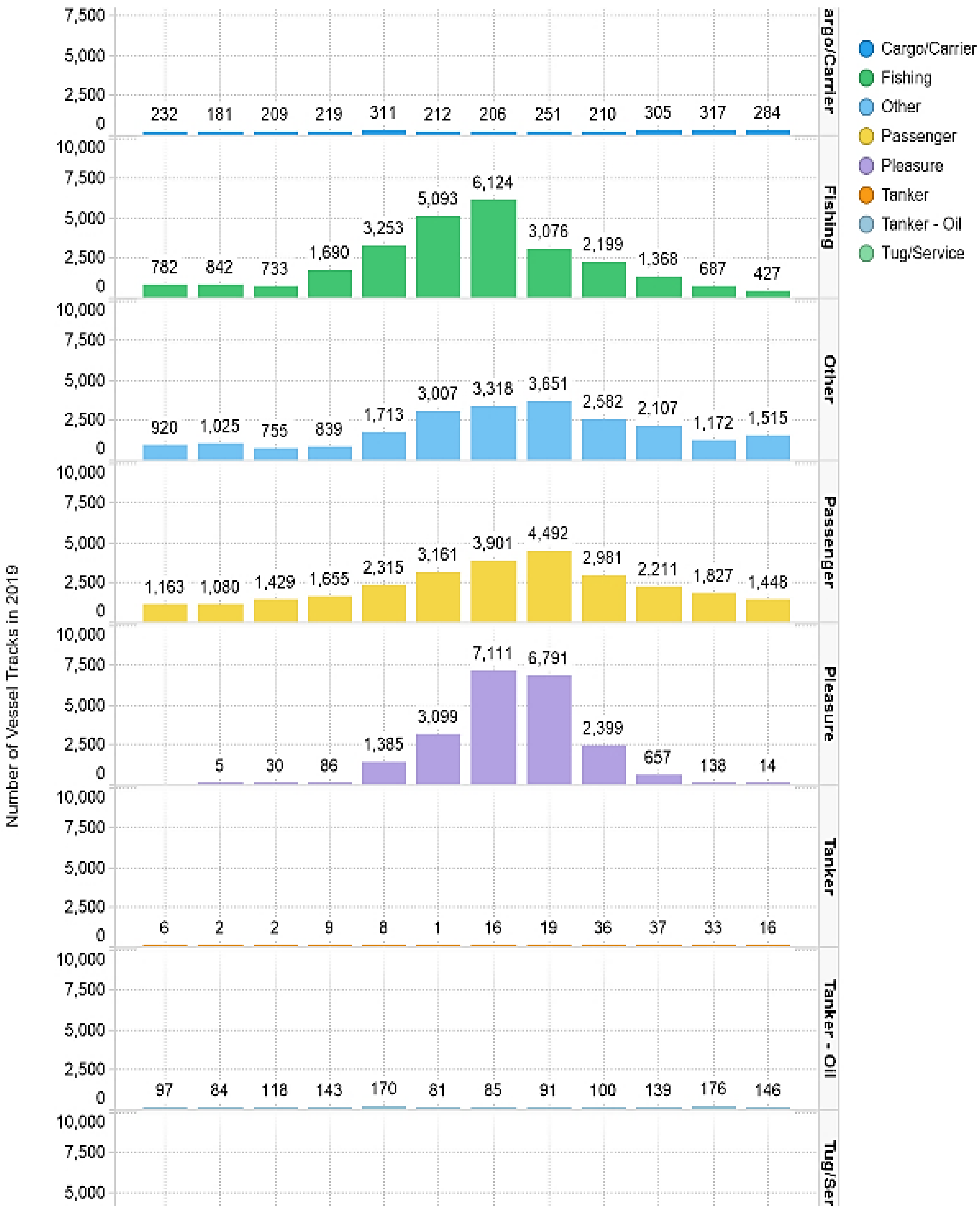


Figure 2-40 Seasonality of Vessel Transits in the NSRA Study Area (North and South)[4]

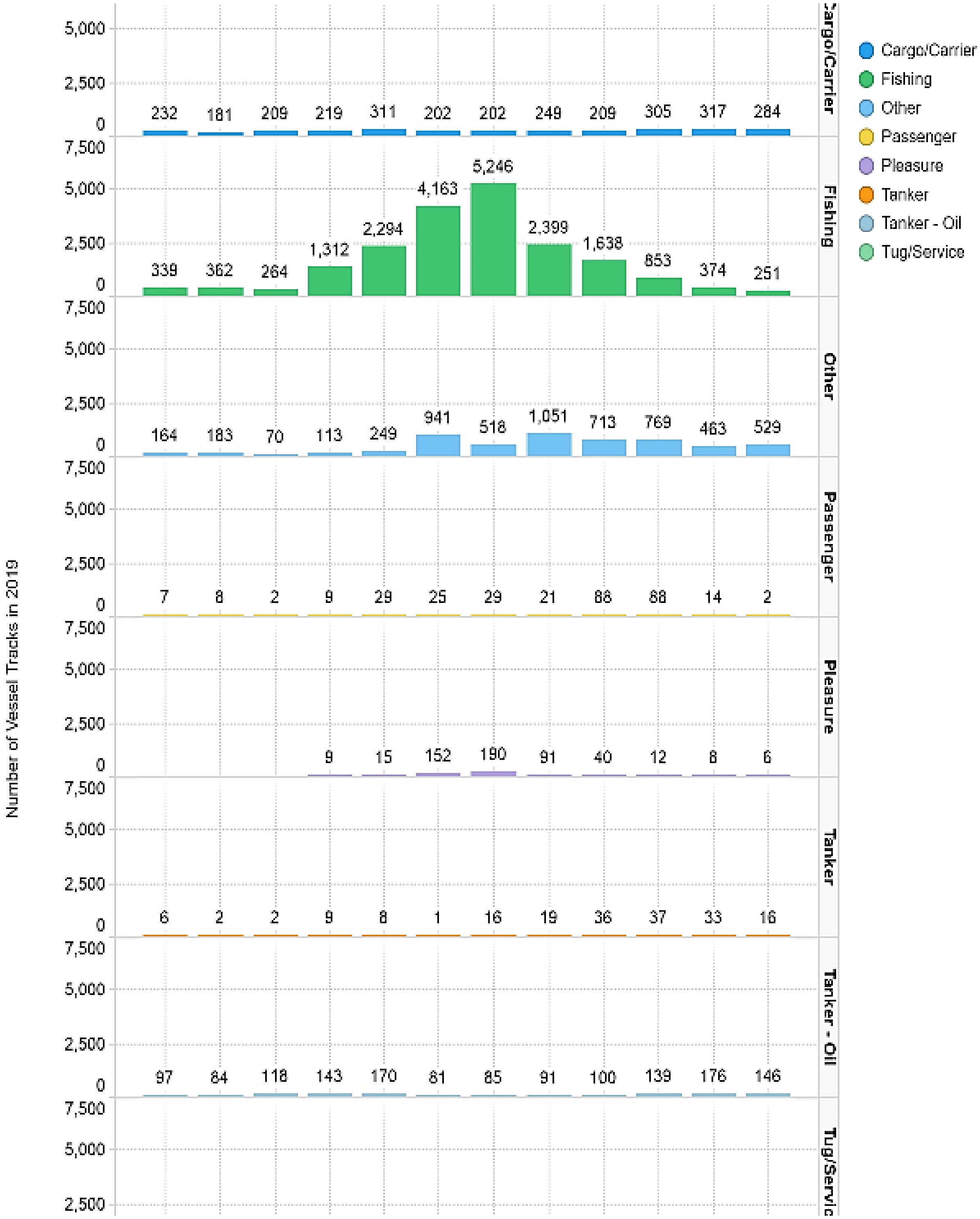


Figure 2-41 Seasonality of Vessel Transits in the MARCS Study Area (South Study Area) [4]

3 OFFSHORE ABOVE WATER STRUCTURES

Per NVIC 01-19, this section assesses potential interactions between vessels and above-water Project structures:

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

3.1 Hazards to vessels

A hazard identification exercise was completed to determine the primary hazards posed to vessels from the Project:

- **Stationary object at or near the waterline** – A Project structure with associated platform and/or external equipment could pose a hazard to: (1) a vessel on course with the foundation or (2) a vessel adrift and being pushed (primarily by the wind) toward the foundation. This risk is analyzed in Section 11.0. Section 11.1 discusses the consequences of an allision with a Project structure and Section 11.1.1 presents an estimate of the frequency of an allision with a Project structure.
- **Mobile gear fishing techniques and subsea cables** – Mobile fishing techniques are employed in the Project Area. A hazard of potential contact between mobile fishing gear and Project cables exists because the gear penetrates the seabed and could contact cables that are no longer buried as deep or cables that are no longer covered as intended. In addition, a high intensity hydraulic clam dredge could contact export cables buried at depths of 1 to 2 m (Tetra Tech, 2020). This risk is analyzed in a separate preliminary cable burial risk assessment (Tetra Tech, 2020) and is also discussed in Section 4.1.
- **Mobile and fixed gear fishing techniques and Project structures** –Fishing gear in the Project Area could snag on a foundation or ancillary components on the outside of a foundation such as J-tubes. This assessment has not been able to identify any documented occurrences of gear snags that have caused a vessel to lose stability, but the possibility cannot be ruled out.
- **Air draft (air gap)** – Project structures could pose a hazard to a vessel with a mast or other structural component taller than 16.75 m (54.95 ft) above MHHW. This is the smallest air gap of any Project structure. Risks related to the air gap of Project structures are analyzed in Section 3.2.
- **Keel clearance (water depth)** – The water depths south, west, and immediately north of the Project Area are more than sufficient for the vessels that transit these areas (see Section 6.3). In contrast, shoaling hazards are significant in the eastern part of the Study Area. The traffic pattern in the AIS data reveals deep draft vessels and tugs avoid shoaling areas (see Section 2.1.1). Anticipated changes in traffic from the Project are discussed in Section 2.3. For the purposes of risk modeling, deep draft and tug vessel types that transited the Project Area in the AIS data were assumed to transit around the Project Area in the Future Case. They were re-assigned to routes west of the Project. These new routes were rationally aligned with their original routes. The risk to

fishing vessels in the route along the shoals is not reasonably quantifiable because of the changing nature of the shoals and the number of AIS points (and therefore tracks) that transit the shoals in the AIS data.

The quantified risk from the Project assumed that all fishing vessels continue their current routes, and if so aligned, transit through the Project. If instead, some or all of these vessels chose to transit to the east of the Project, there would be a corresponding increase in vessel density, particularly in the narrowest part of the route, 5 NM (9.3 km) between the Project Area and the shoals. Section 12 presents SAR events, which give a general indication of the level of hazard. Four SAR events occurred east of the Project Area over a period of 14 years, representing about 3 percent of the events with high data quality in the MARIPARS study area (USCG, 2020a).

- **Keel clearance (subsurface structural components)** – It is plausible that a vessel adrift upwind of a Project structure or on course with a Project structure might strike a jacket leg below the water surface. Based on DNV GL expert judgment and individual conversations with mariners, vessels passing at a safe distance (determined by a mariner based on ordinary practices and good seamanship) from a structure will be well away from the jacket legs.
- **Radar clutter** – WTGs and the movement of turbine blades can potentially interfere with communication signals from radio and radar transmitters by either blocking or reflecting the signals (DOE, 2013). These effects are summarized in Section 10 of this NSRA and Section 14 of the COP, and analyzed in Appendix Y4 of the COP, Radar Line of Sight Study.
- **Noise** – Noise from Project operations could add to background noise levels at close proximity to Project structures. Pile driving, likely to be used during construction, would pose the most significant noise level of any Project-related activity. It is anticipated that the USCG will implement a safety zone around construction-related vessels and activities (see Section 5.1 for more detail about safety zones). Noise levels outside the safety zone are not expected to have negative effects on navigation safety or USCG missions.

  During operations, no negative effects from wind turbine noise on USCG missions or navigation safety are expected from the Project. Additional information on operational noise is provided in COP Section 9.1.3.1.

3.2 Vessel clearances from project components

Project WTGs will have a minimum air gap of 16.75 m (54.95 ft) (Figure 3-1). For Project OSP, the minimum air gap is 20 m (66 ft). The largest possible hazard area from an OSP would result from the combination of a 10 m (33 ft) diameter monopile foundation and the largest OSP topsides being considered, 100 m x 70 m (328 ft x 230 ft).

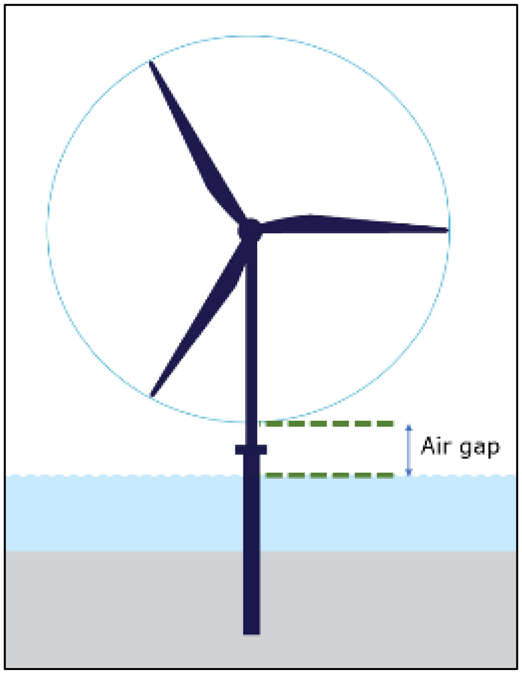


Figure 3-1 Illustration of WTG Air Gap

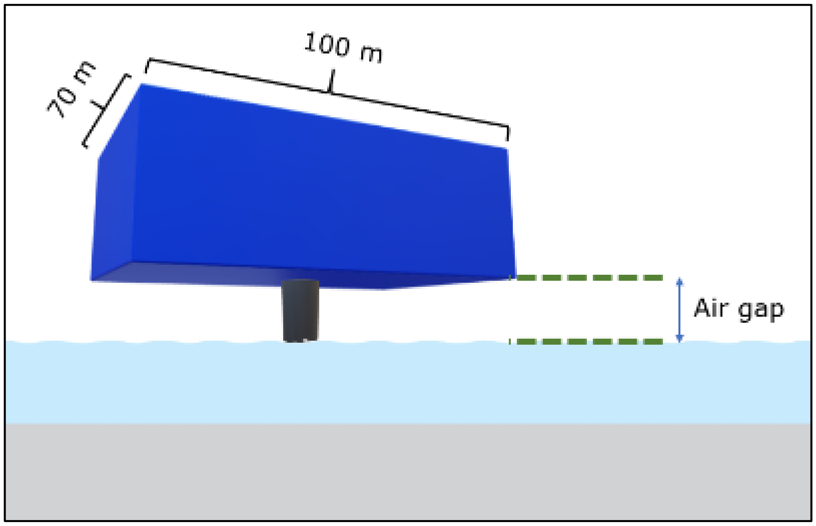
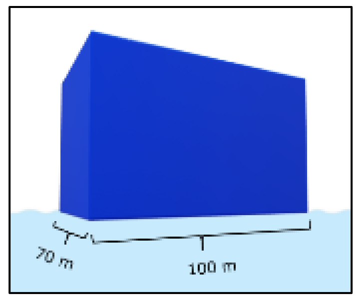


Figure 3-2 Illustration of OSP Air Gap

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.

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

- Larger pleasure vessels, including sail boats with masts taller than the air clearance of the Project structures. In 2019, there were 30 tracks made by 24 sailing vessels that transited the Project Area based on AIS data (MarineTraffic, 2020). Without available particulars, it is assumed that all of these vessels could have a mast taller than 16.8 m (55 ft).
- Larger fishing vessels. According to a study of traffic at the New Bedford-Fairhaven Bridge (MassDOT, 2015), average fishing vessel heights range from 12 to 18 m (40 to 60 ft). Fishing vessels larger than the average fishing vessel passing the bridge could exceed the air clearance of the Project structures.
- Cargo/carrier and tanker vessels and passenger vessels (cruise ships); however, these vessels are not expected to transit through the offshore wind farm, in line with safe practices (IMO, 1972).



The modeling conducted to estimate collision, allision, and grounding risk accounted for the air hazard from OSP topsides by assigning the topsides' dimensions to the structure foundations, essentially accounting for the OSP as a rectangular prism rising from the sea bottom.

3.3 Emergency rescue activities and project components

The USCG is the U.S. maritime SAR coordinator. Emergency response assets (vessels, aircraft) from federal, state, local, commercial, and private sources could be utilized should an emergency arise in the vicinity of the Project.

The hazards identified for vessels underway in Section 3.1 apply to SAR vessels. The primary hazards to aircraft are the offshore structures themselves and blade movement.

The MARIPARS (USCG, 2020) examined potential navigation safety and SAR issues associated with anticipated offshore wind farm development off New England. The study concluded that a wind turbine array "developed along a standard and uniform grid pattern with at least three lines of orientation and standard spacing," like the Project, would "maintain the USCG's ability to conduct SAR operations."

Table 3-1 lists key rotor tip specifications.

Table 3-1 WTG Rotor Tip Hazard Envelope (Mayflower Wind, 2020)

Blade tip height	WTG extreme value
Maximum upper blade tip height (MSL)	325 m (1,066 ft)
Minimum lower tip height (MHHW)	16.75 m (54.95 ft)
Maximum hub height (MHHW)	184 m (605 ft)
Maximum rotor diameter	280 m (919 ft)

A potential concern to SAR air response is blade movement during a mission. To mitigate this hazard in an emergency, the control center will lock the rotation and yaw of turbine blades in rotation and feather the blades.

In 2005, the UK Maritime & Coastguard Agency (MCA) conducted helicopter trials at the UK North Hoyle Wind Farm (UK MCA, 2005), which had 5 MW WTGs (smaller than the Project) and more closely spaced than the Project. The UK MCA found 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 meters 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:

- 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 Project structure impact analysis

This section describes the potential damage to a WTG from a marine accident and provides a sense of whether or not WTGs may present a hazard to navigation if struck. There are several standard methods to assess ship-jacket collisions. A similar approach could be used for monopiles. Such analyses require detailed design as inputs, which are not available for a project in the early permitting stage of development, like the Project. The assessment in this section attempts to frame the likely consequences from an impact from the general designs being considered by the Project.

During construction and maintenance activities, the primary risk is a Project vessel striking a structure while transiting through the Project Area. Construction vessels are anticipated to be transiting at low speeds through the construction zone and are unlikely to cause significant damage in the event of an allision but could cause harm to personnel on board.

Below is a discussion of the effect on Project structures from powered and drift allision scenarios after construction of the Project.

3.4.1 Powered allision

The consequences evaluated below are for a scenario in which a WTG is struck by a vessel transiting at cruising speed. This is a conservative scenario and provides a high-end estimate of the potential damage.

The level of damage is directly related to impact energy transmitted by the ship to the structure, which is dependent on the weight and speed of the vessel and the design of the structure. The effect on the offshore structure is highly dependent on its inherent design strength. The discussion below relates to generic designs.

Monopile

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 of this size hit a monopile foundation, the study identified three main factors that influence the location and extent of the damage to the foundation:

- Impact energy
- Height of the vessel - vessels with a lower profile are expected to result in less damage to a monopile
- Location of the impact (Moulas et al., 2017)

As a result, it is very unlikely that smaller vessels with lower DWT and speed (e.g., commercial fishing vessels actively 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 speeds and DWT, and therefore higher impact energies, the monopile foundation is likely to deform nearer to the seabed, which could lead to potential structural instability, depending on the stiffness of the soil.

Jacket

Should a vessel strike a jacket foundation, the main factors affecting the resulting damage include the vessel speed and where the strike is on a leg or brace. However, for a 4,000-ton vessel traveling at about

7.8 kt, the forces generated could be sufficient to result in multiple failures of joints and/or rupture of elements of a jacket foundation. This is equivalent to 32 megajoules (MJ).

Given the range of vessel sizes (Table 3-2) and speeds (Table 3-3) in the South Study Area based on supplemented, unadjusted AIS data[4], a range of impact energies was estimated for each vessel type (Table 3-4).

Table 3-2 Vessel Sizes in South Study Area[4]

Vessel type	DWT (metric tons)		
	Low	Average	High
Cargo/Carrier	31,260	62,520	155,000
Fishing	250	500	500
Other/Undefined	756	1,512	14,620
Passenger	3,671	7,341	19,189
Pleasure	61	121	1,500
Tanker	23,171	46,341	159,152
Tanker-Oil	28,263	56,526	158,933
Tug/Service	333	666	2,000

The low DWT in Table 3-2 is 50 percent of the average DWT in the AIS data. The high DWT is the maximum in the data set, except for fishing, which is based on large assigned values. The speeds in Table 3-3 are based on the time between points in the AIS data set for the South Study Area[4]. The low and high speeds in this table were generated using similar distributions as are used in the MARCS model: high speed is calculated as 120 percent of the representative speed based on AIS data. The low speed is 50 percent of the representative speed.

Table 3-3 Assumed Vessel Speed When Allision Occurs

Vessel type	Low speed (kt)	Representative speed[4] (kt)	High speed (kt)
Cargo/Carrier	6.9	13.7	16.4
Fishing	2.4	4.7	5.6
Other/Undefined	2.1	4.1	4.9
Passenger	7.5	15.0	18.0
Pleasure	5.2	10.4	12.5
Tanker	5.9	11.8	14.2
Tanker - Oil	5.9	11.7	14.0
Tug/Service	2.5	4.9	5.9

A rough estimate of kinetic energy (in joules) is obtained using the following formula, using inputs of DWT (in kilograms) and speed (in meters per second [m/s]):

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

Table 3-4 gives the resulting range of kinetic energies. Table cells filled with yellow indicate energies above 32 MJ, which could cause severe damage to a jacket foundation.

Table 3-4 Ranges of Kinetic Energy Per Ship Type

Vessel Type	Impact energy (MJ)		
	Low	Average	High
Cargo/Carrier	194	1,553	5,543
Tanker-Oil	128	1,024	4,146
Tanker	107	854	4,223
Passenger	27	219	823
Other/Undefined	0.4	3	47
Tug/Service	0.3	2.1	9
Pleasure	0.2	1.7	30.9
Fishing	0.2	1.5	2

The estimated energies are considered extreme bounds because:

1. The kinetic energy is assumed to be received by the WTG/structure. However, the energy received by the structure will be less than the kinetic energy, as some of the energy will be dispersed during the collision (e.g., vessel hull plastic deformation, vessel movement or rotation).
2. The estimated minimum and maximum speeds are probably much higher than the reality. In case of a near-collision situation, the crew will do everything they can to avoid the collision, and if it is not avoidable, at least decrease vessel speed.

Due to the range of sizes and speeds of vessels in this study, it can be concluded that small passenger, tug, service, fishing, and pleasure vessels are much less likely to cause extensive damage to a foundation because of their low tonnage. Deep draft vessels such as tankers, carriers, and cruise ships can cause significant damage to a monopile or jacket, even at lower speeds.

The highest postulated consequences would be from allision by a deep draft vessel. An impact by a large vessel at average cruising speed is expected to cause severe damage, potentially failure of the structure.

The risk modeling conducted for this assessment anticipates that tankers or any deep draft or large vessel types will intentionally avoid the Project Area. Based on the MARCS model results summarized in Section 11, the annual frequency of a powered allision with a Project structure involving a deep draft vessel is 0.003 per year; a 1 in 376 years event.

3.4.2 Drift allision

Drift allisions are typically lower consequence than powered allisions. The allision location on the ship could be anywhere along the ship's length, but the most significant energy transfer would occur at contact near the center of mass. If the allision location is off-center, some of the energy will not go toward deformation of the vessel or Project structure, but instead will rotate the vessel around the foundation. Significant vessel damage may occur in scenarios where a vessel's hull scrapes along a structure. The sea state and wind will have substantial influence on the level of damage to the structure and the vessel from a drift allision.

Based on the MARCS model results summarized in Section 11, the annual frequency of a drift allision involving a cargo/carrier, tanker or passenger vessel is 0.019 per year; a 1 in 52 years event.

4 OFFSHORE UNDERWATER STRUCTURES

During operations, the Project will not include devices that are not visible above the water, that is, all components in the water column will be visible above sea level. However, Project cables will be buried below the seabed or otherwise covered, and can pose a hazard to anchoring and to fishing with bottom gear; conversely, anchoring and fishing with bottom gear can pose hazards to Project cables.

4.1 Outside the Project Area

The greatest risk of contact with an export cable is posed by anchoring and fishing with bottom trawl and dredge gear. To understand the risks associated with these hazards, a preliminary cable burial risk assessment has been completed for the Project by Tetra Tech, Inc. (2020).

Emergency anchoring of large vessels is a risk along high-traffic areas of the routes, which are primarily in Nantucket Sound. Among large vessels in the sound, ferries transit the most often, followed by cruise ships and mega-yachts (Tetra Tech, 2020).

The risk assessment's primary recommendation related to export cable hazards and anchoring was:

- A burial depth of 1.5 m to 2 m (4.9 ft to 6.6 ft) should provide adequate protection given that ferry captains should be aware of the cable locations included on nautical charts.

Risks from cable becoming exposed after burial were also evaluated in the preliminary cable burial risk assessment. The study recommended leveraging additional information from the geophysical survey and scour study, when available, to identify areas requiring additional burial of 0.5 m to 2 m (1.6 ft to 6.6 ft) where seabed mobility occurs.

Figure 4-1 shows the AIS locations of vessels transiting less than 0.5 kt, which might have dropped anchors in the North Study Area in 2019. The majority of the points are close to shore rather than the center of the sound.

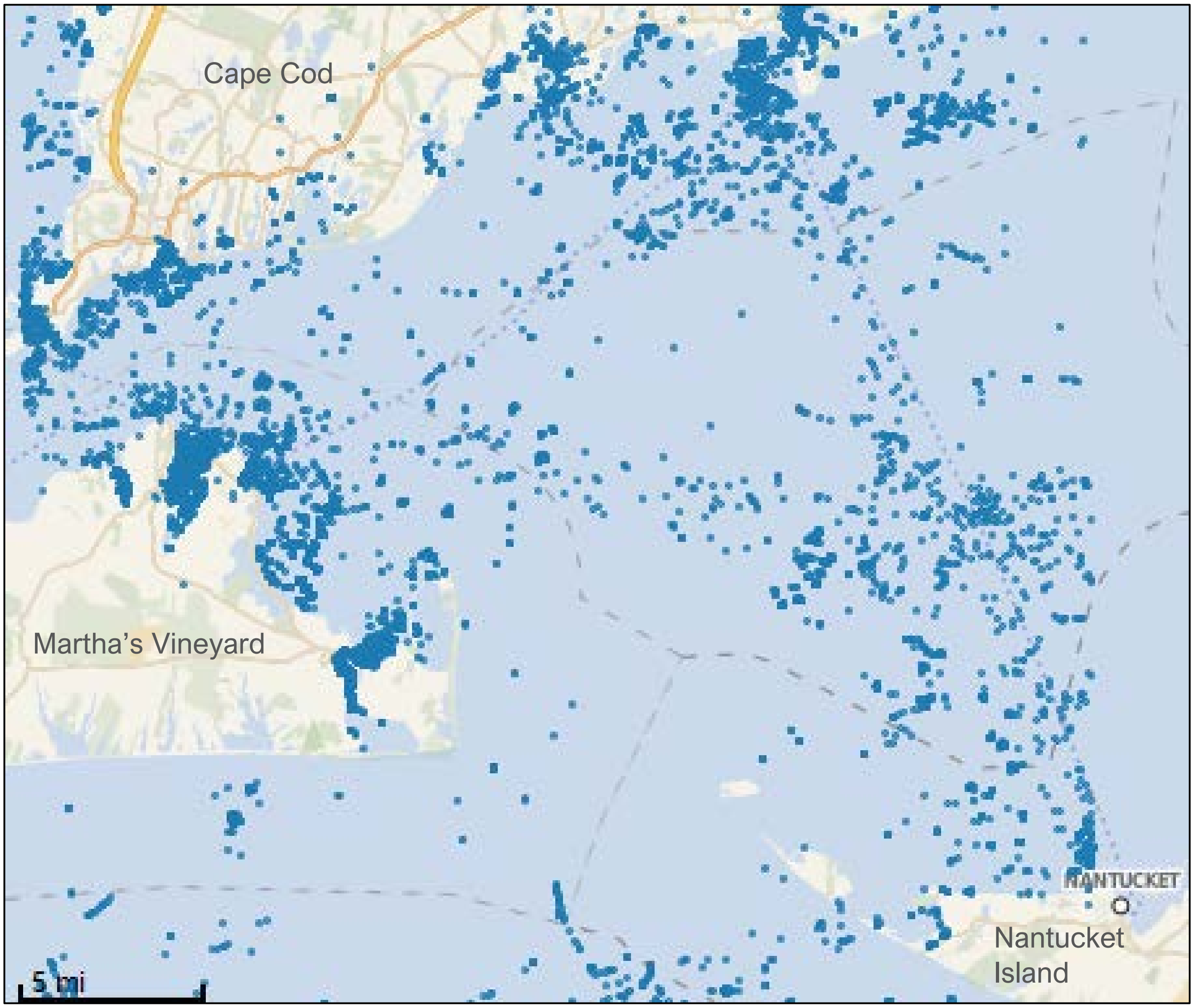


Figure 4-1 AIS Points of Vessels Transiting Less Than 0.5 kt [4]

4.2 In the Project Area

Risks to vessels from Project cables in the Project Area could occur from anchoring or from fishing activities.

4.2.1 Hazards related to anchoring

During construction, construction vessels could inadvertently damage a cable during anchoring or jacking up (BOEM, 2011). The risks can be mitigated through clear communication and awareness of the locations of cables. The Project will develop a seabed management plan for all installation and construction operations in the area.

Concerning anchoring in the Project Area during Project operation, a review of the 2019 AIS data (MarineTraffic, 2019) gives no indication that planned anchoring occurs in or near the Project Area. As a result, once constructed, the Project structures and inter-array cables are not anticipated to affect planned cargo/carrier, tanker, or cruise ship anchorage operations.

Emergency anchorage of these large vessels could pose a hazard, more to the inter-array cables than to the vessels. Large ships rarely drop anchors outside of normal operations, but cable snagging could occur if an anchor is dropped directly on top of a cable or dragged across a cable line. Credible causal events include human or mechanical failures leading to emergency anchoring of a deep draft vessel, human error in checking a current chart for subsea cables.

Based on the AIS data set, Table 4-1 lists the number of AIS vessel tracks within 5 statute miles (mi) (4.34 NM, 8 km) of the Project Area by vessels larger than 50,000 DWT.

Table 4-1 Vessels Greater Than 50k DWT Within 5 Statute Miles (4.34 NM, 8 km) of the Project Area[4]

AIS ship type	Maximum DWT	Number of AIS tracks with >50k DWT
Crude Oil Tanker	158,933	65
Container Ship	155,000	498
Tanker	113,850	24
Oil Products Tanker	75,013	47
Oil/Chemical Tanker	74,127	265
Bulk Carrier	72,105	60
Self-Discharging Bulk Carrier	69,304	8
Ro-Ro/Container Carrier	55,828	11
Vehicles Carrier	55,828	158
Cargo/Containership	50,792	3

All other vessels in the AIS data set in the South Study Area are smaller and unlikely to contact cables even in an emergency anchoring situation. It is anticipated that deep draft vessels will avoid the Project Area; however, smaller vessels, such as pleasure and commercial fishing vessels, may transit through the Project Area.

4.2.2 Hazards related to fishing

Fishing activities in the Study Area are discussed in Section 2.2.1.1. Pleasure and commercial fishing vessels may continue to fish in the Project Area and some may transit through the Project Area to fishing grounds further offshore.

Dredge and bottom trawl gear comprise the majority of landings revenue from fishing in the Massachusetts Wind Energy Area (WEA) in which the Project Area is included (Kirkpatrick et al., 2017). Data specific to the Project Area through the year 2018 (NOAA/NMFS/GARFO, 2020) shows that trawling, potting for lobster, and gillnets represented more than 95 percent of the total VTR landings by weight in the Project Area during an 11-year period.

In the 2019 AIS data, no fishing vessels longer than 32 m (105 ft) were transiting at 5 kt or less in the Project Area. Based on the limited evidence for the current use of large dredges in the Project Area, information on the sizes of fishing vessels, and information about the types of gear, an inter-array cable burial depth of about 1 m (3 ft) should be sufficient to manage this risk, supported by conclusions drawn in the preliminary cable burial risk assessment north of the Project Area (Tetra Tech, 2020).

5 NAVIGATION WITHIN OR CLOSE TO A STRUCTURE

This section assesses:

- The safety of navigation during construction
- The safety of navigation in the Project Area during operation
- The safety of navigation during decommissioning
- 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 phase navigation risks

Construction activities are envisaged to occur over a period of up to 3 years, with approximately 2,200 round trip vessel transits from several ports (see Section 1.1). An installation strategy will be developed and finalized based on the selected turbine design and vessels selected to conduct installation activities. There are multiple installation strategies available for the WTG installation; the final installation strategy will be identified based on the turbine selected, along with the vessel spread used to execute the works. Potential installation strategies include:

- A multi-lift strategy, where individual components or pre-assembled sections of the WTG are installed resulting in multiple offshore lifts. This would typically see tower section(s) lifted, followed by the nacelle and hub and finally the blades; however, the rotor-nacelle assembly may be a single lift.
- A single-lift strategy, where the complete turbine is assembled either onshore or on the deck of the installation vessel. It would then be lifted onto the substructure interface.

Transportation vessels for WTG installation may include heavy lift vessels, feeder vessels, and Ro-Ro (roll-on roll-off) vessels. A jack-up vessel will install the WTGs. Each turbine installation is expected to require one jack up and one jack down. After WTG installation, the WTGs will be commissioned and connected to the OSP(s) via inter-array cables.

A portion of the construction-related port transits are likely to occur in one or more major ports in the region, potentially including the Port of New York and New Jersey. Port maritime safety is evaluated on a periodic basis by several entities, which vary depending on port size, traffic volume, and the presence of hazards. Typical entities that review safety practices include port authorities, the USCG, and harbor safety committees. When changes to port traffic are anticipated, the potential effects are evaluated, and as required, operational changes are implemented to mitigate the potential increase in maritime safety risk. In addition, movements of large components typically trigger a marine warranty review to evaluate the risk during each transit and identify appropriate risk mitigation measures.

Because the Project is currently in the planning stage, logistical details and mitigations will be finalized at a later date. As logistics plans mature, the Project will coordinate with appropriate entities to identify risks/mitigation (Mayflower, 2021). As is routine practice, the agreed mitigations will be communicated with the maritime community via established channels such as published and/or broadcasted notices to mariners from the Project, USCG updates to Local Notices to Mariners, and/or updates to port safety and navigation guidelines.

Offshore construction activities within the Project Area could be a hazard to vessels in the immediate vicinity, primarily (see previous Figure 2-24 transects 8 through 11):

- Fishing vessels that are fishing. This activity occurs at comparatively low levels throughout the Project Area compared to regional activity, based on AIS, regional VMS, and regional VTR data discussed in Section 2.1.1.2. Hazards related to fishing are presented in Section 4.2.2. Additional detailed information on commercial fishing activity and typical gear types is in COP Section 11.1.
- Fishing vessels that are transiting to other fishing grounds. Fishing vessel transits occur in relatively higher numbers in the northeastern portion of the Project Area based on AIS supported by VMS summary data. Additional detail is presented in Section 2.1.1.2. Hazards related to transiting are presented in Section 3.1.
- Other vessels, whose activities are challenging to identify specifically based on the obtained AIS data.

Proximate vessels could experience collision risk from Project construction vessels and vice-versa. Three primary means of reducing this risk are safety zones around construction activity, updates to mariners, and Project safety vessel(s) and/or personnel on scene, as necessary.

Safety zones are an important tool to protect mariners from potential hazards during construction activities. It is anticipated that the USCG will implement safety zones during construction of the Project, based on precedent set by the Block Island Wind Farm (18 FR 31862). The William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021[7] became law in January 2021. It authorizes the USCG to establish and enforce safety zones on the OCS for activity related to wind energy development and operation.

In addition to potential establishment of safety zones during construction activity, Project actions to assure mariner safety during construction and decommissioning include:

- Notice to Mariners on its website http://www.mayflowerwind.com/our-commitment/mariners/
- Submission of Local Notice to Mariners to the USCG, Fleet Command
- On-scene safety vessel(s) and/or personnel to advise mariners of construction activity, as necessary

Mariner awareness will be vital during Project construction, as it is during all marine activities. All mariners are to follow Convention on the International Regulations for Preventing Collisions at Sea. (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

[7] https://www.congress.gov/bill/116th-congress/house-bill/6395/text#H07669B44D8C54EC9887FF078B3A3165F

the prevailing circumstances and conditions. To determine a safe speed as defined in the COLREGs, the elements a vessel's captain 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 metocean working windows and stop-work conditions, and proactive monitoring of conditions and forecasts.

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 Study Area. The number of transits between port and the Project Area during the Project's operations phase is estimated to be less than 1 per day.

The Project design includes a minimum distance of 1 NM (1.9 km) between offshore structures in an aligned grid. These layout constraints are risk control measures. The USCG final MARIPARS report (2020a), concluded that such a layout provides sufficient room for anticipated vessels to transit through and safely maneuver within the Project. Fishing in the Project Area is assessed in Section 3.1.

Section 4 describes the potential hazards posed by Project structures and export cables to vessels in the vicinity of the Project Area or export cable; Section 4.2.2 specifically describes hazards related to fishing and types of fishing gear. Mayflower COP Section 16 summarizes avoidance, minimization, and mitigation measures related to commercial and recreational fishing. In contrast to risk controls anticipated during construction, no safety or exclusion zones are anticipated around Project structures or activities during Project operation. 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.

Project-related service vessels such as Crew Transfer Vessels will also transit within the Project. Based on a qualitative review of vessel size, structure spacing, and in alignment with the evaluation in the MARIPARS report, the Project provides sufficient sea room for service vessels to transit between Project structures if the risks have been considered and vessels are transiting at a safe speed per COLREGs.

The NVIC 01-19 Enclosure 3 provides Marine Planning Guidelines, which are intended to inform the NSRA and inform the siting of offshore wind structures. There are no national or international requirements regarding minimum distances between offshore wind structures and shipping routes, although there are guidelines and recommends that risk assessment be used to evaluate the risk should a structure be closer to the TSS than the guideline.

Table 5-1 lists the marine planning guidelines concerning navigation distances referenced in the NVIC and compares them to the Project.

Table 5-1 Relationships Between USCG Marine Planning Guidelines (2019a) and Project Characteristics

USCG Guideline	Project characteristics	Comments
TSS or port approaches planning guidelines		
2 NM from the parallel outer or seaward boundary of a traffic lane.	Project structures are more than 2.2 NM (4.1 km) from the nearest traffic lane.	Congruent with the guideline.
5 NM from the entry/exit (terminations) of a TSS	WTGs in the evaluated layout are more than 20 NM (37 km) from the nearest traffic lane termination.	Congruent with the guideline.
Coastal shipping route planning guidelines		
Identify a navigation safety corridor to ensure adequate sea area for vessels to transit safely	Coastal shipping traffic (primarily tug traffic) is limited within 20 NM (37 km) of the Project Area (USCG, 2020)	Congruent with the guideline.
Provide inshore corridors for coastal ships and tug/barge operations	The Project structures are too far from shore to affect inshore corridors.	Congruent with the guideline.
Minimize displacement of routes further offshore	The Project structure locations minimize route displacement for deep draft vessel traffic in the Study Area.	Congruent with the guideline.
Avoid displacing vessels where it will result in mixing vessel types	The location of the Project and layout of Project structures is such that vessels with more than one track per day within 1 NM (1.9 km) of the Project Area would not need to mix with different vessel types when taking a route around the Project, if they choose to do so.	Congruent with the guideline.
Identify and consider cumulative and cascading impacts of multiple Offshore Renewable Energy Installations (OREI), such as offshore wind farms.	Other offshore wind lease areas are adjacent to the Project. The presence of multiple OREI is assessed in Section 11.4.	Congruent with the guideline.

USCG Guideline	Project characteristics	Comments
Offshore deep draft routes		
Avoid creating an obstruction or hazard on both sides of an existing route; and, If not practicable to avoid structures or hazards on both sides of a route, a navigation safety corridor should be of sufficient size to provide for the safe transit of the largest vessels. Large ocean-going ships often operate at high speeds that affect maneuvering response time. This should be accounted for when making the determination.	Project structures are located approximately 2.2 NM (4.1 km) from the Nantucket Ambrose Fairway. Traffic in the Study Area, whether inside or outside the approach, is included in the risk model.	Accounted for in risk modeling presented in Section 11.1.
Navigation safety corridors		
Cross track error	Cross-track error is most often a concern regarding tug vessels. Section 2.1.1.5 describes the low level of tug traffic in the Study Area. Tug tracks are included in the risk model and are routed around the Project Area in the Future Case. Cross-track error was not specifically modeled, and is not considered to be a potentially significant risk contributor for this Project.	Tugs are accounted for in risk modeling presented in Section 11.1, but do not frequent the Project Area.
Closest Point of Approach (CPA)	Potential encounters between vessels due to proximity is included in risk modeling. Vessels routed around the Project Area in the Future Case are assumed to take routes with edges about 1 NM (1.9 km) from the Project (a realistic minimum CPA). See Section 11 and Appendix E.	Accounted for in risk modeling presented in Section 11.1.
Density of traffic	The traffic levels in the Study Area are described in Section 2.1 and Section 2.5, and are highest at/beyond the northeastern edge of the Project Area and about 5 NM (9.3 km) south of the Project Area.	Accounted for in risk modeling presented in Section 11.1.

USCG Guideline	Project characteristics	Comments
Other site-specific considerations		
Crossing or converging routes	The frequency of encounters between vessels during crossing, merging, or overtaking is part of the risk model. See Section 11 and Appendix E.	Accounted for in risk modeling presented in Section 11.1.
Hazards on opposite sides of a route	A popular fishing vessel route lies between Nantucket Shoals and the Project.	Accounted for in risk modeling presented in Section 11.1. Modeling decisions concerning the shoals are discussed in Section 2.2.2.2.
Severe weather/sea state	Historical distributions for metocean conditions are used to estimate effects on vessels that are adrift.	Accounted for in the risk modeling. See Section 7, Section 11, and Appendices D and E.
Severe currents	Outside Nantucket Shoals, currents are generally not an issue in amenable weather conditions. Modeling options concerning the shoals are discussed in Section 2.2.2.2. Storm conditions can be hazardous in the area.	Accounted for in risk modeling presented in Section 11.1.
Displacement of vessels into routes with other vessel types	The displaced traffic generally joins similar traffic in nearby routes.	Accounted for in risk modeling presented in Section 11.1.
Complexity of vessel interactions	Complex vessel interactions occur southeast of the Project, where fishing vessels fish in the NY Eastern Fairway.	Accounted for in risk modeling presented in Section 11.1.
Transit distance affected by a new hazard	The transit distance is expected to increase for certain vessel types anticipated to choose routes around the Project Area.	Accounted for in risk modeling presented in Section 11.1.

USCG Guideline	Project characteristics	Comments
Undersized routing measures	While risk assessment as a tool can be used to evaluate the size of a routing measure, it is difficult to draw conclusions concerning adequacy of the Nantucket Ambrose Fairway based on information available to inform this Project-specific NSRA. The USCG is currently conducting several PARS to evaluate the adequacy of existing vessel routing measures. See Section 11.3.	None identified.

5.3 Decommissioning phase navigation risks

This section describes decommissioning activities. The risks from decommissioning activities closely resemble risks from construction, described in Section 5.1.

Prior to decommissioning, Mayflower Wind will consult with BOEM and submit a decommissioning application for review and approval in line with regulations in place at the time. An approved decommissioning plan will dictate the removal of Project components and is planned to essentially reverse the construction and installation process.

As currently envisaged, Mayflower Wind will disconnect, dismantle, and remove WTGs and the OSP(s). WTG nacelle, blades, and towers may be removed in separate lifts. Depending on the design, an entire OSP may be lifted and placed onto a transportation vessel, or major equipment from each OSP could be removed individually before the entire topside or structure is lifted. Heavy transport vessels or barges will then transfer WTG and OSP components ashore.

In accordance with 30 CFR § 585.910, foundations will be cut 4.5 m (15 ft) below the mudline. Alternatively, complete removal may be achieved. Heavy transport vessels or barges will then transfer the substructures ashore. Mayflower Wind may or may not remove scour protection depending on which strategy minimizes environmental impacts.

The offshore export cable(s) and inter-array cables may be retired in place or removed. Cable protection measures, such as concrete mattresses or rocks, could be removed before any cable recovery activities. If removed during decommissioning, the cables will be disconnected and pulled out of the J-tubes before being extracted from the seabed. Dredging vessels may be used to unearth the cables before the cable it is reeled onto barges or other transport vessels.

5.4 Project impact on anchorage areas

NVIC 01-19 guides applicants to consider the effect the Project will have on anchorage areas. Previous Figure 2-35 shows anchorage areas and Project export cable corridors. The closest anchorage is Anchorage

G, located more than 20 NM (39 km) from the Project. The export cables will cross Anchorage G. Section 4.1 describes the risks associated with the export cables and anchoring.

6 EFFECT OF TIDES, TIDAL STREAMS, AND CURRENTS

Table 6-1 provides a summary of the waterways' characteristics and Figure 6-1 shows the Project Area on a nautical chart. A metocean study completed for the Project by DHI Water & Environment, Inc. (2020) provides much of the summary data in this section. Project structures will be located offshore in waters where tides and currents are lesser concerns to mariners compared to shoals and weather.

Table 6-1 Summary of Waterways' Characteristics in the Project Area

Site characteristic	Summary	Source
Tidal range	Semi-diurnal tide with mean range of 0.8 m (2.6 ft)	DHI, 2020
Tide height	0.41 m (1.3 ft) mean high water 0.48 m (1.6 ft) mean higher high water	DHI, 2020
Tidal stream speed	0.4 knots (0.21 m/s) average 1.1 knots (0.59 m/s) maximum	DHI, 2020
Tidal stream direction	Rotary near Nantucket Shoals	NOAA, 2020a
Current speed	0.1 knots (0.05 m/s) avg (residual) 0.9 knots (0.46 m/s) max (residual) 0.4 knots (0.21 m/s) avg (total) 1.3 knots (0.67 m/s) max (total)	DHI, 2020
Current direction	SW-NE (tidal) NW-SE (residual)	DHI, 2020
Water depth	37 m to 64 m (121 ft to 210 ft) MSL	NOAA National Geophysical Data Center (NGDC) (1999)
Waves	The 1-year extreme significant wave height is 6.4 m (21 ft).	DHI, 2020

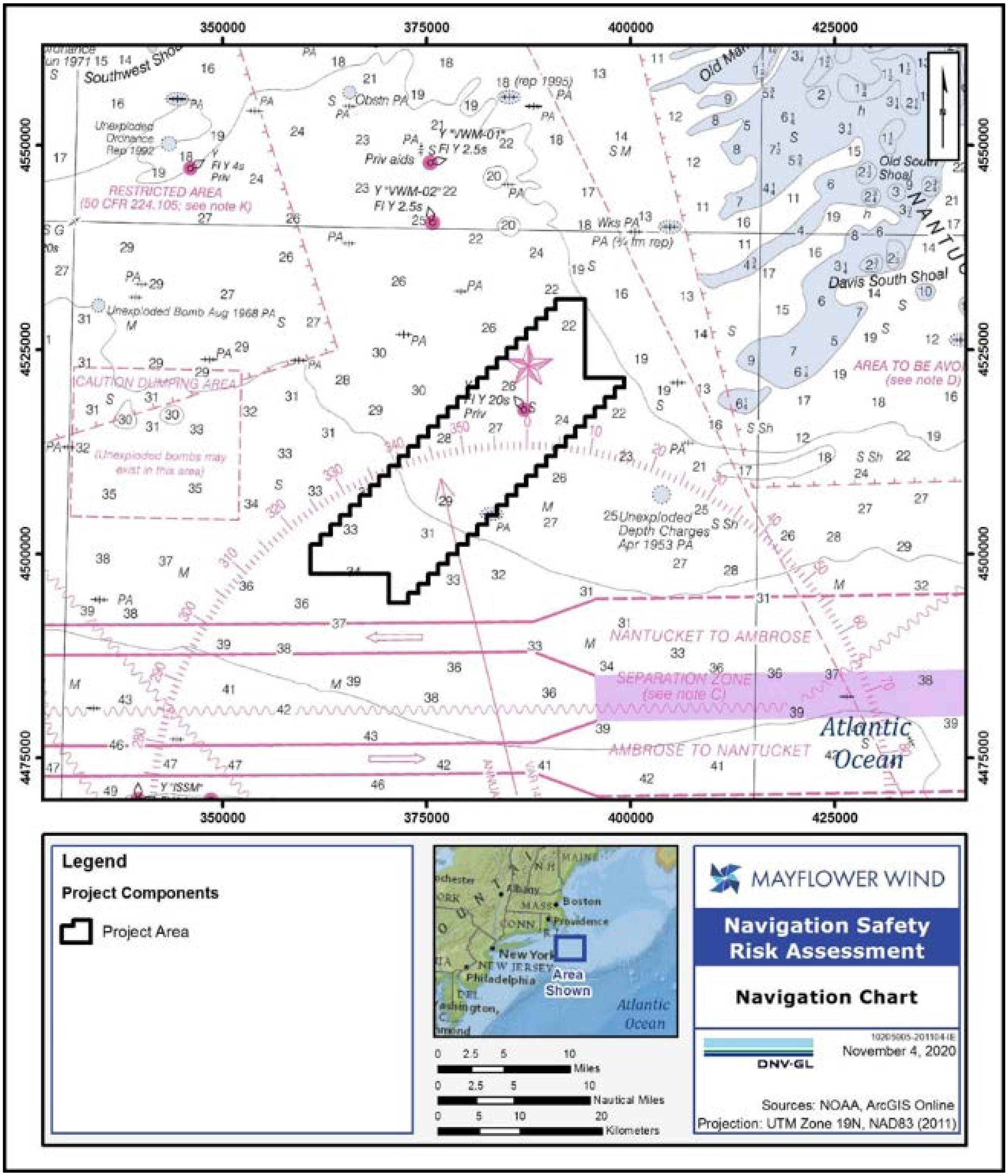


Figure 6-1 Location of the Project on a Navigation Chart

6.1 Tides

While detailed tidal data has not been measured over a long period of time within the Project Area, water levels were modeled for three locations within the Project Area to predict tide levels as part of the Project's metocean study (DHI, 2020). Table 6-2 summarizes the estimated tidal data averaged across the three locations.

Table 6-2 Summary of Estimated Project Area Tides (from MSL) (DHI, 2020)

Highest Astronomical Tide	Lowest Astronomical Tide	Mean Lower-Low Water	Mean Low Water	Mean High Water	Mean Higher-High Water
0.81 m (2.7 ft)	-0.69 m (-2.3 ft)	-0.42 m (-1.4 ft)	-0.40 m (-1.3 ft)	0.41 m (1.3 ft)	0.48 m (1.6 ft)

6.2 Tidal stream and current

Tidal, residual, and total current speeds were modeled for three locations within the Project Area to predict current speeds as part of the Project's metocean study because historical data on currents are not available for the Project Area. Table 6-3 presents the average current speeds for a location in the center of the Project.

Table 6-3 Summary of Tidal and Current Speeds in Project Area (DHI, 2020)

	Tidal stream speed	Residual current speed	Total current speed
Average	0.4 kt (0.21 m/s)	0.1 kt (0.05 m/s)	0.4 kt (0.21 m/s)
Maximum	1.1 kt (0.57 m/s)	0.9 kt (0.46 m/s)	1.3 kt (0.67 m/s)

The Project metocean report (DHI, 2020) also estimated the directional frequency of the tidal stream, residual current, and total current. The total current speed directional frequency distribution is shown in Figure 6-2. Current direction (CD) is indicated by cardinal direction, current speed (CS) is indicated by color, and percentage of the time is indicated by distance from the center. The tidal currents in offshore areas east of the Project are generally rotary, changing 30° clockwise every hour, resulting in two complete rotations every day (NOAA, 2020a). Anecdotal evidence from the geotechnical and geophysical surveys indicate that the tides in the Project Area are predominantly east-west. The axes of the Project structure layout are in a north-south, east-west pattern, so the axis of the predominant current aligns with diagonal lines of orientation in the layout.

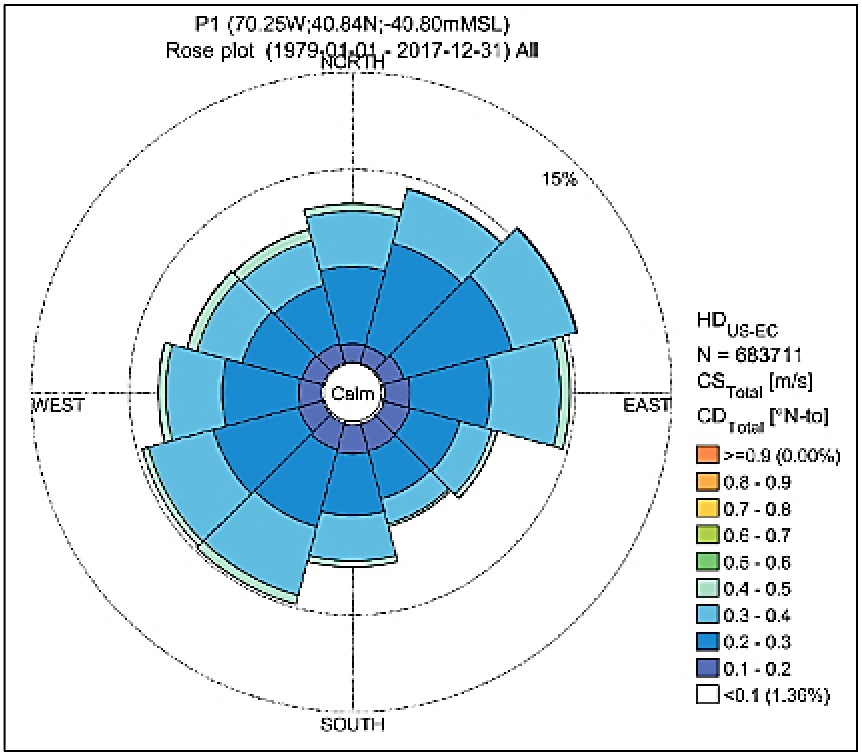


Figure 6-2 Current Speed Directional Frequency in the Project Area (Taken from DHI, 2020)

The effect of sea state and its effect on drift speed and direction after an equipment failure on a vessel are directly accounted for in the modeling described in Section 11 that estimates the effect of the Project on the risk of collision, allision, and grounding.

The effect of rotary currents is not accounted for in the risk model primarily because the additional insights it would provide would be limited, and a comprehensive, scenario-based model would be necessary. The complexity and level of detail required to model such effects is prohibitive for a study of this nature. If a risk model were developed to include this factor, the modeled change in accident risk from the Project would be the same to a great extent, because some scenarios would result in additional accidents and other scenarios would result in fewer accidents, depending on the direction of the current at a critical time during accident development.

It is not anticipated that Project structures will affect the general set and rate of the tidal stream or current. Anticipated effects of the Project, if any, to tides, currents, air column, water column, seabed, or sub-seabed are discussed in the appropriate section(s) of the COP.

6.3 Bathymetry

NOAA Chart 13200 (NOAA, 2020d) shows water depths in the Project Area range from approximately 35 m to 64 m (115 ft to 210 ft), noting that accuracy of the elevation is ±1 m. Bathymetry in the area changes over time, and mariners of even light-draft vessels are urged to avoid Nantucket Shoals without local knowledge (NOAA, 2020a). Bathymetry from the NGDC is shown in Figure 6-3.

Nantucket Shoals lies to the northeast and east of the Project. The shoals shift over time, with minimum depths on some of 1 m to 7 m (3 ft to 23 ft) on others. Depths between shoals can be as much as 40 m (131 ft) (NOAA, 2020a).

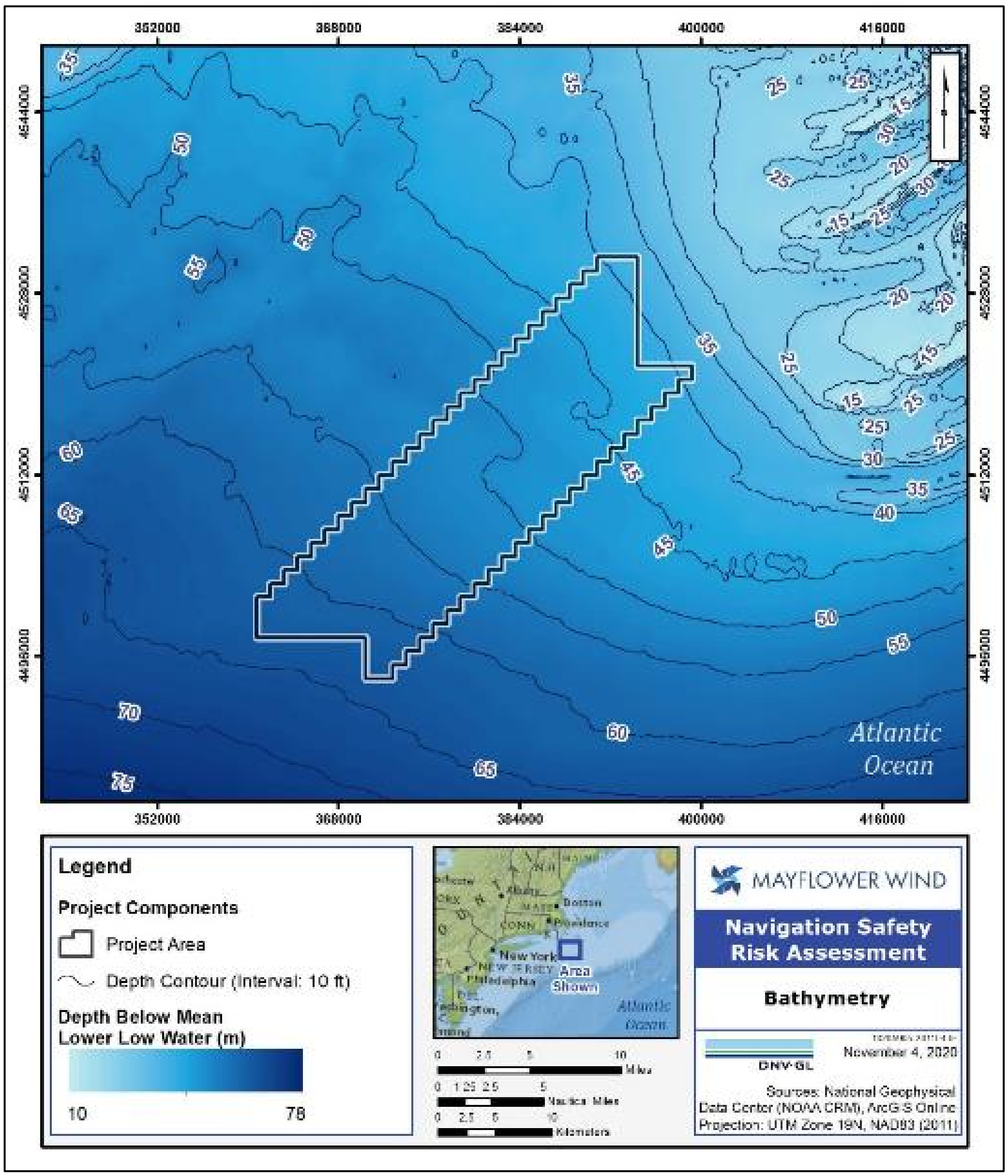


Figure 6-3 Bathymetry of the Project Area (NOAA, 1999)

6.4 Waves

Wave conditions vary seasonally in the South Study Area. According to Coast Pilot 2 (NOAA, 2020a), in winter, waves greater than 2.4 m (8 ft) occur about 10 to 15 percent of the time. The remainder of the year, wave heights of more than 2.1 m (7 ft) frequently last a day or more.

In the Project Area, significant wave height is 6.4 m (21 ft) with a 1-year return period. 10-year and 100-year return periods have significant wave heights of 9.4 and 13.0 m (31 ft and 42.6 ft), respectively (DHI, 2020).

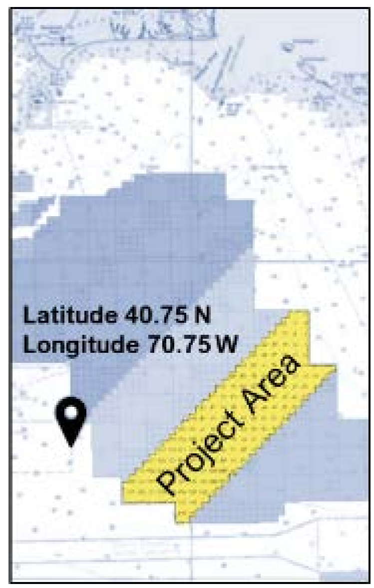
7 WEATHER

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, 2020a).

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.

7.1 Wind

Given that less than one year of detailed wind data has been collected within the Project Area, additional data from the following sources was evaluated:



1. The metocean study for the Project (DHI, 2020) predicted winds at 30 m (98 ft) from MSL. The DHI wind statistics best align with the descriptions in Coast Pilot 2 and discussions with local mariners.
2. Wind rose plots and wind speed and direction data obtained from the Climatology of Global Ocean Winds (COGOW) (2009) and were provided courtesy of Oregon State University's Cooperative Institute for Oceanographic Satellite Studies (CIOSS)[8] (Risien and Chelton, 2006). The data are daily averages of speed and direction from ten years of QuikSCAT measurements (through the year 2009). The COGOW wind statistics were downloaded for latitude 40.75 N, longitude 70.75 W. This data set does not contain any storm winds (greater than 45 kt).
3. The closest wind speed measurement station to the Project Area is buoy 44008 approximately 60 NM (111 km) east of the Project Area. This station has collected more than ten years of wind data at a height of 4 m (13 ft), which results in under-reporting of higher wind speeds.

The DHI (2020) wind speed/direction distributions at 30 m (98 ft) above MSL in the Project Area are shown in Table 7-1. This wind data set was used in the MARCS model described in Appendix E.

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

Table 7-1 Wind Speed Distribution Used In NSRA Modeling (COGOW, 2009)

Wind speed category	North	Northeast	East	Southeast	South	Southwest	West	Northwest	Total
Calm <20 kt (< 10 m/s)	6.82%	10.13%	7.04%	4.27%	8.24%	19.67%	17.04%	11.76%	84.96%
Fresh 20-30 kt (10-15 m/s)	1.57%	2.37%	0.48%	0.13%	0.03%	0.59%	4.56%	4.53%	14.26%
Gale 30-45 kt (15-23 m/s)	0.16%	0.09%	0.02%	0.00%	0.05%	0.00%	0.19%	0.16%	0.67%
Storm >45 kt (>23 m/s)	0.02%	0.01%	0.00%	0.00%	0.01%	0.00%	0.03%	0.02%	0.10%
Total	8.58%	12.61%	7.54%	4.40%	8.32%	20.26%	21.81%	16.48%	100.00%

Wind directions in the wind rose at 137 m (449 ft) above MSL in Figure 7-1 (DHI, 2020) align well with the COGOW wind rose at 10 m (33 ft) above MSL, shown in Figure 7-2. Higher speed winds are indicated in the DHI wind rose because of the difference in height.

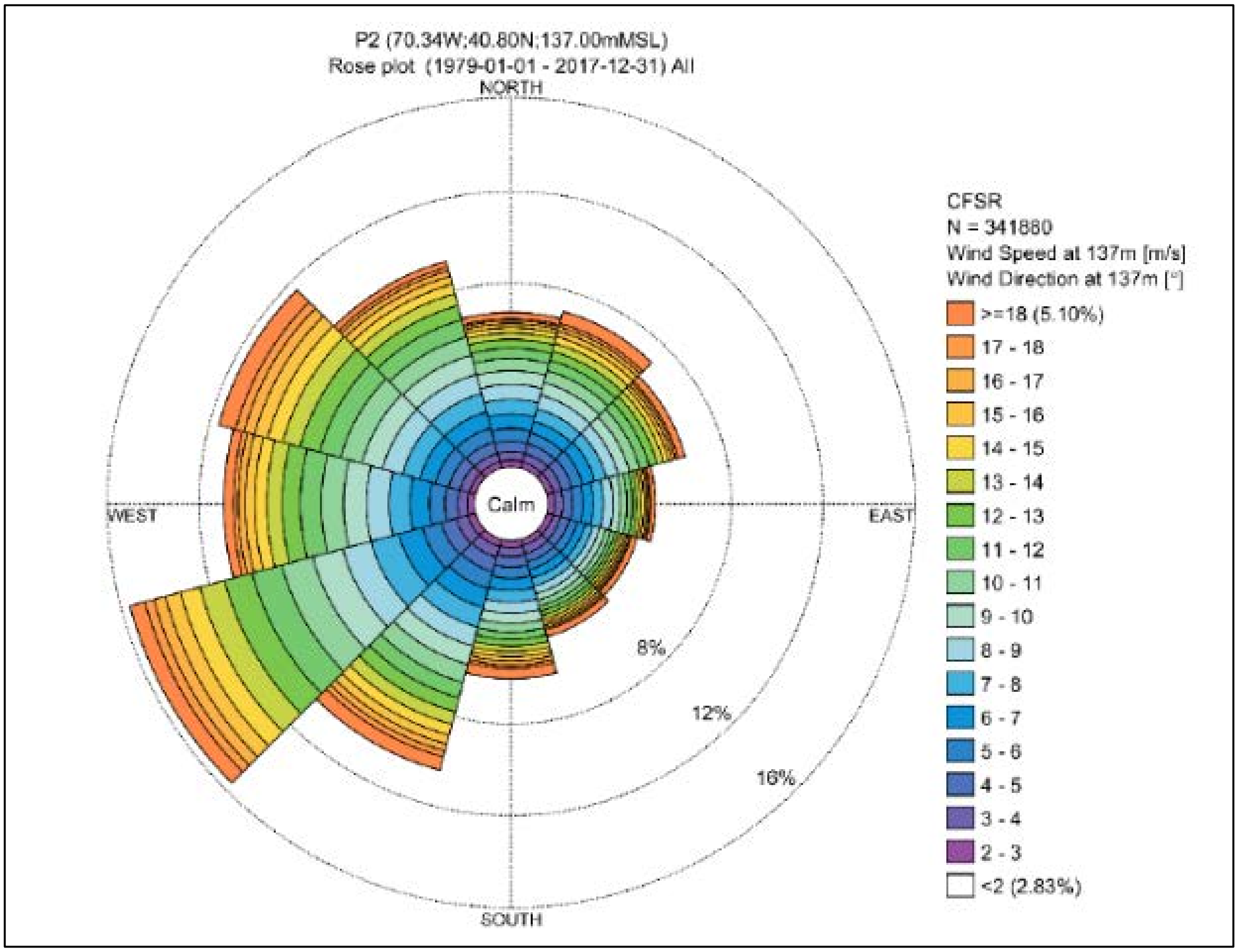


Figure 7-1 Wind Rose Based on 39 Years of Data (taken from DHI, 2020)

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

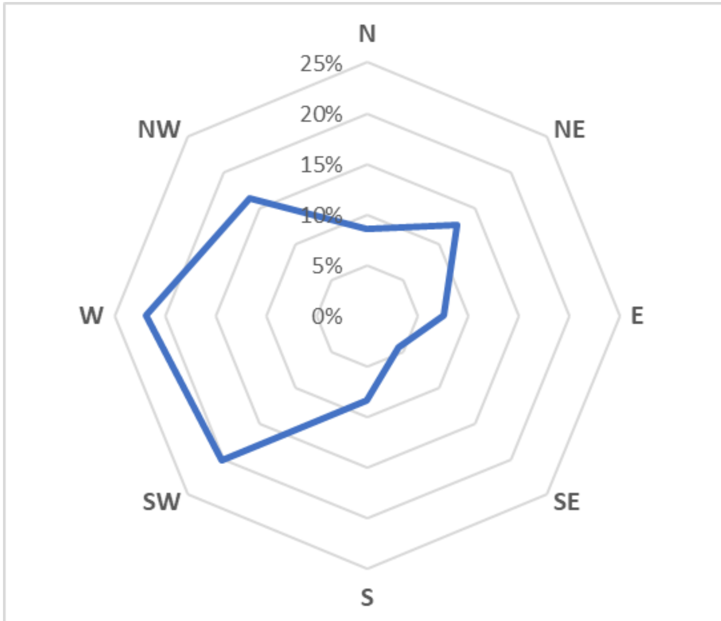


Figure 7-2 Wind Rose at 10 m (33 ft) MSL at Latitude 40.75N, Longitude 70.75W (COGOW, 2009)

The figures show prevailing winds from the west and southwest. The distribution of wind directions shows that winds come from almost all directions over the course of a year.

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 from MSL is 14.0 kt (7.2 m/s).

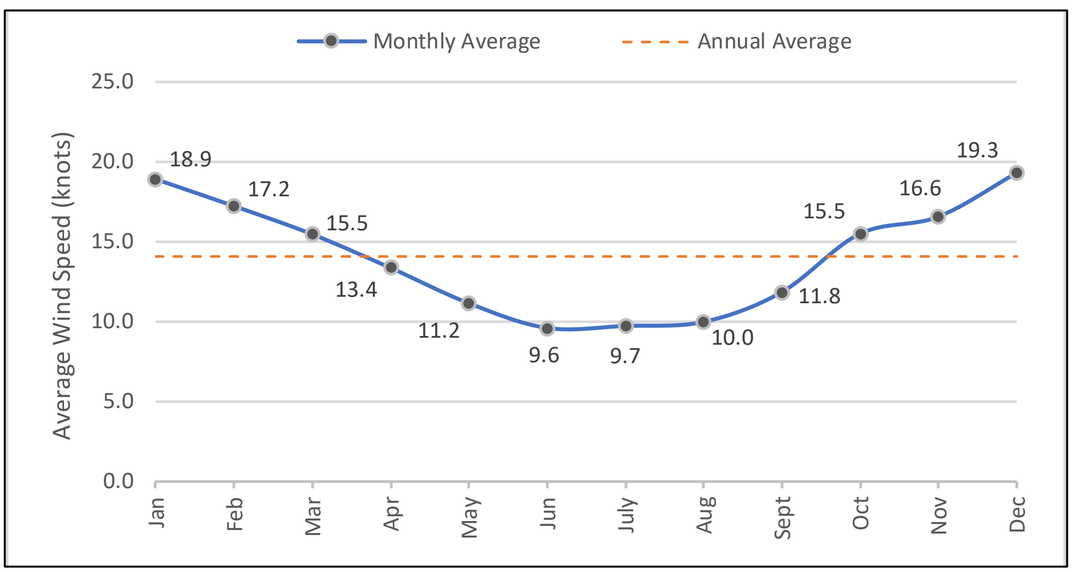


Figure 7-3 Average Daily Wind Speeds at 10 m (33 ft) Height Above MSL at Latitude 40.75N, Longitude 70.75W (COGOW, 2009)

Storms, which are more prevalent in the winter, can restrict navigation in the region. Winter storms can cause strong winds and rough seas, and average two to four per month. Usually, these storms are forecasted well in advance so mariners can make plans accounting for the expected sea state. However, storms can develop in less than 24 hours. In open water, the storms can generate 12.2-m (40-ft) waves and hurricane force winds (Coast Pilot, 2020).

The International Best Tracks for Climate Stewardship database provided the data for tracks that passed within five degrees of the Project Area between 1969 and 2019 (Figure 7-4) (NOAA, 2020b; Knapp et. al., 2010; Knapp et. al. 2018). Of the 71 storms passing within 5 degrees of the Project Area, 85 percent were Category 1 or tropical events.

Table 7-2 Number of Cyclones Within 5 Degrees of the Project Area (NOAA, 2020b)

Hurricane Scale (Saffir Simpson)	Number of occurrences 1969-2019
Tropical Depression	10
Tropical Storm	35
Category 1	15
Category 2	7
Category 3	4
Total	**71**

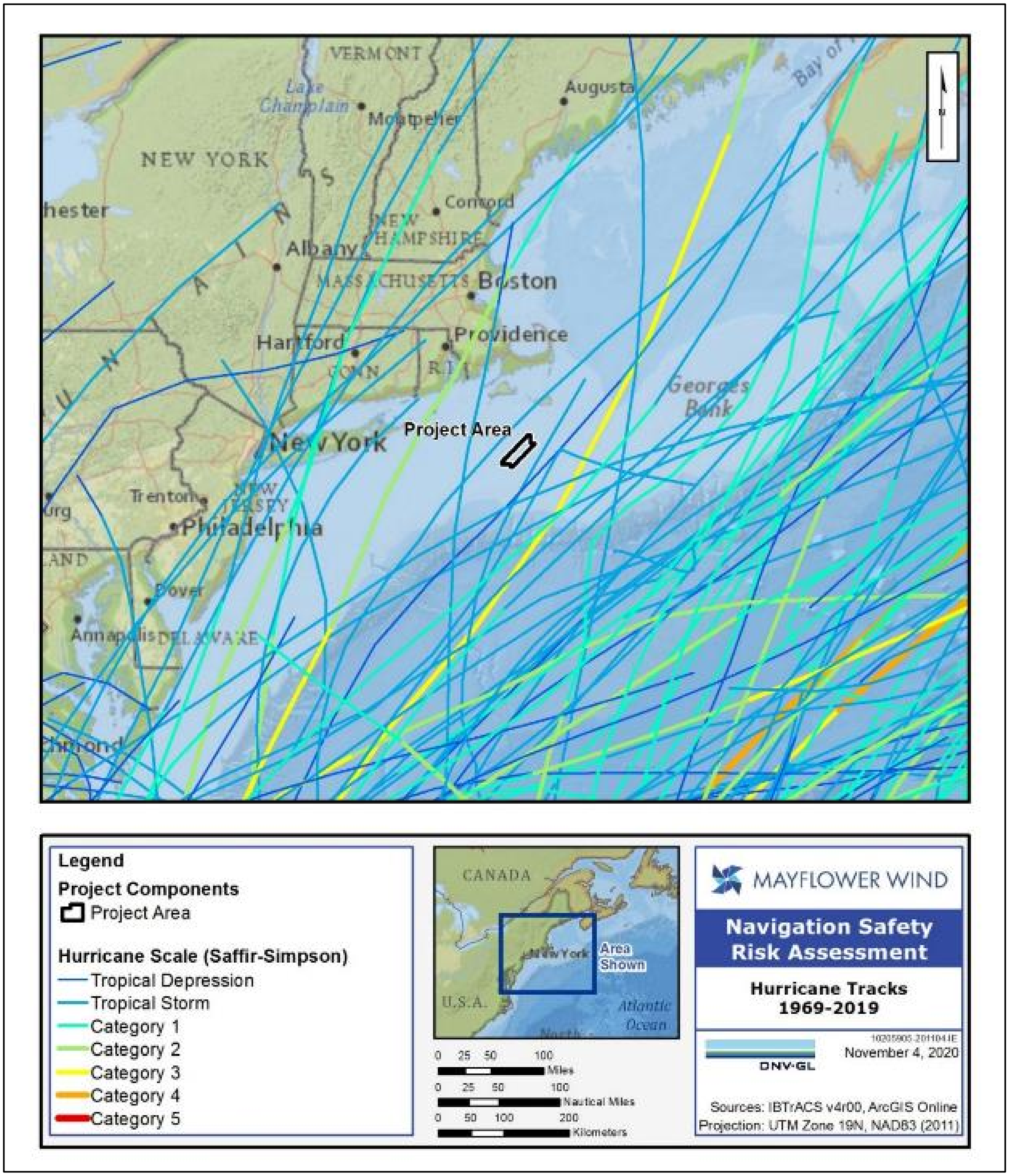


Figure 7-4 Tracks of Cyclones Within 5 Degrees of the Project Area (1969-2019) (NOAA, 2020b)

7.2 Consideration of vessels under sail

Vessel under sail could enter the Project 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

Advection fog (an effect from warm air over cool water) is most frequent from April through August - visibility can be less than 2 NM (3.7 km) 10 to 18 percent of the time. The densest fog often occurs in May, June, and July (NOAA, 2020a).

Visibility data were obtained from Climate Data Online for Nantucket Memorial Airport station (NOAA, 2020c). This is the closest station with available visibility data and is therefore taken to be the best available data for the purposes of this assessment.

Figure 7-5 summarizes 10 years of visibility data from the Nantucket Memorial Airport station. Visibility was less than 2 NM (3.7 km) about 12.7 percent of the time.

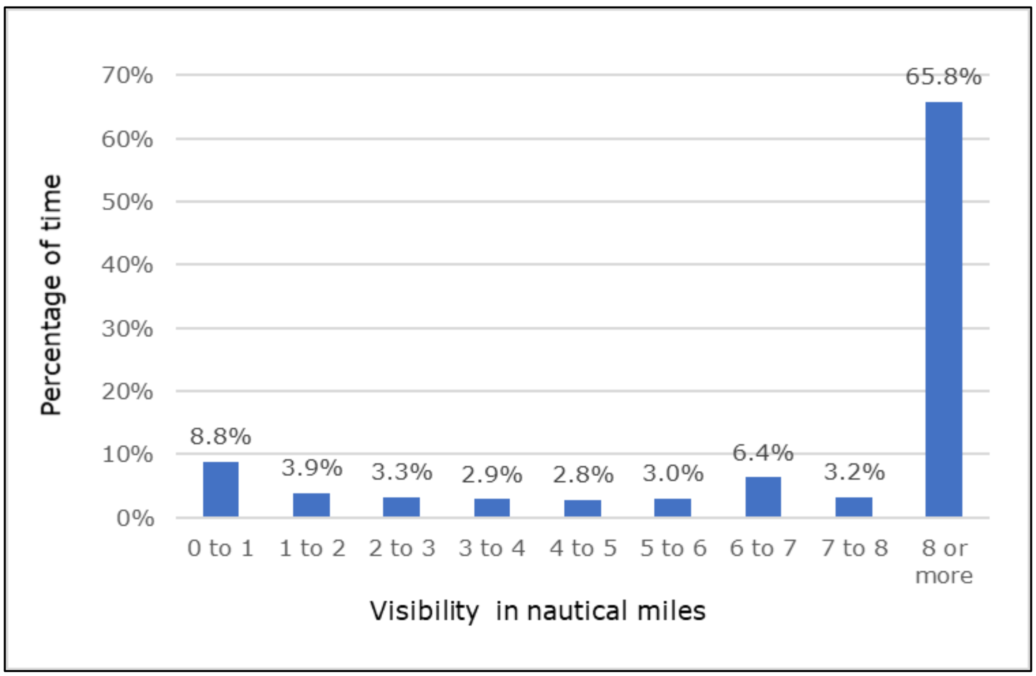


Figure 7-5 Summary of Visibility Measurements at Nantucket Memorial Airport (2009-2019) (NOAA, 2020c)

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 an offshore structure causing potentially hazardous conditions for any people or vessels beneath should ice fall from the structure.

According to the metocean report for Mayflower Wind:

> "The wind turbine blades are most likely to be affected by meteorological conditions due to the height above sea level. Low wind speeds (<10 ms^{-1}) and cool air temperatures (-20 - 0°C) allow for an environment conducive to icing. Supercooled water droplets landing on sub-zero surfaces result in icing, which could reach diameters of 1-2cm. Dry snow is unlikely to stick to surfaces, unless it is damped on contact by other forms of precipitation or sea spray." (DHI, 2020)

In addition, spray from wind and waves can reach structures to about 20 m (65.6 ft). The metocean report concluded that there is a risk of ice accumulation on near-sea-level structures approximately 2.3 percent of the time based on ISO 19906 parameters and 39 years of hindcast (DHI, 2020).

Floating ice

Coast Pilot 2 (NOAA, 2020a) does not directly discuss ice accumulation in the region but does note that prevailing northerly winds in winter generally keep Nantucket Sound free from drift ice. Admiralty Sailing Directions Volume 2 (UK Hydrographic Office, 2017) also describes floating ice as being extremely rare even during severe winter seasons. Pack ice usually lies well north of 40°N latitude and pack ice that does drift south has always been well east of the Project Area. This assessment has found no other information to suggest that floating ice is present or poses a risk to navigation near the Project.

Falling ice

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

No hazard to structural integrity is anticipated from ice accumulation on the structure because when ice builds up on WTG blades, the weight and center of mass of the blades changes, causing an imbalance in the rotor. Should it rotate in this condition, vibration sensors installed in the WTG would automatically trigger rotor shut down. As a result of the widespread use of this control strategy, DNV GL is aware that ice throw occurs rarely, if ever, on modern WTGs; most accumulated 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 structure. This hazard is most relevant to fishing, pleasure, and Project maintenance 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 (DNV GL, 2021).

Risk to fishing and pleasure vessels from falling ice is expected to be very low because of the limited conditions under which ice might fall, but also because there is less fishing and pleasure traffic during such times (see Section 2.5). Based on the traffic statistics in the Project Area, transits of vessel types that frequent the Project Area are greatly reduced in the winter months, with no pleasure vessel tracks January through March in 2019.

As an additional precaution, Mayflower has committed to publishing and/or broadcasting notices to mariners when icing conditions are present, when the WTGs are automatically shut down due to icing, or when ice build-up is observed.

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).

When a project area is optimized with an objective of maximizing power output, tradeoffs consider many factors, including geology of the seabed, water depth, foundation type, wind direction, and wind speed. For this Project, navigation safety and consideration of other marine uses were primary factors, resulting in a proposed layout with 1 NM (1.9 km) between adjacent structures in a linear pattern, intended to align with adjacent offshore wind projects (Equinor Wind US, Eversource Energy, Mayflower Wind, Orsted North America, and Vineyard Wind LLC, 2019).

Assuming a limited area in which to lay out 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 cost of inter-array cable installation and maintenance

The MARIPARS report provides the following conclusion about potential effects of structures on SAR in the WEA that includes the Project:

> "After considering all options and the vessel traffic patterns within the MA/RI WEA, a standard and uniform grid pattern with at least three lines of orientation throughout the MA/RI WEA would allow for safe navigation and continuity of USCG missions through seven adjacent wind farm lease areas over more than 1400 square miles of ocean." (USCG, 2020a)

An ALARP assessment evaluates any additional risk reduction measures with the goal of weighing the potential benefits against the costs.

Planned Project risk controls most relevant to collision avoidance include:

- Project structures will be in linear rows and columns oriented north-south and east-west with a minimum distance of 1 NM (1.9 km) between structures. Multiple straight-line routes will be available for vessels or aircraft transiting the Project Area:
  - 1 NM wide corridors: 19 oriented N-S and oriented 19 E-W
  - 0.7 NM wide corridors: 33 oriented NW-SW and 9 oriented SW-NE
- The offshore wind developers in the Rhode Island and Massachusetts lease areas have proposed a layout for wind turbines across the BOEM leases in the region, a 1 NM by 1 NM (1 .9 km by 1.9 km) uniform turbine layout (Equinor Wind US, Eversource Energy, Mayflower Wind, Orsted North

America, and Vineyard Wind LLC, 2019). The layout of Project structures analyzed in this NSRA conforms to the joint developers' proposal.

A list of additional risk controls that could be reviewed further is listed in Section 11.3.

9 VISUAL NAVIGATION

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

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

A geometric approach was used to determine potential visual obstruction caused by Project structures with a focus on a mariner's ability to see another vessel. The 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 uniform layout minimizes visual obstruction caused by Project structures compared to a staggered layout. It maximizes visual distances and uninterrupted lines of sight when passing near or through the Project.

Supposing two vessels were each located in the center of a 1 NM (1.9 km) lane, separated by a 16 m (52 ft) diameter monopile foundation. When directly opposite each other, view of a vessel of up to 56 m (183 ft) could be blocked by the monopile. Once either vessel moved, the vessel would be visible.

The potential length of visual obstruction for a Project structure was estimated based on the effective diameter of the obstruction, plus a buffer. The largest monopile foundation being considered has a maximum diameter, at the sea bottom, of 16 m (52 ft). Additional buffers are added to the diameter as follows:

- 1 m is added to each side to account for ancillary equipment, resulting in an effective diameter of 18 m (59 ft). A vessel up to 18 m (59 ft) LOA could be unobservable from a similar sized vessel in a stationary, opposite position.
- A safety buffer of 10 m (33 ft) is added to the effective diameter to account for the uncertainty in the distance between the unseen vessel and the obstructing Project structure. The resulting evaluated diameter is 28 m (92 ft), representing the maximum obstruction size including the buffer.

For a vessel travelling at 5 kt, the visual obstruction would persist for 11 seconds. This is the period of time that a monopile structure could potentially limit a vessel's visibility of a second vessel, assuming the second vessel was equidistant on the opposite side of the structure and was not moving. A hazardous situation could exist if two vessels were transiting at speed on intersecting courses while close to the same monopile structure. Both vessels would be aware that their line of sight was limited by the structure, and in line with COLREGS, should reduce speed and keep vigilant watch.

This is a conservative approach since the structures are spaced so far apart, both vessels would need to be transiting on a very narrow range of possible routes to lose sight of each other for the calculated 11 seconds. On more probable routes, the visual obstruction would be shorter. Table 9-1 summarizes the potential time of limited visibility for vessels transiting at various speeds. The distance travelled without the other vessel in sight is approximately 0.015 NM (28 m).

Table 9-1 Duration (in Seconds) of Potential Visual Obstruction Based on Vessel Speed

Speed of vessel (kt)	Duration of obstructed visibility of a fixed object (seconds)
5	11
10	5.4
15	3.6

The Project layout evaluated in this assessment (Figure 9-1) has a minimum of 1.0 NM (1.9 km) between Project structures. 1 NM (1.9 km) is equivalent to 74 vessel lengths for the average 25 m (82 ft) fishing vessel in the Study Area, and equivalent to 6 lengths of a fishing vessel towing gear totaling 304.8 m (1000 ft).

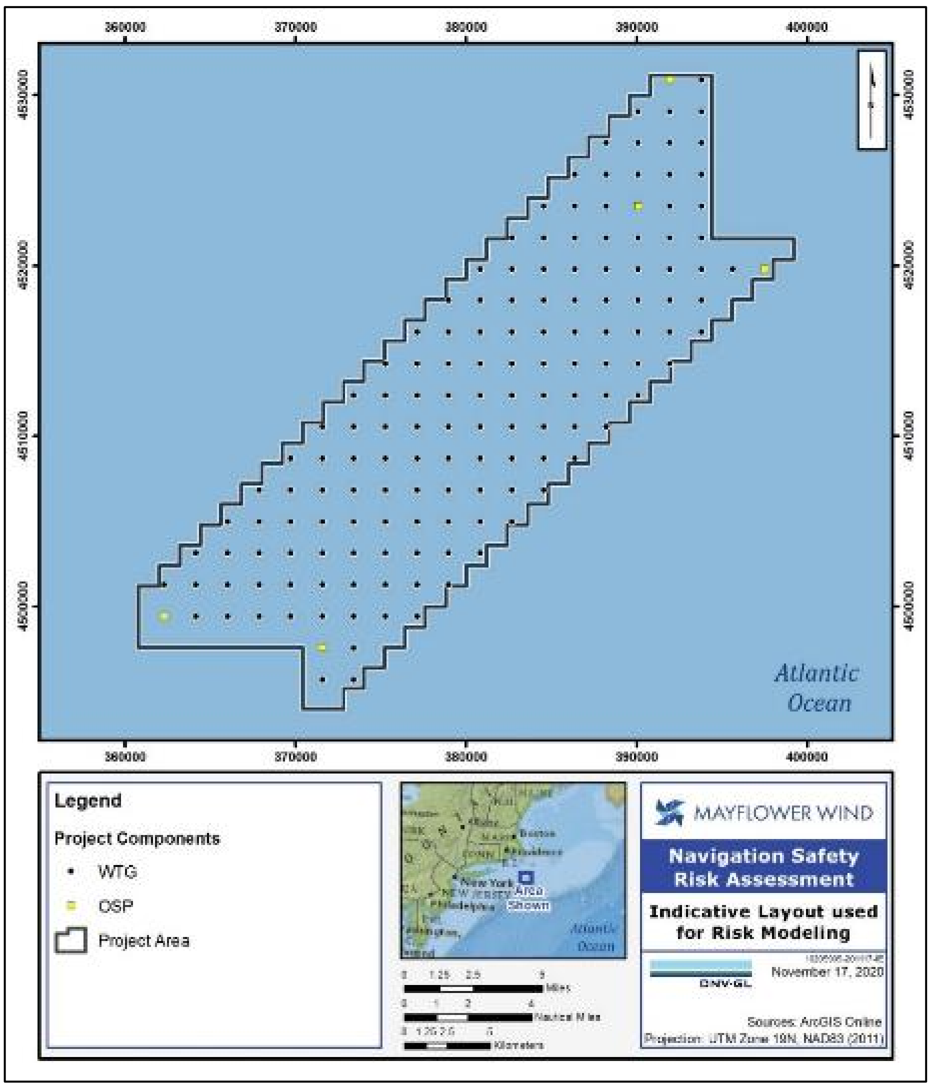


Figure 9-1 Evaluated Project Layout

A quantitative evaluation of navigation safety within the boundaries of the Project is included in Section 11.

During Project operation, each structure will be lighted at night and marked and could be used to assist mariners in determining and communicating their position. To evaluate whether the Project will affect the ability of mariners to utilize ATON for navigation, a geospatial plot of current ATON, the coastline, and the Project was reviewed (Figure 9-2). No significant obstruction was noted.

The Project is working with the USCG toward Project PATON permits that consider a range of issues related to navigation safety. The requirements for marking Project structures are described in Section 13.

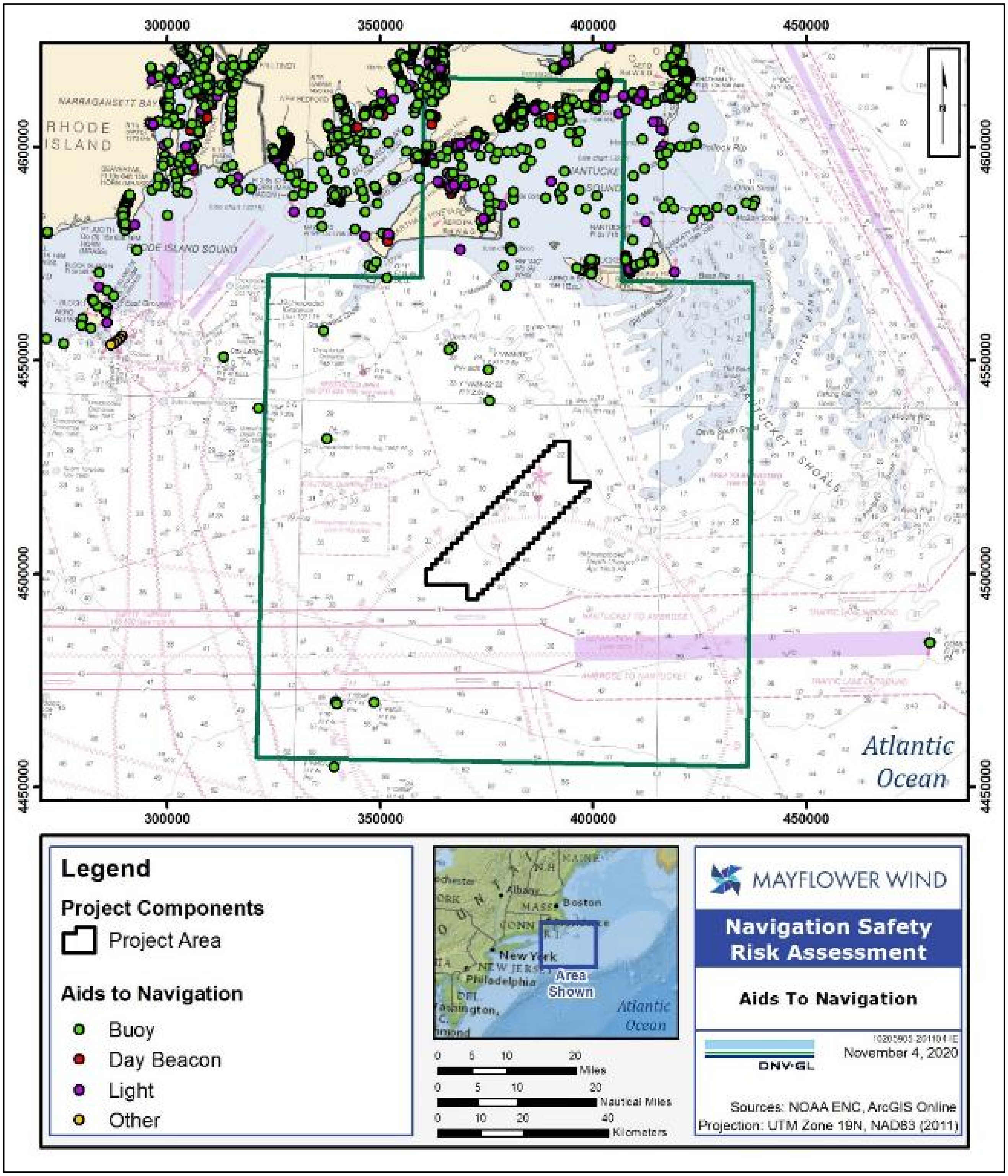


Figure 9-2 Locations of ATON (NOAA 2020e)

10 COMMUNICATIONS, RADAR, AND POSITIONING SYSTEMS

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

Given the current level of scientific understanding, some types of specific effects from this Project, or any other specific offshore wind farm, can be most effectively assessed after its construction. However, a general level of anticipated effect can be understood through study. Publicly available literature and project-specific studies were reviewed concerning potential effects of offshore WTGs on communication and navigation systems. Indicative studies are summarized below.

In-air construction and operational noise is discussed in COP Section 9.1.3.1 and COP Appendix U1, In-Air Acoustic Study Report.

10.1 Effects on communications

The assessment of Project effects on communications includes marine communications systems (both ship-to-ship and ship-to-shore). The research included evaluations of High Frequency (HF), Very High Frequency (VHF), and Ultra High Frequency (UHF) radio systems. Based on conversations with mariners in the region, the effects of offshore WTGs on marine communications are minor or not discernable.

Rescue 21, Digital Selective Calling (DSC), and AIS are all based on VHF radio communications. The characteristics of VHF radio wave prorogation lends itself to quick recovery from structural interference due to its inherent wavelength (~1.8 m [5.9 ft]); the signal recovers within a few hundred yards.

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, 2004). 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 radar

10.2.1 Marine radar

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

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

The potential effects on and mitigations for coastal land-based radar have been the subject of studies by BOEM, MIT Lincoln Laboratory, Lawrence Berkeley National Laboratory, Sandia National Laboratory, and others. For example, a public summary from 2017 (DOE, et. al.) states that radar mitigations are currently in various stages of development, testing, and deployment.

10.2.2 Land-based radar

BOEM recently issued a study identifying potentially impacted land-based radars from offshore wind farms, including the Project (2020). The work studied effects of potential Atlantic offshore wind energy installations on land-based radar systems and potential mitigations for these impacts. It qualitatively ranked the impacts from each evaluated offshore wind farm, incorporating an aligned 1 NM by 1 NM (1 .9 km by 1.9 km) layout for Mayflower Wind and contiguous wind farms. Among the evaluated wind farms, Mayflower Wind was found to lie in the middle of the range concerning the number of affected radars and severity of impacts. Based on literature review and expert interviews, specific mitigations were identified to reduce the potential impacts, including combining available tools and data, enhancing signal processing, and antenna modifications.

The Project's Radar Line of Sight Study is presented in Appendix Y4 of the COP.

10.2.3 High Frequency Radar

NOAA operates over 160 coastal High Frequency Radar (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, 2021).

HFR data are anticipated to experience signal losses from the presence of an operational offshore wind farm, as shown 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, and NOAA Integrated Ocean Observing System. Presently, the Wind Turbine-Radar Interference Mitigation 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 the Integrated Ocean Observing System (NOAA, 2021). 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.

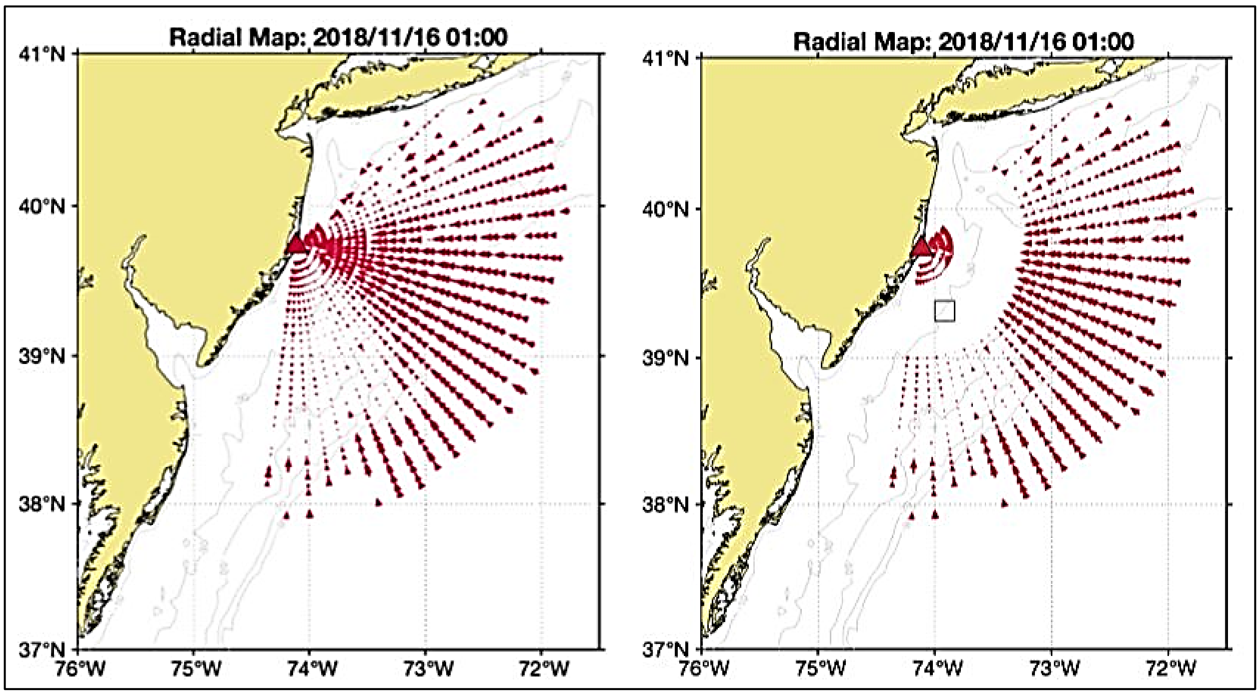


Figure 10-1 HFR data before (left) and after (right) installation of an offshore wind farm (NOAA, 2021)

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
    Require in-fill radar placements where impact is significant.

10.3 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 offshore wind farm structures on marine GPS. The potential concern is that electromagnetic energy from 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.”

10.4 Potential risk control measures for marine radar effects

Potential measures to reduce the impacts of an offshore wind farm on radar and communications identified by this study include the following, in no particular order:

- Positioning of radar scanner/antenna on the vessel, particularly in relation to ship structures and fittings
- Experience with radar setting coupled with use of a reference target when adjusting radar settings, particularly gain
- Reducing the radar cross-section of the turbines, such as by design changes or through use of special coatings

11 COLLISION, ALLISION, AND GROUNDING ASSESSMENT

This section presents the results of a quantitative assessment of collision, allision, and grounding (i.e., a marine accident) in the Study Area from operation of the Project. This quantified risk builds upon earlier work conducted by the USCG (e.g., USCG, 2020a). The risk assessment consists of estimates of frequency or likelihood of each accident for each vessel type using the Marine Accident Risk Calculation Software (MARCS) model (Section 11.1) and a “what if” consequence analysis (Section 11.2). The consequence analysis discusses the ranges of severity for reasonably foreseeable accidents.

The change in frequency is estimated using the MARCS model to estimate how often a marine accident is estimated to happen with and without the Project. Risk models are generally conservative and by design, predict higher numbers of events than come to fruition.

The risk results are presented by accident type and by vessel type. For most vessel types, risk change from the Project is estimated in terms of the difference in frequencies of marine events based on multiple data inputs into the MARCS tool. MARCS has been utilized globally to assess navigation risk of more than 20 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.

Ideally, the model results should be compared with the historical record; however, the historical accident record for offshore wind farms is sparse. Offshore wind farms have been in operation in the European Union for 30 years and very few accidents have been reported. This study identifies three documented allisions in wind farms involving vessels not associated with the affected wind farm:

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

11.1 Frequencies of marine accidents

This section presents the estimated changes in frequencies of marine accidents due to the Project using the MARCS model. 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, including the following:

- Vessel speed
- Vessel direction/route
- Distance traveled on the route
- Probability of steering and/or propulsion failure
- Probability of error in navigation
- 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

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

The general model is described in Appendix D. A detailed description of the Project-specific model for collision, grounding (drift and powered), and allision (drift and powered) is in Appendix E. The vessel tracks accounted for in the model are presented in Section 2.1.1. The transits added to the AIS data are presented in Table 11-1 and discussed for each vessel type in Section 2.1.1.

Table 11-1 Summary of Transits Added to AIS Data for Modeling

Vessel type	Activity	Included in Base Case model (each way)	Included in Future Case model (each way)
Pleasure, recreational without AIS (see Section 2.1.1.4)	Fishing/sightseeing	-	100
	Correction for pleasure vessels near the Project and under-represented in AIS	+100%	+100%
Fishing, commercial without AIS (see Section 2.1.1.2)	Increased level of fishing in Project Area due to the Project	-	+20%
	In Study Area	+100%	+100%
Carrier, LPG deep draft (see Section 2.1.1.1)	Traffic growth	50	50
Passenger, cruise deep draft (see Section 2.1.1.3)	Traffic growth	50	50

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

Table 11-2 Modeled Incremental Change in Accident Frequencies from the Project in the Study Area

Vessel type	Increase in frequency of any accident (number per year)	Percentage of Total
Cargo / Carrier	0.012	3.4%
Fishing	0.248	69.5%
Other / Undefined	0.057	16.0%
Passenger	0.003	0.9%
Pleasure	0.029	8.1%
Tanker	0.002	0.5%
Tanker - Oil	0.005	1.4%
Tug / Service	0.001	0.2%
Total	0.357	100.0%

The MARCS model shows that the frequency of marine accidents increases by 0.36 accidents per year. Marine accidents involving (commercial) fishing vessels represent 70 percent of the increase (Figure 11-1). To put the results into regional context, there are an average of approximately 6 SAR cases per year in the NSRA Study Area[9] based on SAR cases with high data quality presented in a recent USCG Port Access Route Study (USCG, 2020a). Note this modeled accident frequency increase is for accidents of any consequence, including small and zero damage such as bumping into a foundation while drifting.

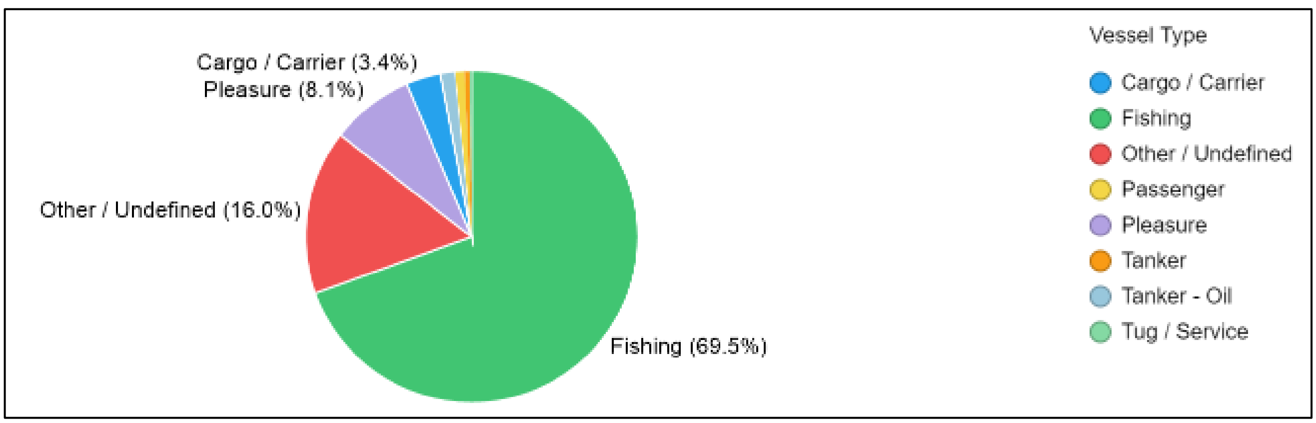


Figure 11-1 Relative Contribution to Project Risk from Each Vessel Type in the Study Area

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

[9] For the avoidance of doubt, not all accidents modeled in MARCS are expected to require SAR activities.

Table 11-3 Modeled Incremental Change in Accident Frequencies from the Project for Each Accident Type in the Study Area

Accident type	Increase in frequency of any accident (number per year)	Percentage of Total
Drift allision	0.215	60.3%
Powered allision	0.138	38.5%
Drift grounding	0.002	0.5%
Powered grounding	<0.0005	<0.5%
Collision	0.003	0.7%
Total	**0.357**	**100.0%**

Allision accidents comprise 98.8 percent of the 0.36 increase in accidents per year from the Project and are predicted to occur an average of 2.8 times every 10 years. There is almost no increase grounding risk estimated by the model. Nantucket Shoals lies to the east, but because a key assumption in this assessment is that all fishing tracks in the Base Case are the same in the Future Case (after the Project is constructed) the presence of structures does not affect grounding risk in the model. Any vessel on a collision course with a structure is assumed to result in an allision accident, no avoidance actions are accounted for in the model. If avoidance actions were taken, some of these estimated allisions could instead result in no accident, a collision, or a powered grounding. The model is designed to over-estimate the risk where uncertainties exist.

The risk model accounted for risk control measures that are implemented today such as modern navigation equipment on vessels in international trade, electronic charts, and Port State Control. (See Appendix D Section D.3.2 for descriptions of each risk control.) The model did not account for other risk controls that are widely regarded as beneficial. Not accounting for these is a conservative approach to the modeling, resulting in 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.
- A consistent and coordinated numbering system for marking offshore structures in this and adjacent lease areas.
- Tug capability and availability to intervene and prevent a drift allision by a vessel that has lost power. Accounting for this measure would require a detailed evaluation of tug availabilities and capabilities in the region. Not accounting for it is a conservative approach to the modeling, resulting in higher risk estimates for drift allision than would be estimated with a model that included this measure.
- The potential for some deep draft vessels, if they have lost power, to prevent an allision by dropping anchor.

The remainder of this section presents the risk for each sub-area shown in Figure 11-2. The sub-areas are simple polygons drawn for the purposes of reporting model results, to provide clarity on locations where risks are affected by the Project and insights into contributing factors and affected vessel types.

The model was designed so that nearly all of the risk from the Project is within the Project Area; however, vessel maneuvers to avoid a structure could effectively transfer allision risk to collision risk. Modeled risk increases outside the Project Area are related to routing of deep draft and tug vessels around the Project.

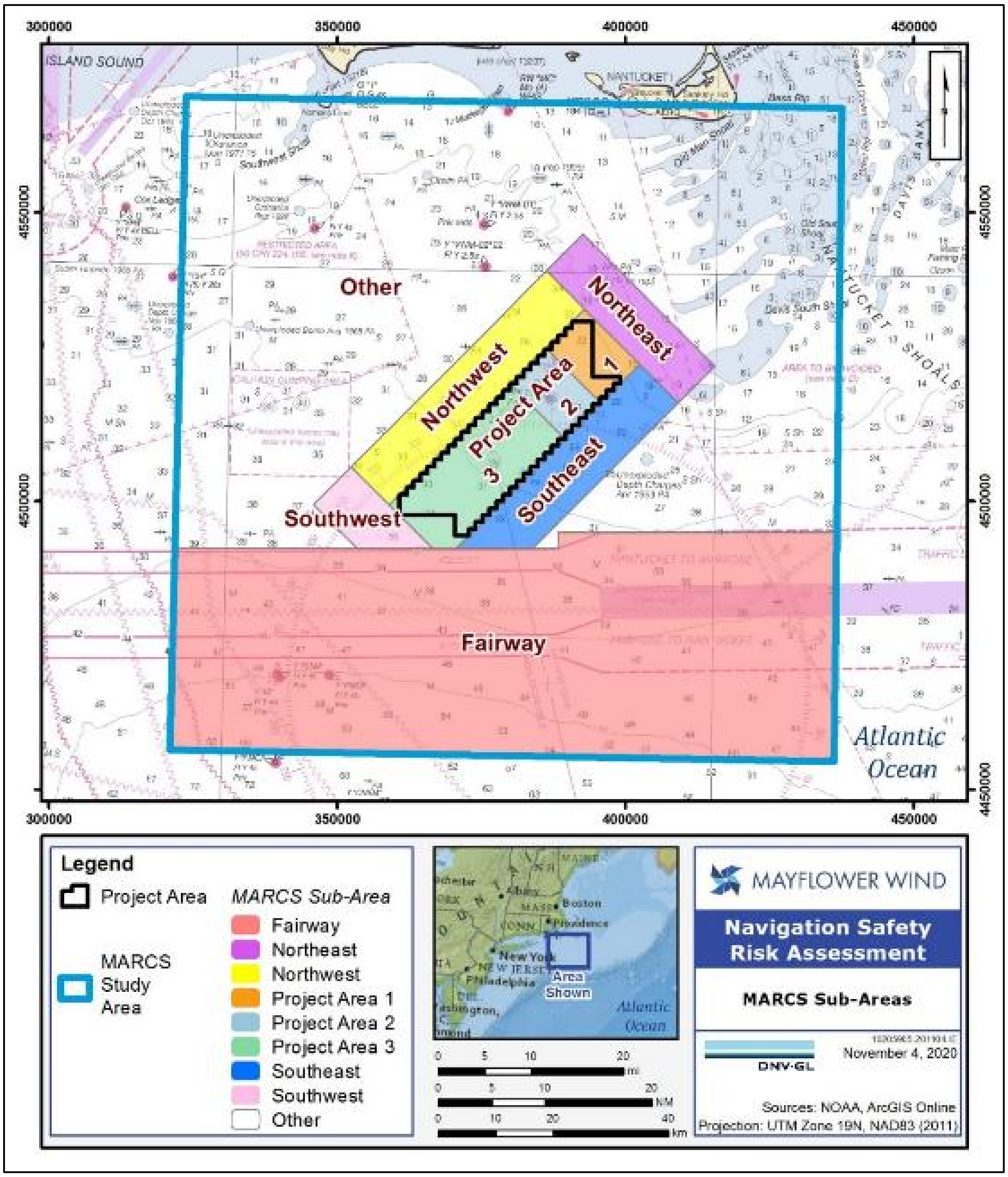


Figure 11-2 Sub-Areas Defined for Risk Modeling

11.1.1 Project Area

Table 11-4 presents the risk from the Project in the Project Area.

The summed risk increase in the Project Area is 0.36 marine accidents per year, an average of 1 additional accident of any severity every 2.8 years.

Table 11-4 Modeled Incremental Change in Accident Frequencies from the Project in the Project Area (Annual Accident Frequencies)*

Vessel type	Drift allision	Powered allision	Drift grounding	Powered grounding	Collision	Total
Cargo / Carrier	0.011	0.001	0	0	0	0.012
Fishing	0.145	0.100	0	0	<0.0005	0.245
Other / Undefined	0.039	0.018	0	0	<0.0005	0.057
Passenger	0.003	<0.0005	0	0	0	0.003
Pleasure	0.012	0.017	0	0	<0.0005	0.029
Tanker	0.002	<0.0005	0	0	0	0.002
Tanker - Oil	0.004	0.001	0	0	0	0.005
Tug / Service	0.001	<0.0005	0	0	0	0.001
Total	**0.215**	**0.138**	**0**	**0**	**<0.0005**	**0.357**

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

Risk to fishing vessels in the Project Area increases by 0.25 marine accidents per year, comprising 69 percent of the total change to risk from the Project (Figure 11-3).

Since, by definition, all Project structures are in the Project Area, all of the modeled allision accidents occur here. A vessel in any sub-area could lose propulsion and drift into a Project structure. The postulated initiating event would occur outside the Project Area, but the accident would be accounted for in the Project Area.

Grounding risk is not anticipated in the Project Area because of the water depths.

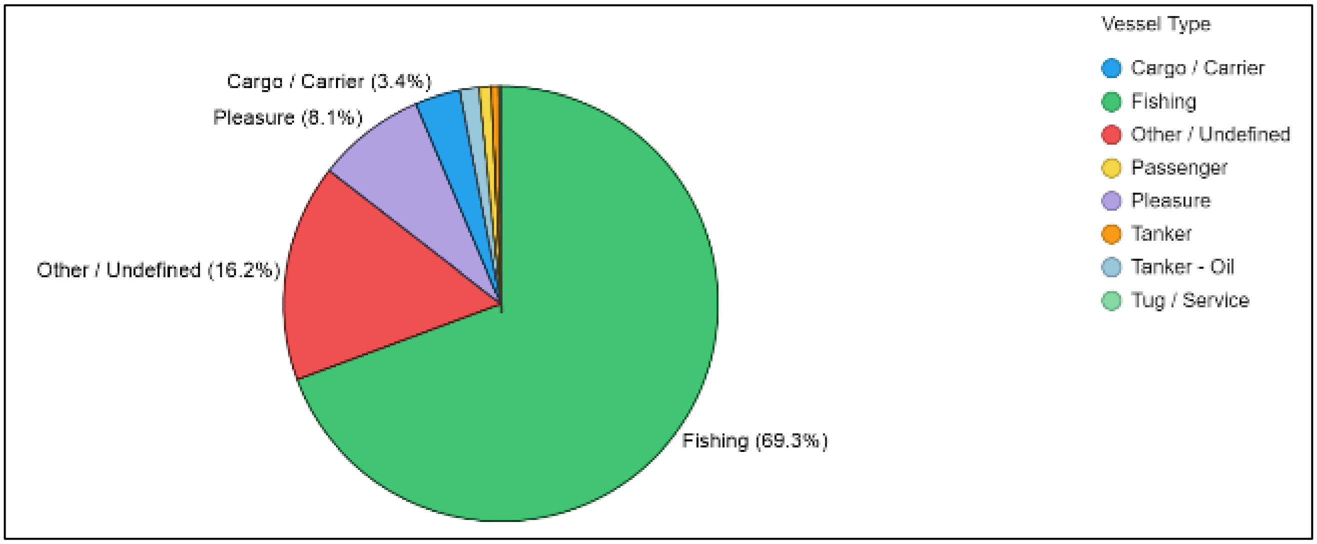


Figure 11-3 Relative Contribution to Project Risk from Each Vessel Type in the Project Area

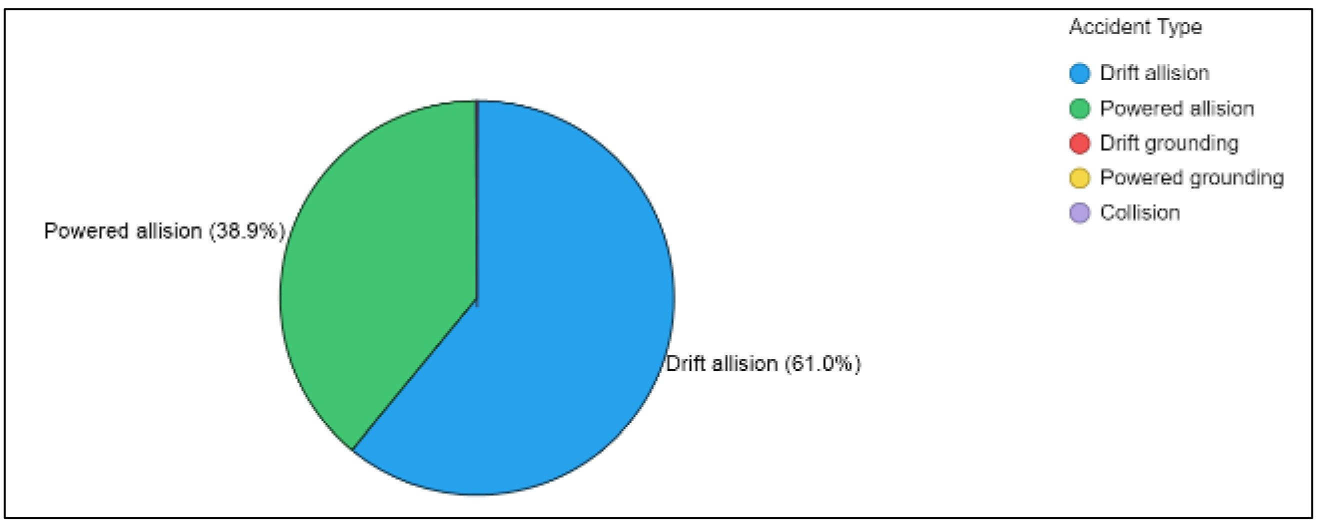


Figure 11-4 Relative Contribution to Project Risk from Each Accident Type in the Project Area

The Project Area was subdivided into three sections for the MARCS modeling (Project Area -Section 1, Section 2, and Section 3) to allow a clearer evaluation of how the exiting traffic relates to the risk increase from the Project. Figure 11-5 shows how much of the total modeled risk in the Project Area (0.35 accidents per year) is attributable to each section.

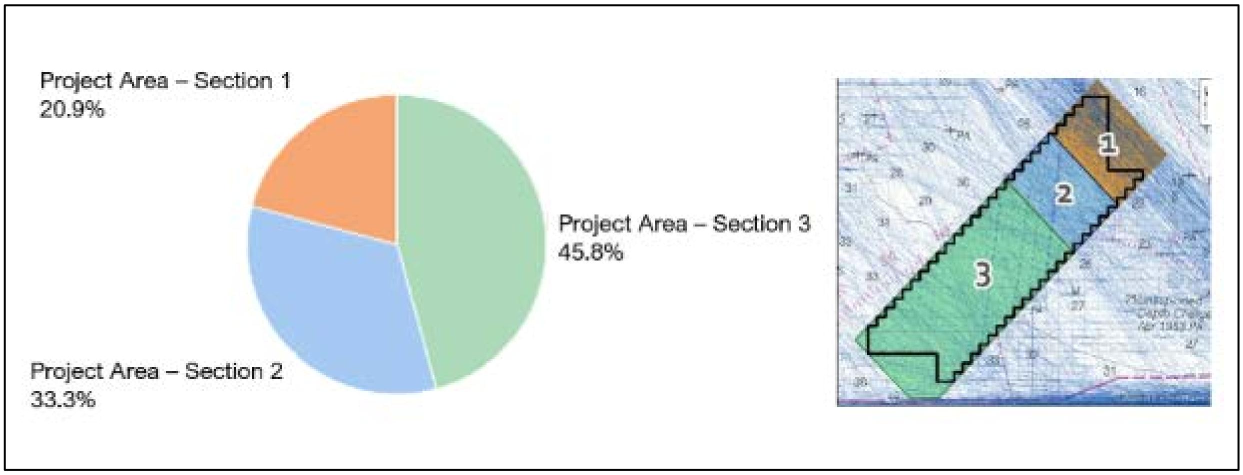


Figure 11-5 Spatial Distribution of Risk Within the Project Area

Focusing solely on cargo/carrier and tanker vessels in the Project Area, the risk increase for this group of vessels is 0.019 per year, equivalent to 1 additional accident every 52 years. Figure 11-6 and Figure 11-7 show that the accidents reflect the relative proportion of vessel types in the traffic, and the most common accident is drift allision. In the model, all deep draft traffic is routed around the Project, so all allisions of deep draft vessels are due to vessels off course or adrift.

The scenario contributing the most to deep draft risk is an onboard failure on a vessel outside the Project Area leading to the vessel eventually drifting into a Project structure.

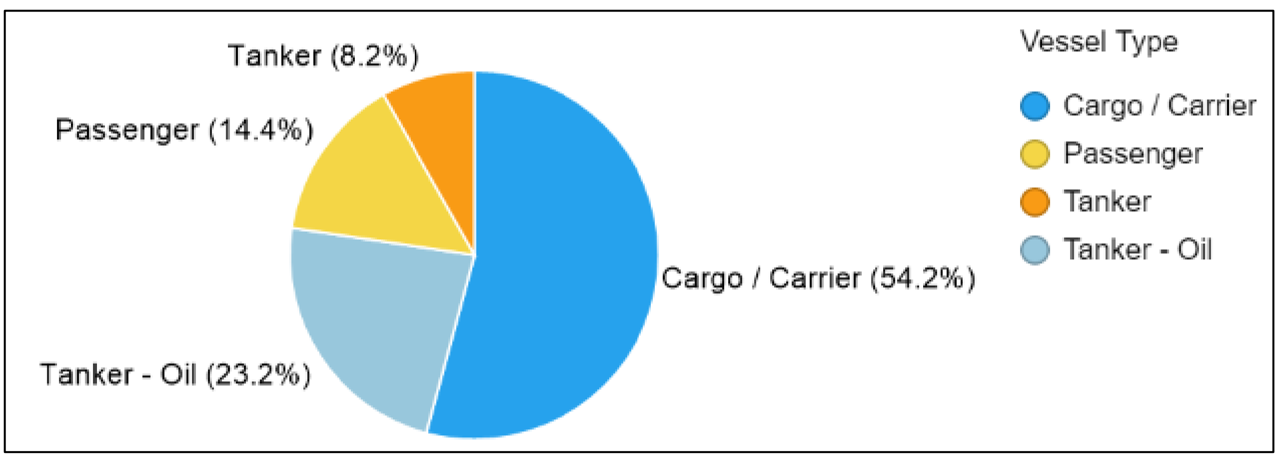


Figure 11-6 Relative Contribution of Project Risk from Deep Draft Vessel Types in the Project Area

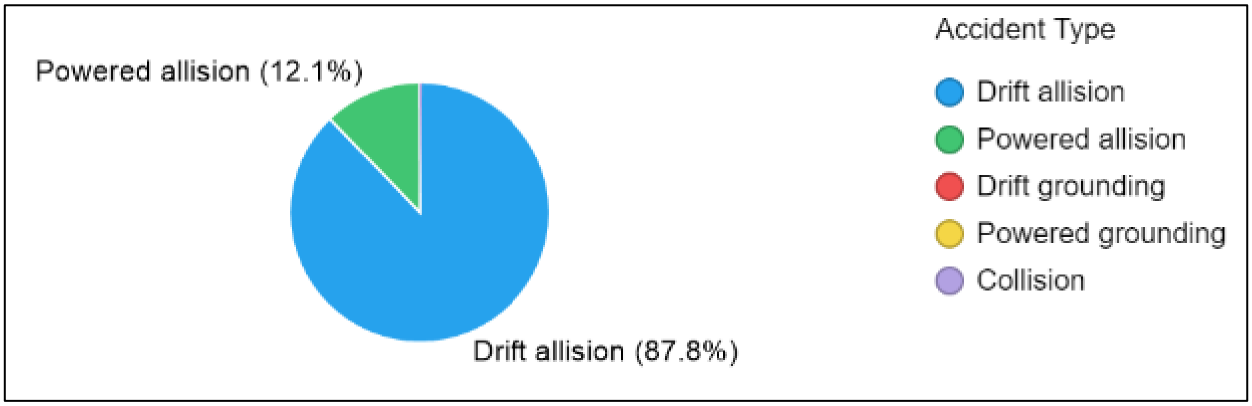


Figure 11-7 Relative Contribution of Accident Types Among Deep Draft Vessel Types in the Project Area

Figure 11-8 shows that nearly all of the deep draft allision risk lies in the southern section of the Project, closest to the Nantucket Ambrose Fairway. As discussed in the traffic survey (Section 2.1.1.1), there is no deep draft vessel traffic near Nantucket Shoals east of the Project.

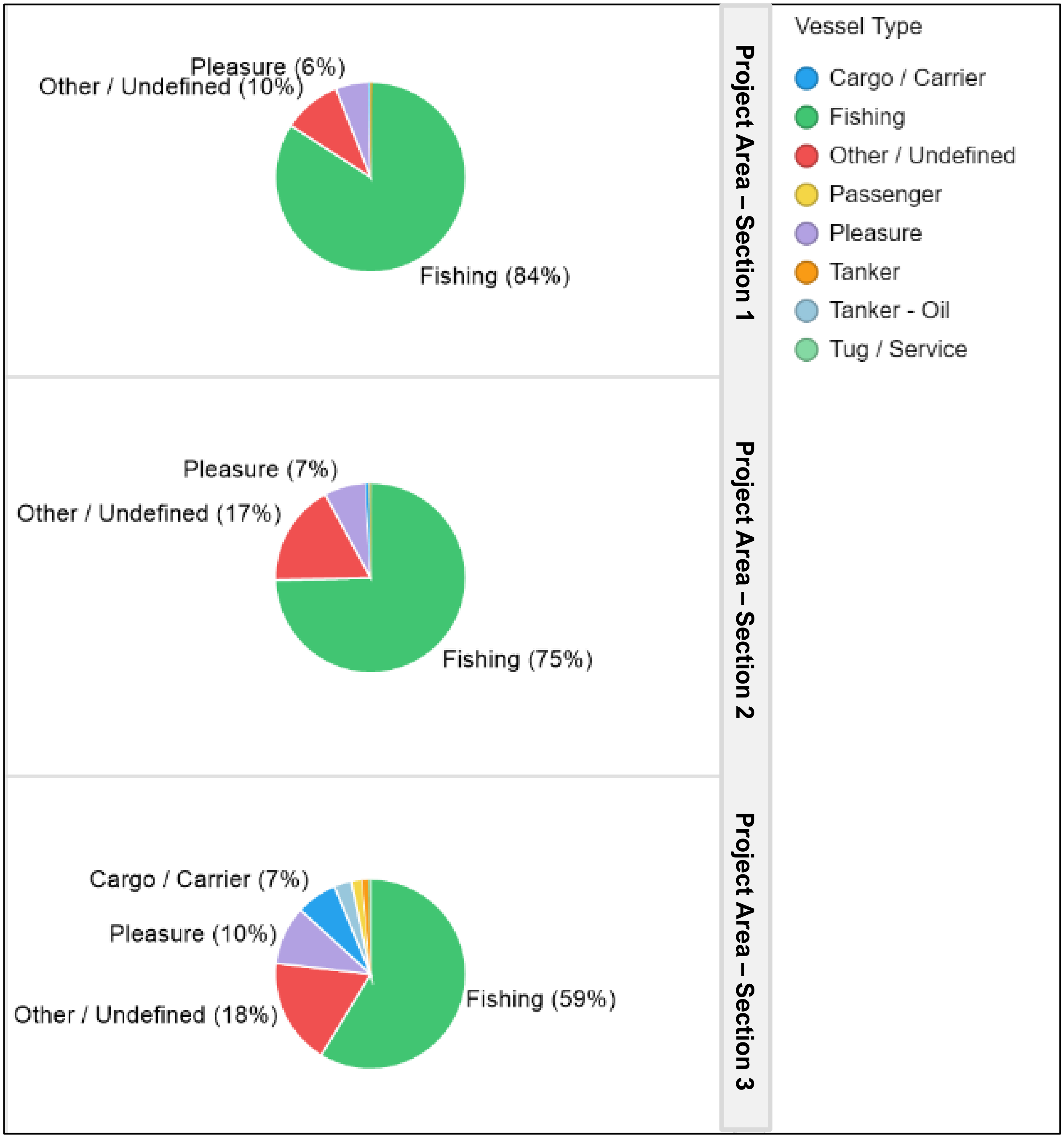


Figure 11-8 Risk Contributors Within the Three Sections of the Project Area

The risk results per structure (Figure 11-9) are within the same order of magnitude of risk. Because they are within a multiple of ten, at a high level, there is little differentiation between structures concerning summed risk. However, differences lie in which vessel types are involved, with cargo/carrier, tanker, and cruise ships increasingly contributing to the risk closer to the Nantucket Ambrose Fairway.

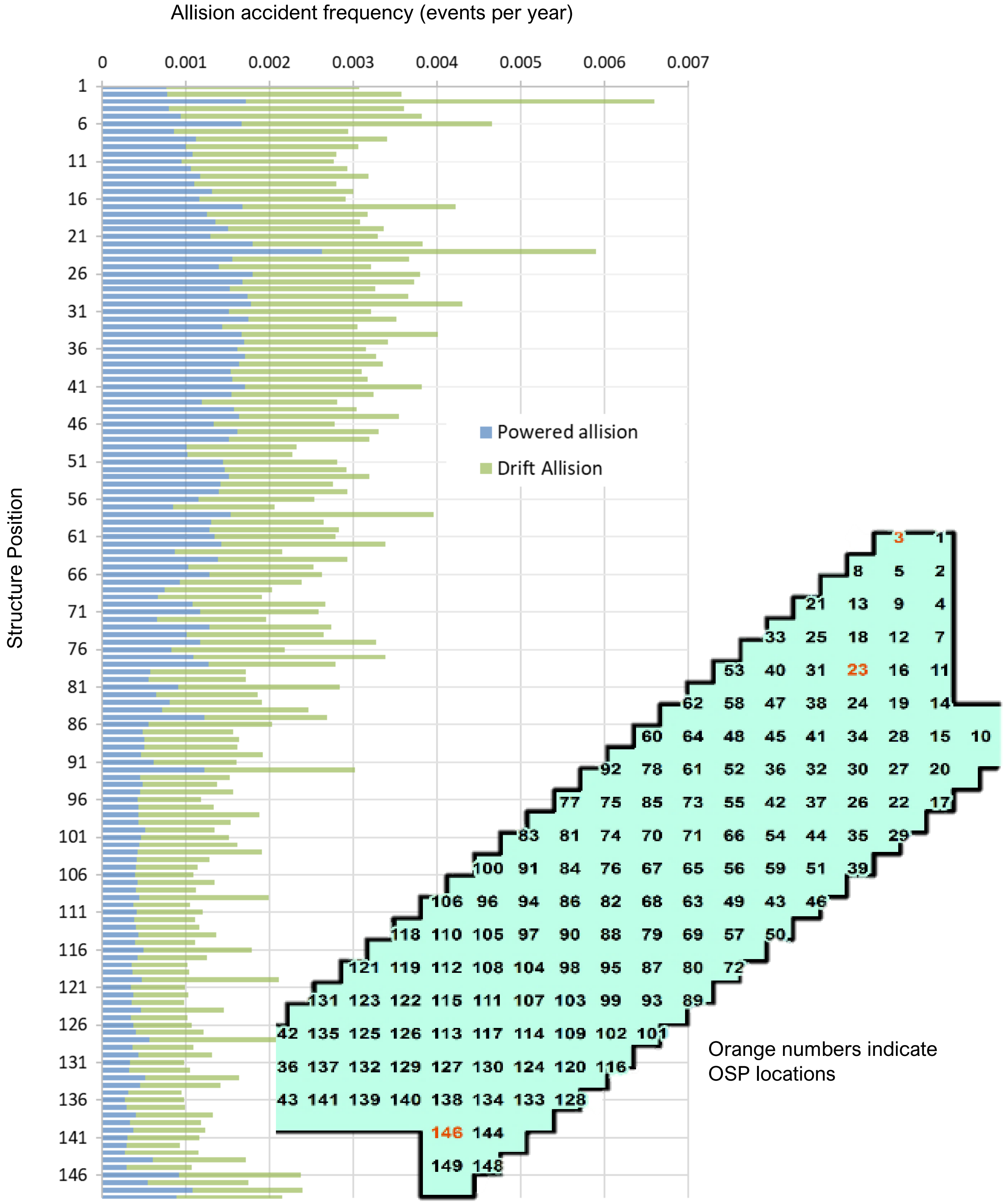
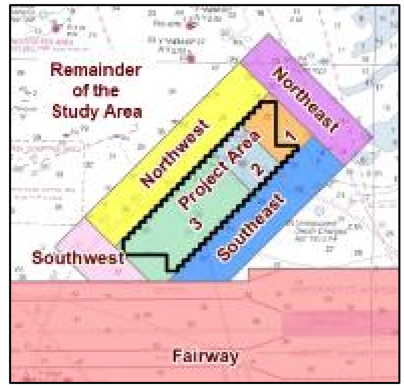


Figure 11-9 Allision Risk Per Structure (Numbering Not In Line With Planned Marking Scheme)

11.1.2 Adjacent sub-areas



The five sub-areas adjacent to the Project Area (NE, SE, SW, NW, and Fairway) surround it, and were created to evaluate the Project's influence on marine risk near the Project Area. By design, none of the adjacent sub-areas contain grounding risk or allision risk. The adjacent areas, summed together, show increased risk from the Project of 0.001 collisions per year, most of which lies within the Nantucket Ambrose Fairway. This is equivalent to an additional accident every 900 years.

Given the design of this assessment, it is possible that some of the modeled risk assigned to the Project Area could instead be realized in the adjacent sub-areas. For instance, if a vessel on course with a perimeter structure took emergency evasive action it could instead strike a vessel transiting outside the Project Area. Given a number of such scenarios, one would expect that some evasive actions would succeed in avoiding an accident altogether and some would not; therefore, the model accident frequency presented above is an over-estimate of the risk posed by the Project.

11.1.3 Remainder of the South Study Area

This section describes the risk posed by the Project in the Remainder of the South Study Area, the large portion of the South Study Area that is not the Project Area or the five adjacent sub-areas. Changes in risk from the Project in the Remainder of the Study Area are presented in Table 11-5.

Table 11-5 Modeled Incremental Change in Accident Frequencies in the Remainder of the South Study Area (Annual Accident Frequencies)

Vessel type	Drift allision	Powered allision	Drift grounding	Powered grounding	Collision	Total
Fishing	-	-	0.002	<0.0005	0.001	0.003
Pleasure	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Cargo / Carrier	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Other / Undefined	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Tanker - Oil	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Tug / Service	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Passenger	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Tanker	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Total	**-**	**-**	**0.002**	**<0.0005**	**0.001**	**0.003**

This is a large area - many times larger than the sub-areas combined. The risk increase from the Project is 0.003 accidents of any level of consequence per operating year of the Project. It is a direct result of the model assumption that 20 percent more fishing vessels would transit in the Project Area in the future because of the presence of Project structures.

In this large area, fishing and pleasure vessels comprise about 95 percent of the 0.003 accidents per year risk from the Project. Concerning the type of accidents, drift groundings (likely off Nantucket), comprise 62 percent of the risk from the Project, while collisions comprise another 37 percent of the risk from the Project.

11.2 Consequences of marine accidents

11.2.1 Consequences from a collision

In a collision, 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 (DWT), collision angle, and location of contact on the vessels. The most extreme collisions in the historical data resulted in fatalities and total loss of a vessel.

11.2.2 Consequences from a grounding

The most likely consequence to a vessel from a grounding on a soft seabed is minor vessel damage because of the low energies involved when seas are calm. However, Coast Pilot 2 (NOAA, 2020a) describes the seriousness of the hazard:

> "Because of the great danger of stranding and for reasons of environmental protection, the International Maritime Organization (IMO) has established an area to be avoided in the area of Nantucket Shoals. All vessels carrying cargoes of oil or hazardous materials and all other vessels of more than 1,000 gross tons should avoid the area…"

When two or more unwanted failures/conditions occur in combination near the shoals, severe damage or even structural failure can occur. Examples are:

- Navigation system failure and human error in recognizing the failure
- A loss of propulsion and bad weather

Less likely in the south Study Area, a grounding on a rocky bottom could also lead to structural damage and eventual structural failure.

11.2.3 Consequences from an allision

A wide range of potential consequences to a vessel exists should an allision occur. The least severe consequence is a smaller vessel (e.g., less than 20 m [65 ft] LOA) is adrift in calm seas and good weather and grazes a Project structure. 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. As the impact energy increases (a function of effective speed and weight), the severity of consequences from an allision increases. A bunker fuel or liquid cargo spill cannot be ruled out, although the oil tanker fleet in U.S. waters is entirely double hulled. 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.)

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

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

11.3 Control of marine accident risks

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

Aspects that affect the risk level from the Project include:

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

Risk controls – Maritime

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

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

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

As noted in Section 2, routing measures have been established by the 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.

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

One type of study conducted by the 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 this study is to reconcile the need for safe access routes with other waterway uses. A PARS is typically conducted before the USCG establishes or changes Regulated Navigation Areas or Traffic Separation Schemes.

The PARS relevant to this assessment published as of December 2020 are:

- Final Port Access Route Study: The Areas Offshore of Massachusetts and Rhode Island (MARIPARS), which was published on 27 May 2020 (USCG, 2020a)
- Atlantic Coast Port Access Route Study (USCG, 2015a)
- Buzzards Bay Port Access Route Study (USCG, 2004)

Ongoing PARS in the area include:

- Atlantic Coast Port Access Route Study: Port Approaches and International Entry and Departure Transit Areas announced on 15 March 2019 (84 FR 9541)
- Port Access Route Study: Seacoast of New Jersey Including Offshore Approaches to the Delaware Bay, Delaware announced on 5 May 2020 (85 FR 26695)
- Port Access Route Study: Northern New York Bight announced on 28 June 2020 (85 FR 38907)

Results in PARS reports, including recommendations,

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

The Project conforms to the recommendations in the MARIPARS final report concerning WTG layout, including a standard and uniform grid pattern of structures located 1 NM x 1 NM (1.9 km by 1.9 km) apart, which provides:

> "Lanes for vessel transit should be oriented in a northwest to southeast direction, 0.6 NM to 0.8 NM wide. This width will allow vessels the ability to maneuver in accordance with the COLREGS while transiting through the MA/RI WEA.
>
> Lanes for commercial fishing vessels actively engaged in fishing should be oriented in an east to west direction, 1 NM wide.
>
> Lanes for USCG search and rescue operations should be oriented in a north to south and east to west direction, 1 NM wide. This will ensure two lines of orientation for USCG helicopters to conduct search and rescue operations." (USCG, 2020a)

The study states that if a conforming layout is adopted and approved by BOEM, "the USCG will not pursue vessel routing measure through the MA/RI WEA at this time", presumably because the layout plays a key role in assuring an acceptable level of navigation safety.

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

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

Risk controls – Offshore wind farms

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

During the design and construction stages of an offshore wind farm, a set of design and construction standards lay out 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).

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

Good industry operational practices include:

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

Spacing of WTGs is generally guided by energy production targets, turbine size, available area, wind distributions, and other factors. Regularly spaced turbines can facilitate USCG SAR. Management of risk due to adjacent location of several large offshore wind farms is a nascent challenge in the industry, and many options are being evaluated (see Section 11.4). Adjacent leaseholders have established a Marine Affairs Working Group to address navigation, emergency response, and other safety issues common to all.

Vessel safety for shallow draft vessels (i.e., generally vessels with drafts less than 15 m [49.2 ft]) is a potential concern. Within a wind farm, this is particularly true in poor visibility or high sea states. Advance warnings to mariners and education initiatives could reduce the likelihood of a vessel in peril in the offshore wind farm under such conditions.

The MARIPARS report recommends that mariners desiring to transit the area should use extra caution, ensure proper watch, and assess risk prior to entering an offshore wind farm.

11.3.1 Potential risk control measures

This assessment provides risk information to enable the USCG to evaluate whether Project risks are reduced to meet ALARP criteria. Many risk control measures have been identified throughout this document as standard industry practice or good industry practice. By definition, these should be implemented per ALARP principles.

This study has identified risk control measures that are used in some jurisdictions. Project commitments are listed in Section 17. The below measures are not necessarily standard or best practices, and are listed in alphabetical order:

- Additional ATON
- AIS transponders on Project structures
- Additional cable protection measures, such as armored ducting, rock placement, or concrete mattresses
- Communications repeaters on Project structures
- Designation of additional anchorages
- Designation of additional routing measures
- Designation of areas to be avoided or limited access areas
- Designation of routes for specific vessel types
- Emergency response planning and exercises
- Extension of cellular service

- Fishing / transits limited to daytime
- Highly robust subsea cable protection
- Ice hazard protocol
- Increased requirements for life safety equipment onboard all vessels
- Maximum LOA for vessels allowed to transit the wind farm
- Measures to reduce safety risk for highest risk vessels in the area, i.e., USCG inspections
- Offshore cameras (to facilitate SAR)
- Offshore structures are accessible and can be used as a potential place of refuge
- Pilotage of deep draft vessels near the Project
- Prohibit use of specified designs/kinds of commercial fishing gear in the wind farm
- Project structures along perimeter equipped with radar beacon to allow clear identification via radar
- Real-time vessel monitoring in the wind farm
- Safety zone of 500 m (1,642 ft) around construction vessels during wind farm construction
- Safety zone 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
- Tug on standby to assist vessels in distress
- Vessel design and equipment maintenance requirements for all vessels entering a wind farm
- Vessel traffic services
- Visible and consistent marking and lighting of each structure

11.4 Cumulative effects

Cumulative effects from proposed offshore wind farms on navigation were evaluated on a qualitative basis for the other BOEM leases in the Study Area (Figure 11-10).

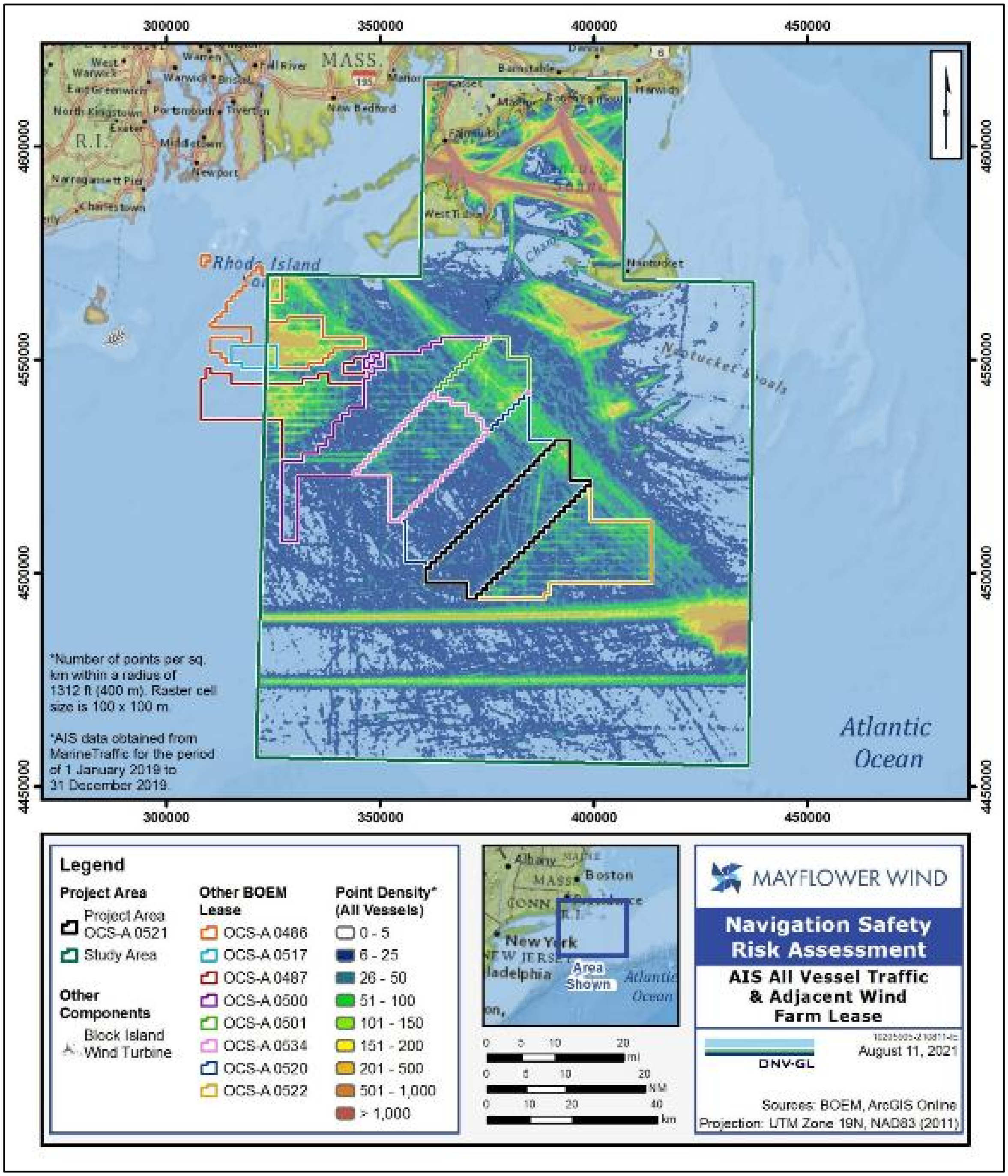


Figure 11-10 AIS Traffic with Mayflower and Adjacent OREI Leases[4]

Potential effects related to navigation safety resulting from the projects in combination may include:

1. Deep draft and tug traffic that currently transits through the leases may instead decide to take routes to the west of the leases, avoiding Nantucket Shoals east of the leases.

2. Commercial fishing traffic that currently transits through the leases may instead decide to take routes to the east or west around the lease areas, despite the conservative approach taken in the modeling that assumes fishing traffic continues to transit through the lease areas.

   - These vessels generally avoid TSS, per Coast Pilot guidance (NOAA, 2020a). Deep draft vessels generally follow only the TSS, so a result would be an increase in interaction among the various vessel types, which may increase navigation risk.
   - An increase in distance sailed and resultant increase in vessel transit time. The preliminary identified effects 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
     - Increase in the number of vessel transits and therefore the vessel density, particularly in the Buzzards Bay traffic lanes, and therefore increased interactions between different vessel types.

3. Commercial and recreational fishing patterns may change in the future, changes which are largely unpredictable at this time.

4. The USCG MARIPARS report (USCG, 2020a) stated that SAR efforts may be more challenging in bad visibility or in high seas over the fairly large, contiguous area but that it would be able to execute its SAR mission if the entire Massachusetts/Rhode Island WEA array layout were in a 1 NM by 1 NM (1.9 km by 1.9 km) uniform pattern. A uniform pattern with a congruent layout is jointly proposed by leaseholders in the Study Area (Equinor Wind US, Eversource Energy, Mayflower Wind, Orsted North America, and Vineyard Wind LLC, 2019).

12 EMERGENCY RESPONSE CONSIDERATIONS

To determine the impact on emergency response missions, SAR and marine environmental protection/ response were assessed.

The MARIPARS (2020a) report provides a summary of SAR incident data for 14 years through the year 2018. The number and types of cases discussed below are taken from that report. Based on mission data determined to be of high quality by the USCG, an average of 9.5 SAR cases per year occurred in the MARIPARS study area, which encompassed the NSRA MARCS Study Area. The locations of SAR cases over the 14-year period (USCG, 2020a) are shown in Figure 12-1.

Significantly, the high-quality data do not include: SAR cases that drift into the WEA, SAR assets transiting through the WEA to reach a SAR location, and towing/transporting a disabled vessel through the WEA.

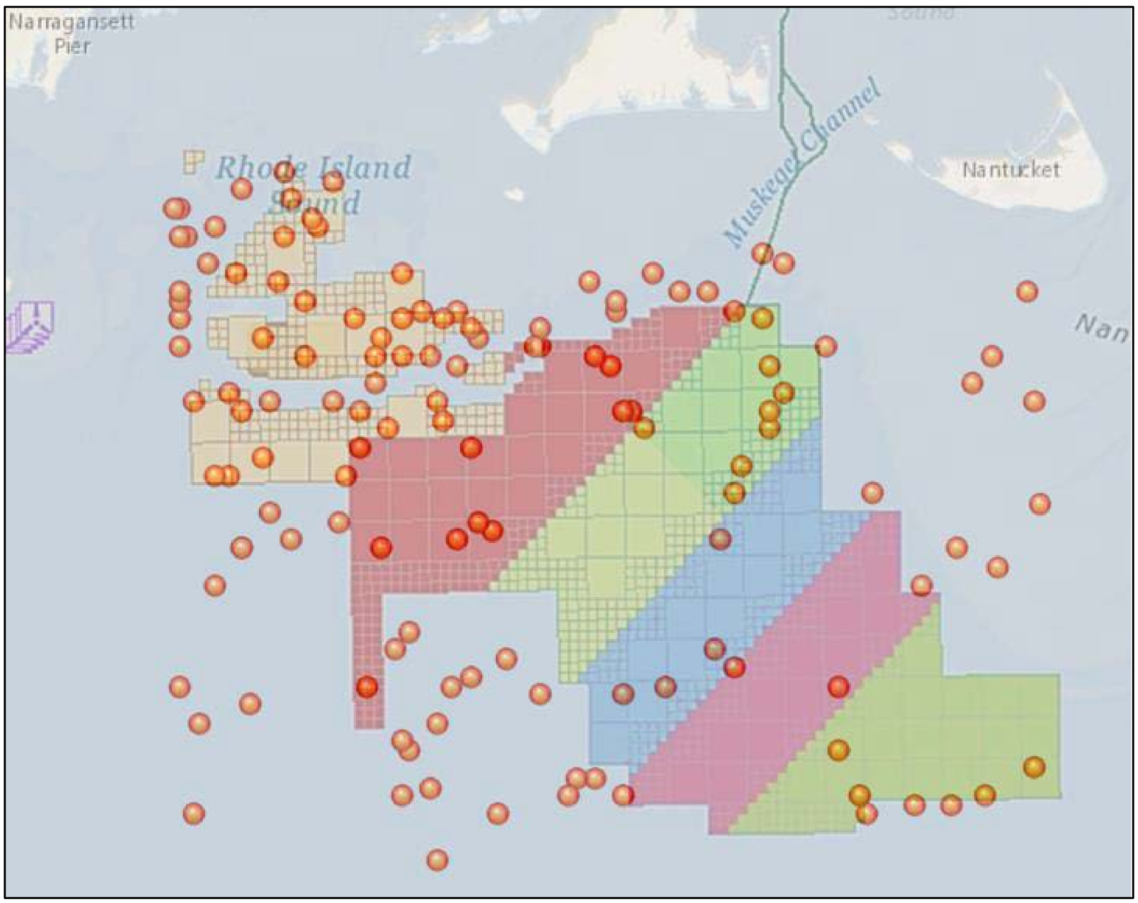


Figure 12-1 Locations of SAR Cases 2005-2018 (Taken from USCG, 2020b)

Figure 12-2 and Figure 12-3 show the number of SAR cases per year in the MARIPARS study area and the distribution of the types of cases.

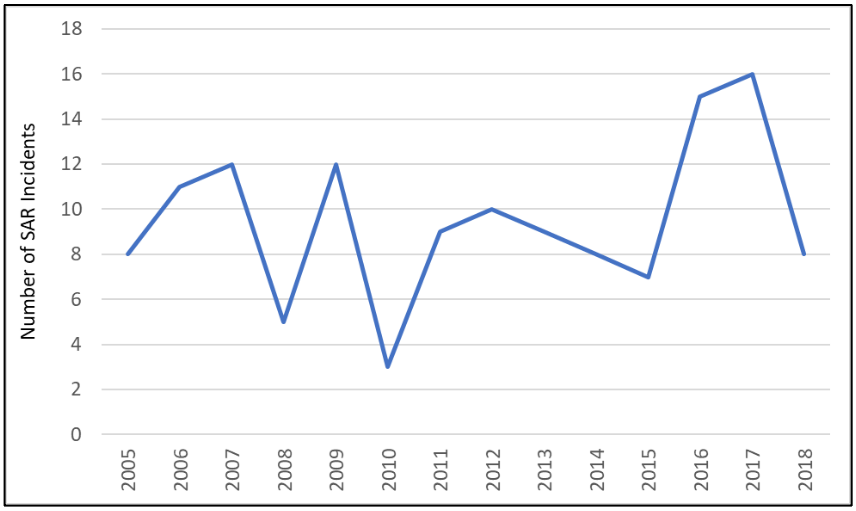


Figure 12-2 Number of SAR Cases per Calendar Year in the MARIPARS Study Area (USCG, 2020a)

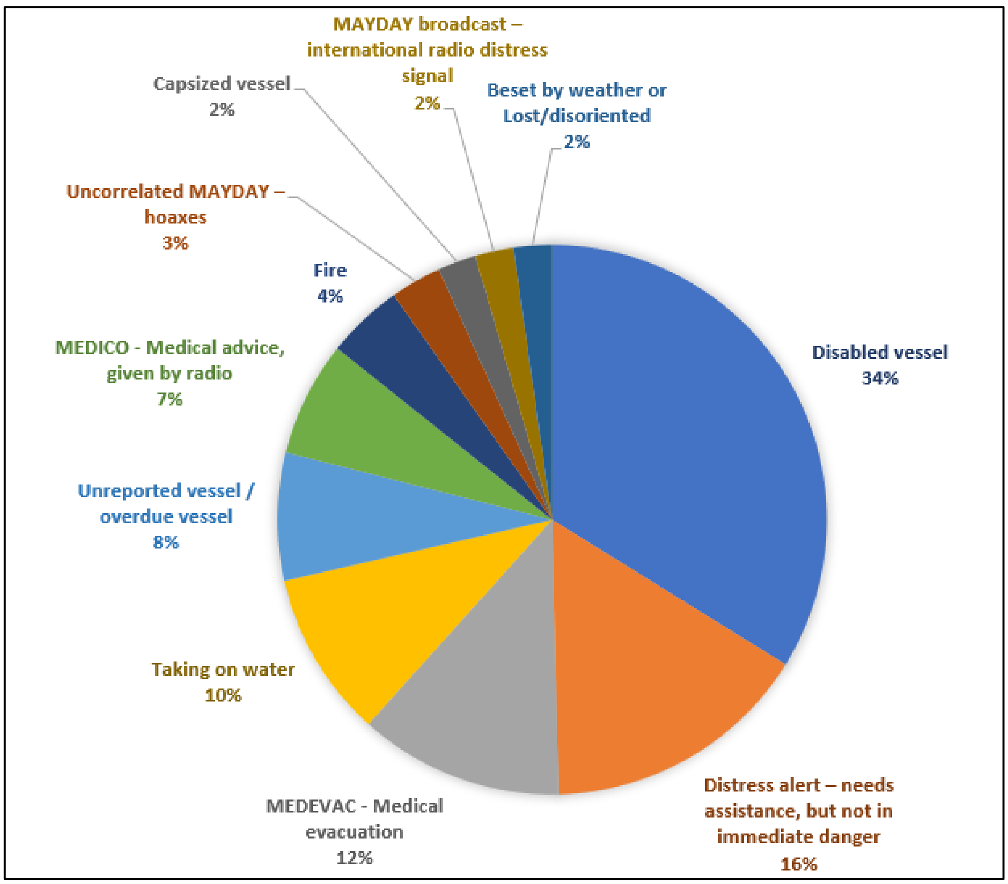


Figure 12-3 Percentage of SAR Cases by Type in the MARIPARS Study Area (Taken from USCG, 2020a)

The layout of the Project is a factor that will be considered by the USCG when planning SAR activities in the Project Area. The MARIPARS states,

> "Multiple orientations of 1 NM spacing between structures would provide more flexible options for search patterns, especially where USCG assets are constricted by weather and wind. In some cases, weather and wind may be so severe as to not allow for USCG assets to go into the WEA."

Project offshore structures will be equally spaced in a grid-type pattern, 1 NM (1.9 km) apart. This conforms to the USCG helicopter pilot recommendation for minimum spacing between structures along a search path (USCG, 2020a) and visual flight rules in 14 CFR 91.155 specifying a minimum of 0.5-statute-mile visibility in daytime without clouds.

Table 12-1 lists the available information specifically requested in NVIC 01-19 regarding emergency response. The extent of SAR activities for any case is dependent on many factors and may encompass a large offshore area. Two SAR cases were recorded in the Project Area over a 14-year period (USCG, 2020a); however, the search area for other cases in the MARIPARS data was likely to have included all or a portion of the Project Area.

The NVIC also requests information on cases at night or in poor visibility/low ceiling, cases involving aircraft (helicopter, fixed-wing) searches, and number of times commercial salvors responded to assist vessels in the proposed structure region over the last ten years. These data were not included in the MARIPARS report and are not available in the public domain.

Table 12-1 Summary of SAR Cases

Situation	Number of occurrences
SAR cases conducted by USCG in the Project Area	In the Project Area, an average of 0.14 cases per year; In the MARIPARS study area, an average of 9.5 cases per year (USCG, 2020a).
Additional SAR cases estimated by modeling due to allision with the Project structures	A maximum estimated additional 0.4 marine accidents per year (conservative maximum estimate based on modeling presented in Section 11).

The USCG MARIPARS report (USCG, 2020a) stated that SAR efforts may be more challenging in bad visibility or in high seas over the fairly large, contiguous area. The report concluded,

> "After considering all options and the vessel traffic patterns within the MA/RI WEA, a standard and uniform grid pattern with at least three lines of orientation throughout the MA/RI WEA would allow for safe navigation and continuity of USCG missions through seven adjacent wind farm lease areas over more than 1400 square miles of ocean."

Another aspect identified in this NSRA is that the presence of structures will allow their markings / lighting to assist with position reporting, potentially assisting responders.

Cases of marine environmental protection/response were not mentioned in the MARIPARS report. An analysis was conducted of marine casualty data from January 2002 through July 2015 (USCG, 2015b). Although the data are not as recent as would be preferred, trends in both the number of spills and quantity spilled have shown a marked decline since 1970 and even since 2000 (USCG, 2012; ITOPF, 2021), indicating that use of this data is likely to result in a conservative estimate because the data is aged by 5 years.

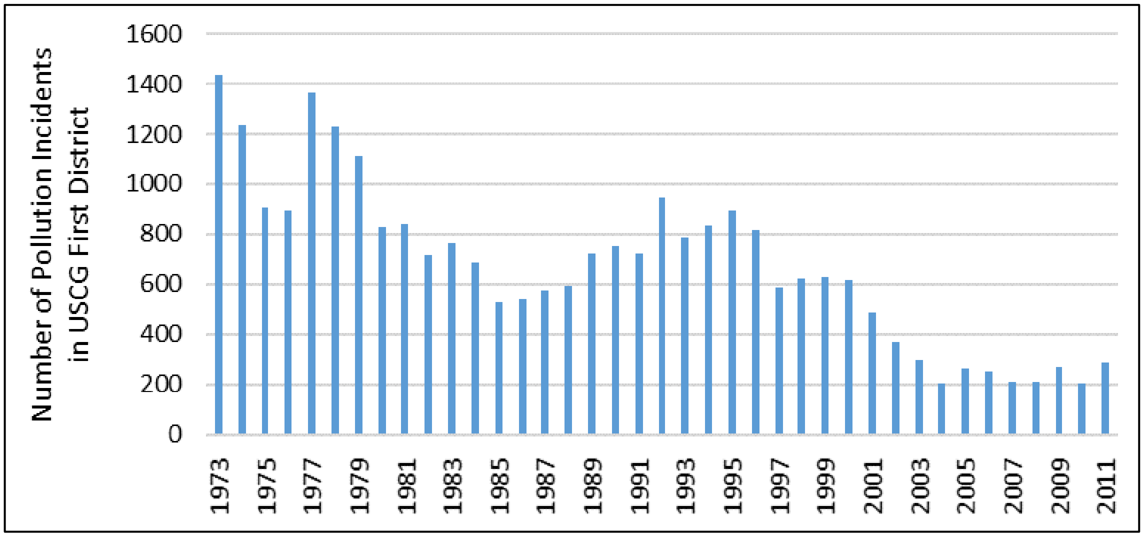


Figure 12-4 Number of Marine Pollution Incidents in USCG First District: 1973 - 2011 (USCG, 2012)

It is assumed that the great majority of offshore marine spills in the South Study Area that were entered into the marine pollution database would have been marine environmental protection/response cases.

Based on the pollution events with recorded locations over 14 years, there have been 16 suspected or acknowledged pollution events in the South Study Area; an average of 1.1 per year. The largest estimated spill quantity was 568 liters (150 gallons) and 15 of the 16 spills were less than 114 liters (30 gallons). The primary vessels involved (13 of the 16) were fishing or recreational vessels. Over the same period, there were 453 marine casualties in the South Study Area, a ratio of about 3.5 reported/suspected spills per 100 marine casualties. (USCG, 2015b)

The summed accident frequencies estimated via modeling (see Section 11) is 0.3 per year, of which, only a small portion would result in a marine environmental protection case. Very likely, less than 10 in 100 accidents would result in a spill of any size. The resulting estimate is 0.03 additional cases per year, on a maximum base occurrence rate of 1.1 per year.

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 (ref https://www.itopf.org/knowledge-resources/data-statistics/statistics/) and have been decreasing over time (Figure 12-3).

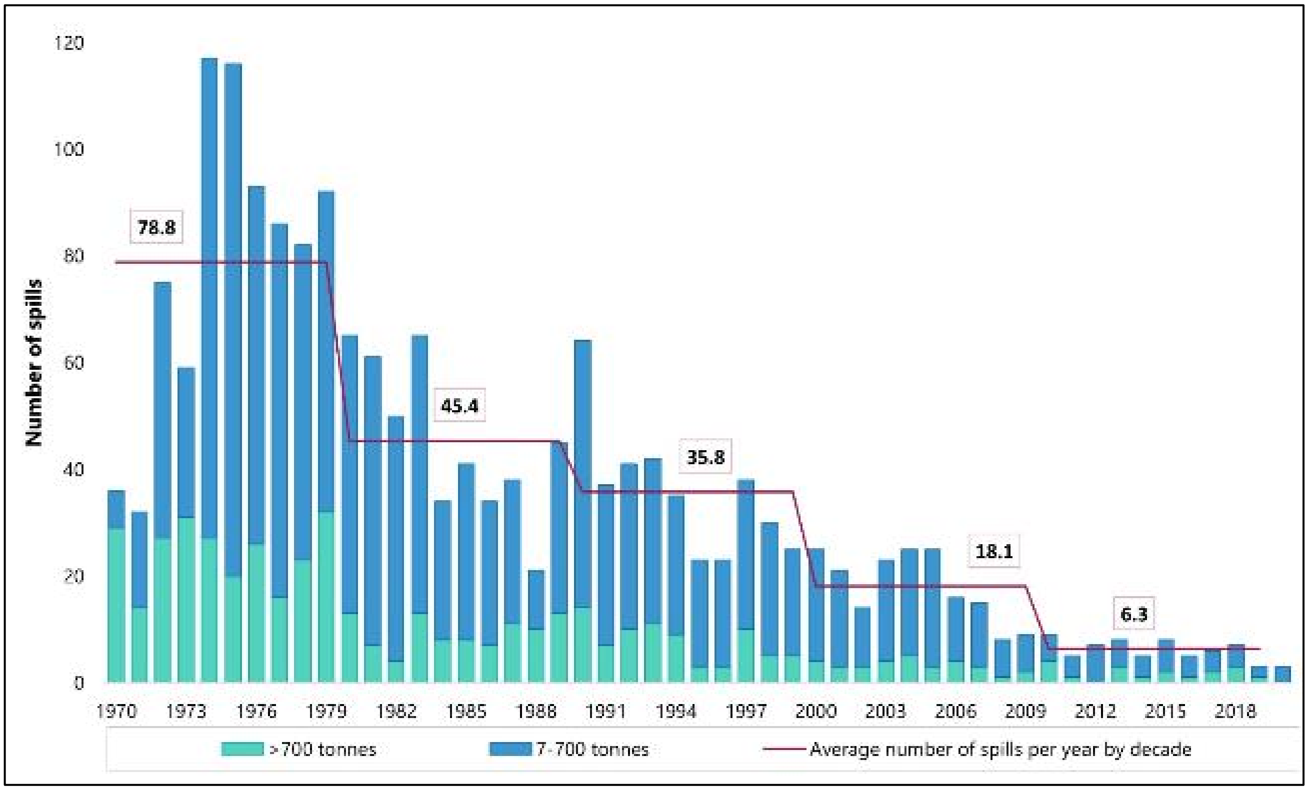


Figure 12-5 Global Oil Spill Trend from Tankers (ITOPF, 2021)

The most common material spilled is oil. Historically, vessels with oil cargoes were the primary sources of spills; 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.

13 FACILITY CHARACTERISTICS

The structures in the leases contiguous with the Project (see previous Figure 11-10) will be marked with identifiers that have a consistent pattern across the leases, as agreed between the developers, BOEM, and USCG. The identifiers for the Project structures are listed in Appendix A. Marking of offshore structures is specified in international standards and USCG guidance.

The most relevant standards include:

- First Coast Guard District Local Notice to Mariners 44/20, “ME, NH, MA, RI, CT, NY, NJ-Atlantic Ocean-Offshore Structure PATON Marking Guidance-Revised” (USCG, 2020b)
- 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
- “Draft Proposed Guidelines for Providing Information on Lighting and Marking of Structures Supporting Renewable Energy Development” (BOEM, 2019)

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

Marking and lighting of the structures will be subject to future permitting and BOEM and USCG oversight, including USCG availability standards. Project ATON are likely to include the following, and include 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 Light 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 9-2. 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 seabed 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 OSP(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 (Mayflower Wind, 2020).

15 OPERATIONAL REQUIREMENTS

Personnel in the onshore control center will monitor the offshore wind Project 24 hours per day, 7 days per week. Outlines of the Safety Management System and Emergency Response Plan are provided as separate appendices in the Project COP (Appendices Z and AA, respectively). They will continue to be updated as Mayflower Wind progresses design, construction, and operations. In their implemented form, these documents will specify the tools (such as updated navigation charts) and contact numbers that will be available for use in an emergency (Mayflower Wind, 2020). 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 (Mayflower Wind, 2020). 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 CONTROLS

The primary conclusions of this study are:

1. Site location and coordinates
   - 1 NM (1.9 km) is the nominal distance between Project structures[10], and the structures will be aligned, providing multiple routes through the Project.[11]
2. Traffic survey
   - There is wide variance in traffic density, vessel types, and vessel sizes within the Study Area.
     - Vessel traffic in the northern part of the Study Area is highly seasonal and mainly comprised of smaller vessels, most of which do not enter the southern portion of the Study Area.
     - A portion of a major fishing vessel transit route in the area crosses the northeastern part of the Project Area.
     - Vessel traffic in the southern part of the Study Area is more complex due to interactions between deep draft vessels and fishing vessel tracks in the Nantucket Ambrose Fairway, outside the Project Area.
     - Most of the deep draft vessel transits are to the west and south of the Project. The great majority of deep draft vessel transits occur in the Nantucket Ambrose Fairway traffic lanes along the southern edge of the Study Area.
3. Offshore above water structures
   - The primary hazards to transiting vessels include powered and drifting allision.
   - Subsea cables can pose a hazard to vessels who are actively fishing with bottom gear in the Project Area.
   - The minimum air clearance from a WTG would pose a hazard to a vessel taller than 16.75 m (54.95 ft) in line with the blades.
   - The minimum air clearance from an OSP would pose a hazard to a vessel taller than 18.8 m (61.7 ft) under the topsides, potentially as large as 100 m x 70 m (328 ft x 230 ft).
   - Helicopter-aided SAR may be a higher-risk activity within the Project Area, more so in poor visibility.
   - The MARIPARS report concluded that spacing between Project structures similar to the evaluated layout provides sufficient sea room for maneuvering for vessel types expected to transit and fish in the offshore wind Project assuming that “mariners desiring to transit the area should

[10]The target value or requirement, knowing that site conditions may cause small fluctuations.
[11] The five New England offshore wind leaseholders proposed 1 NM spacing between WTGs in fixed east-to-west rows and north-to-south columns to create a 1 NM by 1 NM grid arrangement in November 2019 (Equinor Wind US, Eversource Energy, Mayflower Wind, Orsted North America, and Vineyard Wind LLC, 2019).

	use extra caution, ensure proper watch, and assess risk prior to entering an offshore wind farm." (USCG, 2020a)
4. Offshore under water structures	• A separate preliminary cable burial risk assessment recommends a burial depth of 1 m to 2 m (3.3 ft to 6.6 ft), accounting for possible interactions with ferry anchors fishing gear, and other factors.
5. Navigation within or close to a structure	• Important risk controls during construction include safety zones, communication to local mariners, and on-scene safety vessel(s) and/or personnel as necessary. • Important risk controls during operation include the Project's distance from established traffic lanes, limited deep draft and tug traffic through the Project Area, mariner diligence, and offshore standard work safety practices.
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.
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. o Gale and storm winds occur 0.77 percent of the time. o The visibility in the area is less than 2 NM (3.7 km) 12.7 percent of the time.
8. Configuration and collision avoidance	• The MARIPARS report provides the following conclusion about potential effects of structures on SAR in the WEA, which includes the Project: "After considering all options and the vessel traffic patterns within the MA/RI WEA, a standard and uniform grid pattern with at least three lines of orientation throughout the MA/RI WEA would allow for safe navigation and continuity of USCG missions through seven adjacent wind farm lease areas over more than 1400 square miles of ocean." (USCG, 2020a) • The layout evaluated in this NSRA conforms to the layout described in MARIPARS and with the layout proposed by all of the developers of Rhode Island and Massachusetts lease areas (Equinor Wind US, Eversource Energy, Mayflower Wind, Orsted North America, and Vineyard Wind LLC, 2019).
9. Visual navigation	• Project structures are not anticipated to decrease vessel safety by obscuring the view of other vessels, ATON, or the coastline.
10. Communications, radar, and positioning systems	• The impacts on marine radar are variable, with the most likely effect being some signal degradation. Proximity to WTGs is the primary factor that determines the degree of radar signal degradation.

	• Due primarily to the quality of radars and the proficiency of professionally licensed crew, radar operations on commercial ships are not anticipated to be adversely affected by the Project. • Smaller vessels operating in the vicinity of the Project may experience radar clutter and shadowing; however, these effects can be reduced through operational adjustments.
11. Risk of collision, allision, or grounding	• In this assessment, the modeled increase in risk from the Project is 0.4 accidents per year. The majority of this risk is allision risk to fishing vessels. This is DNV GL's current best estimate of the additional risk that results from the presence of the Project. • The risk increase from the Project to cargo/carrier and tanker vessels is 0.019 per year, equivalent to 1 additional accident every 52 years. • A qualitative evaluation of the potential consequences of a marine accident due to the Project concluded that a wide range of outcomes are possible, with the majority of accidents being of a minor nature.
12. Emergency response considerations	• An estimated maximum of 0.4 SAR missions are anticipated per year in the Project based on the model results for collision, allision, and grounding. • The presence of structures will allow their markings / lighting to assist with position reporting, potentially assisting responders.
13. Facility characteristics	• Marking and lighting of the structures will be subject to future permitting and BOEM and USCG oversight, including USCG availability standards, and will be consistent across the WEA as agreed upon with the other lease holders (Mayflower Wind, 2020).
14. Design requirements	• The WTGs and OSP(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.
15. Operational requirements	• The onshore control center will monitor the Project 24 hours per day, 7 days per week.
16. Operational procedures	• The Project Safety Management System and Emergency Response Plan will specify the tools (such as updated navigation charts), contact numbers, and procedures to use in an emergency. An outline of the Safety Management System is provided as a separate appendix in the COP (Appendix Z).

Potential Project risk controls

Current Project plans include the risk control measures summarized in Table 17-1 (Mayflower Wind, 2020). The columns "Type" and "Threat or Hazard" are included to provide context; however, nearly all of the risk controls would reduce risks from several threats. The complex interrelationships between risk control benefits can be considered during the ALARP review.

Because the Project is still in planning and early design phases, these measures will be refined as the Project moves forward in the permitting process.

Table 17-1 Summary of Potential Project Risk Controls (Mayflower Wind, 2020)

Type	Threat or hazard	Primary control measure
Design	Allision of a vessel with a WTG	Uniform 1 NM x 1 NM minimum distance between Project structures; north-south/east-west alignment of structures, and alignment with structures in adjacent offshore wind projects.
Design	Vessel anchor or fishing gear snag on Project subsea cable	A preliminary cable burial depth risk assessment recommends a burial depth of 1 m to 2 m (3.2 ft to 6.5 ft) to provide adequate protection along ferry routes and to mitigate risks associated with bottom fishing gear. A seabed management plan will be developed for all installation and construction operations in the area.
Design	Vessel less certain of its location; USCG locating a vessel	Lighting and marking of Project structures according to permit requirements.
Design	Vessel less certain of its course or location relative to Project structures	PATON installed according to permit requirements.
Procedure	Vessel close to Project construction activity	USCG established safety zones around Project construction activities. Project safety vessel(s) and/or Project-related personnel on scene to advise mariners of construction activity, as necessary.
Procedure	Vessel not aware of high level of activity during construction in the Project Area	Project information issued by USCG as Notices to Mariners during construction, operation, and decommissioning activities.

Type	Threat or hazard	Primary control measure
Procedure	Project construction activities in unsafe conditions	A Project construction procedure will define a window related to wind, sea state, and other constraints under which construction activities will start/continue or will stop/be discontinued. Conditions and forecasts will be monitored to enable proactive planning and early warning of future unsafe conditions.
Procedure	Unsafe operation of the Project or continued operation of the Project during emergency conditions	A continuously-manned operations center will remotely monitor the Project and shut down WTGs if required.
Procedure	Vessel not aware of locations of Project-related hazards	Locations and details of offshore Project components will be provided to NOAA so they can be included on nautical charts.
Procedure	Vessel not aware of potential ice hazards	Publishing and/or broadcasting notices to mariners when icing conditions are present, when the WTGs are automatically shut down due to icing, or when ice build-up is observed.

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APPENDIX A – PROJECT OFFSHORE STRUCTURE COORDINATES

Table A-1 lists the locations of the offshore Project structures evaluated in this NSRA. Universal Transverse Mercator coordinate system (UTM) coordinates were provided by Mayflower Wind (2020) and the World Geodetic System 1984 datum (WGS84) decimal degree coordinates were calculated by DNV GL in ArcGIS 10.3.

Table A-1 Coordinates of Evaluated Structure Locations

Identifier	WGS84 UTM Zone 19N (m)		WGS84 (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
AZ46	391954	4530924	40.9223	-70.2832
AZ47	393806	4530924	40.92254	-70.2612
BA45	390102	4529072	40.90537	-70.3048
BA46	391954	4529072	40.90562	-70.2829
BA47	393806	4529072	40.90586	-70.2609
BB44	388250	4527220	40.88844	-70.3265
BB45	390102	4527220	40.88869	-70.3045
BB46	391954	4527220	40.88894	-70.2825
BB47	393806	4527220	40.88918	-70.2606
BC43	386398	4525368	40.87151	-70.3481
BC44	388250	4525368	40.87176	-70.3262
BC45	390102	4525368	40.87201	-70.3042
BC46	391954	4525368	40.87226	-70.2822
BC47	393806	4525368	40.8725	-70.2602
BD42	384546	4523516	40.85457	-70.3698
BD43	386398	4523516	40.85483	-70.3478
BD44	388250	4523516	40.85508	-70.3258
BD45	390102	4523516	40.85533	-70.3039
BD46	391954	4523516	40.85558	-70.2819
BD47	393806	4523516	40.85582	-70.2599
BE41	382694	4521664	40.83763	-70.3914
BE42	384546	4521664	40.83789	-70.3694
BE43	386398	4521664	40.83815	-70.3475
BE44	388250	4521664	40.8384	-70.3255
BE45	390102	4521664	40.83865	-70.3035
BE46	391954	4521664	40.8389	-70.2816
BE47	393806	4521664	40.83914	-70.2596
BF40	380842	4519812	40.82068	-70.413
BF41	382694	4519812	40.82095	-70.391
BF42	384546	4519812	40.82121	-70.3691
BF43	386398	4519812	40.82147	-70.3471
BF44	388250	4519812	40.82173	-70.3252
BF45	390102	4519812	40.82198	-70.3032
BF46	391954	4519812	40.82222	-70.2813
BF47	393806	4519812	40.82246	-70.2593
BF48	395658	4519812	40.8227	-70.2373
BF49	397510	4519812	40.82293	-70.2154
BG39	378990	4517960	40.80373	-70.4346
BG40	380842	4517960	40.804	-70.4126
BG41	382694	4517960	40.80427	-70.3907

Identifier	WGS84 UTM Zone 19N (m)		WGS84 (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
BG42	384546	4517960	40.80453	-70.3687
BG43	386398	4517960	40.80479	-70.3468
BG44	388250	4517960	40.80505	-70.3248
BG45	390102	4517960	40.8053	-70.3029
BG46	391954	4517960	40.80554	-70.2809
BG47	393806	4517960	40.80578	-70.259
BH38	377138	4516108	40.78678	-70.4562
BH39	378990	4516108	40.78705	-70.4342
BH40	380842	4516108	40.78733	-70.4123
BH41	382694	4516108	40.78759	-70.3903
BH42	384546	4516108	40.78785	-70.3684
BH43	386398	4516108	40.78811	-70.3465
BH44	388250	4516108	40.78837	-70.3245
BH45	390102	4516108	40.78862	-70.3026
BH46	391954	4516108	40.78886	-70.2806
BH47	393806	4516108	40.7891	-70.2587
BJ37	375286	4514256	40.76982	-70.4777
BJ38	377138	4514256	40.7701	-70.4558
BJ39	378990	4514256	40.77038	-70.4339
BJ40	380842	4514256	40.77065	-70.4119
BJ41	382694	4514256	40.77091	-70.39
BJ42	384546	4514256	40.77118	-70.3681
BJ43	386398	4514256	40.77143	-70.3461
BJ44	388250	4514256	40.77169	-70.3242
BJ45	390102	4514256	40.77194	-70.3022
BJ46	391954	4514256	40.77218	-70.2803
BK36	373434	4512404	40.75286	-70.4993
BK37	375286	4512404	40.75314	-70.4774
BK38	377138	4512404	40.75342	-70.4554
BK39	378990	4512404	40.7537	-70.4335
BK40	380842	4512404	40.75397	-70.4116
BK41	382694	4512404	40.75423	-70.3896
BK42	384546	4512404	40.7545	-70.3677
BK43	386398	4512404	40.75475	-70.3458
BK44	388250	4512404	40.75501	-70.3238
BK45	390102	4512404	40.75526	-70.3019
BL35	371582	4510552	40.7359	-70.5209
BL36	373434	4510552	40.73618	-70.4989
BL37	375286	4510552	40.73647	-70.477
BL38	377138	4510552	40.73674	-70.4551
BL39	378990	4510552	40.73702	-70.4332
BL40	380842	4510552	40.73729	-70.4112
BL41	382694	4510552	40.73755	-70.3893
BL42	384546	4510552	40.73782	-70.3674
BL43	386398	4510552	40.73807	-70.3454
BL44	388250	4510552	40.73833	-70.3235
BM34	369730	4508700	40.71893	-70.5424
BM35	371582	4508700	40.71922	-70.5205
BM36	373434	4508700	40.7195	-70.4986
BM37	375286	4508700	40.71979	-70.4766

Identifier	WGS84 UTM Zone 19N (m)		WGS84 (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
BM38	377138	4508700	40.72007	-70.4547
BM39	378990	4508700	40.72034	-70.4328
BM40	380842	4508700	40.72061	-70.4109
BM41	382694	4508700	40.72088	-70.389
BM42	384546	4508700	40.72114	-70.367
BM43	386398	4508700	40.7214	-70.3451
BN33	367878	4506848	40.70195	-70.5639
BN34	369730	4506848	40.70225	-70.542
BN35	371582	4506848	40.70254	-70.5201
BN36	373434	4506848	40.70283	-70.4982
BN37	375286	4506848	40.70311	-70.4763
BN38	377138	4506848	40.70339	-70.4544
BN39	378990	4506848	40.70366	-70.4324
BN40	380842	4506848	40.70393	-70.4105
BN41	382694	4506848	40.7042	-70.3886
BN42	384546	4506848	40.70446	-70.3667
BP32	366026	4504996	40.68498	-70.5854
BP33	367878	4504996	40.68528	-70.5635
BP34	369730	4504996	40.68557	-70.5416
BP35	371582	4504996	40.68586	-70.5197
BP36	373434	4504996	40.68615	-70.4978
BP37	375286	4504996	40.68643	-70.4759
BP38	377138	4504996	40.68671	-70.454
BP39	378990	4504996	40.68698	-70.4321
BP40	380842	4504996	40.68725	-70.4102
BP41	382694	4504996	40.68752	-70.3883
BQ31	364174	4503144	40.668	-70.607
BQ32	366026	4503144	40.6683	-70.5851
BQ33	367878	4503144	40.6686	-70.5631
BQ34	369730	4503144	40.66889	-70.5412
BQ35	371582	4503144	40.66918	-70.5193
BQ36	373434	4503144	40.66947	-70.4974
BQ37	375286	4503144	40.66975	-70.4755
BQ38	377138	4503144	40.67003	-70.4536
BQ39	378990	4503144	40.6703	-70.4317
BQ40	380842	4503144	40.67057	-70.4098
BR30	362322	4501292	40.65101	-70.6285
BR31	364174	4501292	40.65132	-70.6066
BR32	366026	4501292	40.65162	-70.5847
BR33	367878	4501292	40.65192	-70.5628
BR34	369730	4501292	40.65221	-70.5409
BR35	371582	4501292	40.6525	-70.519
BR36	373434	4501292	40.65279	-70.4971
BR37	375286	4501292	40.65307	-70.4752
BR38	377138	4501292	40.65335	-70.4533
BR39	378990	4501292	40.65362	-70.4314
BS30	362322	4499440	40.63433	-70.628
BS31	364174	4499440	40.63464	-70.6062
BS32	366026	4499440	40.63494	-70.5843
BS33	367878	4499440	40.63524	-70.5624

Identifier	WGS84 UTM Zone 19N (m)		WGS84 (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
BS34	369730	4499440	40.63554	-70.5405
BS35	371582	4499440	40.63583	-70.5186
BS36	373434	4499440	40.63611	-70.4967
BS37	375286	4499440	40.63639	-70.4748
BS38	377138	4499440	40.63667	-70.4529
BT35	371582	4497588	40.61915	-70.5182
BT36	373434	4497588	40.61943	-70.4963
BU35	371582	4495736	40.60247	-70.5178
BU36	373434	4495736	40.60275	-70.4959

APPENDIX B – AIS MAPS

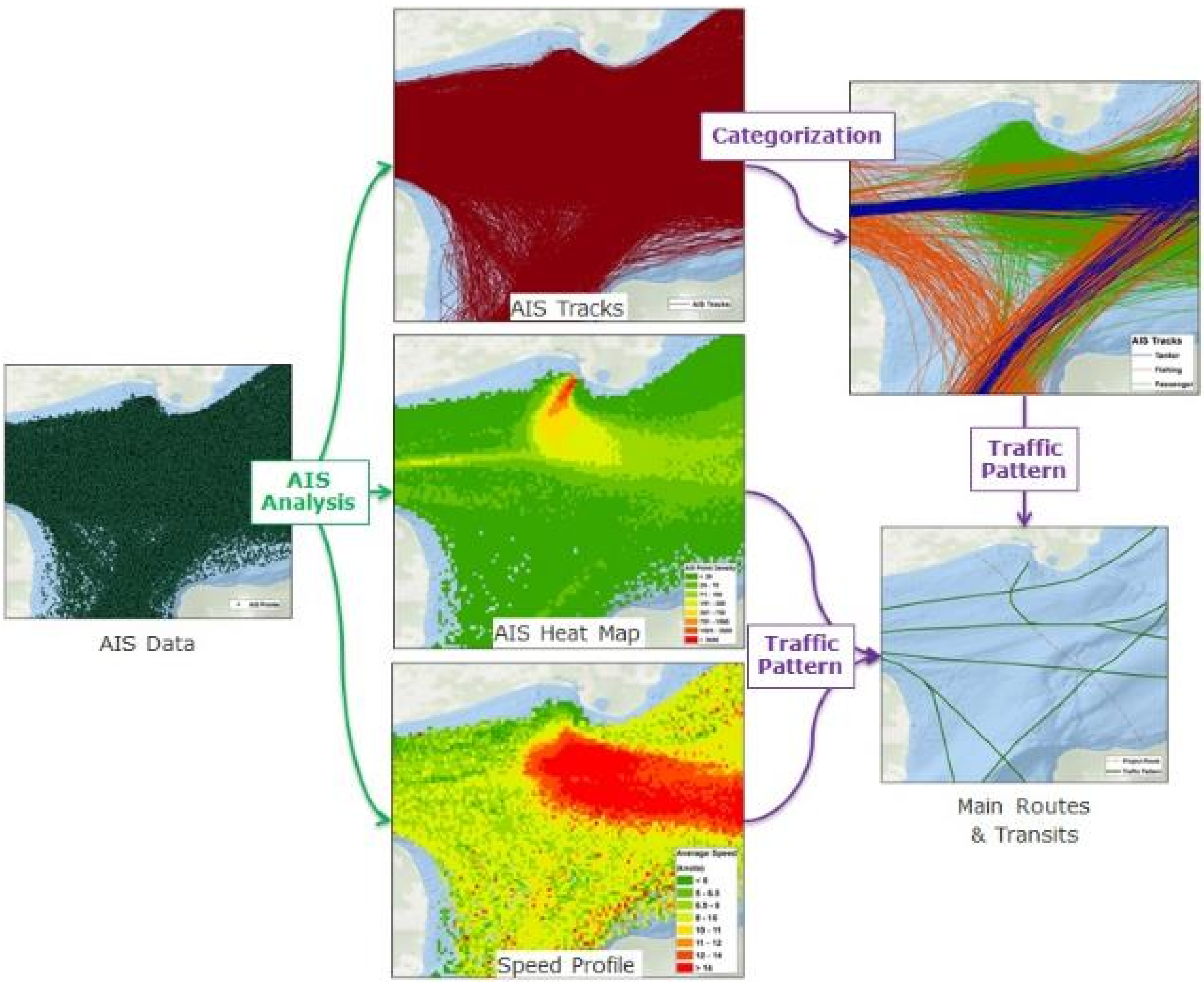
This appendix contains maps of marine traffic showing AIS tracks, AIS density, and vessel speed.

AIS data analysis

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

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

The AIS treatment methodology is schematically represented below:



B.1 AIS Track Maps by Vessel Type

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

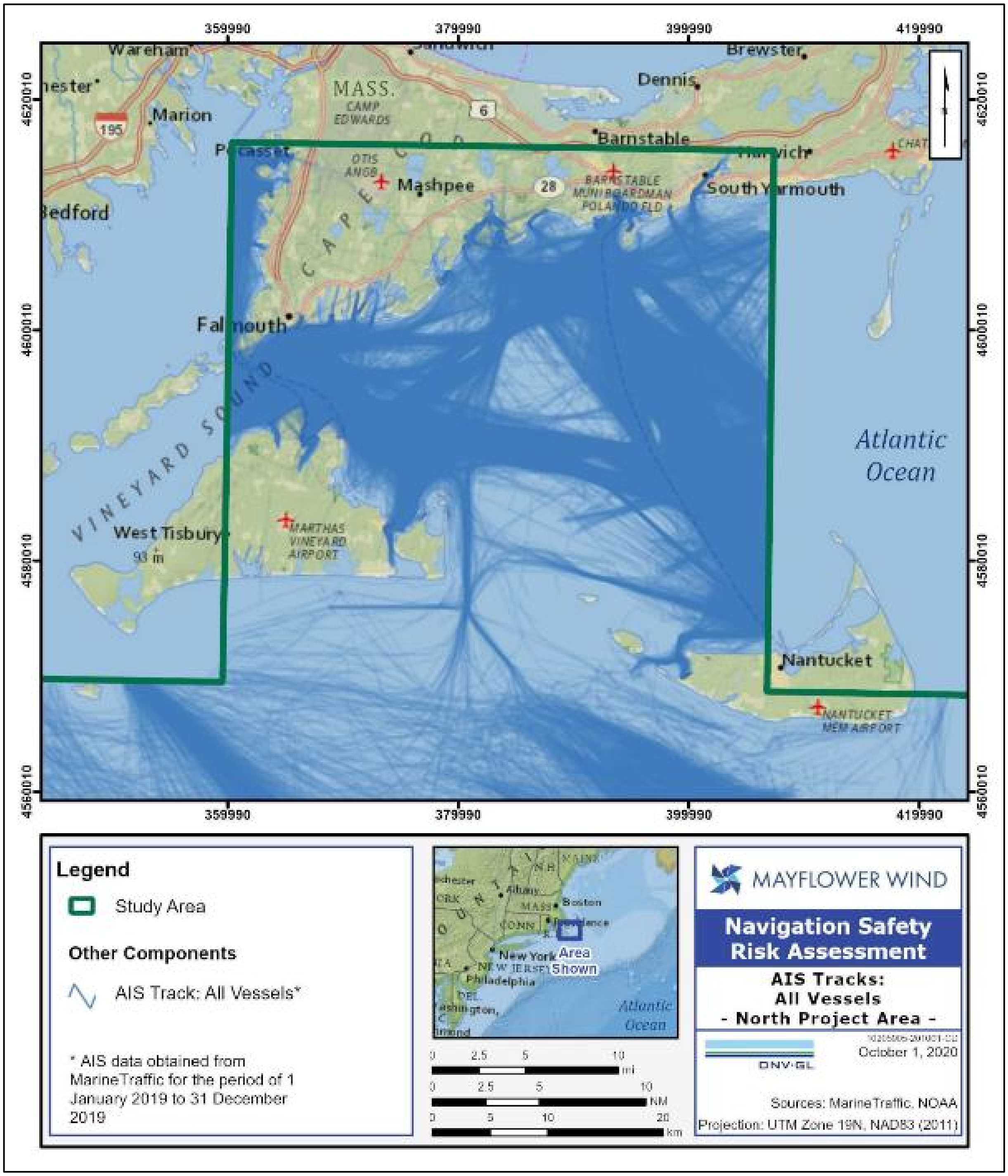


Figure B-1 AIS Tracks for All Vessels (North Study Area)

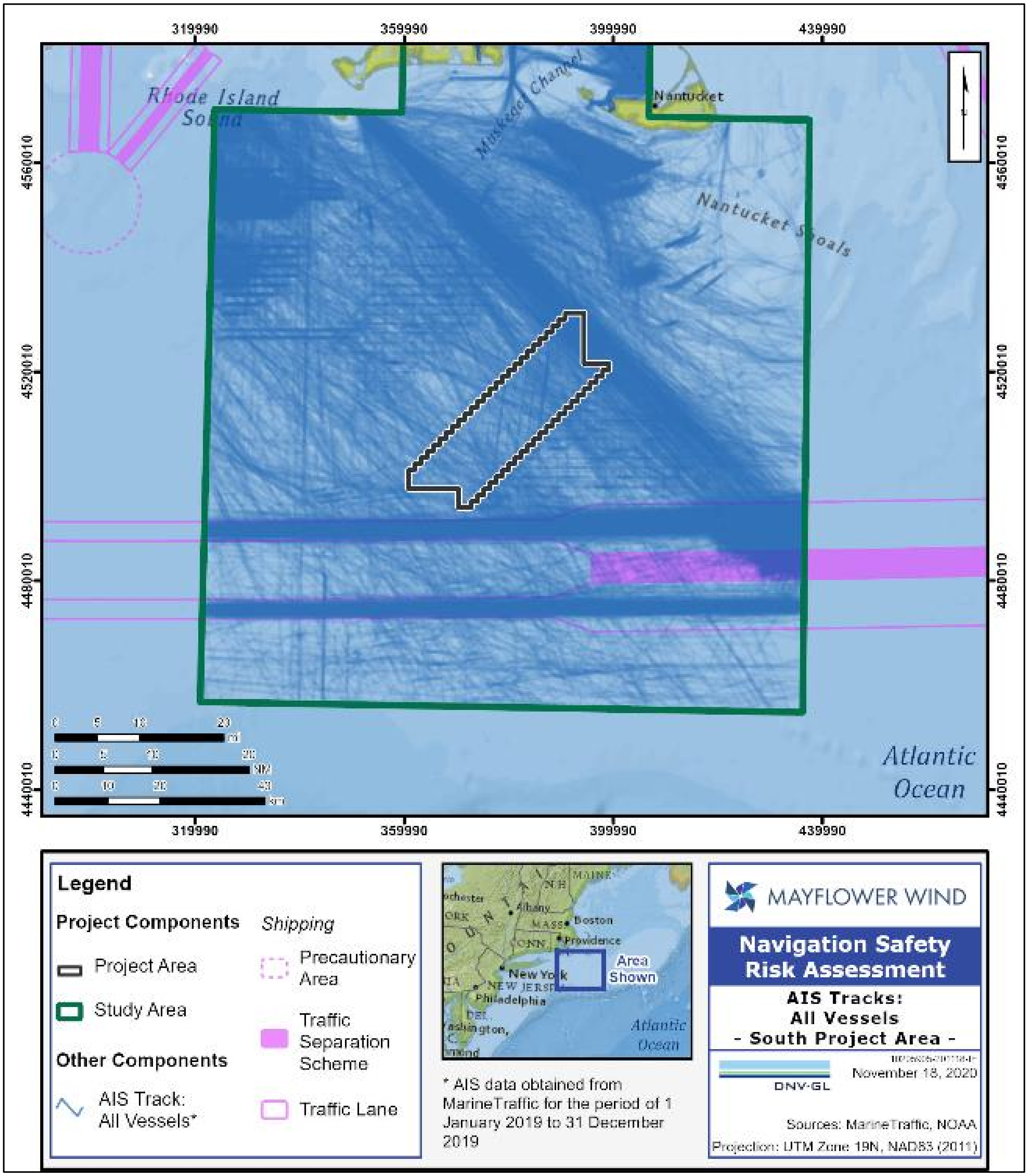


Figure B-2 AIS Tracks for All Vessels (South Study Area)

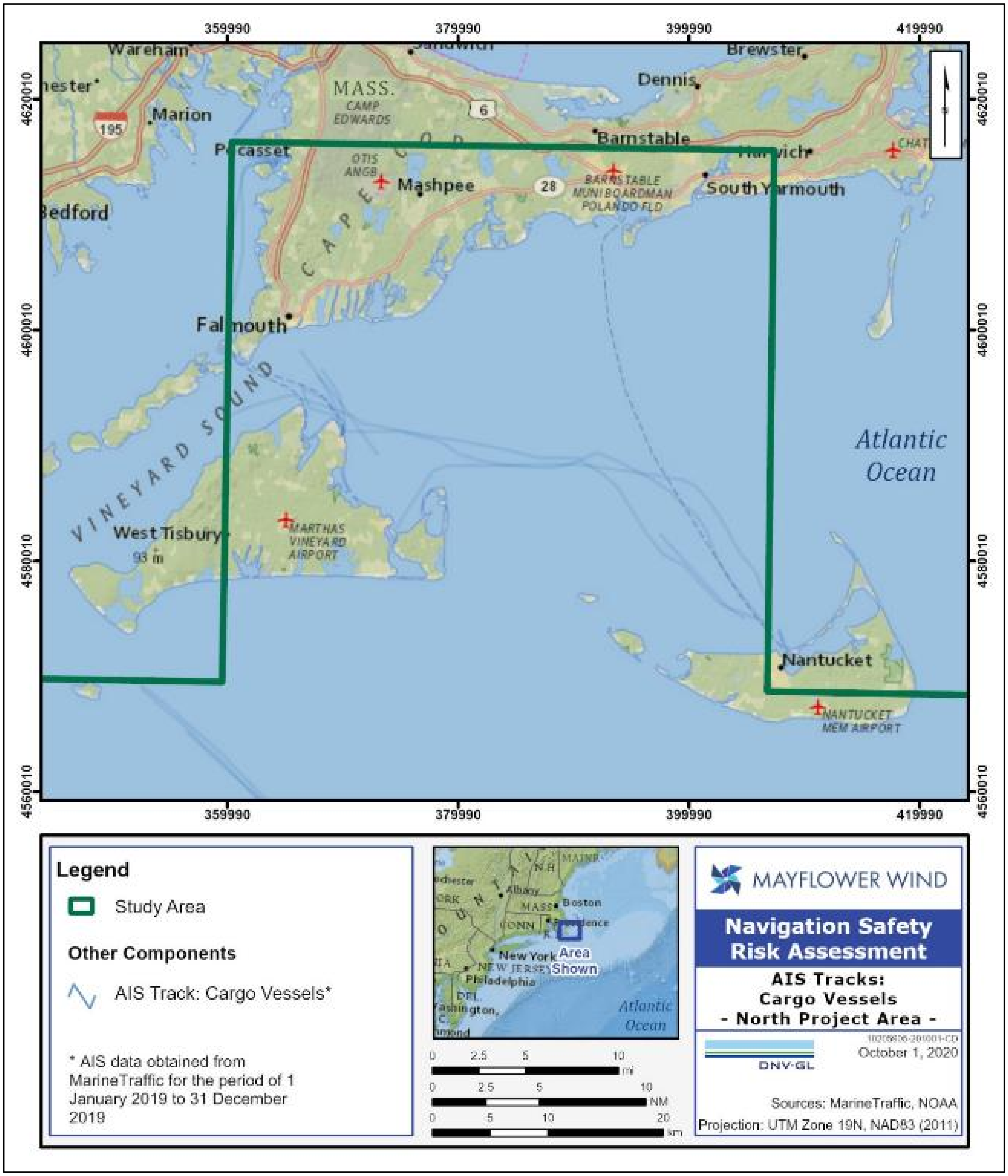


Figure B-3 AIS Tracks for Cargo and Carrier Vessels (North Study Area)

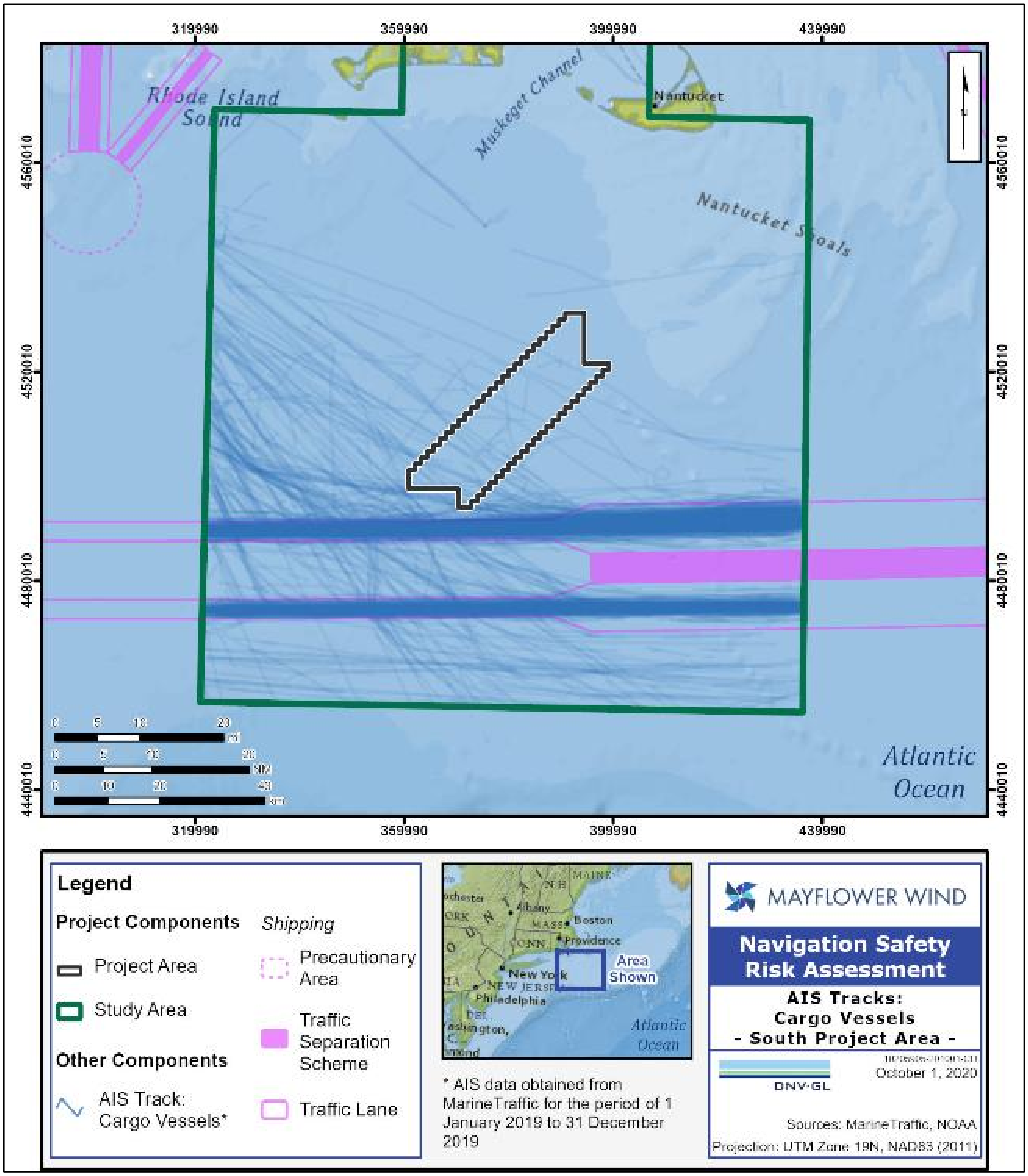


Figure B-4 AIS Tracks for Cargo and Carrier Vessels (South Study Area)

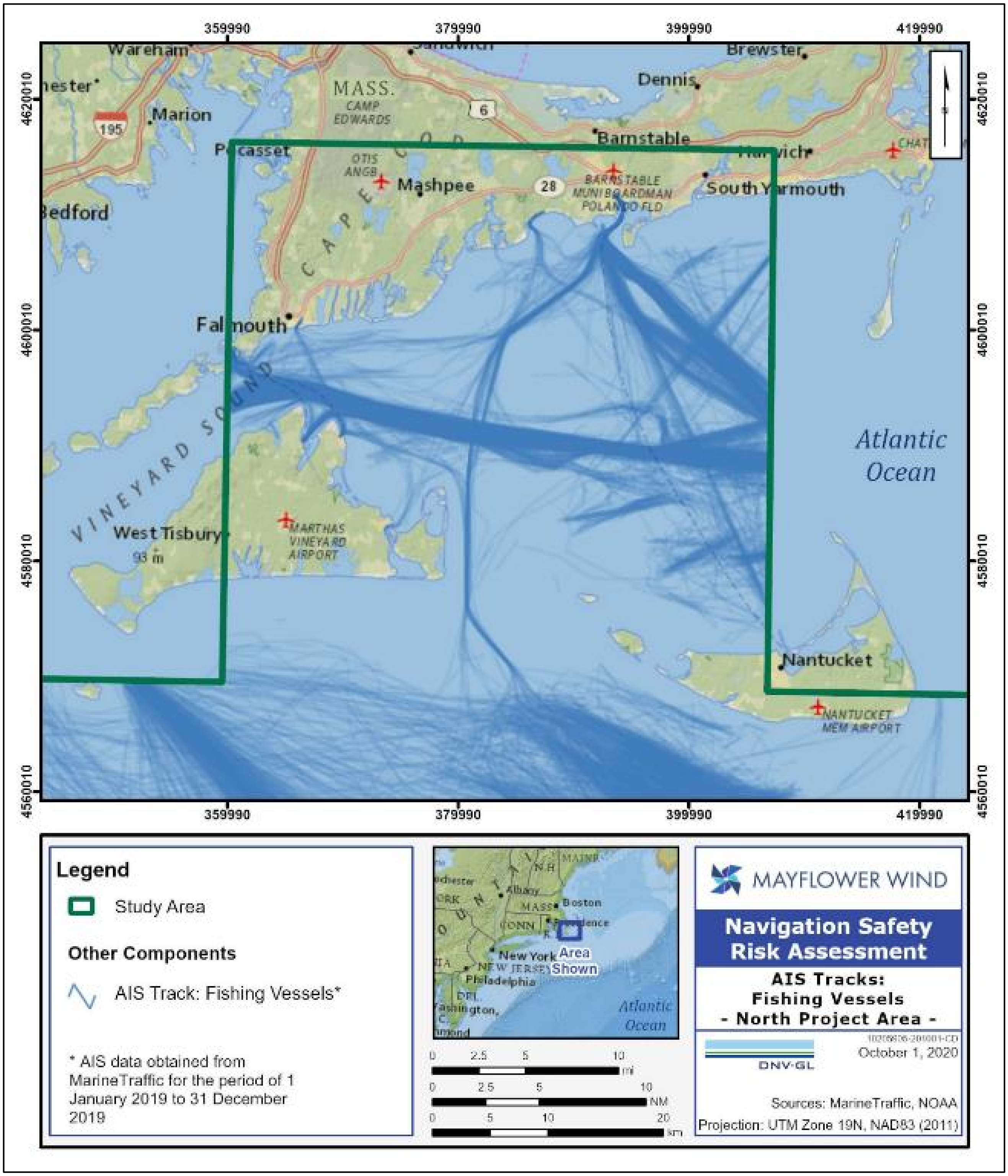


Figure B-5 AIS Tracks for Fishing Vessels (North Study Area)

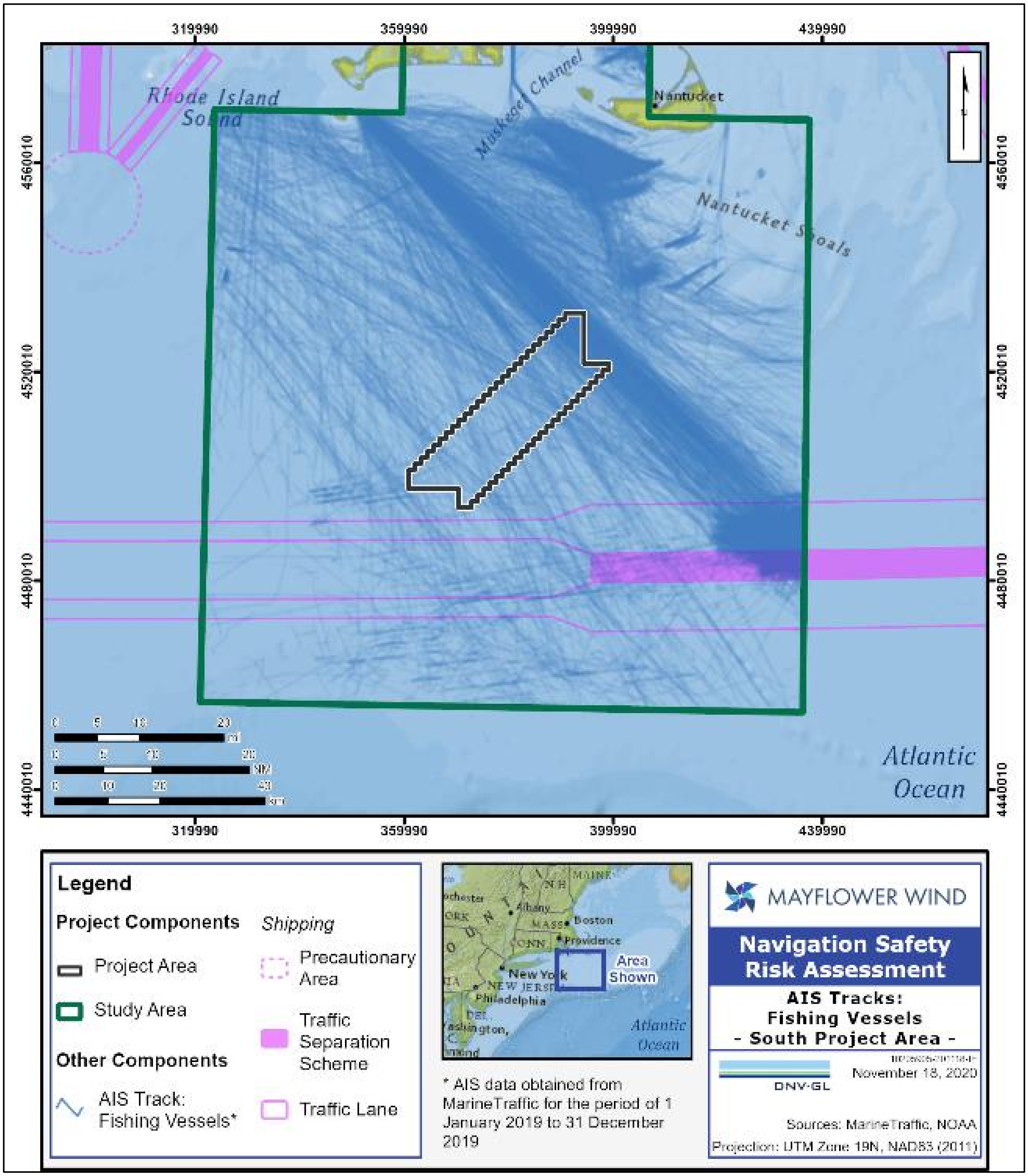


Figure B-6 AIS Tracks for Fishing Vessels (South Study Area)

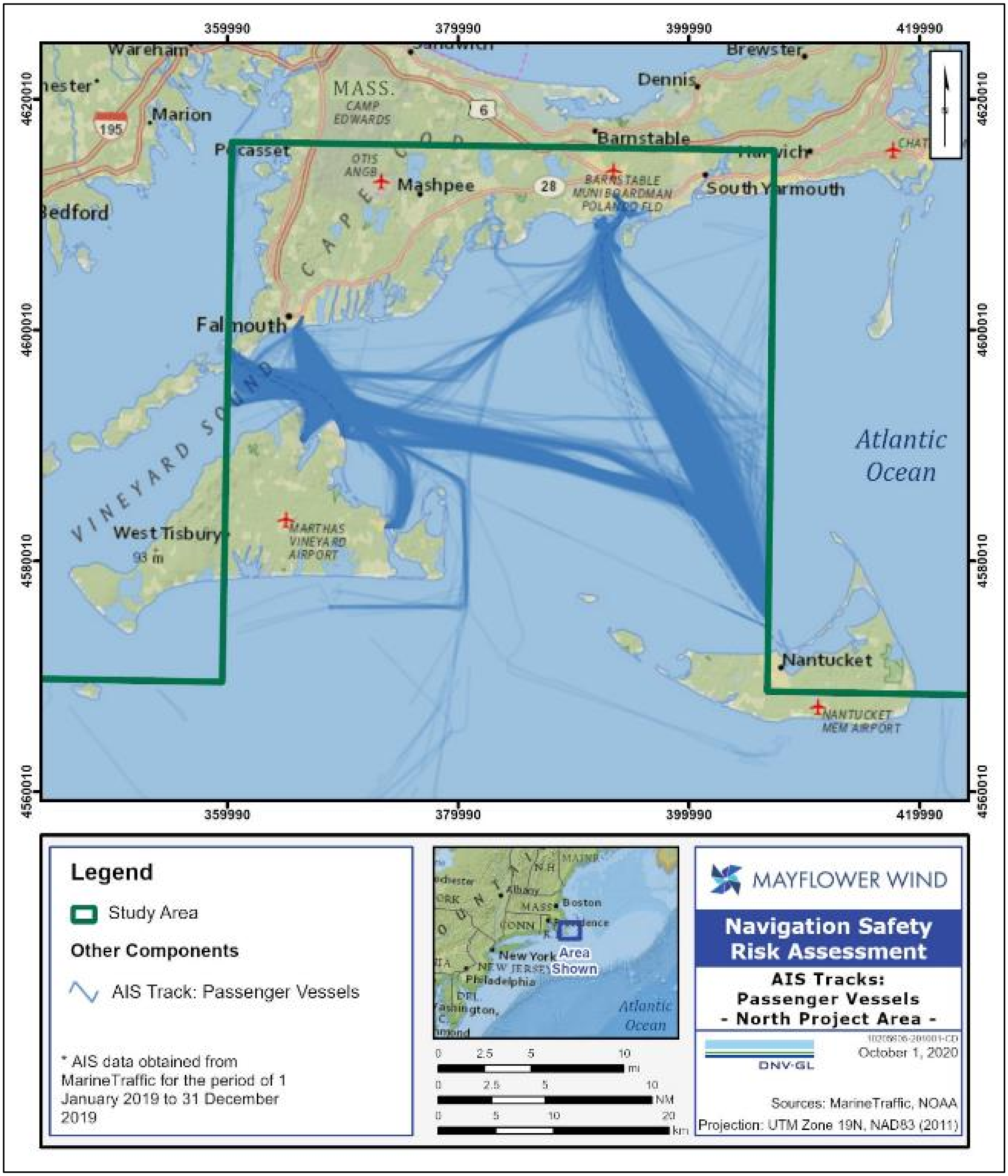


Figure B-7 AIS Tracks for Passenger Vessels (North Study Area)

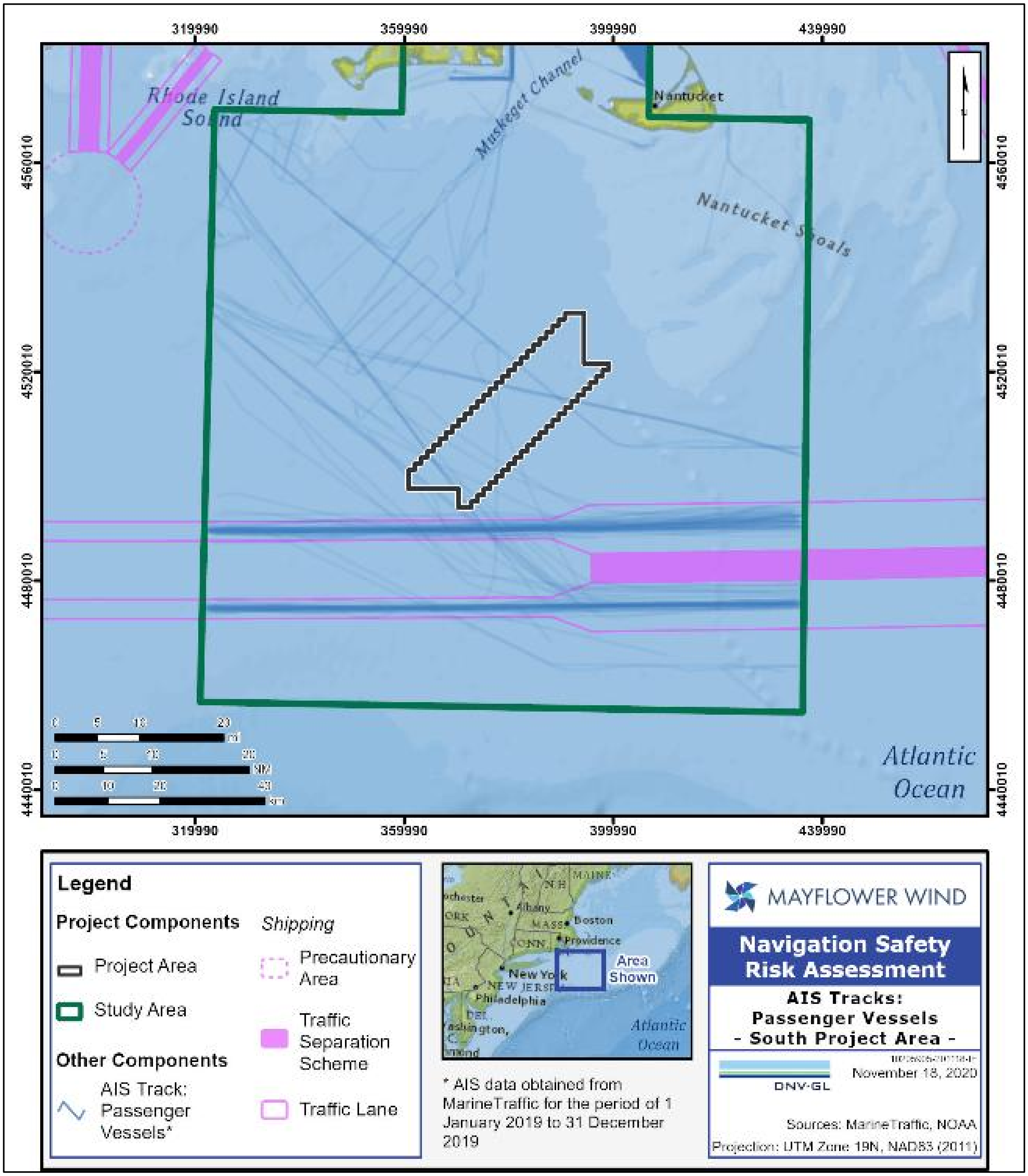


Figure B-8 AIS Tracks for Passenger Vessels (South Study Area)

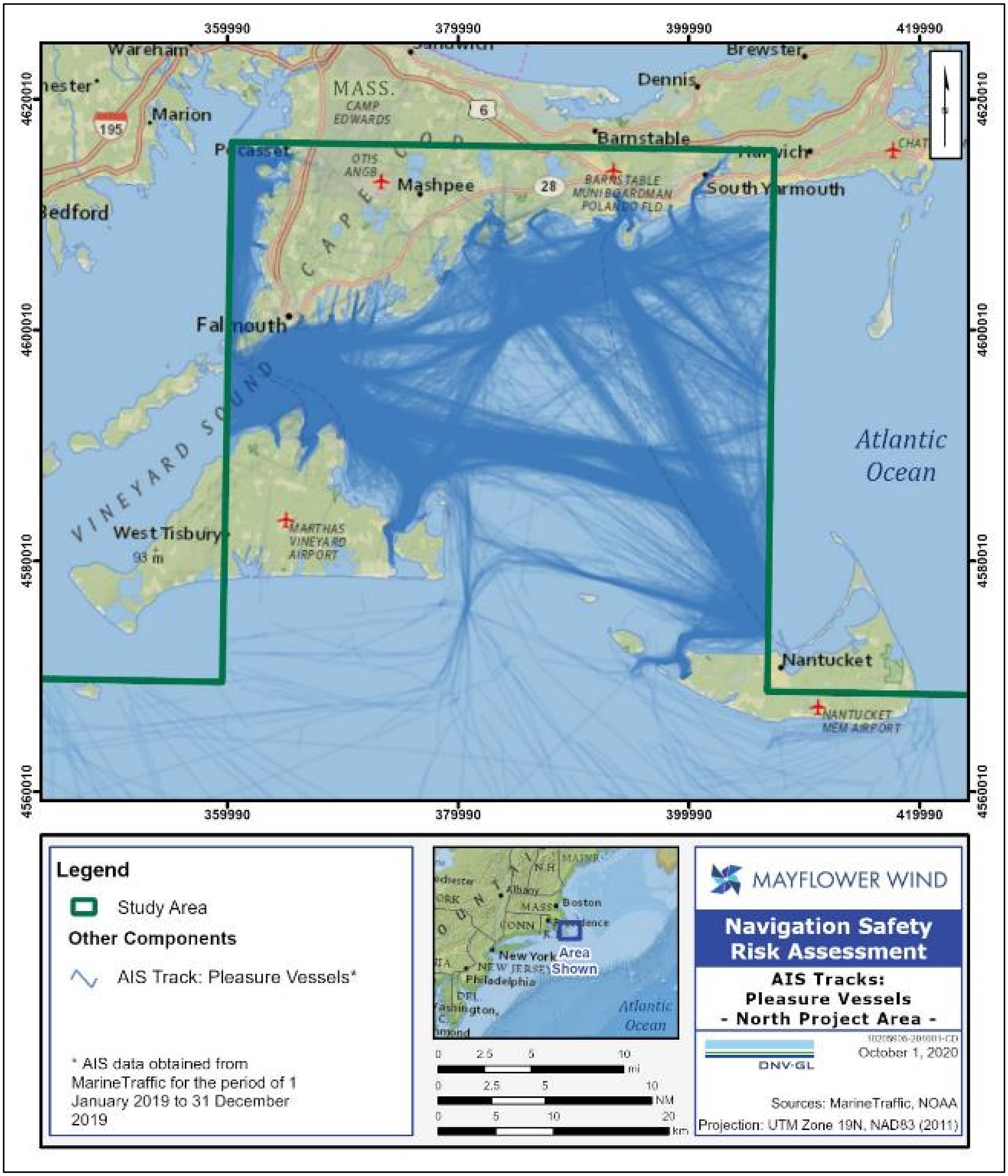


Figure B-9 AIS Tracks for Pleasure Vessels (North Study Area)

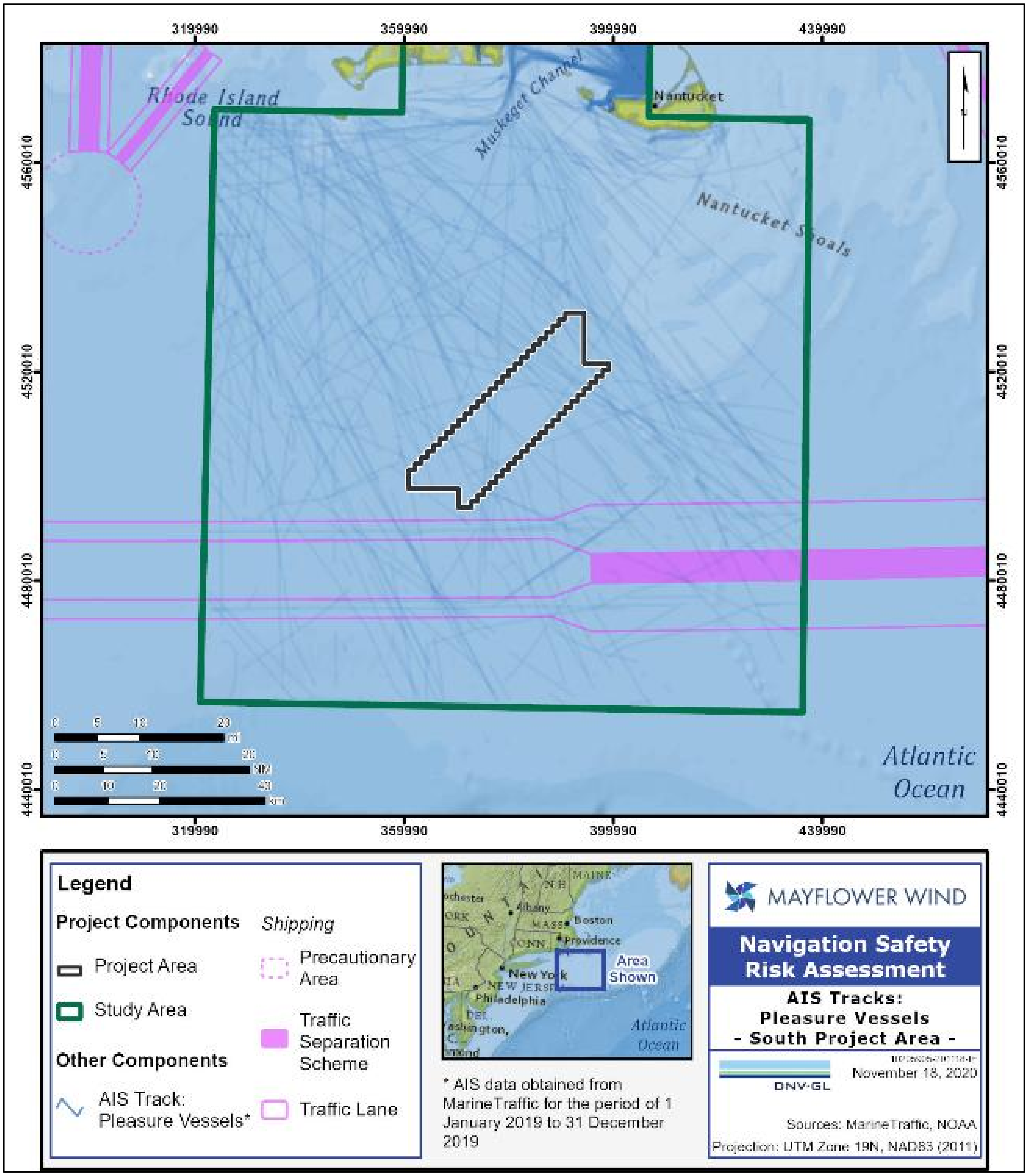


Figure B-10 AIS Tracks for Pleasure Vessels (South Study Area)

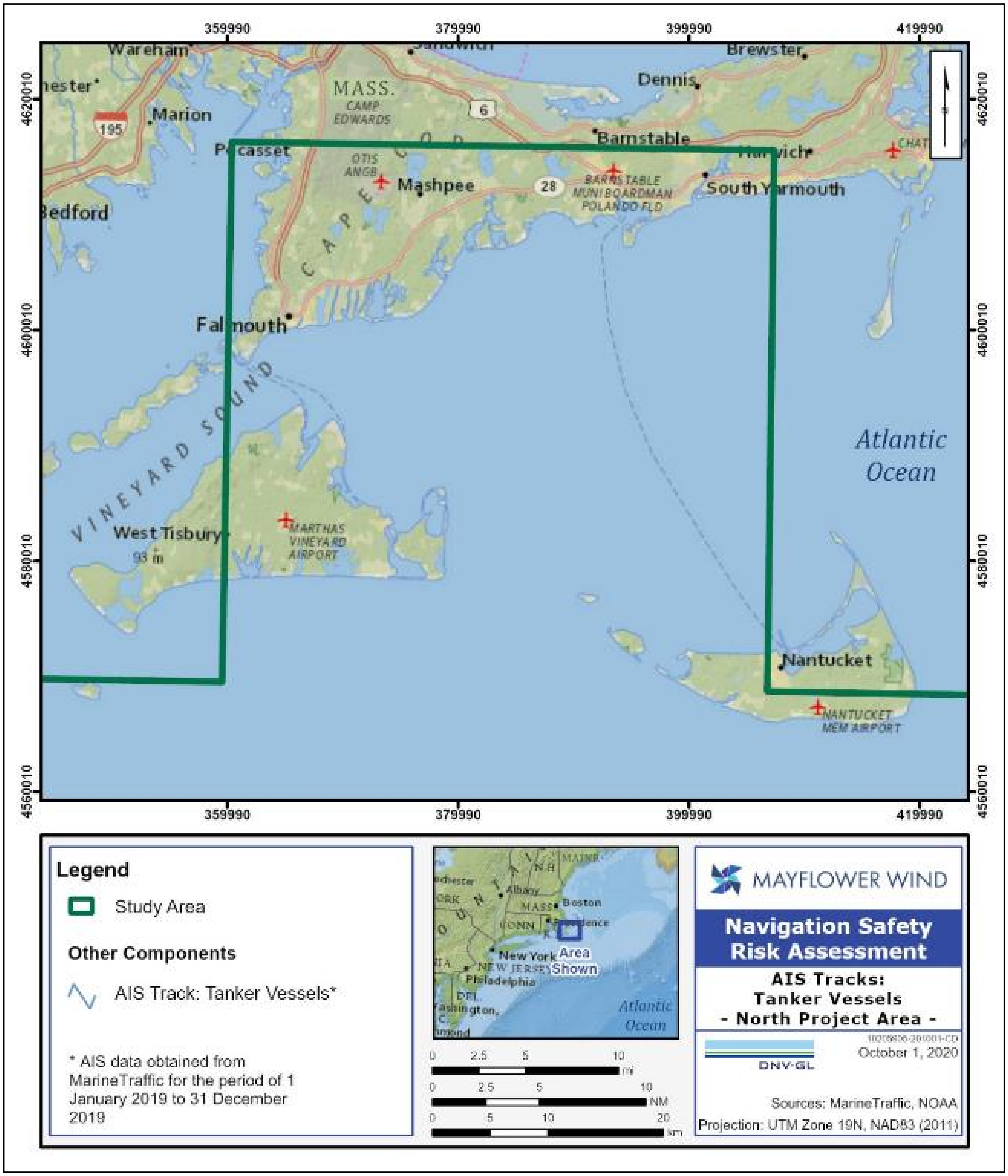


Figure B-11 AIS Tracks for Tanker Vessels (North Study Area)

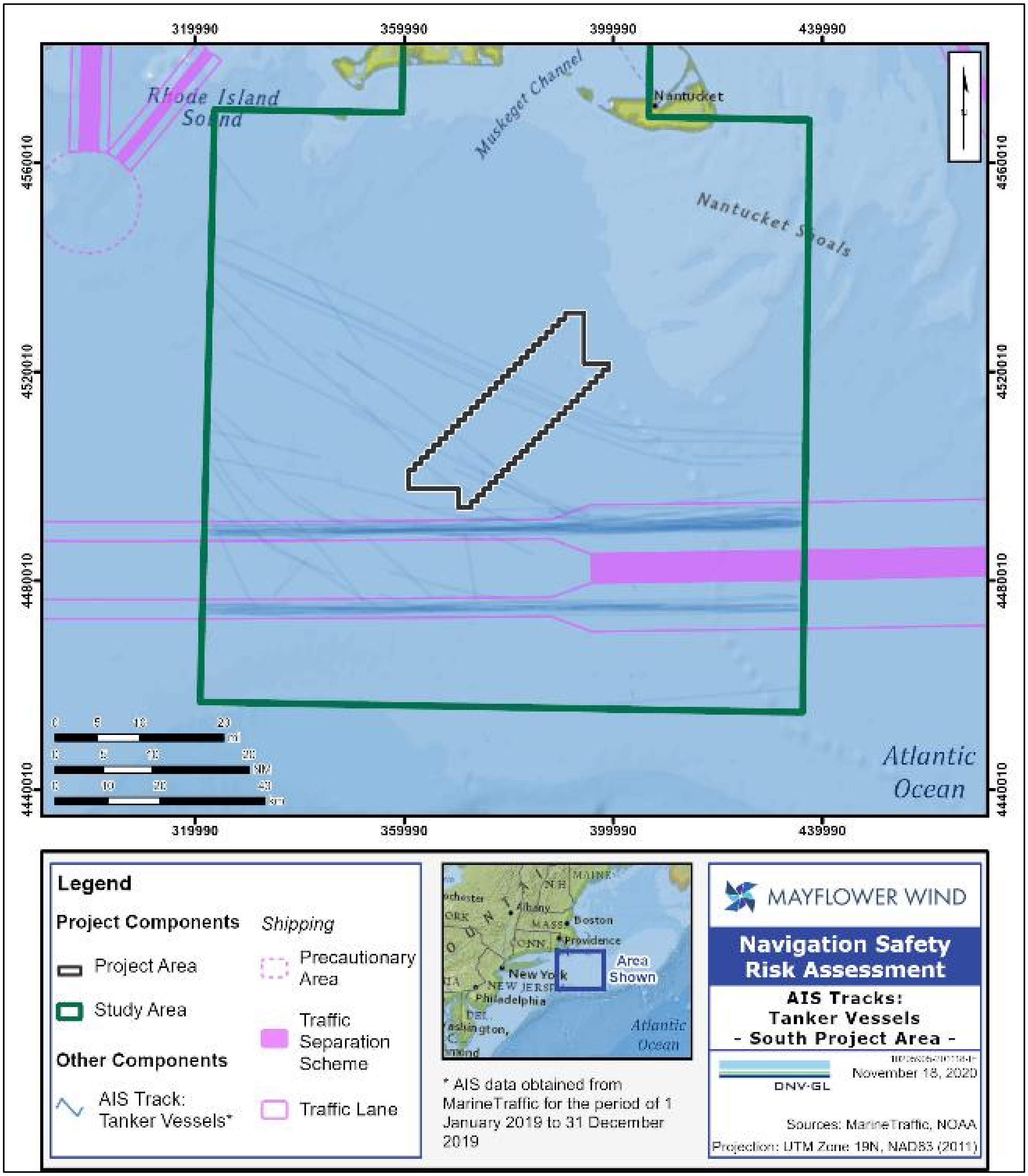


Figure B-12 AIS Tracks for Tanker Vessels (South Study Area)

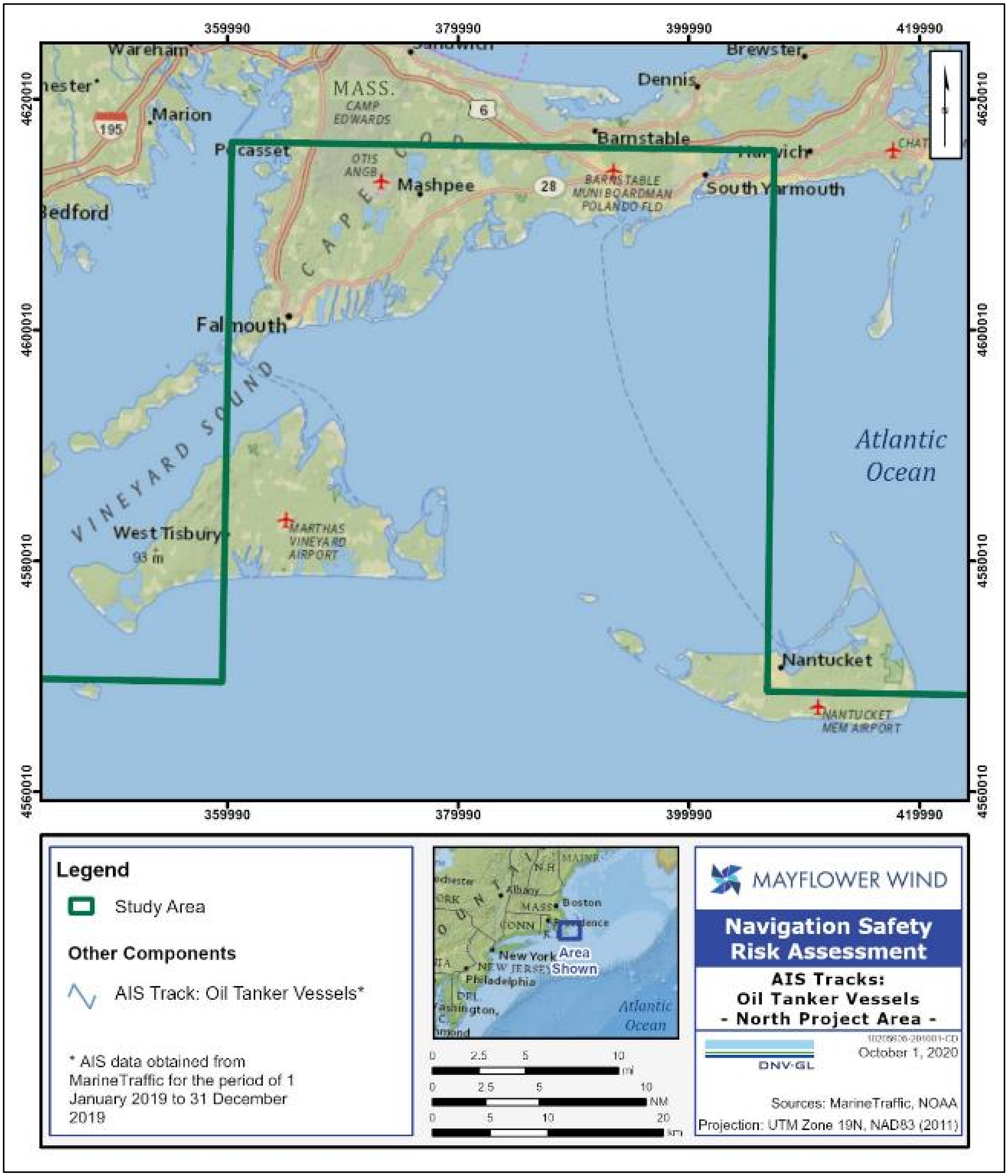


Figure B-13 AIS Tracks for Oil Tanker Vessels (North Study Area)

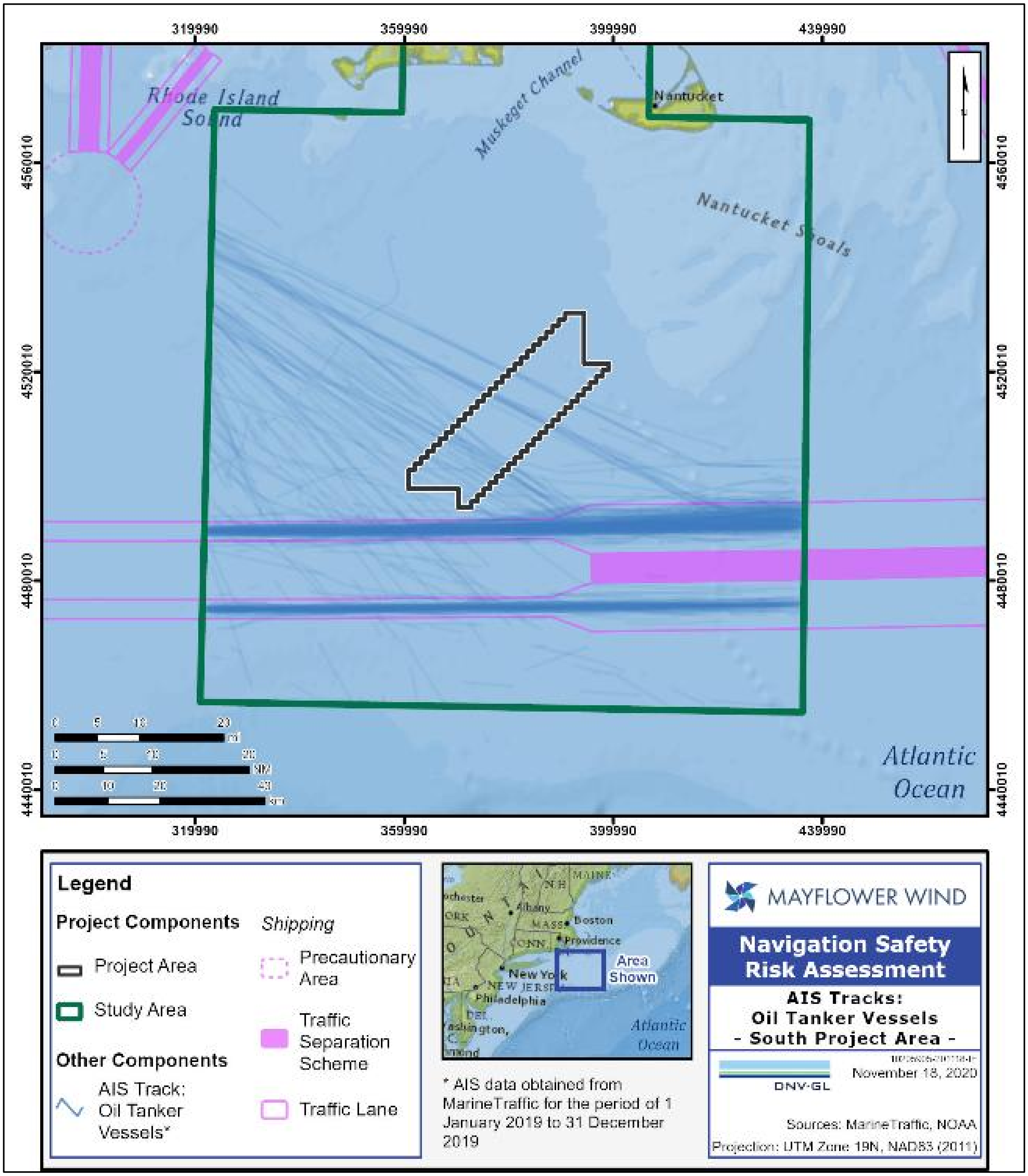


Figure B-14 AIS Tracks for Oil Tanker Vessels (South Study Area)

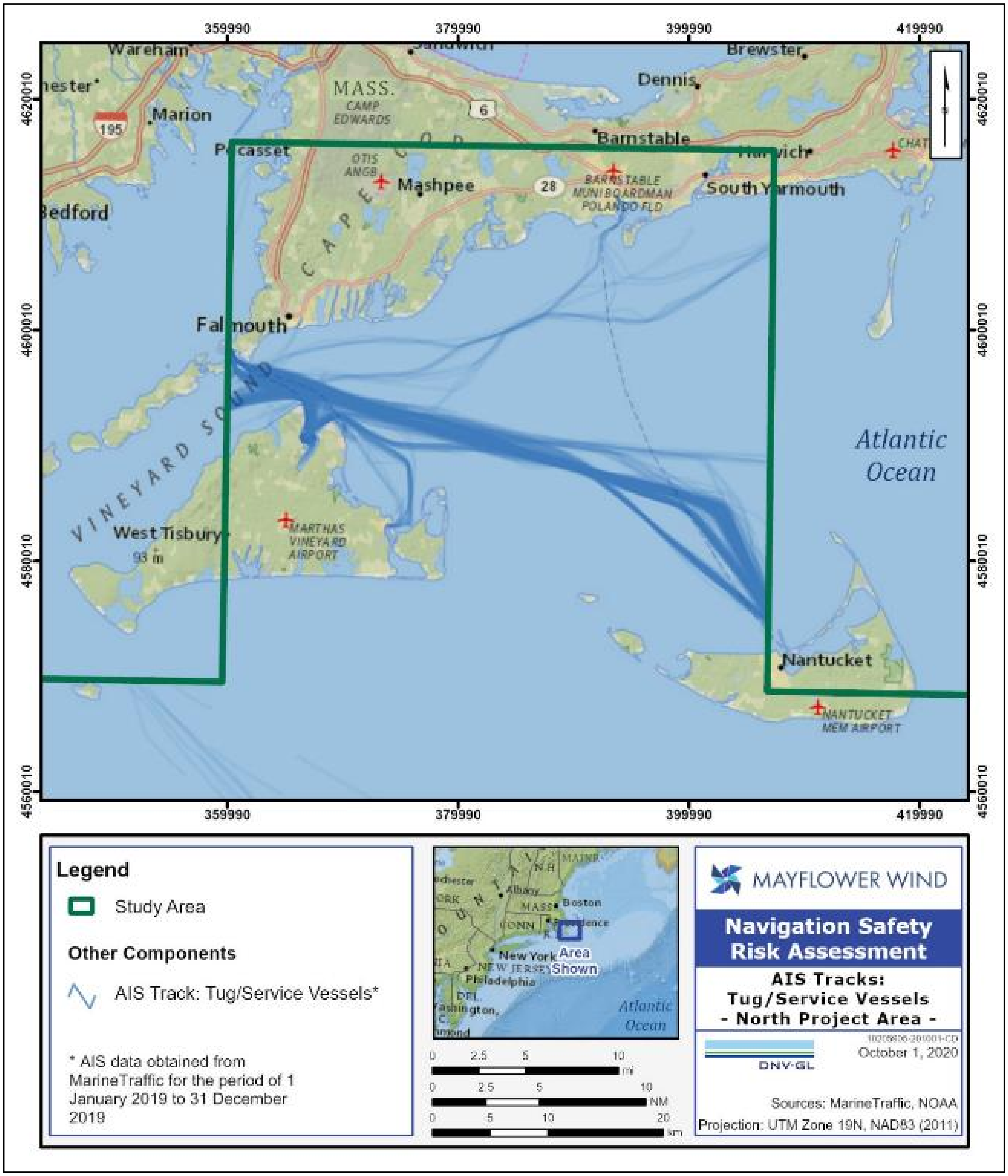


Figure B-15 AIS Tracks for Tug/Service Vessels (North Study Area)

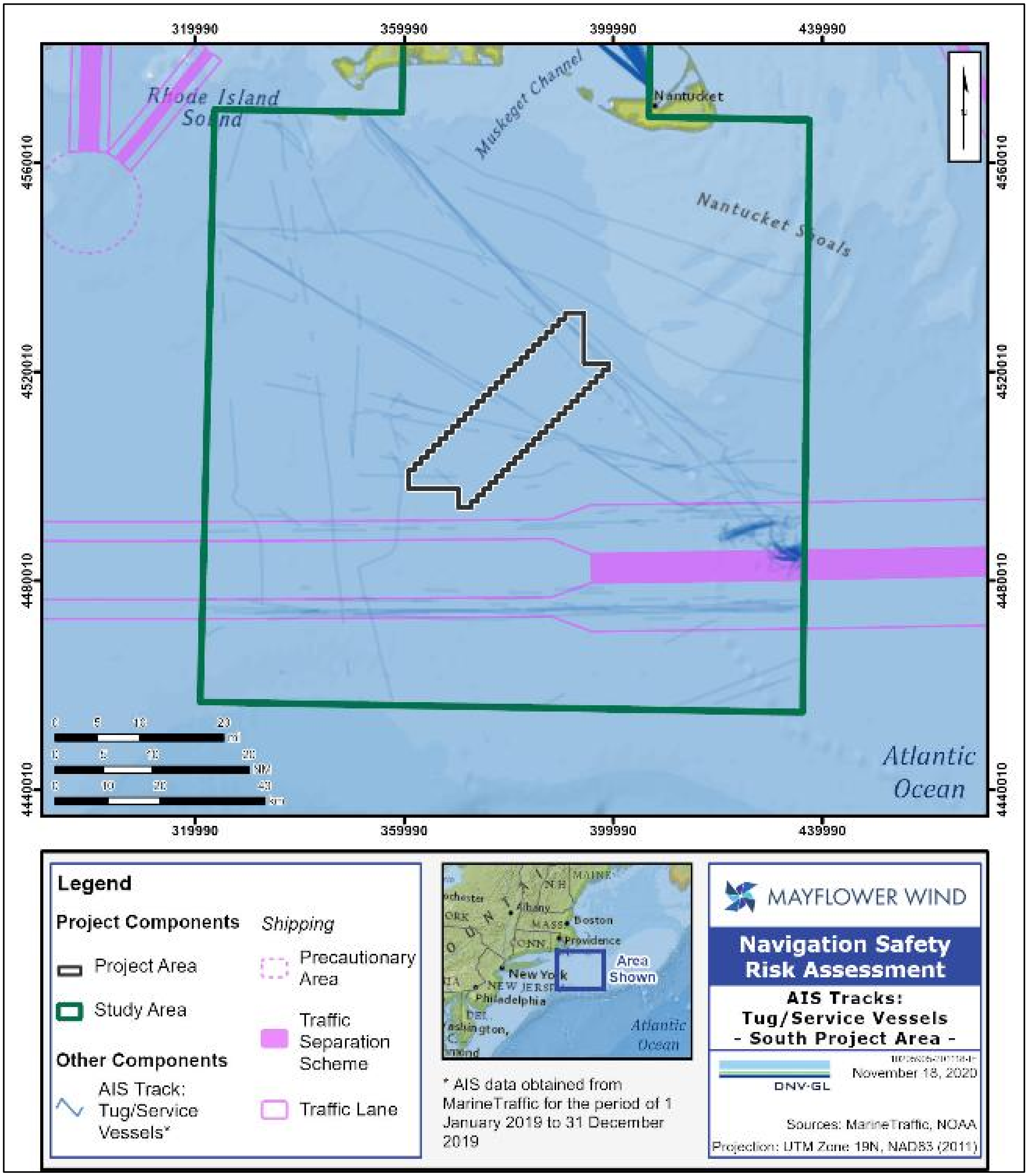


Figure B-16 AIS Tracks for Tug/Service Vessels (South Study Area)

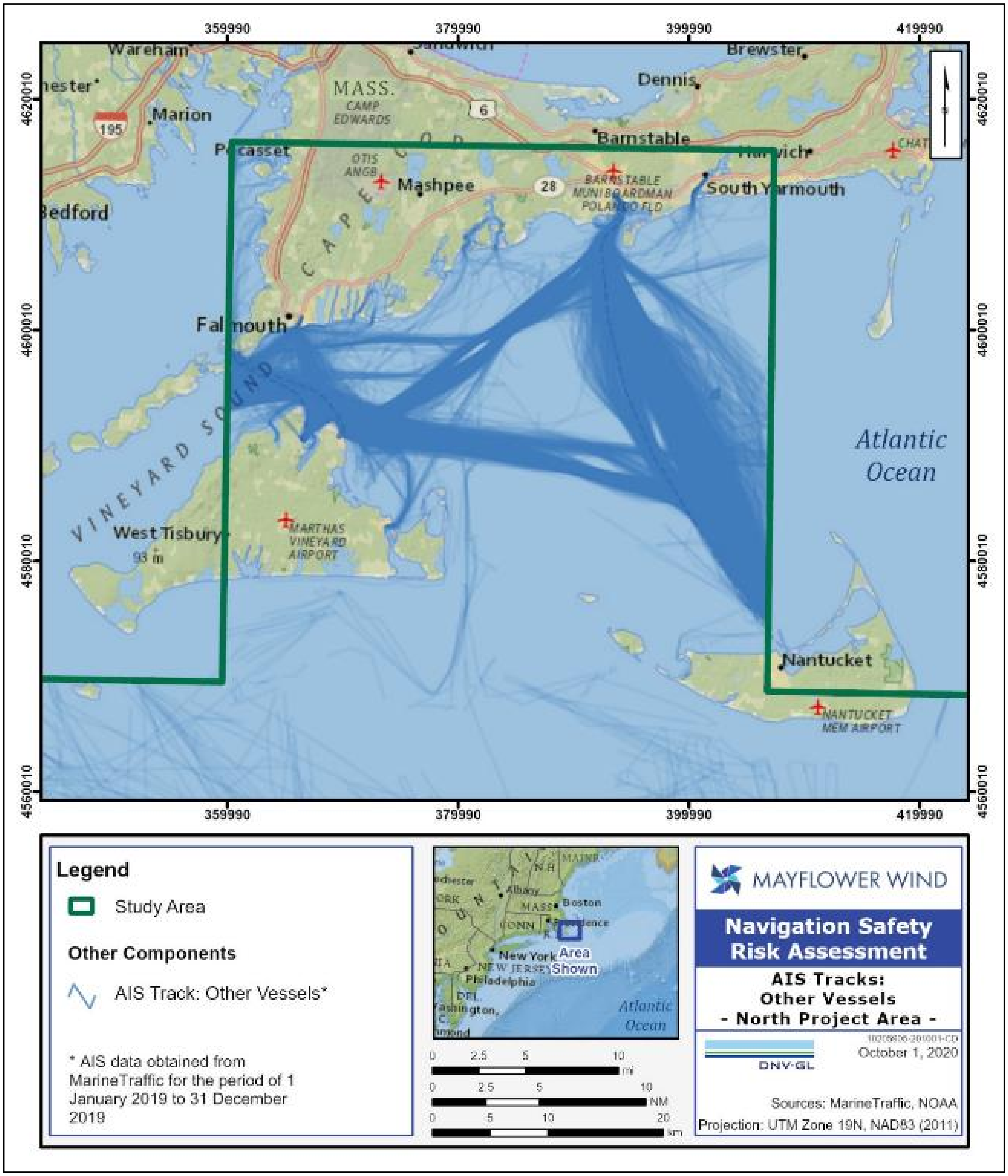


Figure B-17 AIS Tracks for Other Vessels (North Study Area)

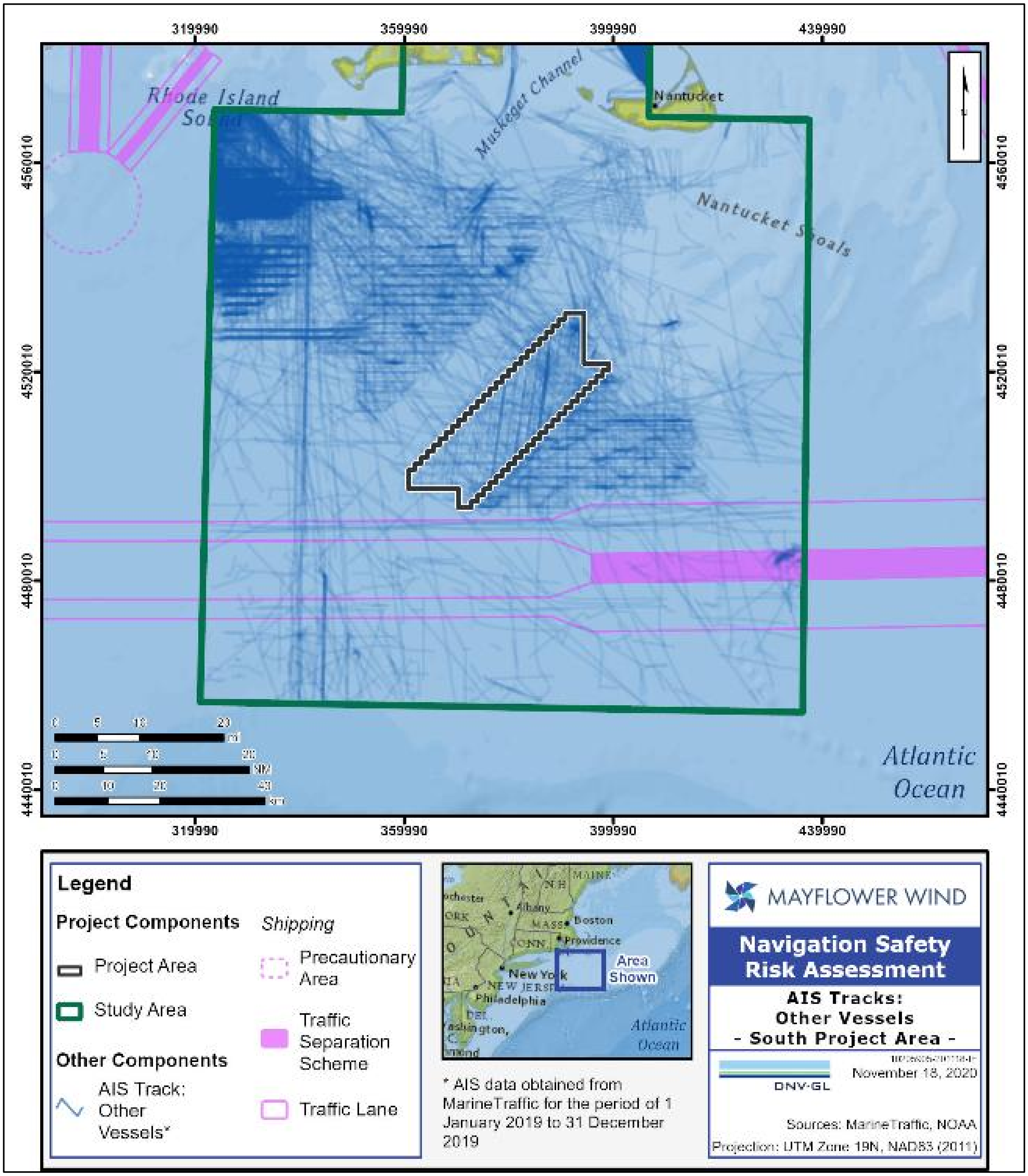


Figure B-18 AIS Tracks for Other Vessels (South Study Area)

B.2 AIS Point Density Maps by Vessel Type

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

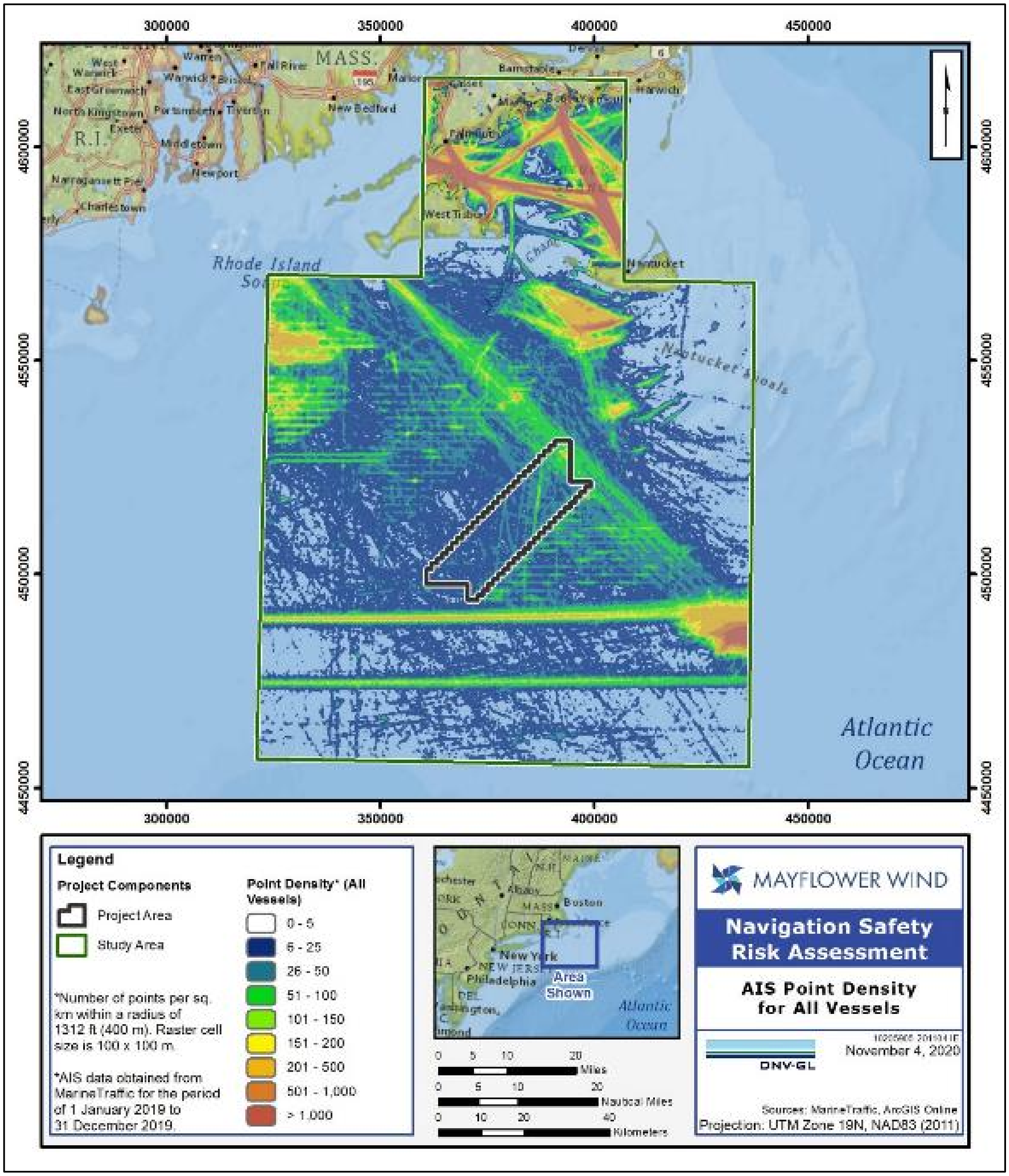


Figure B-19 Density of AIS Points for All Vessels

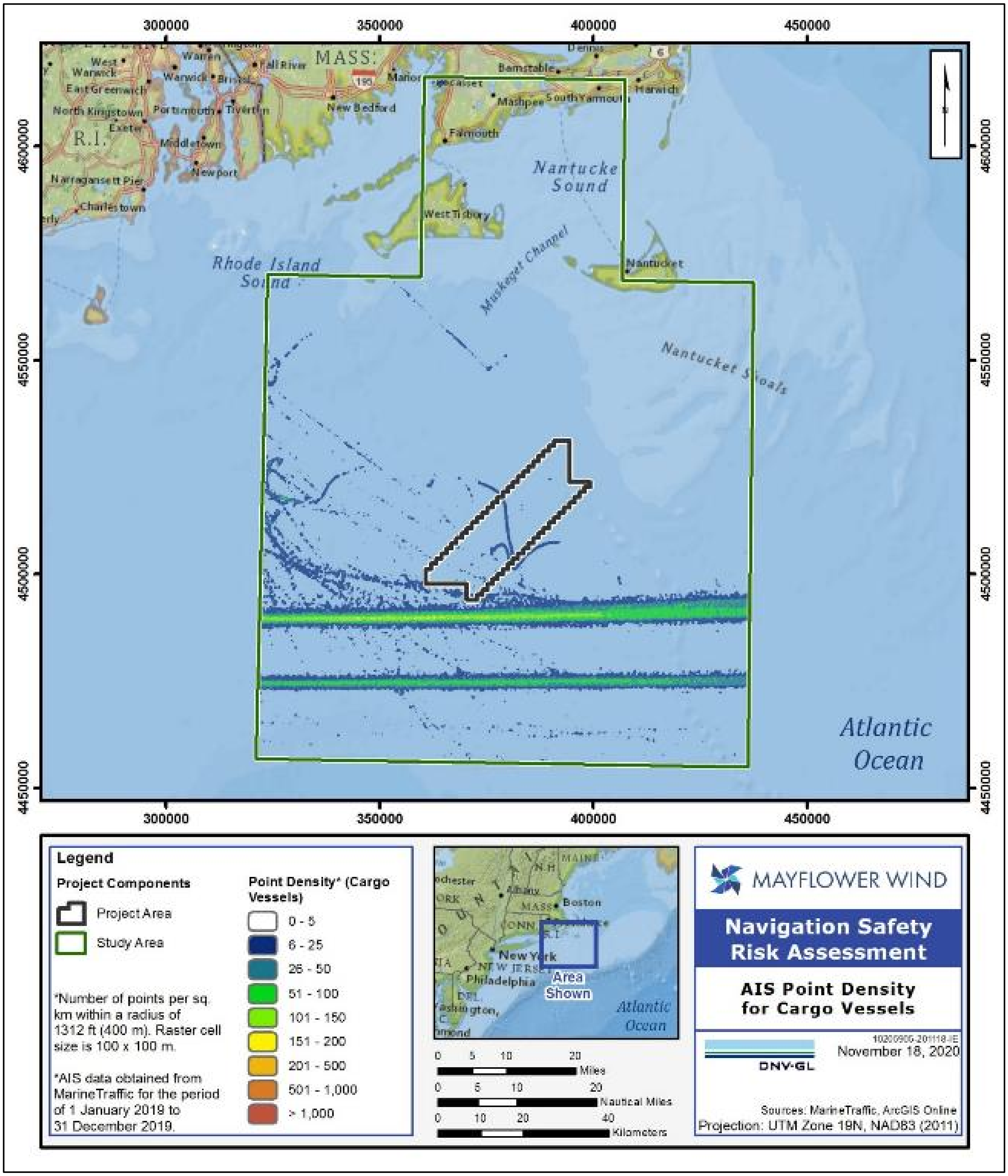


Figure B-20 Density of AIS Points for Cargo and Carrier Vessels

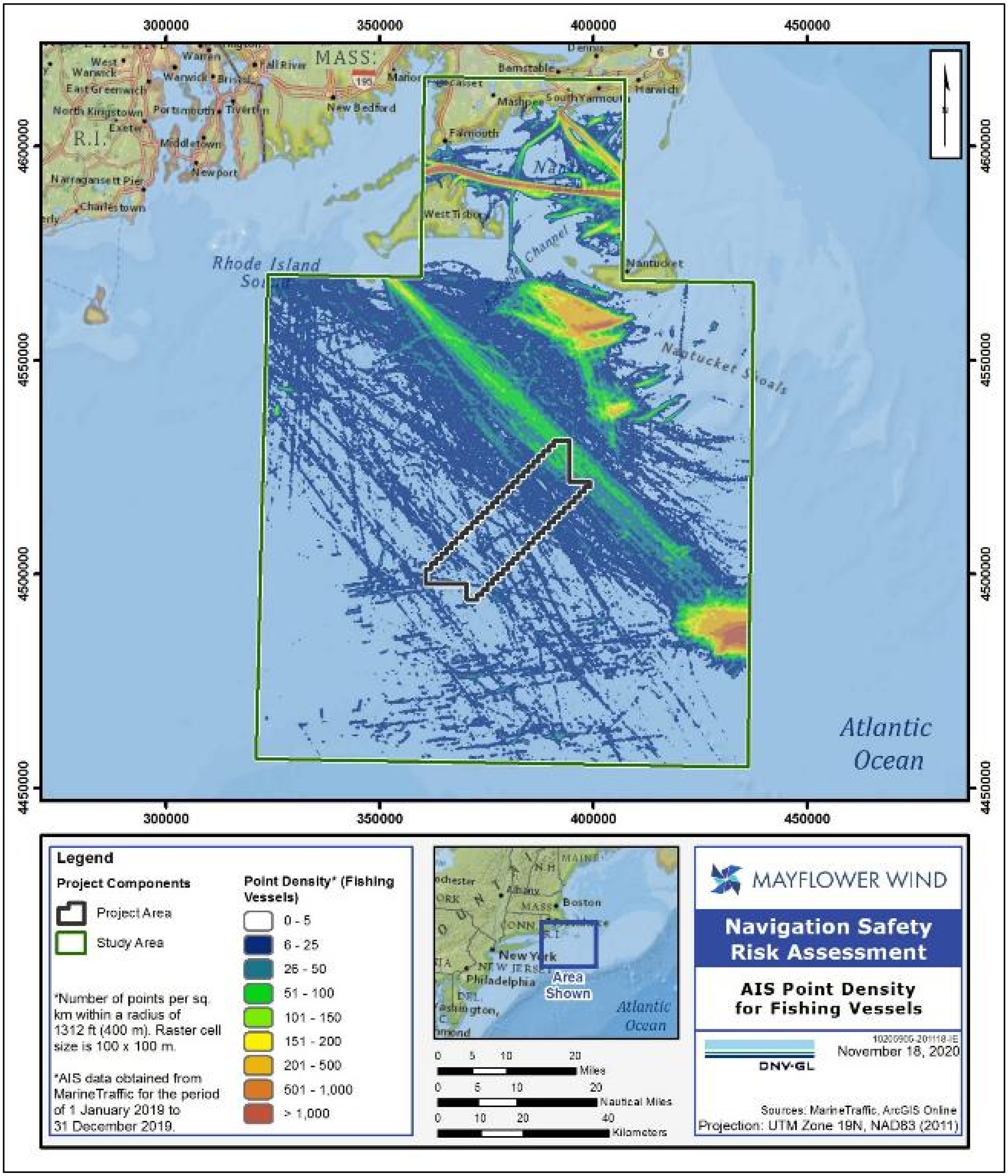


Figure B-21 Density of AIS Points for Fishing Vessels

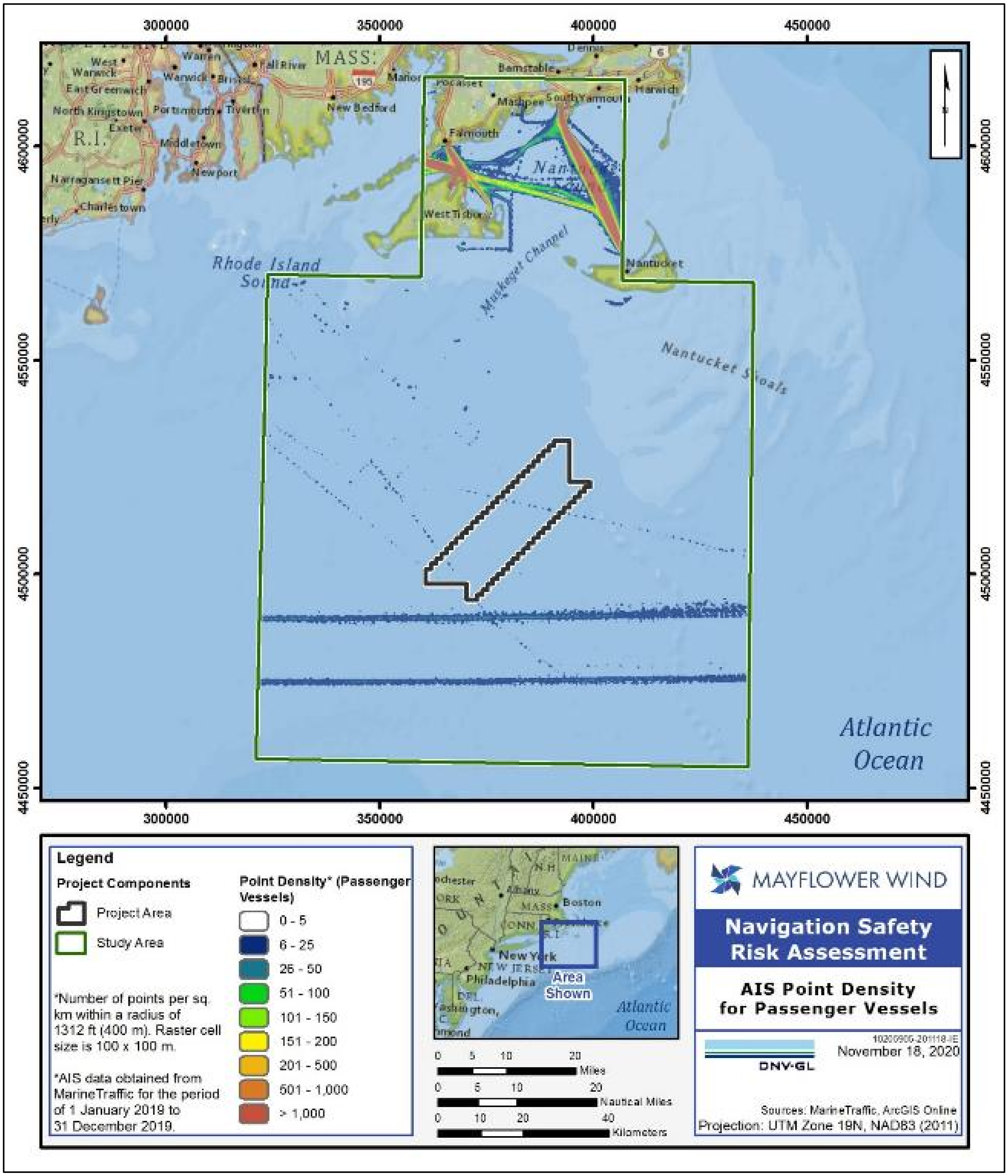


Figure B-22 Density of AIS Points for Passenger Vessels

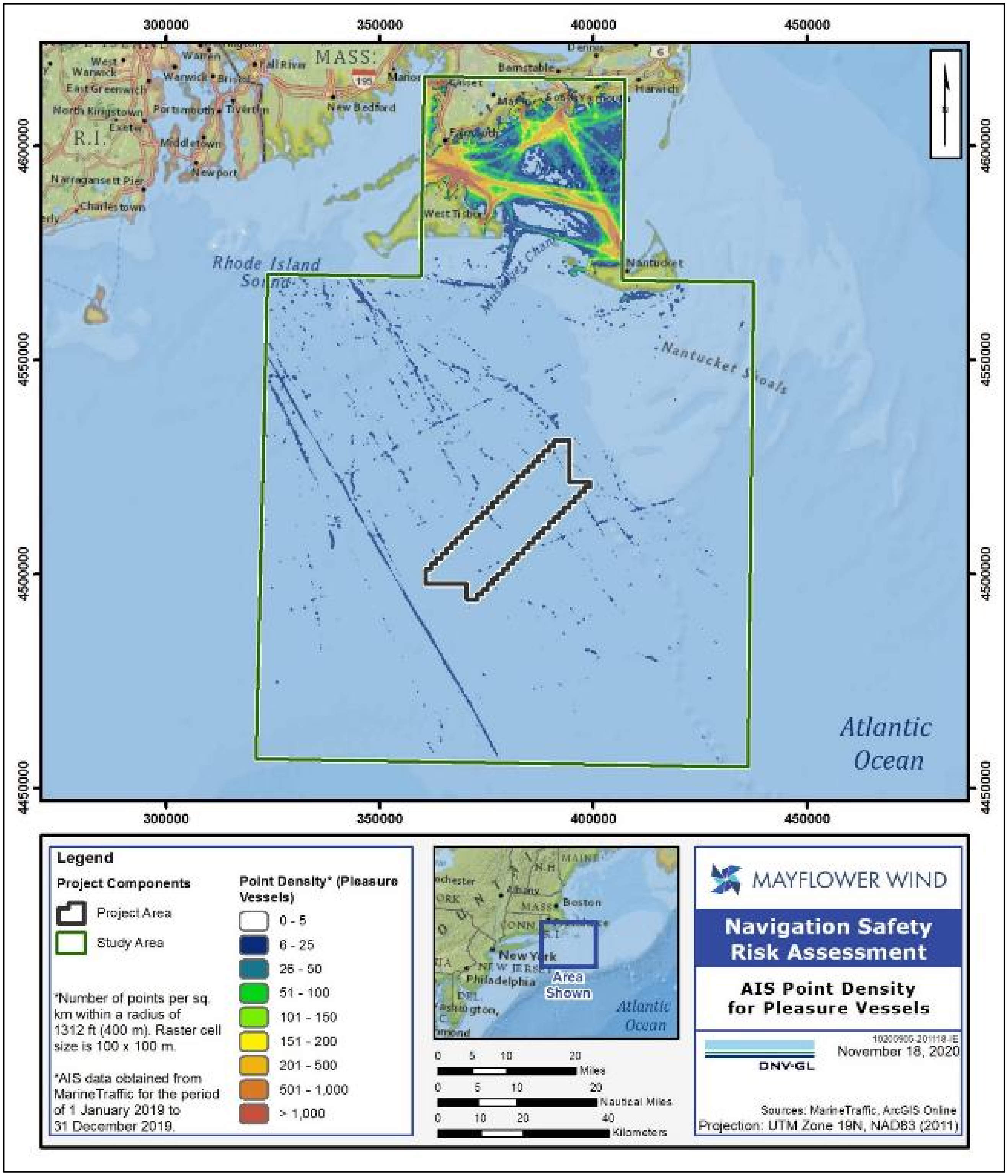


Figure B-23 Density of AIS Points for Pleasure Vessels

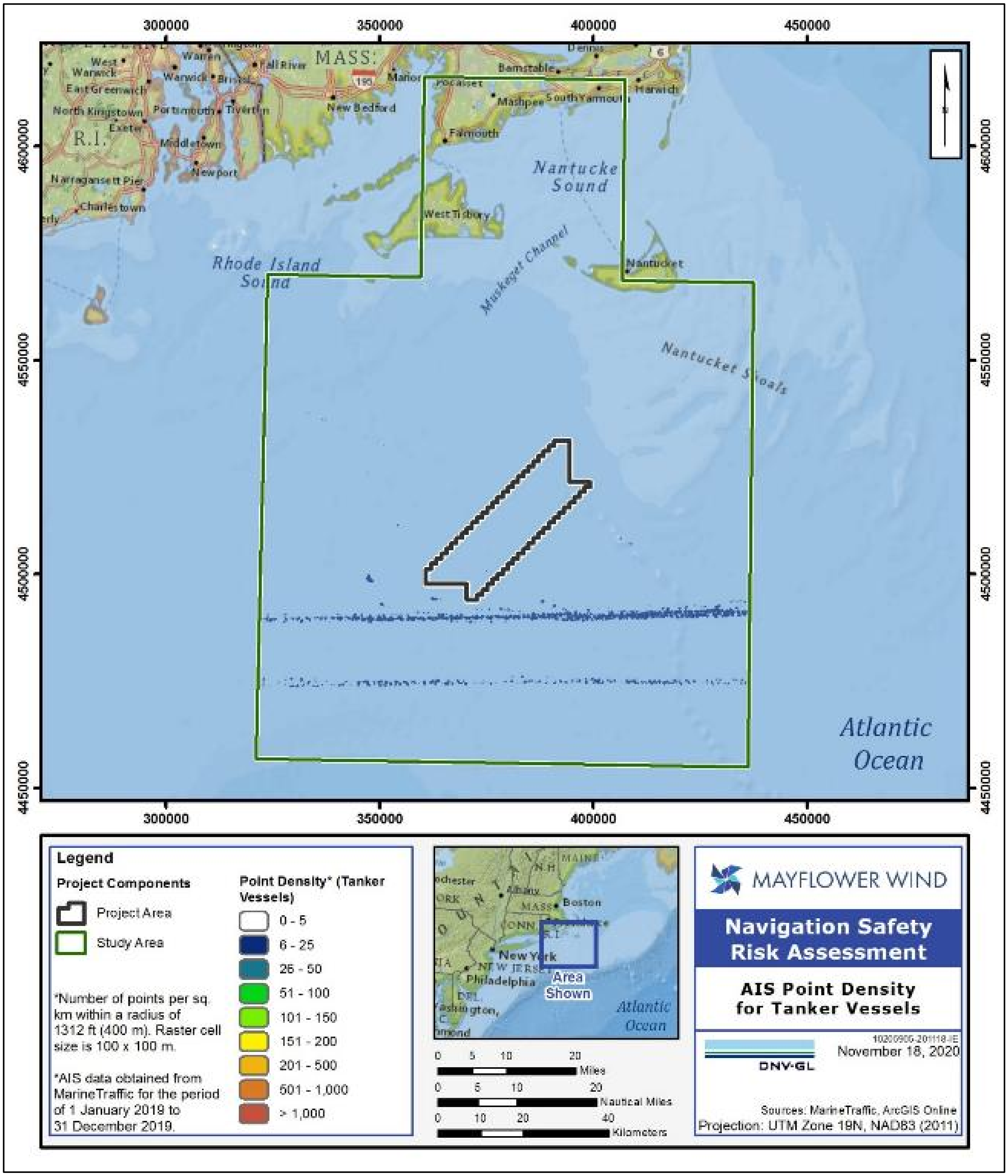


Figure B-24 Density of AIS Points for Tanker Vessels

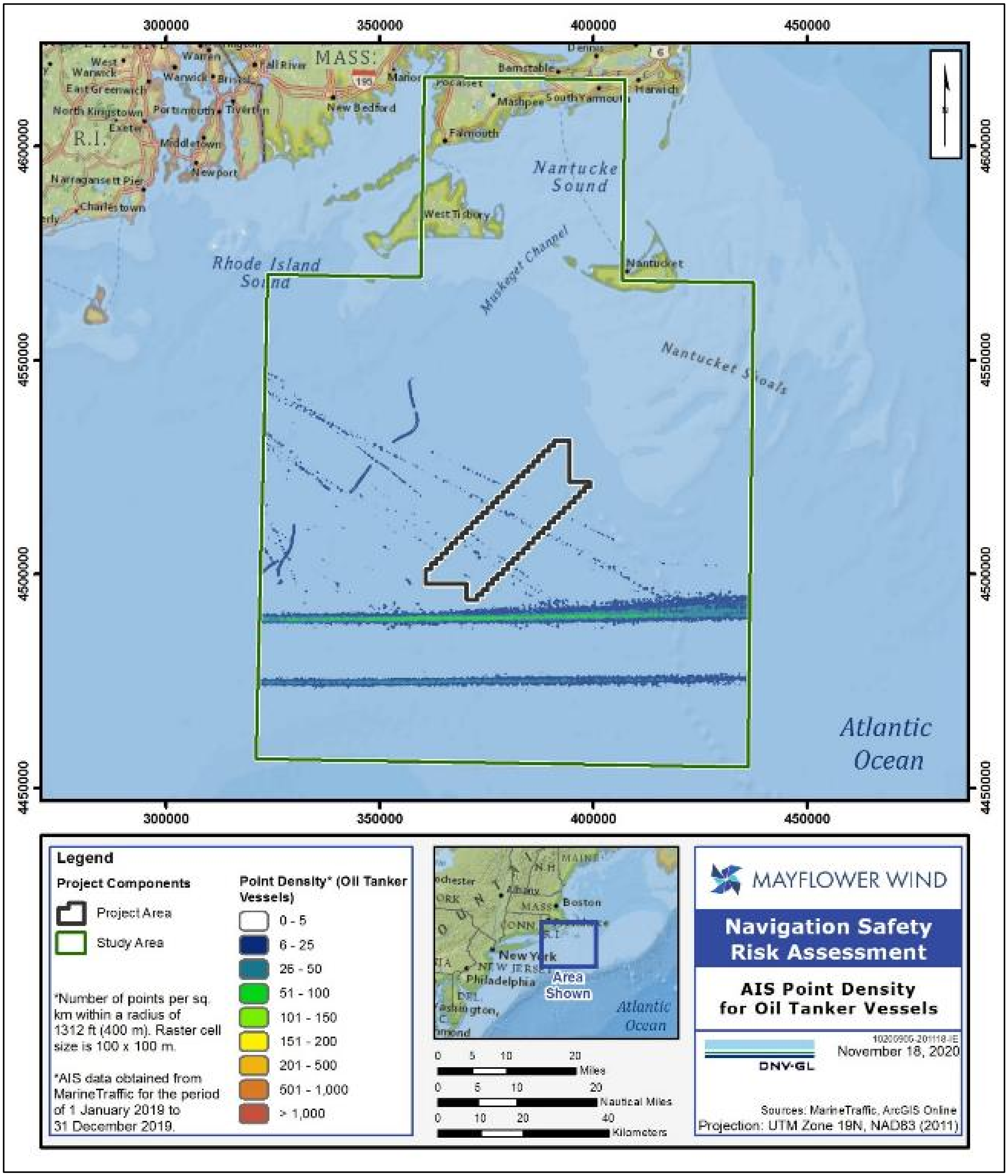


Figure B-25 Density of AIS Points for Oil Tanker Vessels

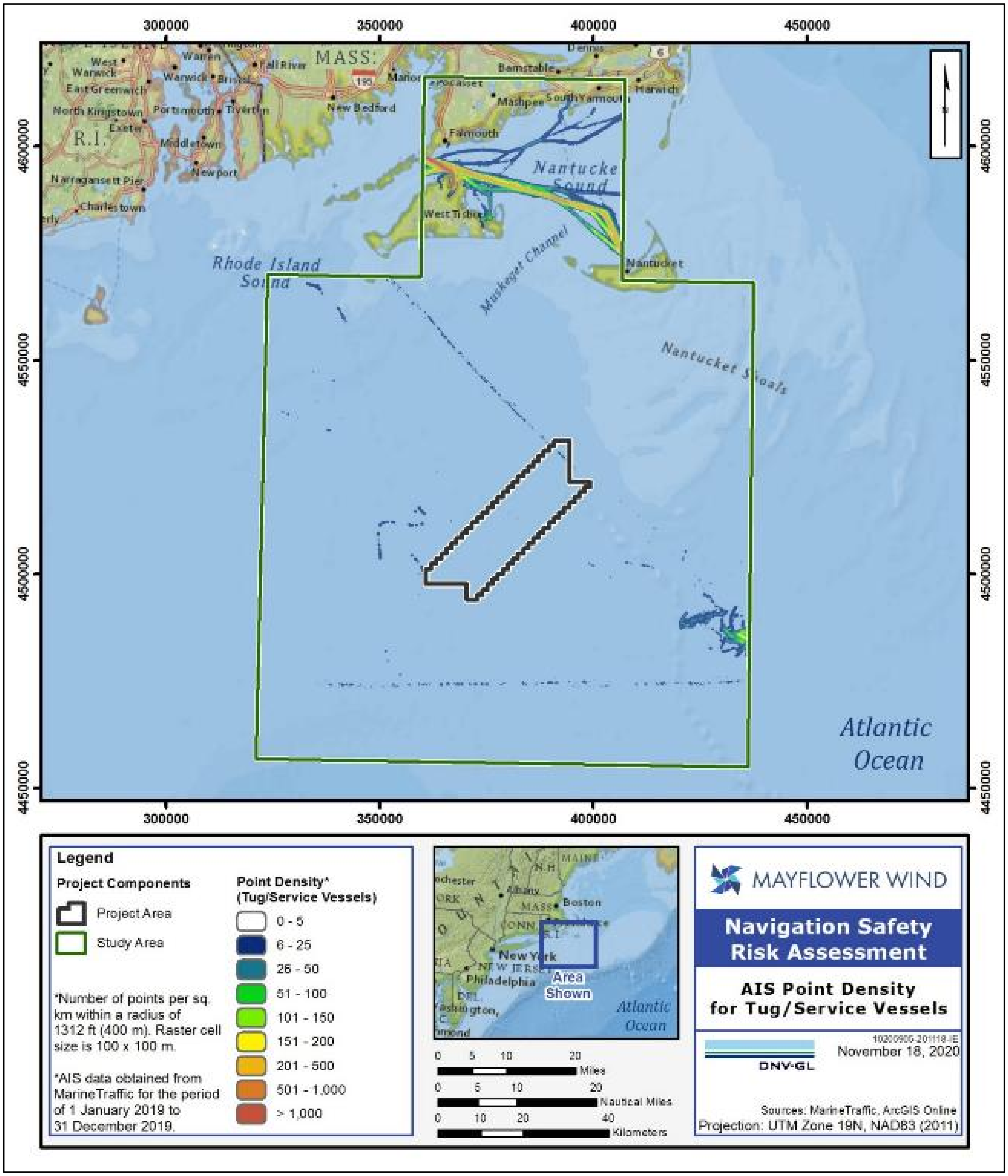


Figure B-26 Density of AIS Points for Tug/Service Vessels

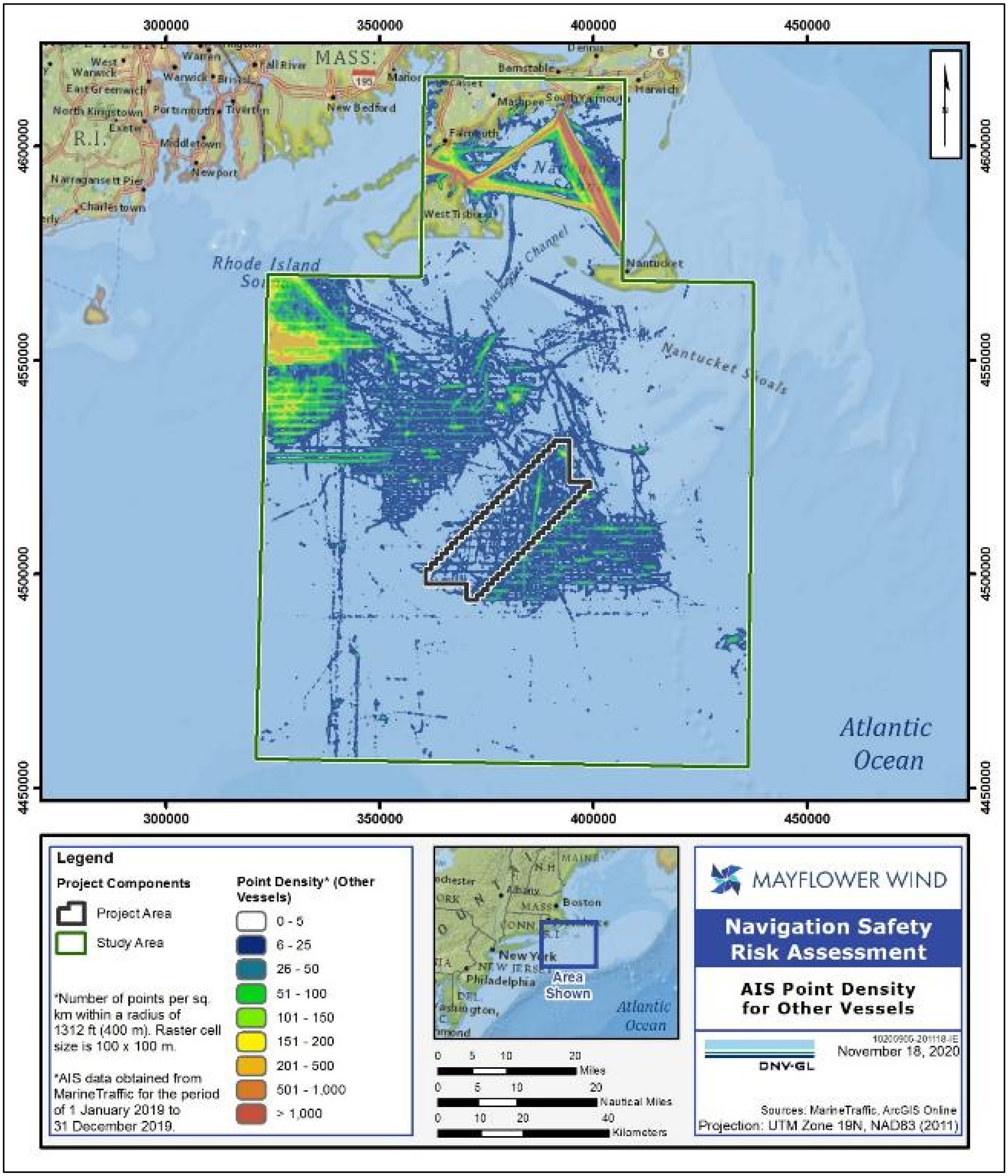


Figure B-27 Density of AIS Points for Other Vessels

B.3 AIS Speed Profile by Vessel Type

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

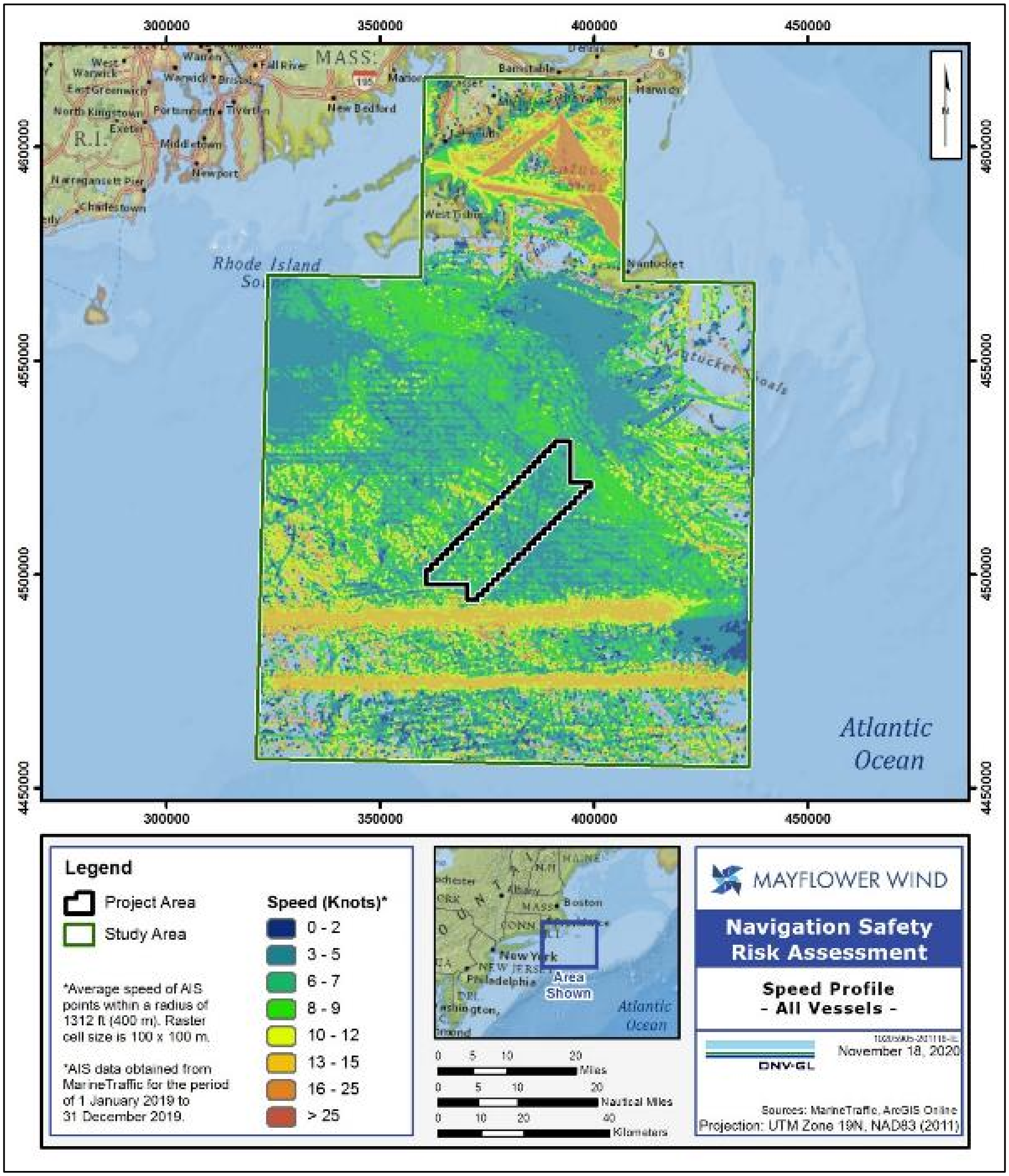


Figure B-28 Average Speed of AIS Points for All Vessels

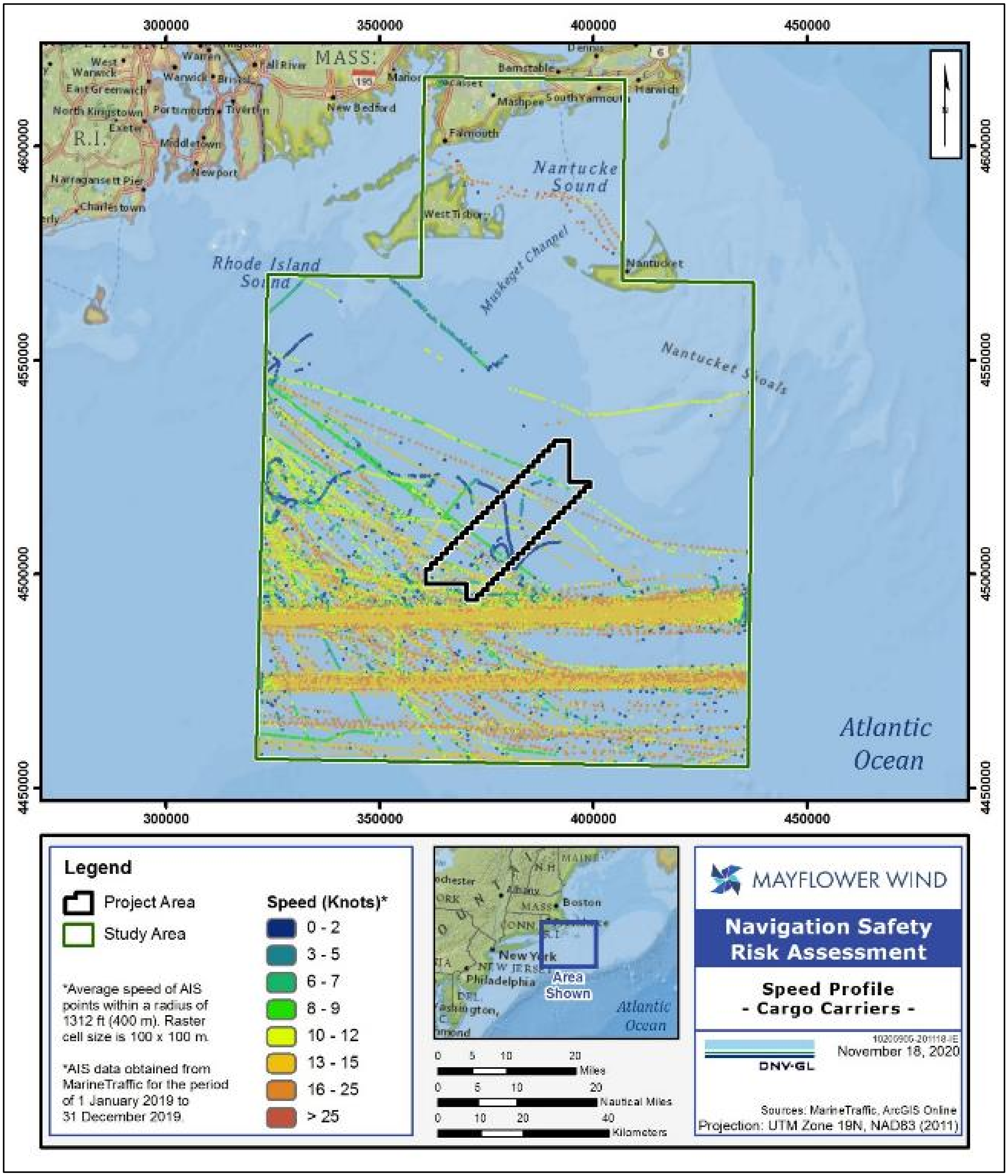


Figure B-29 Average Speed of AIS Points for Cargo and Carrier Vessels

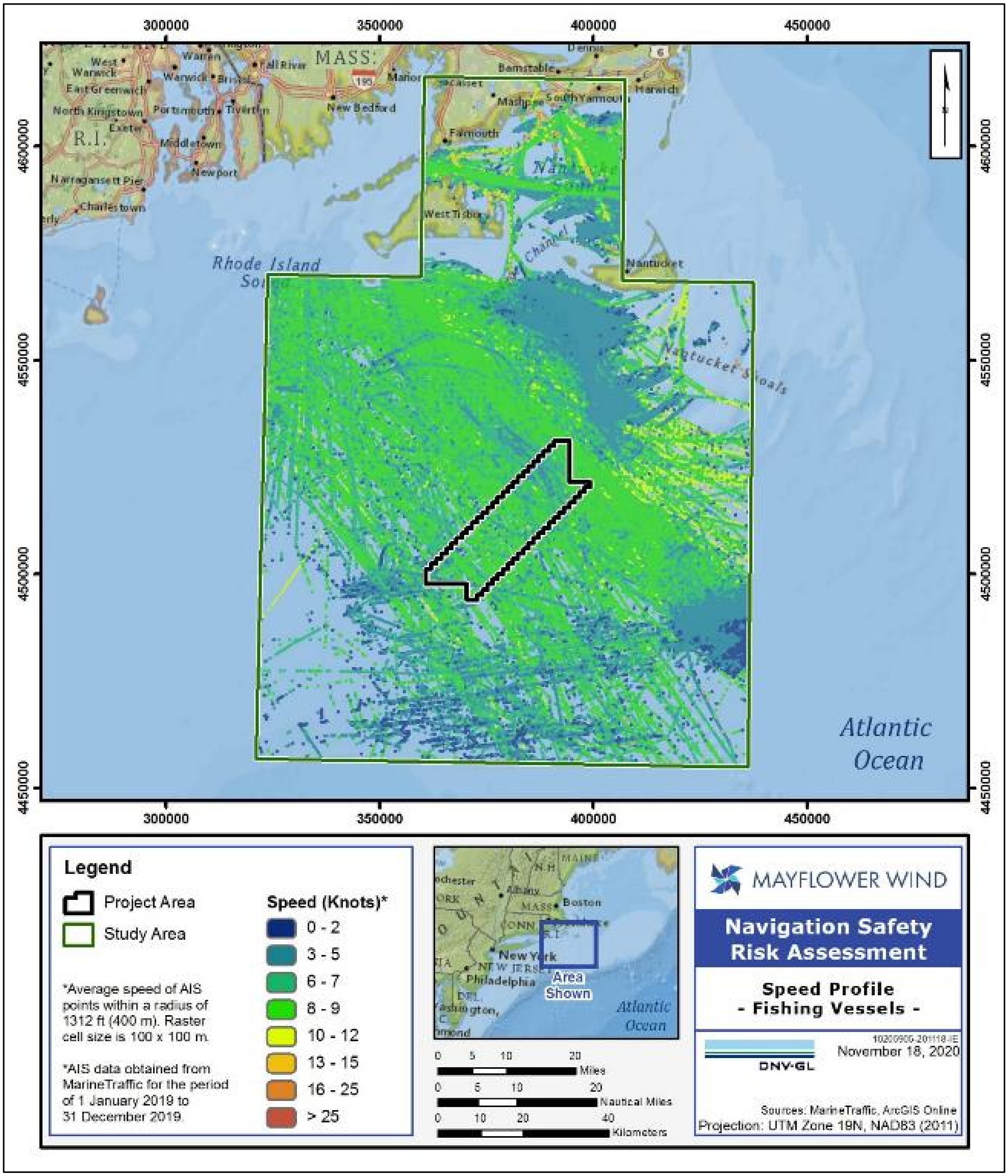


Figure B-30 Average Speed of AIS Points for Fishing Vessels

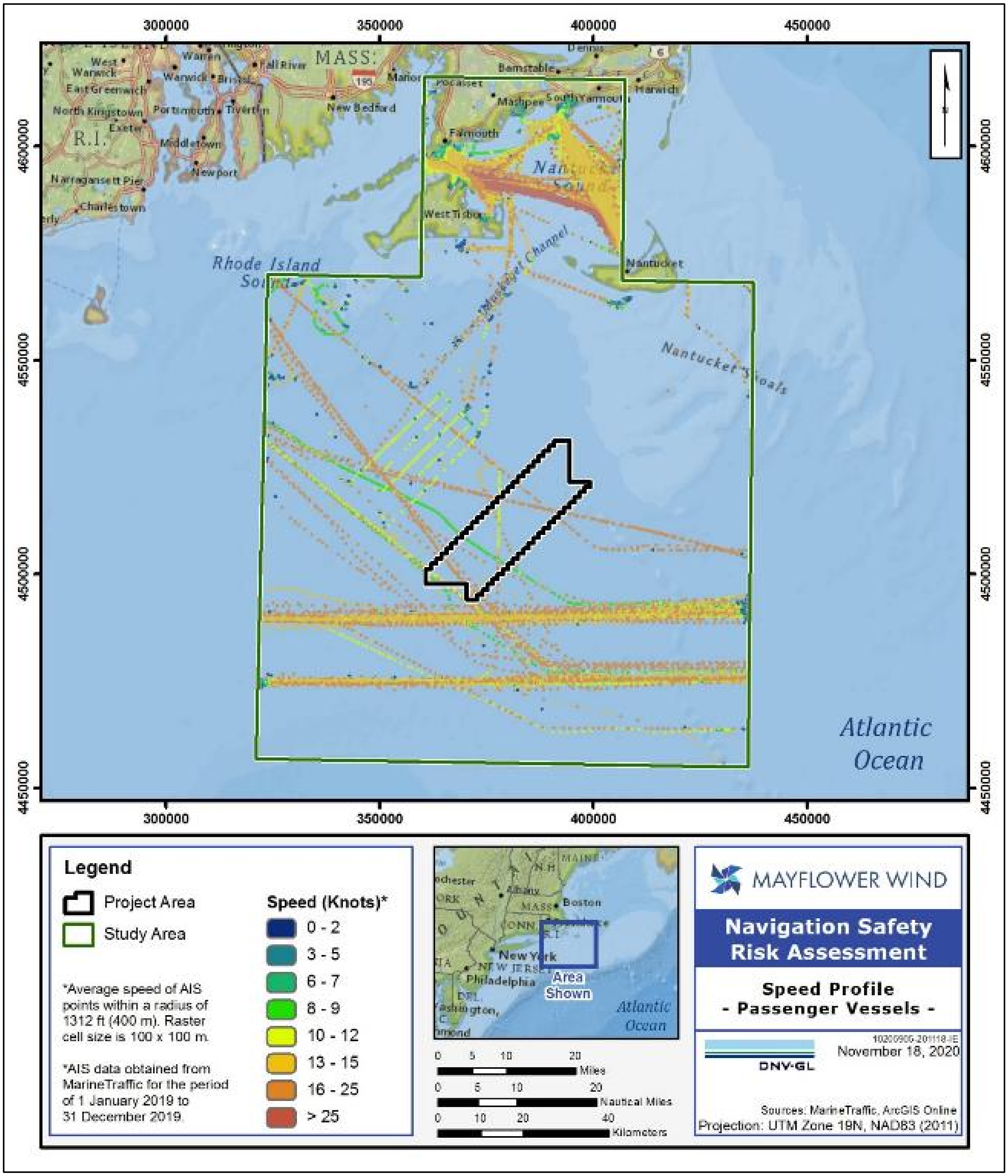


Figure B-31 Average Speed of AIS Points for Passenger Vessels

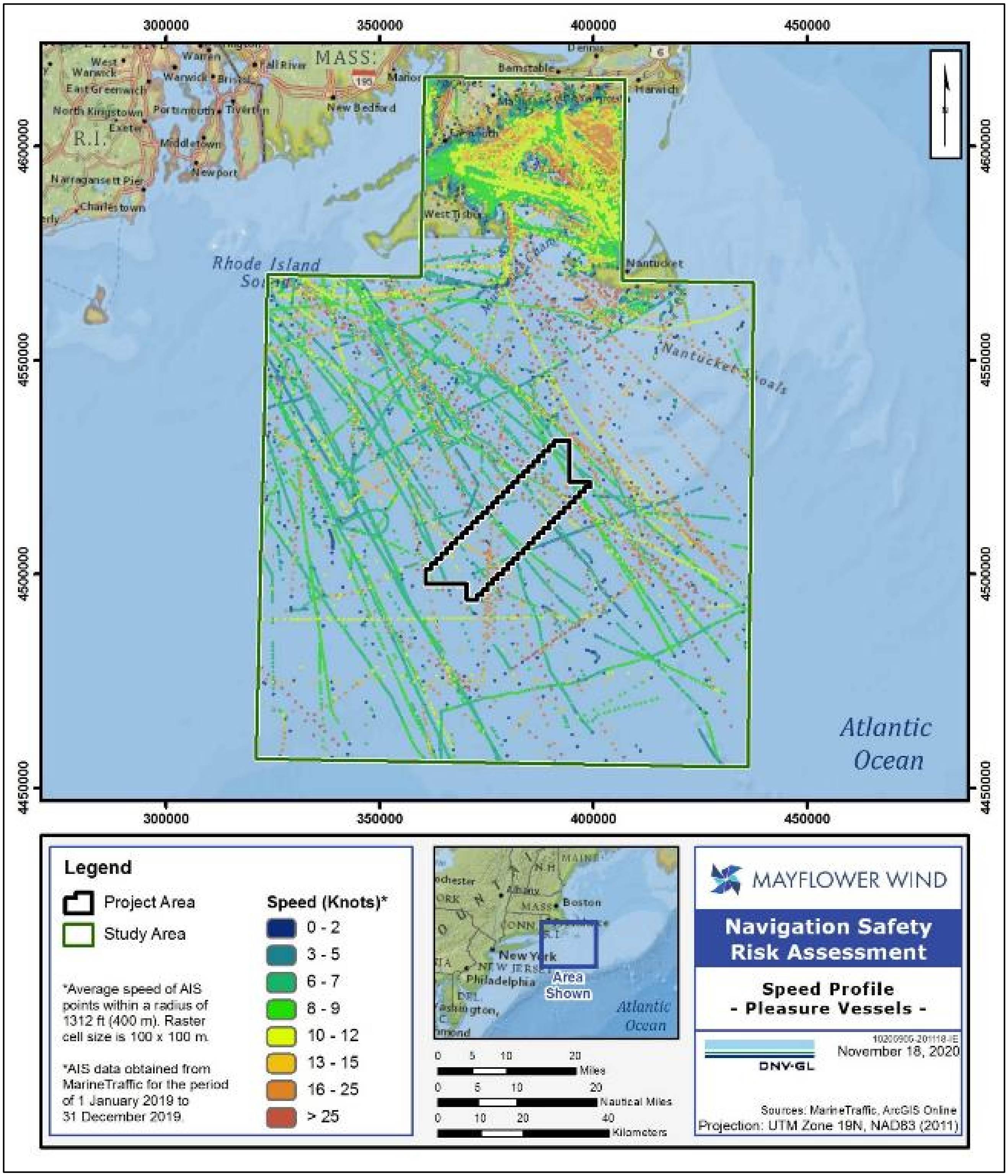


Figure B-32 Average Speed of AIS Points for Pleasure Vessels

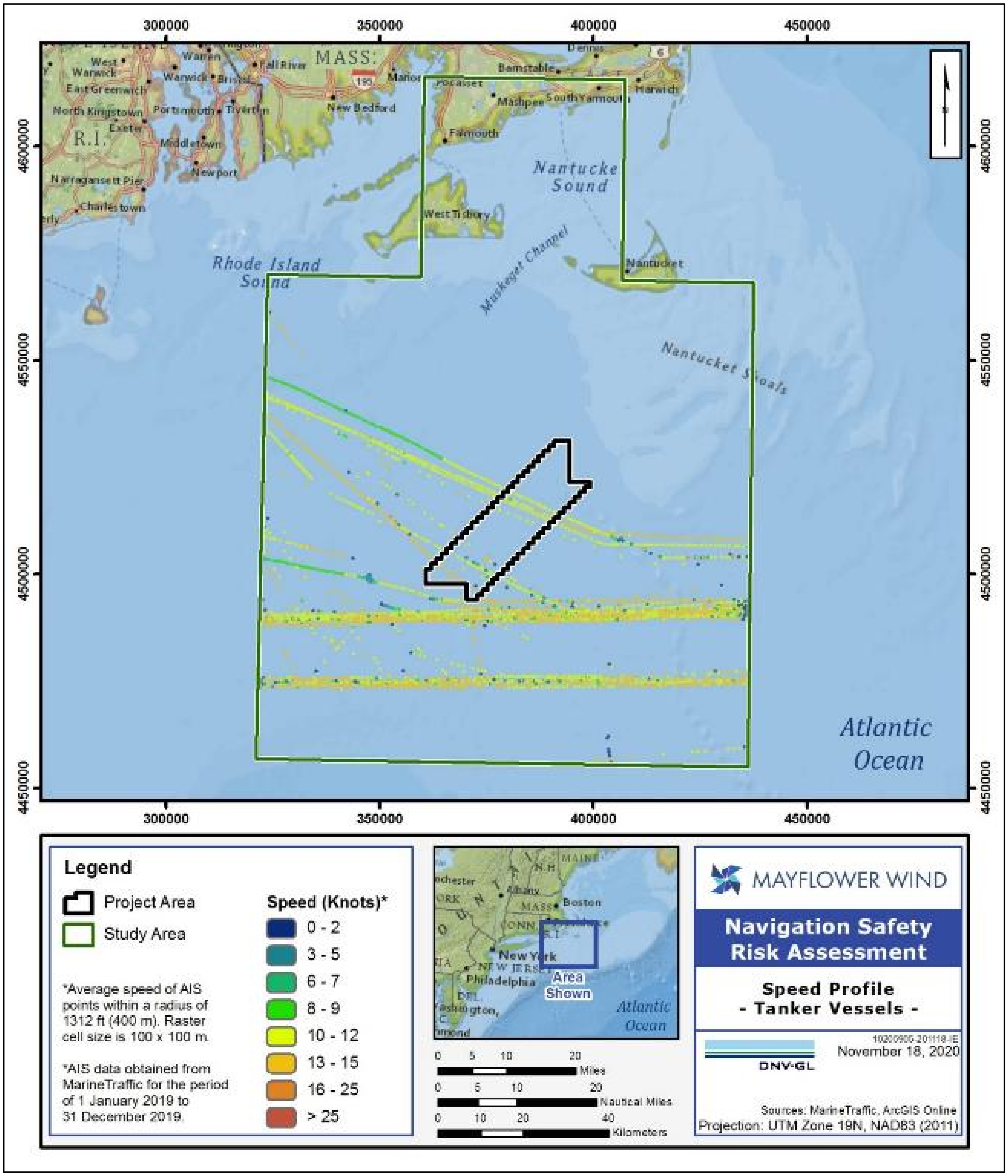


Figure B-33 Average Speed of AIS Points for Tanker Vessels

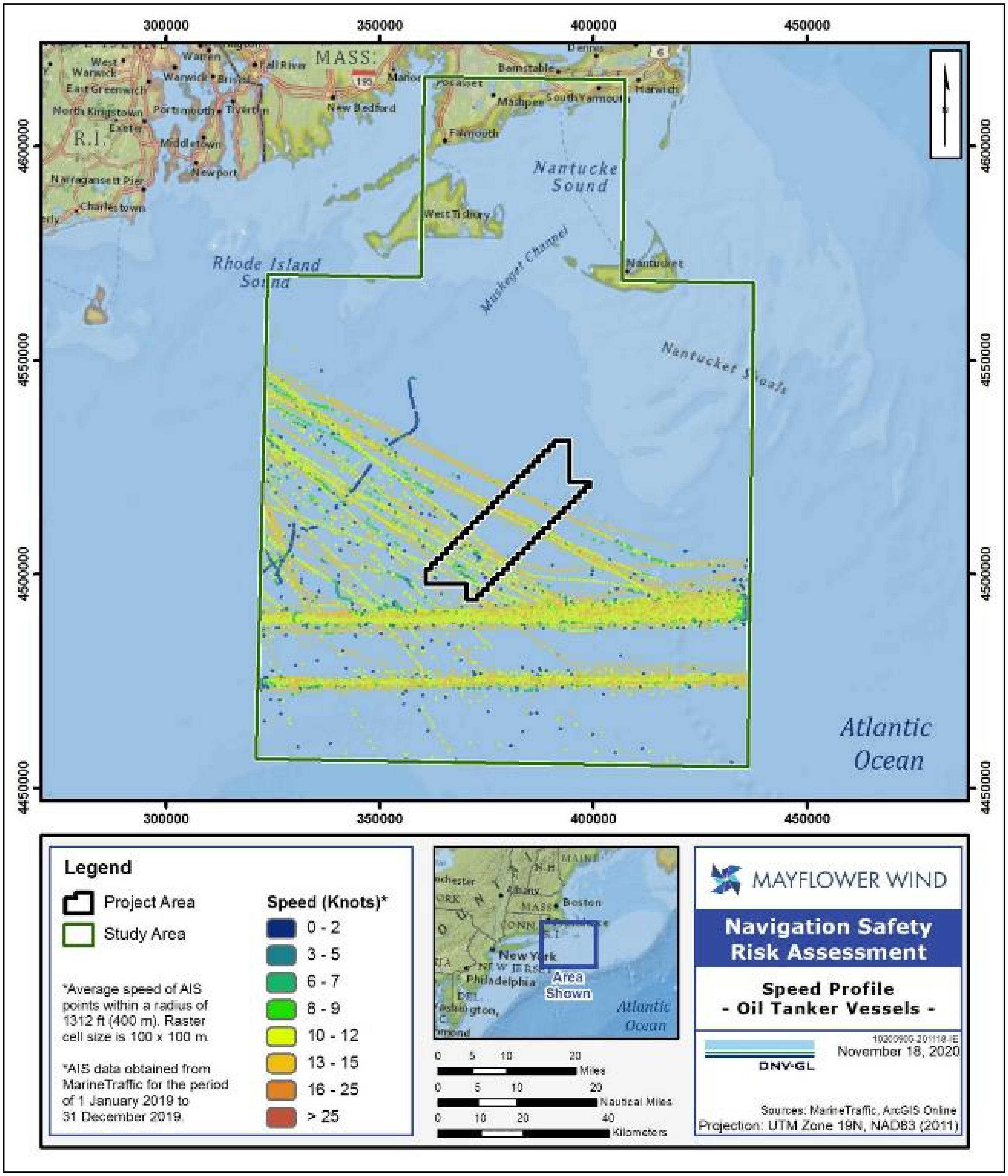


Figure B-34 Average Speed of AIS Points for Oil Tanker Vessels

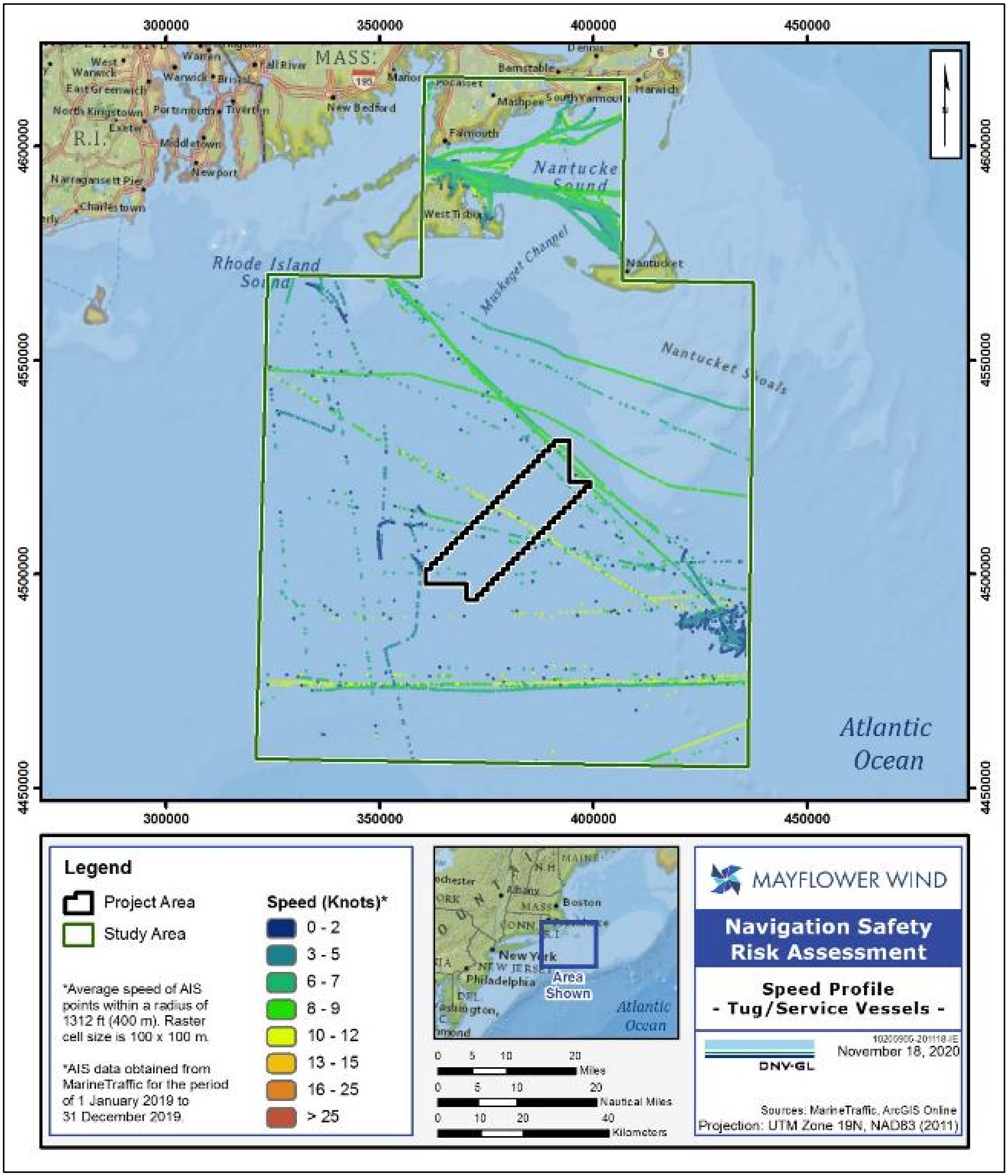


Figure B-35 Average Speed of AIS Points for Tug/Service Vessels

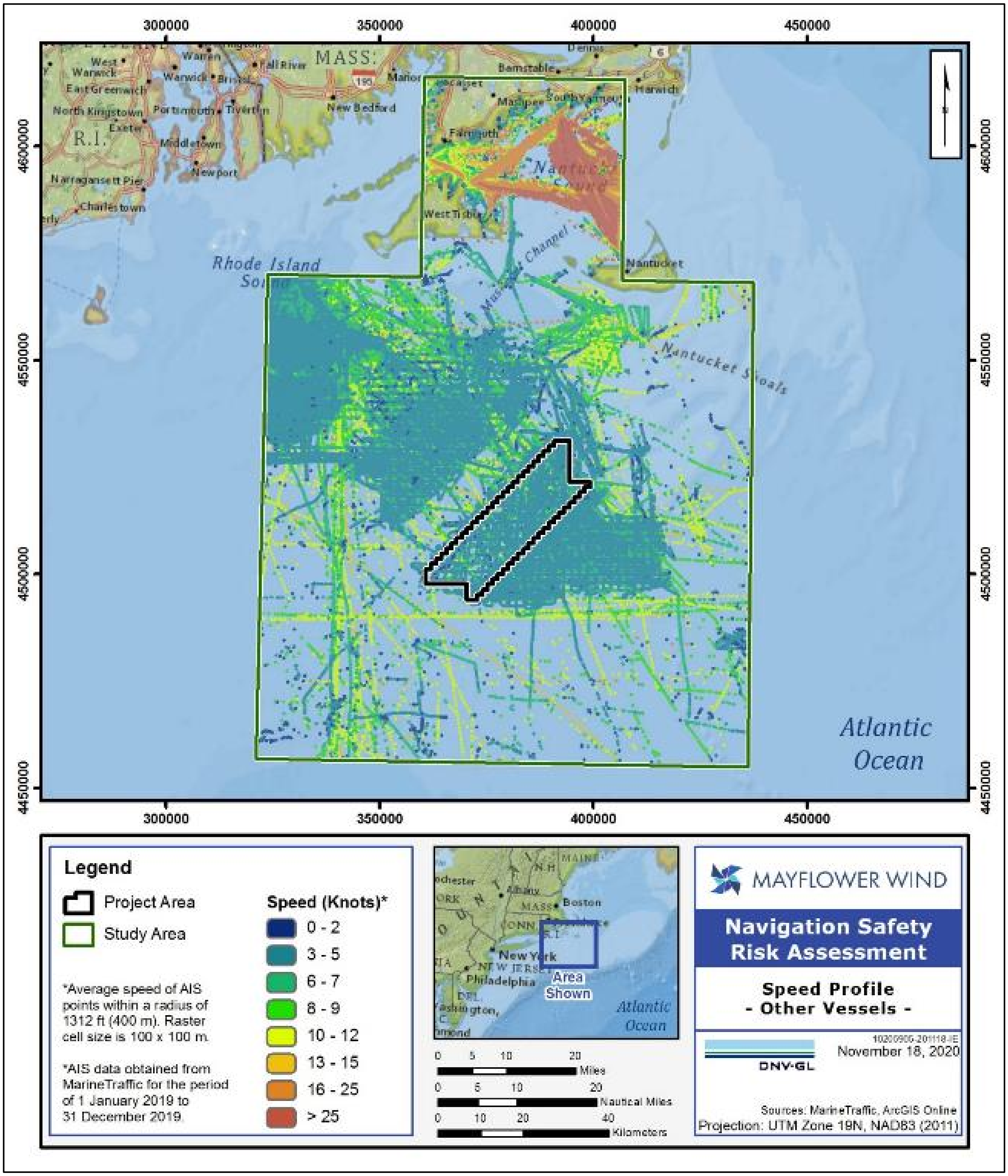


Figure B-36 Average Speed of AIS Points for Other Vessels

APPENDIX C – MARITIME STAKEHOLDER ENGAGEMENT

Below is a summary of selected Project stakeholder interactions.

Date	Type of Stakeholder	Agency/Stakeholder	Type of Correspondence	Topics Discussed
10/16/ 10/17/2019	Federal / State / Fisheries / Developers	Responsible Offshore Development Alliance (RODA)/Special Initiatives for Offshore Wind (SIOW)	In-person meeting	RODA quarterly meeting & SIOW Educational Forum
1/13/2020	Federal / State / Fisheries / Developer	RODA	In-person meeting	Quarterly RODA meeting
1/27/2020	Developers	MA/RI Joint Developer Marine Affairs Working Group	In-person meeting	Monthly Marine Affairs Working Group meeting with MA/RI developers
2/24/2020	Developers	MA/RI Joint Developer Marine Affairs Working Group	In-person meeting	Monthly Marine Affairs Working Group meeting with MA/RI developers
2/25/2020	Federal	USCG	In-person meeting	Offshore wind meeting with USCG and other MA/RI wind energy developers
3/25/2020	Federal	Navy Fleet Command	Email	Submittal of Notice to Fleet Command for Mayflower 2020 geophysical surveys
5/6/2020	Federal	USCG	Call	Introduced project and reviewed planned approach and outline of Navigation Safety Risk Assessment (NSRA)
6/5/2020	Commercial Fishing	Commercial Fisheries Center of Rhode Island	Call	Discussion of strategies to manage interactions between the fishing industry and Mayflower Wind's Geotechnical & Geophysical Surveys.
6/12/2020	Developers	MA/RI Offshore Wind Development Fisheries Liaison Officer Meeting	Call	Planning for joint developer engagement with the fishing industry on navigation safety specific to Summer 2020 Geotechnical & Geophysical Surveys
6/22/2020	Federal	Fleet Forces Atlantic Exercise Coordination Center (FFAECC)	Email	Geotechnical survey notification
6/22/2020	Federal	USCG	Email	Local Notice to Mariners submitted to the USCG
6/23/2020	Fisheries Representative / Commercial Fishing	Massachusetts Lobstermen's Association	Call	Discussion of strategies to manage interactions between the fishing industry and Mayflower Wind's Geotechnical & Geophysical Surveys.
7/1/2020	Federal	FFAECC	Email	Submittal of Notice to Fleet Command for upcoming geotechnical surveys in lease area
7/1/2020	Federal	USCG	Email	Submittal of Local Notice to Mariners for upcoming geotechnical surveys in lease area
7/8/2020	Commercial Fishing / Recreational Fishing	Port of Stonington (CT) Port Hours	In-person meeting	Discussion with local fishermen on navigational safety and other issues with offshore wind developments.

Date	Type of Stakeholder	Agency/Stakeholder	Type of Correspondence	Topics Discussed
7/9/2020	Commercial Fishing / Recreational Fishing	Point of Galilee (RI) Port Hours	In-person meeting	Discussion with local fishermen on navigational safety and other issues with offshore wind developments.
7/9/2020	Commercial Fishing	Commercial Fisheries Center of Rhode Island	In-person meeting	Discussion of navigational safety issues and the proposed 1x1 NM grid for offshore wind lease areas.
7/14/2020	Federal	FFAECC	Email	Submittal of Notice to Fleet Command for the Fugro Brasilis
7/14/2020	Federal	USCG	Email	Submittal of Local Notice to Mariners for the Fugro Brasilis
7/16/2020	Commercial Fishing / Recreational Fishing	Port of New Bedford (MA) Port Hours	In-person meeting	Discussion with local fishermen on navigational safety and other issues with offshore wind developments.
7/17/2020	Commercial Fishing / Developers / State / Federal	Fisheries Technical Working Group (New York State Energy & Research Development Authority)	Call	Discussion of port access studies and other current navigation safety studies/issues.
7/30/2020	Commercial Fishing / Recreational Fishing	Port of New Bedford (MA) Port Hours	In-person meeting	Discussion with local fishermen on navigational safety and other issues with offshore wind developments.
8/5/2020	Commercial Fishing / Recreational Fishing	Port of New Bedford (MA) Port Hours	In-person meeting	Discussion with local fishermen on navigational safety and other issues with offshore wind developments.
8/5/2020	Fisheries Representative / Commercial Fishing	Massachusetts Lobstermen's Association	Call	Coordination of scouting effort provided by MLA to inform Mayflower Wind's Summer 2020 Geotechnical & Geophysical Surveys and their interactions with the fishing industry.
8/6/2020	Federal	FFAECC	Email	Submittal of Notice to Fleet Command for upcoming benthic habitat survey in State and offshore waters of MA; scheduled to commence on/about August 19, 2020
8/6/2020	Federal	USCG	Email	Submittal of Local Notice to Mariners for upcoming benthic habitat survey in State and Offshore waters of MA, scheduled to commence on/about August 19 2020
9/1/2020	Developers	MA/RI Joint Developer Marine Affairs Working Group	Call	Discussion of recent developments with USCG ATON, MARIPARS, NYPARS, standardization of wind turbine labeling schemes on nautical charts, coordination of developer's survey vessel plans, and other navigational safety issues.

Date	Type of Stakeholder	Agency / Stakeholder	Type of Correspondence	Topics Discussed
10/1/2020	Commercial Fishing / Recreational Fishing	Port of New Bedford (MA) Port Hours	In-person meeting	Discussion with local fishermen on navigational safety and other issues with offshore wind developments.
10/2/2020	Commercial Fishing / Recreational Fishing	Port of Galilee (RI) Port Hours	In-person meeting	Discussion with local fishermen on navigational safety and other issues with offshore wind developments.
10/16/2020	Commercial Fishing / Developers / State / Federal	Responsible Offshore Science Alliance (ROSA) Synthesis of the Science Conference	Virtual Conference	Discussion of the impact to fishing operations, including navigation safety, of offshore wind developments
10/28/2020	Developers	MA/RI Joint Developer Marine Affairs Working Group	Call	Discussion of recent developments with USCG ATON (specifically recent lighting and marking requirements), MARIPARS, USCG's Atlantic Coast Fairways proposal, NYPARS, coordination of developer survey vessel activities, wind farm labeling and notes on nautical charts, and information sharing on safety impacts of developer buoy deployments.
11/18/2020	Developers / Commercial Fishing	Joint Industry Task Force	Call	Discussion of safety standards for navigational safety equipment requirements for vessels contracted by offshore wind developers, potential placement of AIS systems on WTGs
11/20/2020	Ports / Terminal and Vessel Operators / Developers / State / Federal	The Southeastern New England Port Safety & Security Forum	Virtual meeting	Presentations from USCG, Army Corps, Environmental Protection Agency, NOAA, local Police Dept., Navy, harbormasters, and offshore wind industry representatives.
12/14/2020	Federal	USCG/BOEM	Virtual meeting	Meeting to review draft NSRA and receive feedback from both agencies
4/13/2021	Federal	USCG	Virtual meeting	Attended and participated in USCG Offshore Wind Symposium and provided Mayflower Wind Project overview
7/21/2021	Federal	USCG	Virtual meeting	Project update meeting with USCG to provide status updates and introduce new Brayton Point export cable corridor
7/28/2021	Federal	US Navy	Virtual meeting	Project update meeting with Naval Seafloor Cable Protection Office

Date	Type of Stakeholder	Agency / Stakeholder	Type of Correspondence	Topics Discussed
8/11/2021	Developers	MA/RI Joint Developer Marine Affairs Working Group	Virtual meeting	Quarterly Marine Affairs Working Group meeting

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.

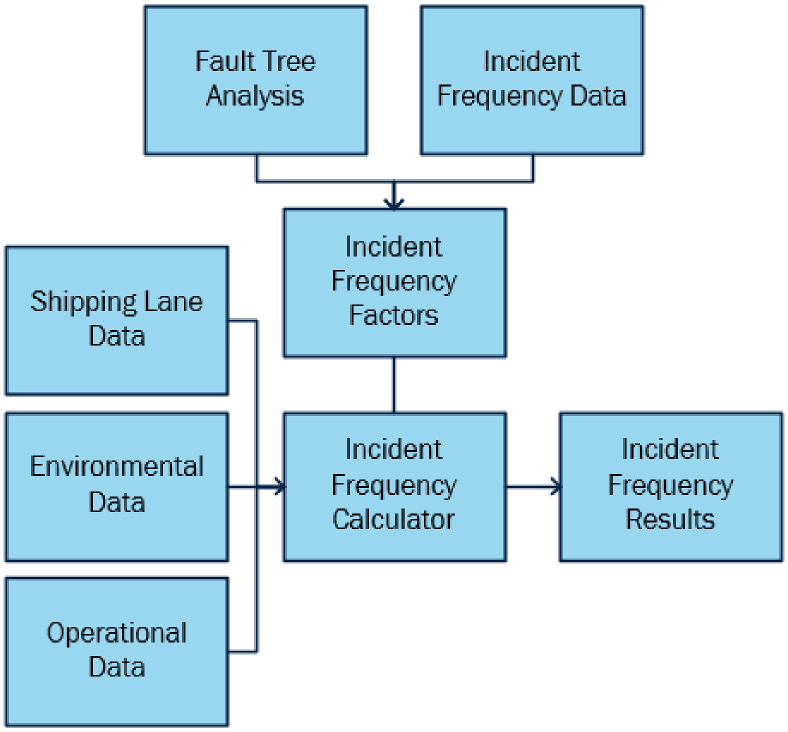


Figure D-1 Block Diagram of MARCS Incident Frequency Model

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.

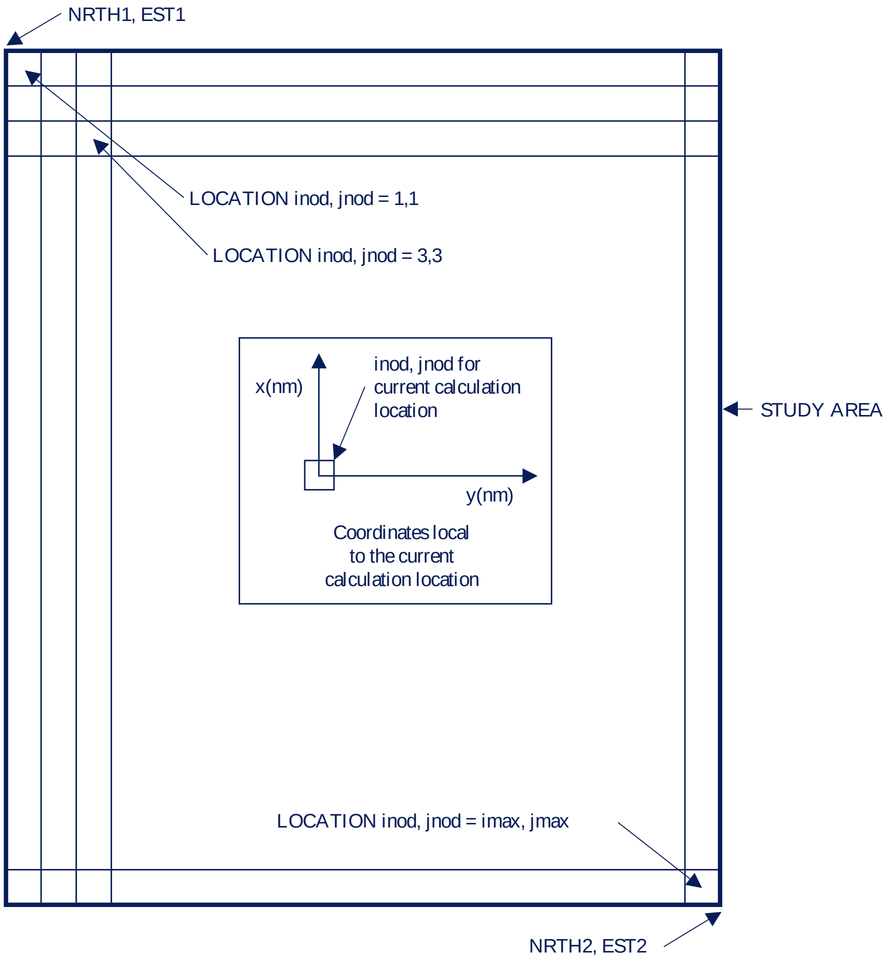


Figure D-2 Basic Definitions and Coordinate Sets

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.

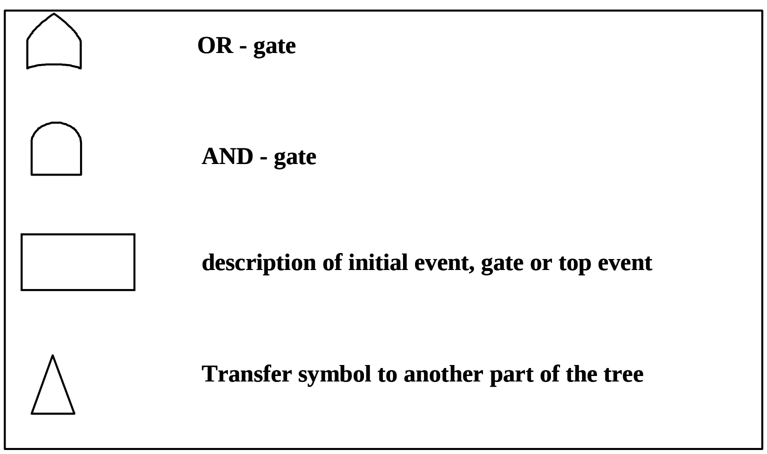


Figure D-3 Fault Tree Symbols

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:

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

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

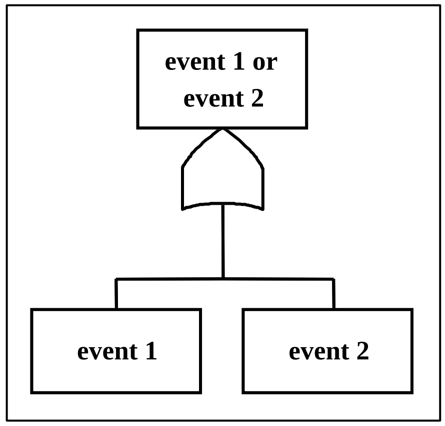


Figure D-4 OR Gate

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

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

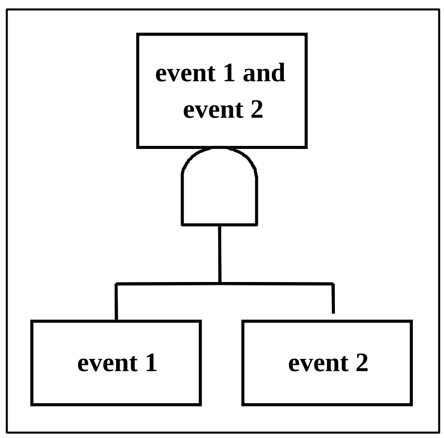


Figure D-5 AND Gate

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

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

D.3 Data used by MARCS

This section describes the various data inputs used by MARCS.

D.3.1 Traffic image data

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

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

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

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

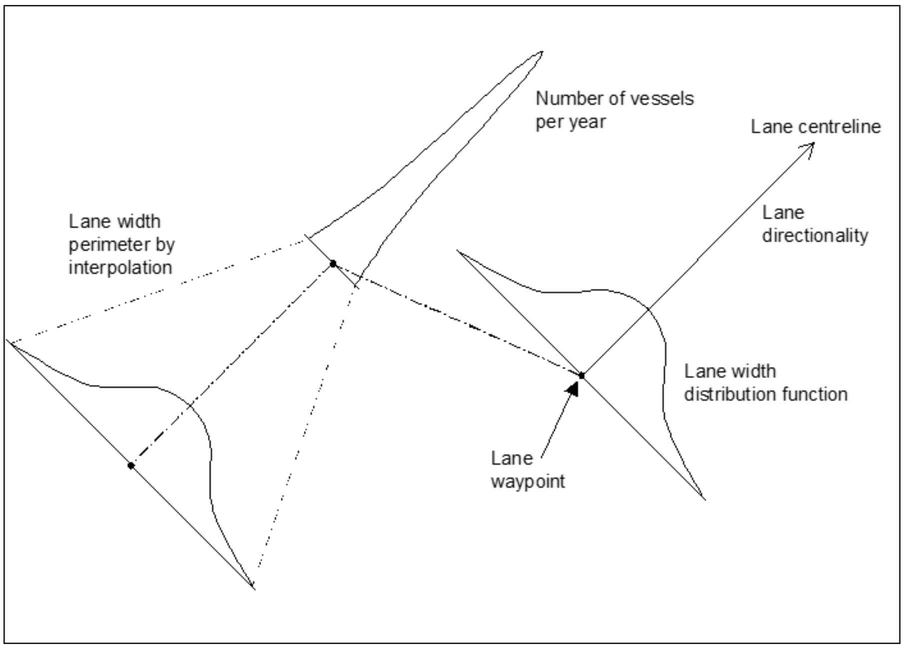


Figure D-6 Shipping lane Representation Used in MARCS

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

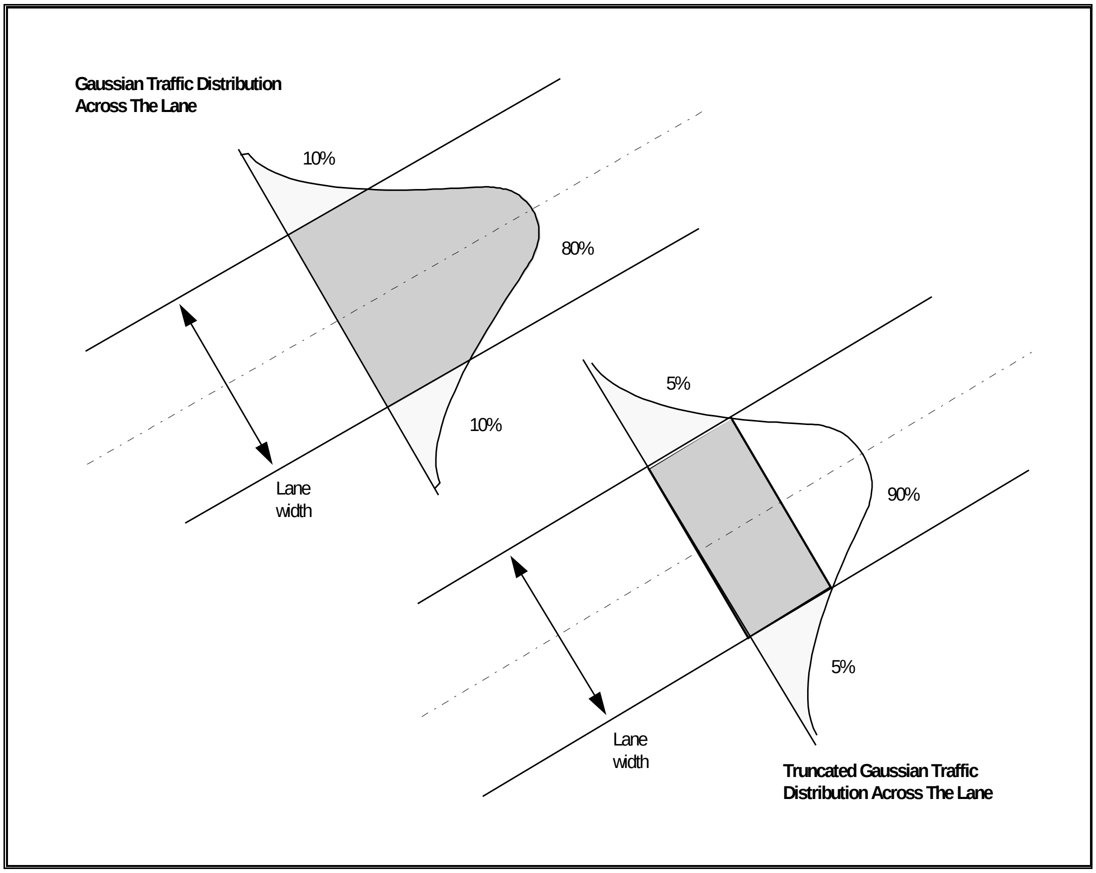


Figure D-7 Shipping Lane Width Distribution Functions Used in MARCS

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

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

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

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

D.3.2 Operational data

Internal operational data 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.

D.3.3 Environmental data

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

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

Wind rose data is defined within 8 compass points (north, northeast, east, etc.) in four wind speed categories: calm (0 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.

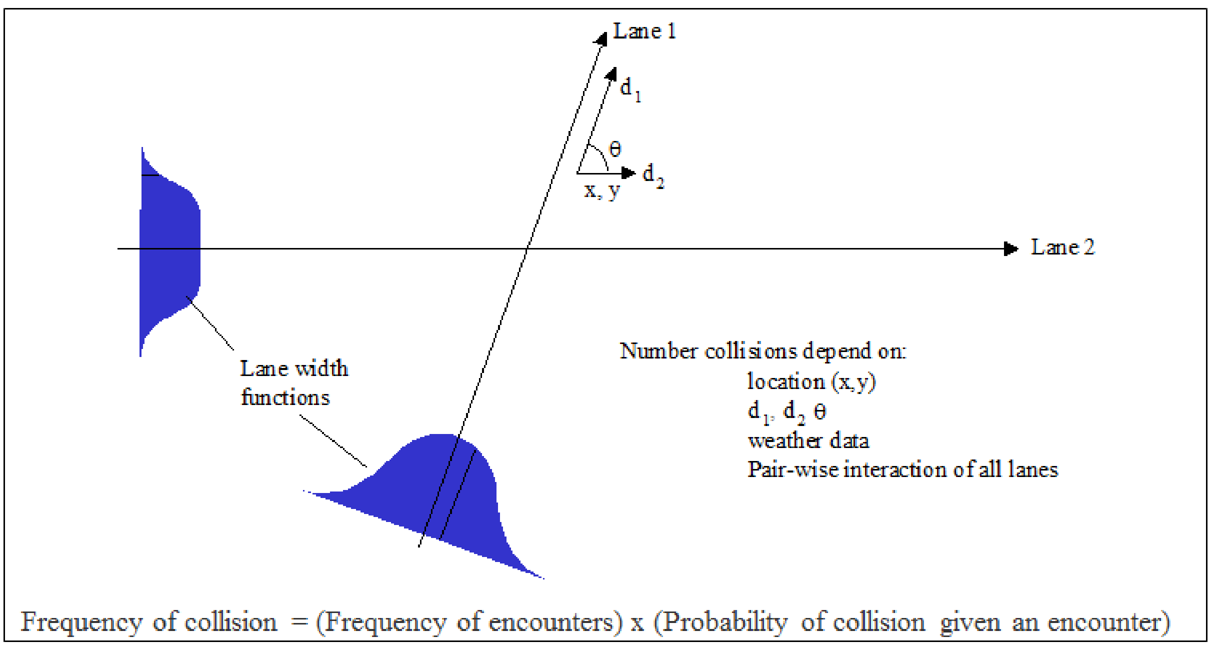


Figure D-8 Graphical Representation of the Collision Model

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.

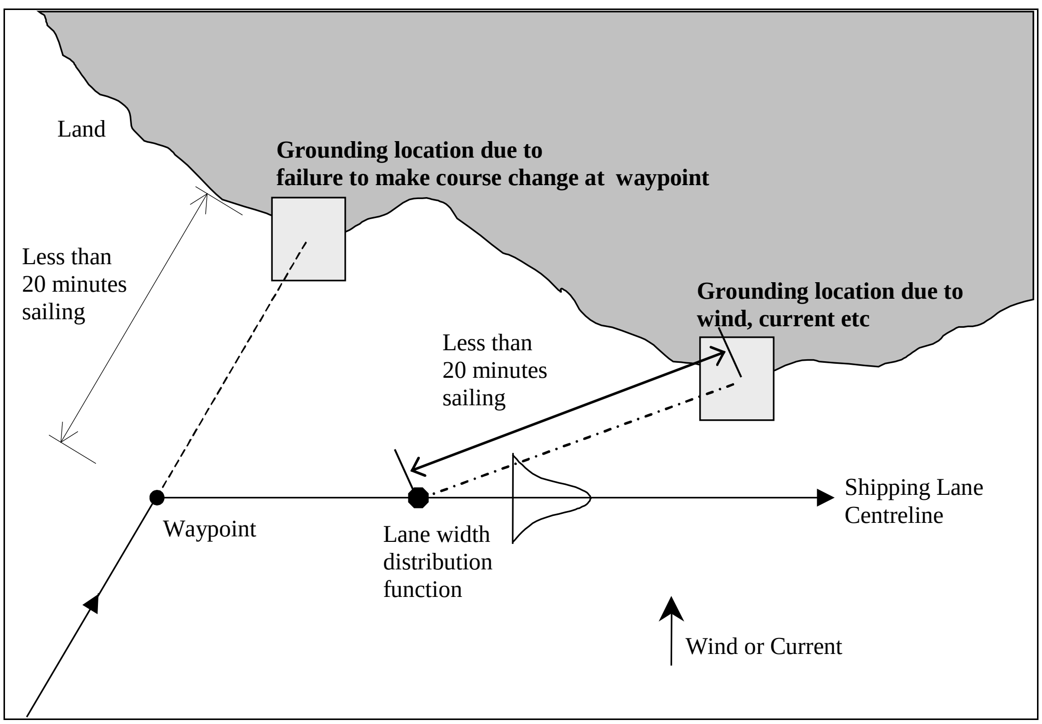


Figure D-9 Graphical Representation of the powered grounding model

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.

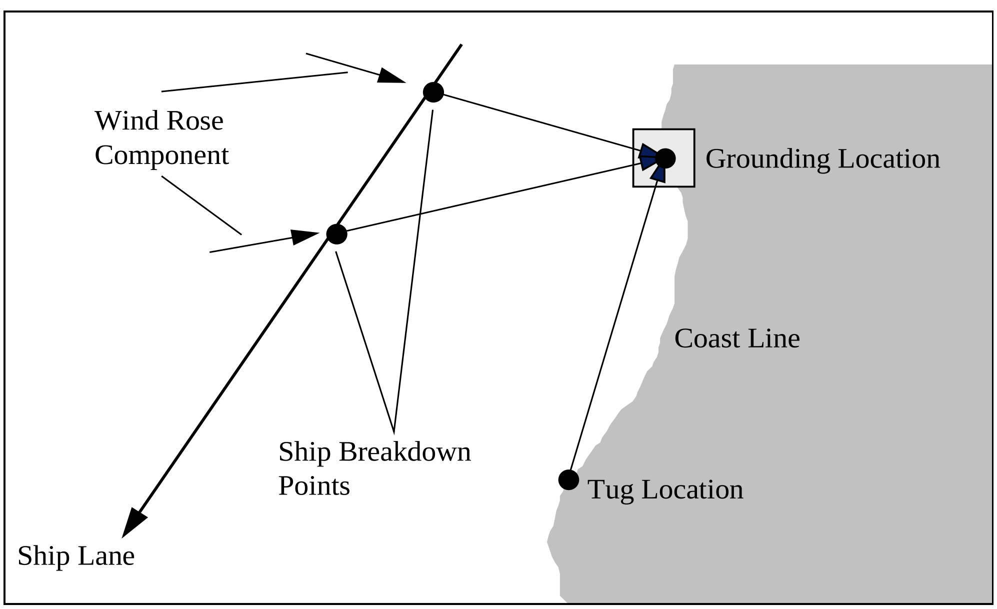


Figure D-10 Graphical Representation of the Drift Grounding Model

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.

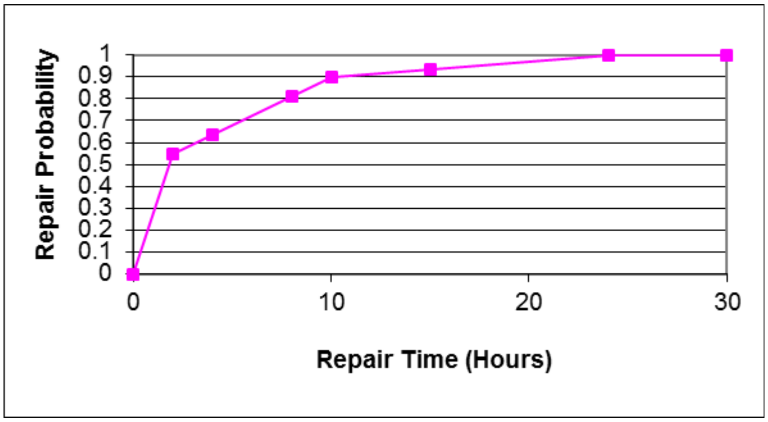


Figure D-11 Graphical representation of the self-repair save mechanism

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 seabed + 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 seabeds consist predominantly of sands, silts, and muds). If the anchor holds, then an anchor save is made.

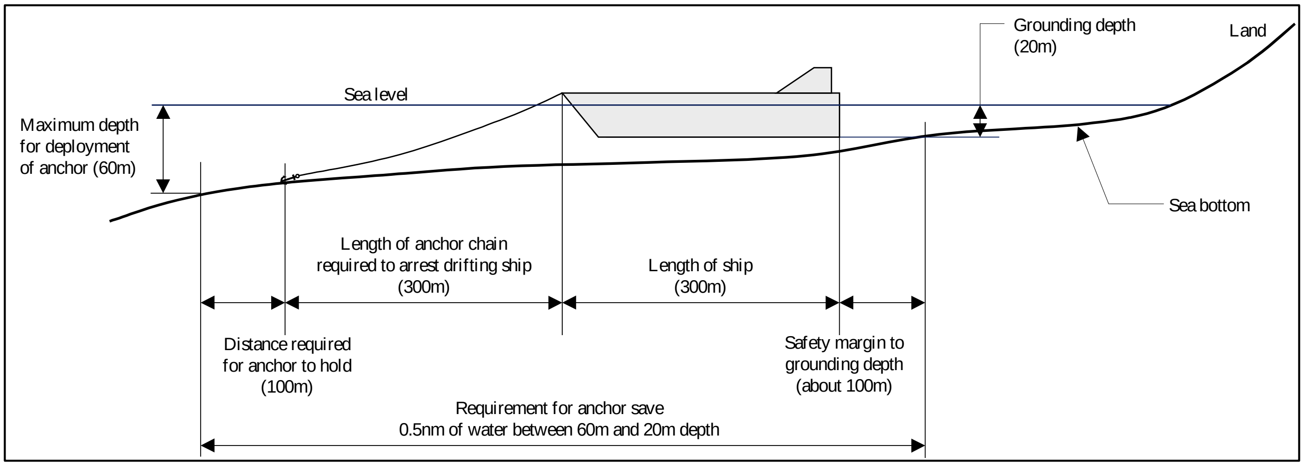


Figure D-12 Graphical Representation of the Anchor-Save Mechanism

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

D.4.4 The powered-impact model

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

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

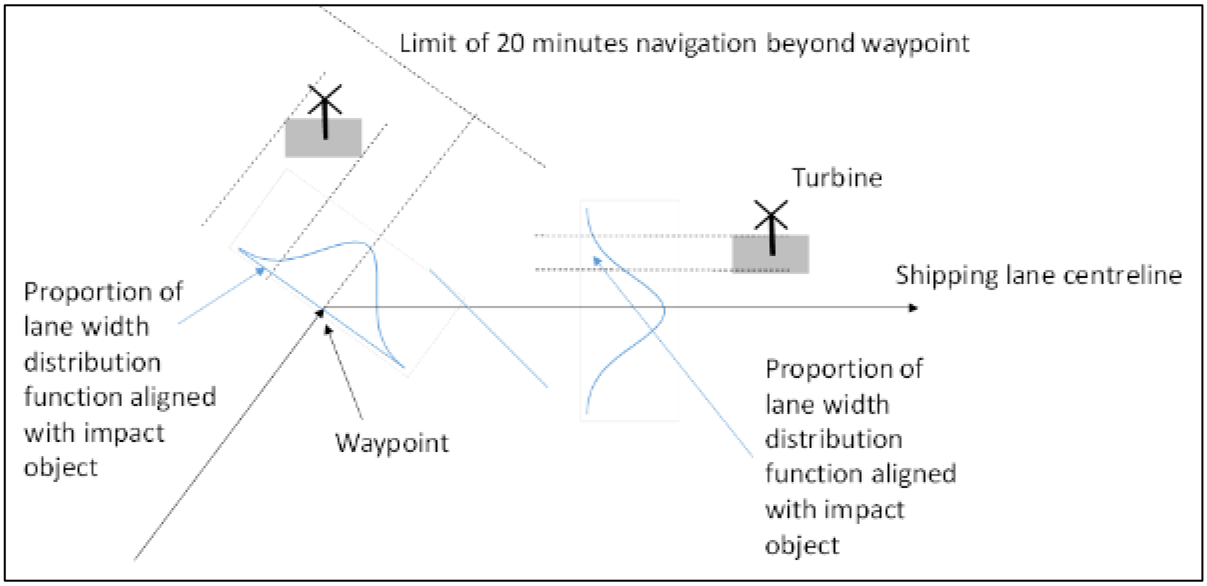


Figure D-13 Graphical Representation of Powered-Impact Model

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

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

- Repair
- Emergency tow vessel assistance
- Anchoring

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

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

In order to avoid over prediction of grounding or impact frequencies MARCS needs to know if a LOS[12] 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.

[12] "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.

- 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.”

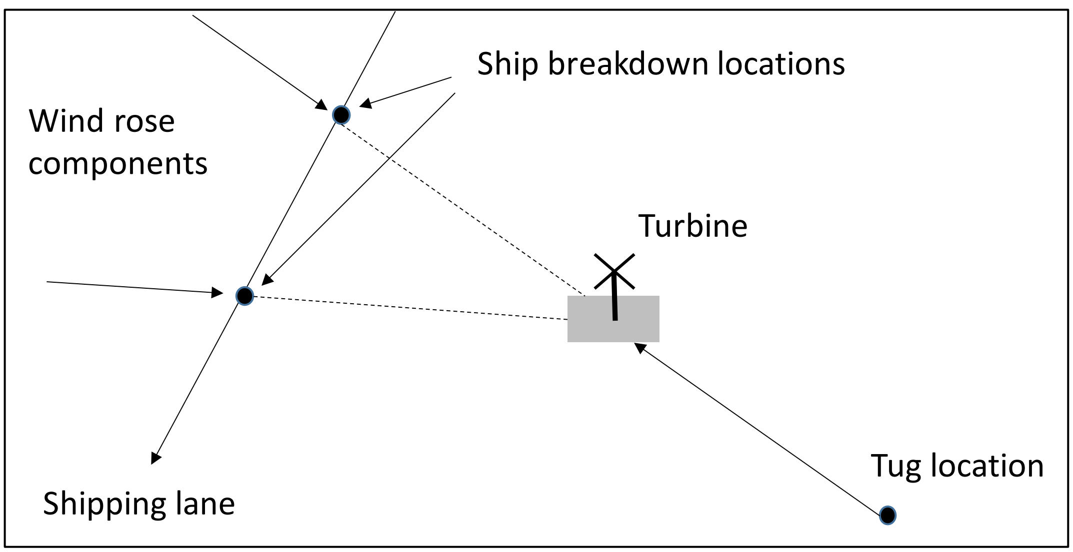


Figure D-14 Graphical representation of the drift impact model

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

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

Recovery methods described in the drift-grounding frequency model are applicable to the drift-impact frequency model.

D.5 Risk control quantification

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

D.5.1 Coastal vessel traffic service

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

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

D.5.2 Pilotage

The use of pilots has two main benefits:

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

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

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

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

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

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

D.5.3 Aids to navigation

D.5.3.1 Electronic chart display and information system

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

D.5.3.2 Conventional aids to navigation

Causal data on groundings provide some indication of the potential benefit of improving conventional 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 percent of incidents. Improving conventional ATON would not necessarily prevent all such incidents but might have indirect benefits on other navigational errors. Therefore, this study uses a reduction in groundings and allisions by 6 percent, which is justified by 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.5.4 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 – MAYFLOWER OFFSHORE WIND PROJECT MARINE ACCIDENT MODEL AND RESULTS

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 Marine Accident Risk Calculation System (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.

Three cases are reported here:

1. The Base Case (or Case 0). This includes the un-modified shipping traffic as transiting the area today prior to the installation of the wind turbines.
2. The Base Case Plus (or Case 1). This includes the un-modified shipping traffic as transiting the area today prior to the installation of the wind turbines. In addition, the wind turbine locations are also included in Case 1 to provide an estimate of the extra risk introduced by the presence of Project structures 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 Project structures and includes modified traffic routes assuming some ships will navigate around the structures once they are installed.

The differences in risk between these cases provide an estimate of the changed risk introduced by Project structures.

E.2 Model inputs

E.2.1 MARCS 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 modeling of Mayflower 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:

- 41.26 North
- 40.25 South
- -71.11 West
- -69.75 East

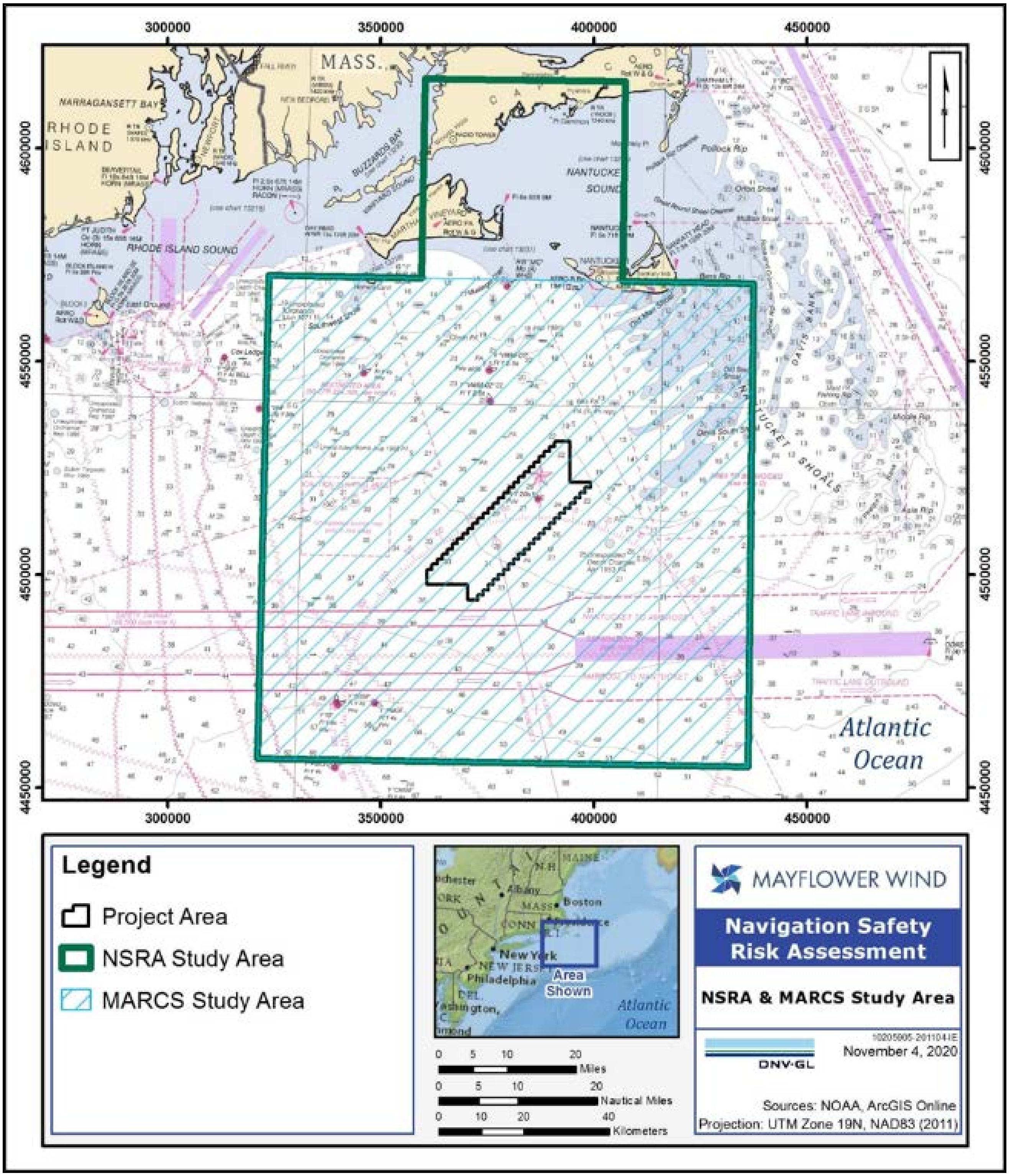


Figure E-1 Quantified Risk MARCS Study Area

Accident frequency result areas (or sub-areas) are presented in Figure E-2.

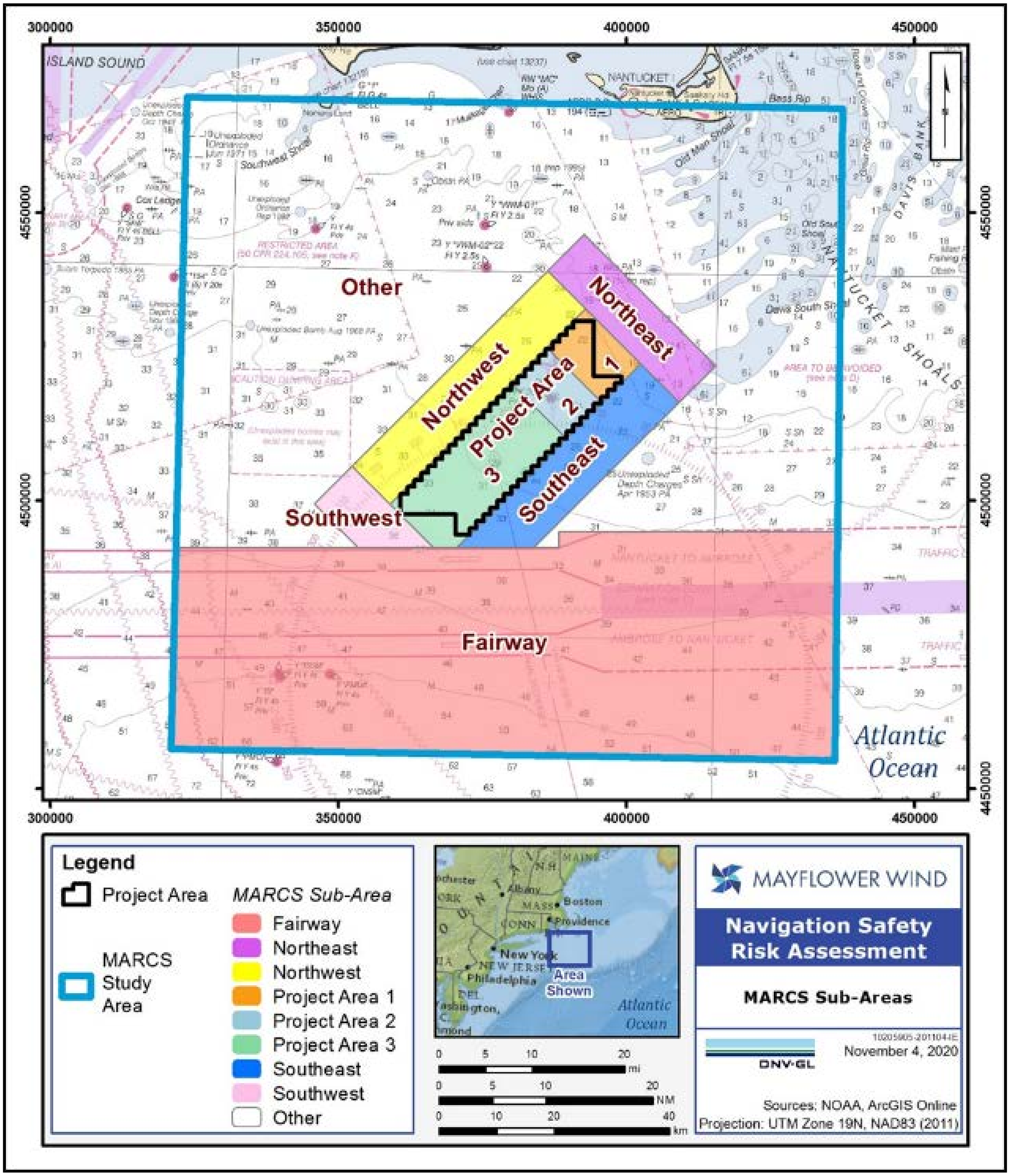


Figure E-2 Defined Sub Areas within the MARCS Study Area

E.2.2 Offshore Wind Project

The Project is modeled as 149 Project structures. Project structures are separated by a minimum distance of 1.0 NM. Each structure has a sea level footprint, a collision cross-section, of 60 m (59.5 m maximum circular diameter rounded up) for the WTGs and 122 m (the diagonal of a 100 m by 70 m rectangle) for the OSPs. The locations of the structures are listed in Appendix A.

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 modeling input. Table E-1 shows the wind data described in Section 7.1 of the main report, formatted for MARCS: eight directions (north, northeast, east, southeast, south, southwest, west, and northwest) and four speed categories (Calm, Fresh, Gale, and Storm). The probabilities presented below are based on the Project metocean report (DHI, 2020).

Table E-1 Annual Wind Direction and Wind Speed Probabilities

Wind speed (kt)	N	NE	E	SE	S	SW	W	NW	Total
< 20 (Calm)	8.09%	8.12%	6.65%	5.39%	7.05%	13.83%	13.18%	12.56%	74.88%
20 – 30 (Fresh)	1.10%	1.88%	0.95%	1.01%	1.97%	7.20%	4.25%	3.41%	21.77%
30 – 45 (Gale)	0.23%	0.51%	0.16%	0.24%	0.58%	0.94%	0.41%	0.24%	3.31%
> 45 (Storm)	0.01%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%
Total	9.43%	10.54%	7.77%	6.64%	9.60%	21.98%	17.84%	16.21%	100%

Visibility

The Journal of Navigation's information regarding marine traffic studies[13] 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.

[13] G.R.G. Lewison, "The Estimation of Collision Risk for Marine Traffic in UK Waters," Journal of Navigation, September 1980.

Table E-2 Visibility (NOAA, 2020c)

Visibility in NM	Frequency	Modeled visibility
< 1	0.0880374	Bad visibility = 12.7% of an average year
1 – 2*	0.0390177	
2 – 3	0.0327303	Good visibility = 87.2% of an average year
3 – 4	0.0288554	
4 – 5	0.0279028	
5 - 6	0.0302887	
6 - 7	0.0637757	
7 - 8	0.0318511	
8+	0.6575364	
Total	0.9999955	

* 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 more than 20 NM (37 km) from the nearest shoreline and is in the Atlantic Ocean.

Shoreline

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

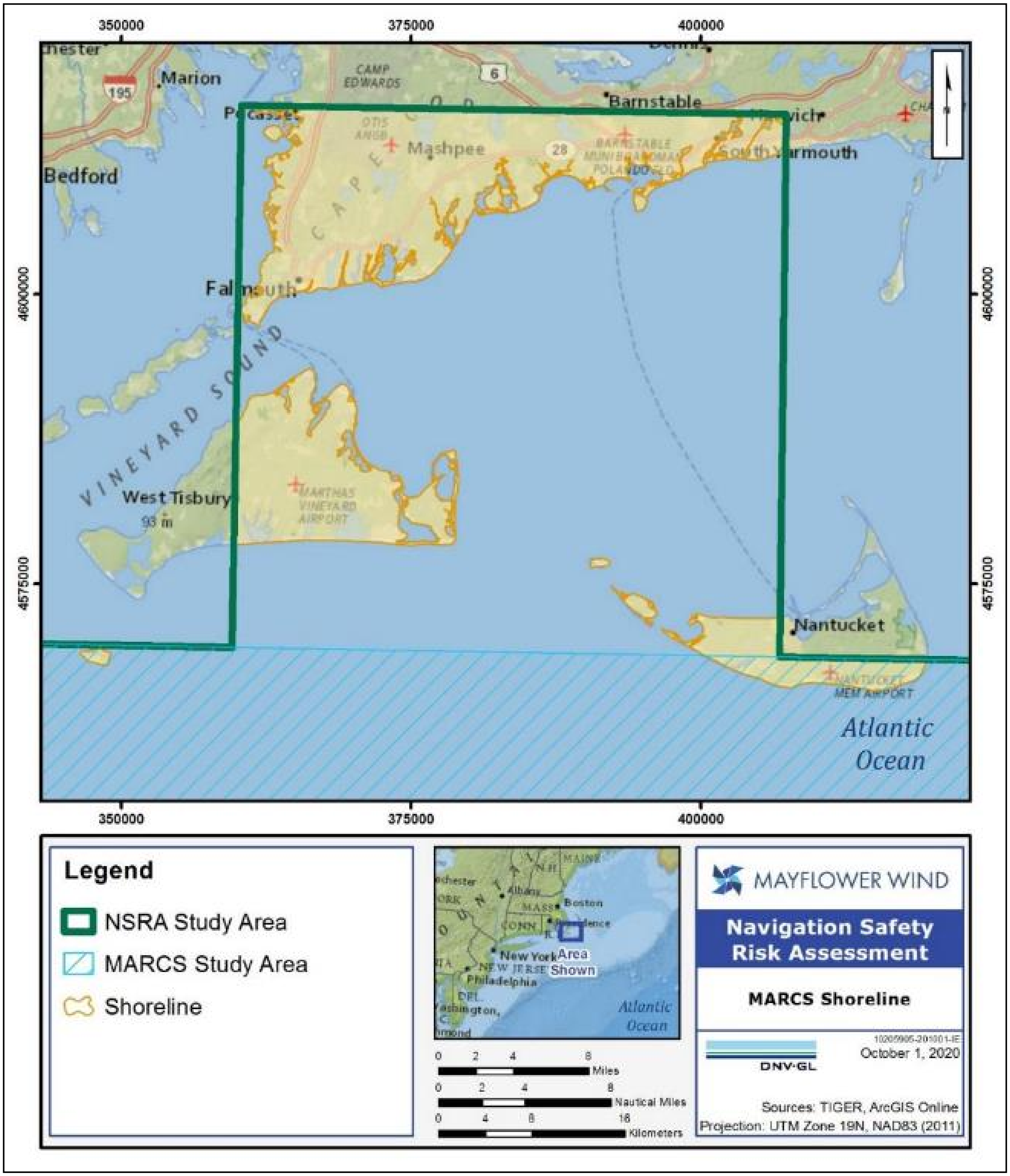


Figure E-3 Shoreline in the MARCS Study Area

E.2.4 Traffic data

Traffic data were derived by analysis of 2.7 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 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 Figure E-3.

Table E-3 Traffic Types Used for MARCS Analysis

Id	Traffic type name	Draft	Average speed (kt)
1	Cargo/Carrier	Deep draft	13.7
2	Fishing	Shallow draft	4.7
3	Other/Undefined	Shallow draft	4.1
4	Passenger	Deep draft	15.0
5	Pleasure	Shallow draft	10.4
6	Tanker	Deep draft	11.8
7	Tanker – Oil Product	Deep draft	11.7
8	Tug/Service	Shallow draft	4.9

The AIS data set 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.

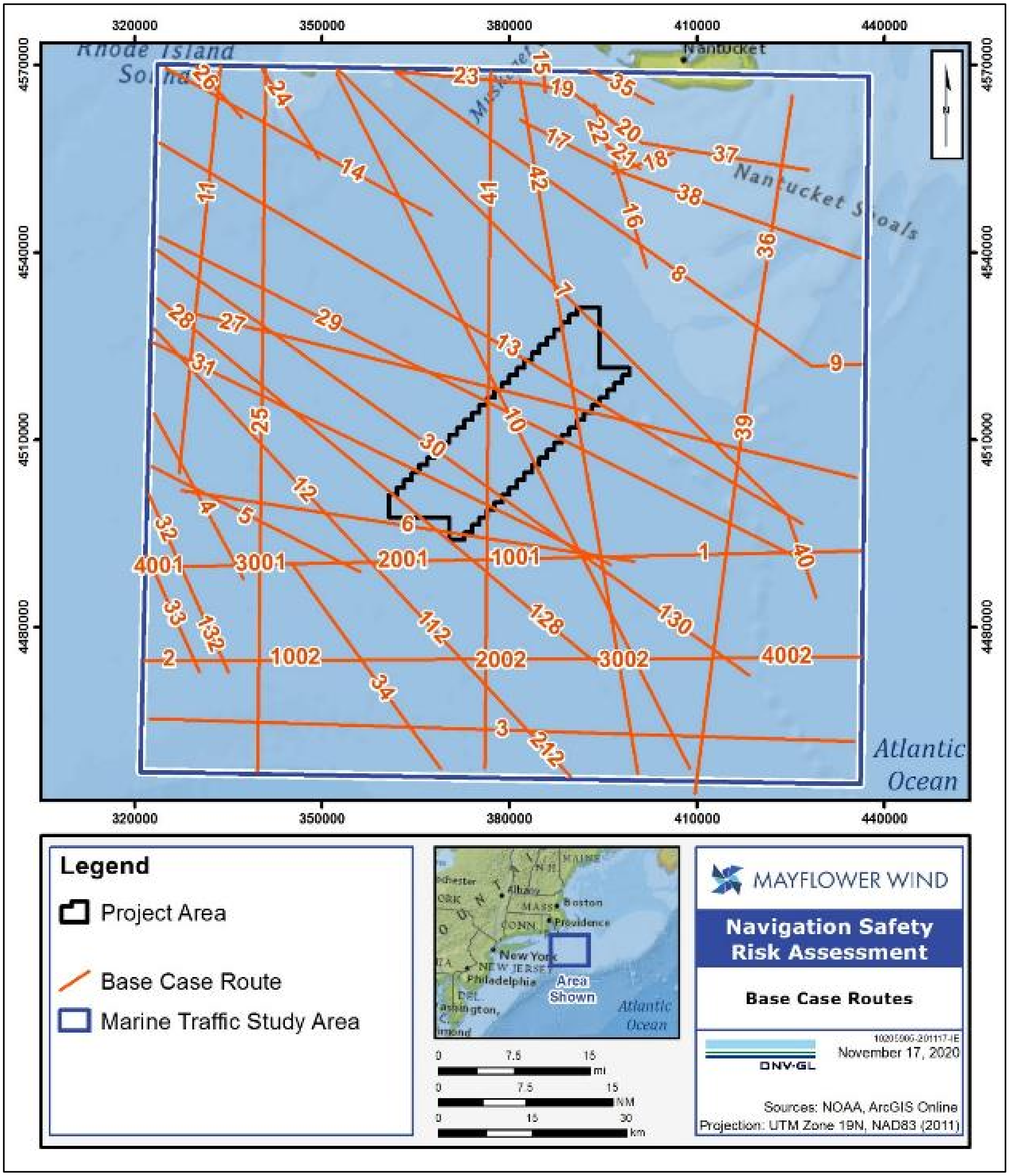


Figure E-4 Route Structure Derived from AIS Data

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. From a practical point of view, the main effect of not taking account of additional lease areas in this Project model is that re-routed traffic transits closer to the Project and therefore the modeled allision is higher than it would have been if the other leases were included.

E.2.5 Traffic data adjustments

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

1. The addition of traffic that is not correctly captured in the AIS data or in the transit numbers in modeled routes
2. The addition of traffic that is projected to be generated by the presence of Project structures
3. The modification of traffic routes for some ship types due to the construction of the Project

Each is described here.

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

The transits captured in MARCS were scaled to reflect the same number of ship-miles per ship type as the AIS data.

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

The AIS data set 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 USCG regulations. To achieve the most realistic results for the MARCS Study Area, special care was placed on estimating recreational and commercial fishing vessel traffic in the vicinity of the Project that may not have been captured in the AIS data set.

The traffic adjustments are as follows.

- The AIS tracks were increased by 100 percent for the pleasure vessels in the routes near or sailing through the Project Area.
- For the fishing vessels, a 100 percent increase of the fishing tracks were applied in the Study Area.
- An additional fifty tanker trips (fifty inbound and fifty outbound per year) were attributed to Routes 1, 30, 130, and 4002 (based on the transit direction) and represent anticipated additional LPG tanker transits (USCG, 2020a) plus other possible port growth.
- Cruise ships taking the Narragansett traffic separation scheme on approach to and departure from Newport are expected to increase. Fifty passenger trips were added to Routes 1, 30, 130, and 4002 based on the transit direction (USCG, 2020a).

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.

The tanker and passenger trips added to the base case are maintained for the Future Case but attributed to Route 32 instead of Route 30 due to the presence of Project structures in this modeled case. This results in adding 50 transits each way to Routes 1, 32, 132, 1001, 1002, 2001, 2002, 3001, 3002, and 4002 according to the transit direction.

In addition, it is anticipated that there will be public interest in the Project that could potentially lead to pleasure tours in the Project Area and a potential increase of recreational traffic (including recreational fishing). It is difficult to estimate a precise number of vessels per year that will be added to local traffic patterns.

The following was assumed:

- Additional pleasure ships for sightseeing / recreational fishing. One hundred transits each way added to Routes 29 (33%), 41 (34%), and 42 (33%).
- Additional fishing vessels for lobster/other fishing. An additional 20% of the fishing tracks going to or through the Project Area from the Base Case are distributed amongst Routes 13 (33%), 41 (34%), and 42 (33%) each way.

Modification of Traffic Routes in the Future Case

Currently, some shipping routes traverse the Project Area. Many ships will choose not to navigate through the Project Area. At this time, the extent to which they will adjust their course is a matter of speculation. DNV GL developed alternative routes for vessels to avoid the Project Area and to minimize the additional navigation while taking account of the existing TSSs using the following principles:

- Deep draft ships (cargo/carrier, tanker [including tanker – oil], and passenger) are routed to the west of the Project.
- Tugs are routed to the west of the Project.
- Fishing, Other and Pleasure ship types all continue to use the same routes in the Future Case as they do in the Base Case.

Figure E-5 shows an example of how this modification was performed for one of the routes that needed modification.

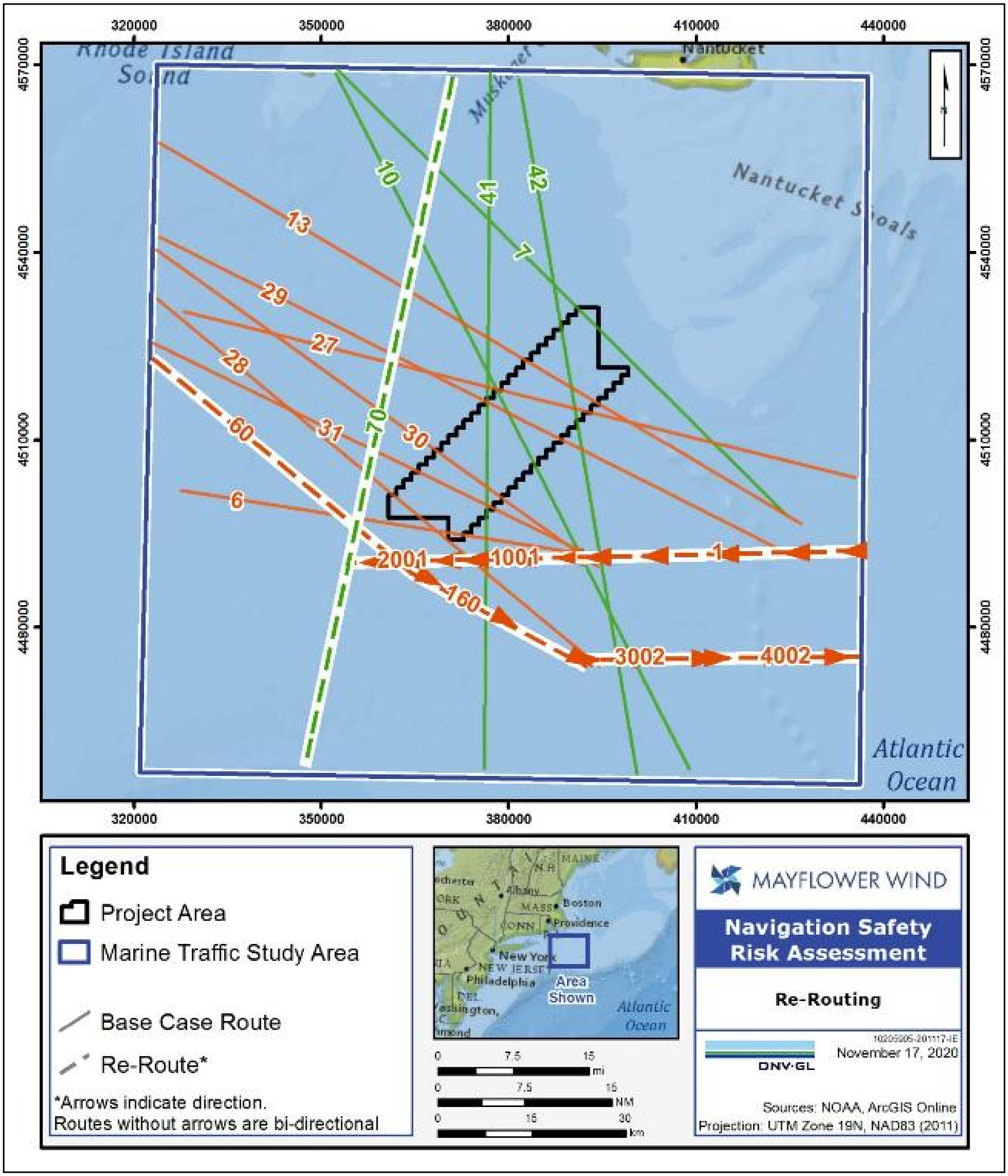


Figure E-5 Re-routing of Routes Going Through the Project Area (dashed routes replaced solid routes in the Future Case)

Consistent with the above principles, any transits from deep draft ships or tugs in Routes 6, 13, 27, 28, 29, 30, and 31 were re-allocated to Routes 60, 160, 3002, 4002, and Routes 1, 1001, 2001, and 60 based on the sailing direction (see Figure E-5 above) while Routes 7, 10, 41, and 42 were re-allocated to Route 70.

In addition, when the project installations are modeled, the widths of Routes 1001, 2001, 3001, and 4001 were reduced to the same value allowing a minimal distance of 1 NM from the closest project installation.

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. This table shows which risk controls are applied based on vessel types.

Table E-4 Risk Controls Applied in MARCS Modeling for the MARCS Study Area

Risk control	Deep draft vessels	All other vessels[1]
Differential global positioning systems	Yes	Yes
Electronic chart display and information system	Yes	Yes
Port State Control	Yes	No
Vessel traffic services	N/A	N/A
Pilotage	N/A	N/A
Portable pilotage unit	N/A	N/A
Underkeel clearance management	N/A	N/A

[1] Some shallow draft vessels may use these risk controls, but not all of them consistently

Note, if a risk control is not applied to all ships of the specified type then it is applied to no ships of that ship type. This is a conservative assumption that tends to over-estimate the calculated risks.

E.2.7 Drift allision

In the MARCS Drift Grounding and Drift Allision accident models (see Appendix D), a drifting ship can recover control (stop drifting) by one of three mechanisms:

- Self-repair. The crew are able to repair the ship and it resumes normal navigation.
- Anchoring. If the sea bottom and water depth in the vicinity of the drifting ship meets defined criteria, then the ship may stop drifting by deploying the anchors.
- Tug control. If a suitable tug is available, the tug may take control of the drifting ship.

The only save mechanism included in this study is self-repair. This is a conservative assumption (tending to calculate a higher accident frequency). Risk reduction via anchoring and rescue tugs are not implemented in the Project risk model.

E.3 Collision, allision, and grounding frequency results

In line with NVIC 01-19, this assessment compares the risk before the Project is built and after it is operational:

- A Base Case (Case 0) was modeled for the current conditions in the 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 Project structures.
- A Base Case Plus (Case 1) was modeled for the current conditions in the MARCS Study Area plus the proposed Project structures. This provides a hypothetical estimate of the risk after construction 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-5 summarizes these cases.

Table E-5 Summary of Modeled Cases

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 - Width reduction of Routes 1001, 2001, 3001, and 4001
Future Case with the Project (Case 2)	- AIS data - Traffic adjustments to some specific vessels not in the AIS data - Re-distribution of traffic lanes for ship types Cargo, Passenger, Tankers (including Tanker - Oil), and Tugs - Implementation of Project structures - Width reduction of Routes 1001, 2001, 3001, and 4001

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 GL 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.

E.3.1 Base Case (Case 0)

The Base Case results define the baseline average annual frequencies of marine accidents. The Base Case utilized AIS data for 2019 plus the additional transits described above in Section E.2.5.

Table E-6 presents the Base Case accident frequencies for each ship type and for each accident type for the MARCS Study Area. Cells shaded grey denote frequencies less than 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-6 Case 0 Accident frequencies (per year) without the Project in the MARCS Study Area[14]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00031	0.00001	0.00001	0.00000	0.00000	0.00033
Fishing	0.00402	0.01514	0.03696	0.00000	0.00000	0.05612
Other/Undefined	0.00041	0.00114	0.00367	0.00000	0.00000	0.00522
Passenger	0.00010	0.00001	0.00003	0.00000	0.00000	0.00014
Pleasure	0.00004	0.00034	0.00043	0.00000	0.00000	0.00080
Tanker	0.00008	0.00000	0.00001	0.00000	0.00000	0.00009
Tanker – Oil Product	0.00012	0.00001	0.00001	0.00000	0.00000	0.00013
Tug/Service	0.00001	0.00001	0.00007	0.00000	0.00000	0.00009
Total	0.00507	0.01666	0.04119	0.00000	0.00000	0.06292

Table E-7 through Table E-9 present the Base Case accident frequencies in the Project Area (sections 1, 2, and 3). They show that allision and grounding frequencies are zero (no wind turbines in the Base Case Project Area). The collision frequency is low compared to grounding because most of the overall accident frequency (about 90%) is from fishing vessels, which transit closer to the shoreline.

Table E-10 through Table E-15 present the Base Case accident frequencies for each ship type and for each accident type for the remaining sub-areas (Northwest, Northeast, Southwest, Southeast, Fairway, and Other) as illustrated previously in Figure E-2.

[14] Note the number of significant figures quoted in this Table, and in similar Tables, is only to facilitate comparison of results. Up to two significant figures are reasonable to evaluate considering uncertainties in the modeling.

Table E-7 Case 0 Accident Frequencies (per year) Without the Project in Project Area Section 1

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Other/Undefined	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00005	0.00000	0.00000	0.00000	0.00000	0.00005

Table E-8 Case 0 Accident Frequencies (per year) Without the Project in Project Area Section 2

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00006	0.00000	0.00000	0.00000	0.00000	0.00006
Other/Undefined	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00008	0.00000	0.00000	0.00000	0.00000	0.00008

Table E-9 Case 0 Accident Frequencies (per year) Without the Project in Project Area Section 3

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00003	0.00000	0.00000	0.00000	0.00000	0.00003
Other/Undefined	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00005	0.00000	0.00000	0.00000	0.00000	0.00005

Table E-10 Case 0 Accident Frequencies (per year) Without the Project in the Northwest Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00010	0.00000	0.00000	0.00000	0.00000	0.00010
Other/Undefined	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00012	0.00000	0.00000	0.00000	0.00000	0.00012

Table E-11 Case 0 Accident Frequencies (per year) Without the Project in the Northeast Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00009	0.00000	0.00000	0.00000	0.00000	0.00009
Other/Undefined	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00009	0.00000	0.00000	0.00000	0.00000	0.00009

Table E-12 Case 0 Accident Frequencies (per year) Without the Project in the Southwest Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001
Fishing	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Other/Undefined	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001

Table E-13 Case 0 Accident Frequencies (per year) Without the Project in the Southeast Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Fishing	0.00010	0.00000	0.00000	0.00000	0.00000	0.00010
Other/Undefined	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00014	0.00000	0.00000	0.00000	0.00000	0.00014

Table E-14 Case 0 Accident Frequencies (per year) Without the Project in the Fairway Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
Fishing	0.00067	0.00000	0.00000	0.00000	0.00000	0.00067
Other/Undefined	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Passenger	0.00005	0.00000	0.00000	0.00000	0.00000	0.00005
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Tanker – Oil Product	0.00009	0.00000	0.00000	0.00000	0.00000	0.00009
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00113	0.00000	0.00000	0.00000	0.00000	0.00113

Table E-15 Case 0 Accident Frequencies (per year) Without the Project in the Other Sub-area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00006	0.00001	0.00001	0.00000	0.00000	0.00008
Fishing	0.00292	0.01514	0.03696	0.00000	0.00000	0.05502
Other/Undefined	0.00030	0.00114	0.00367	0.00000	0.00000	0.00511
Passenger	0.00004	0.00001	0.00003	0.00000	0.00000	0.00008
Pleasure	0.00004	0.00034	0.00043	0.00000	0.00000	0.00080
Tanker	0.00003	0.00000	0.00001	0.00000	0.00000	0.00004
Tanker – Oil Product	0.00003	0.00001	0.00001	0.00000	0.00000	0.00004
Tug/Service	0.00000	0.00001	0.00007	0.00000	0.00000	0.00008
Total	0.00341	0.01666	0.04119	0.00000	0.00000	0.06126

E.3.2 Base Case Plus the Project (Case 1)

The Case 1 results show the average annual frequencies of marine accidents using unmodified Base Case traffic data plus including the Project structures. This case is used to verify the modeling.

Table E-16 shows the results for the MARCS Study Area and Table E-17 through Table E-25 show the results for each sub-area.

The results for Case 1 are compared with the other case results and discussed in Section E.4.

Table E-16 Case 1 Accident Frequencies (per year) With the Project in the MARCS Study Area[15]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00031	0.00001	0.00001	0.00581	0.01259	0.01873
Fishing	0.00402	0.01514	0.03696	0.05981	0.08731	0.20324
Other/Undefined	0.00041	0.00114	0.00367	0.01853	0.03861	0.06236
Passenger	0.00010	0.00001	0.00003	0.01010	0.00964	0.01988
Pleasure	0.00004	0.00034	0.00043	0.00462	0.00340	0.00882
Tanker	0.00008	0.00000	0.00001	0.00706	0.00733	0.01448
Tanker – Oil Product	0.00012	0.00001	0.00001	0.00367	0.00599	0.00979
Tug/Service	0.00001	0.00001	0.00007	0.00055	0.00084	0.00148
Total	0.00507	0.01666	0.04119	0.11016	0.16570	0.33878

Table E-17 Case 1 Accident Frequencies (per year) With the Project in Project Area 1

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00004	0.00019	0.00023
Fishing	0.00004	0.00000	0.00000	0.01357	0.03052	0.04413
Other/Undefined	0.00000	0.00000	0.00000	0.00191	0.00542	0.00733
Passenger	0.00000	0.00000	0.00000	0.00004	0.00015	0.00019
Pleasure	0.00000	0.00000	0.00000	0.00070	0.00067	0.00137
Tanker	0.00000	0.00000	0.00000	0.00001	0.00009	0.00010
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00004	0.00015	0.00018
Tug/Service	0.00000	0.00000	0.00000	0.00008	0.00020	0.00028
Total	0.00005	0.00000	0.00000	0.01639	0.03739	0.05382

[15] 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-18 Case 1 Accident Frequencies (per year) With the Project in Project Area 2

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00030	0.00080	0.00110
Fishing	0.00006	0.00000	0.00000	0.02249	0.02498	0.04753
Other/Undefined	0.00002	0.00000	0.00000	0.00763	0.01287	0.02051
Passenger	0.00000	0.00000	0.00000	0.00040	0.00070	0.00111
Pleasure	0.00000	0.00000	0.00000	0.00162	0.00093	0.00256
Tanker	0.00000	0.00000	0.00000	0.00009	0.00044	0.00053
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00032	0.00055	0.00088
Tug/Service	0.00000	0.00000	0.00000	0.00016	0.00021	0.00037
Total	0.00008	0.00000	0.00000	0.03302	0.04148	0.07459

Table E-19 Case 1 Accident Frequencies (per year) With the Project in Project Area 3

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00548	0.01160	0.01707
Fishing	0.00003	0.00000	0.00000	0.02375	0.03181	0.05559
Other/Undefined	0.00001	0.00000	0.00000	0.00900	0.02031	0.02932
Passenger	0.00000	0.00000	0.00000	0.00965	0.00879	0.01844
Pleasure	0.00000	0.00000	0.00000	0.00230	0.00179	0.00409
Tanker	0.00000	0.00000	0.00000	0.00696	0.00679	0.01376
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00331	0.00529	0.00860
Tug/Service	0.00000	0.00000	0.00000	0.00031	0.00043	0.00074
Total	0.00005	0.00000	0.00000	0.06075	0.08682	0.14761

Table E-20 Case 1 Accident Frequencies (per year) With the Project in the Northwest Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00010	0.00000	0.00000	0.00000	0.00000	0.00010
Other/Undefined	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00012	0.00000	0.00000	0.00000	0.00000	0.00012

Table E-21 Case 1 Accident Frequencies (per year) With the Project in the Northeast Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00009	0.00000	0.00000	0.00000	0.00000	0.00009
Other/Undefined	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00009	0.00000	0.00000	0.00000	0.00000	0.00009

Table E-22 Case 1 Accident Frequencies (per year) With the Project in the Southwest Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Other/Undefined	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001

Table E-23 Case 1 Accident Frequencies (per year) With the Project in the Southeast Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Fishing	0.00010	0.00000	0.00000	0.00000	0.00000	0.00010
Other/Undefined	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00014	0.00000	0.00000	0.00000	0.00000	0.00014

Table E-24 Case 1 Accident Frequencies (per year) With the Project in the Fairway Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023
Fishing	0.00067	0.00000	0.00000	0.00000	0.00000	0.00067
Other/Undefined	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Passenger	0.00005	0.00000	0.00000	0.00000	0.00000	0.00005
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Tanker – Oil Product	0.00009	0.00000	0.00000	0.00000	0.00000	0.00009
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00113	0.00000	0.00000	0.00000	0.00000	0.00113

Table E-25 Case 1 Accident Frequencies (per year) With the Project in the Other Sub-area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00006	0.00001	0.00001	0.00000	0.00001	0.00009
Fishing	0.00292	0.01514	0.03696	0.00000	0.00000	0.05503
Other/Undefined	0.00030	0.00114	0.00367	0.00000	0.00001	0.00511
Passenger	0.00004	0.00001	0.00003	0.00000	0.00000	0.00008
Pleasure	0.00004	0.00034	0.00043	0.00000	0.00000	0.00080
Tanker	0.00003	0.00000	0.00001	0.00000	0.00000	0.00004
Tanker – Oil Product	0.00003	0.00001	0.00001	0.00000	0.00000	0.00004
Tug/Service	0.00000	0.00001	0.00007	0.00000	0.00000	0.00008
Total	0.00341	0.01666	0.04119	0.00000	0.00001	0.06127

Table E-26 and Table E-27 present the results for each individual Project structure respectively for powered and drifting allisions.

Figure E-6 shows the locations of the Project installations and their identification numbers.

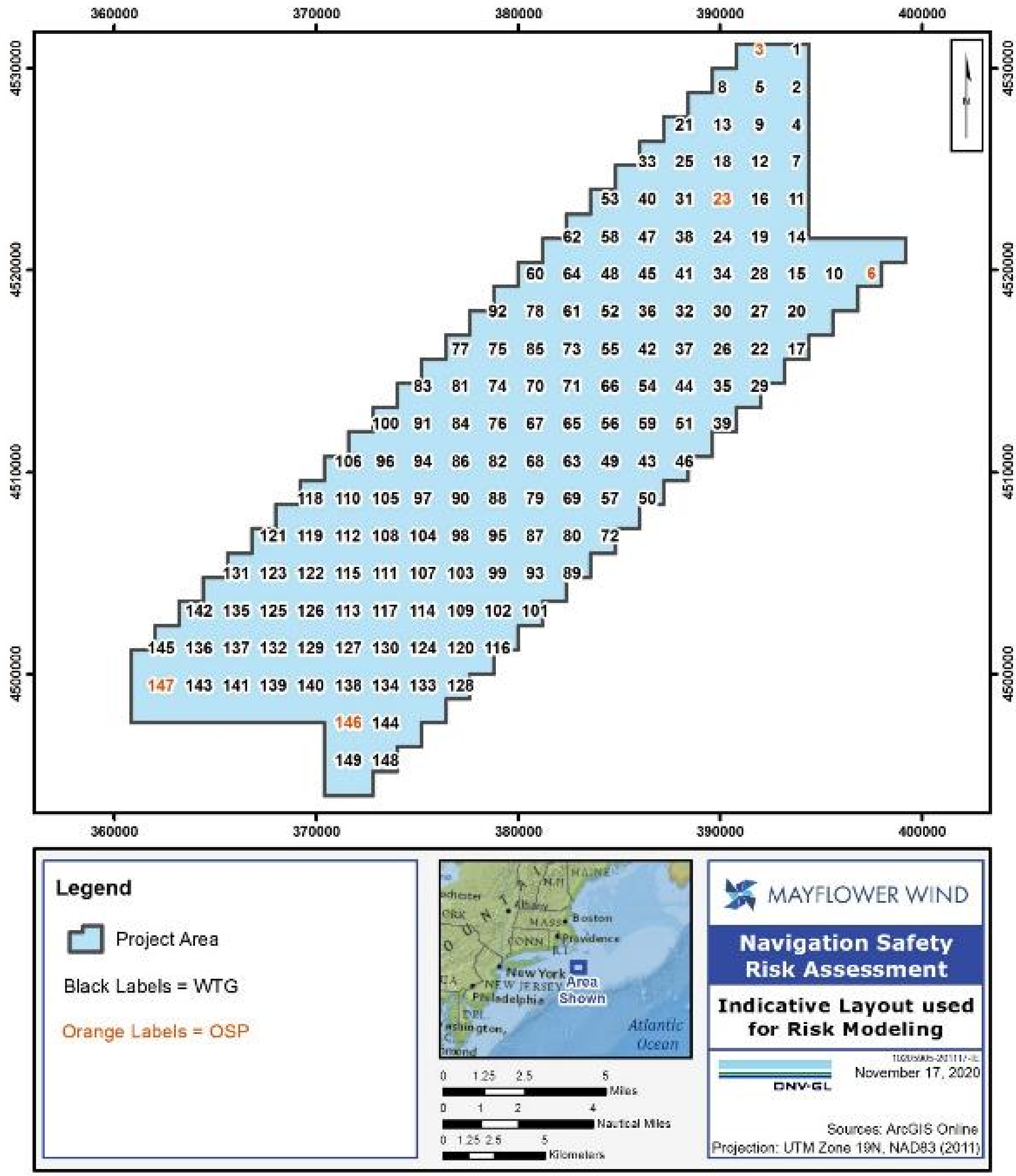


Figure E-6 Locations of Project Structures

Table E-26 Case 1 Powered Allision Accident Frequencies (per year) for Each Project Installation

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
1	0.00000	0.00055	0.00004	0.00000	0.00002	0.00000	0.00000	0.00000	0.00061
2	0.00000	0.00054	0.00004	0.00000	0.00002	0.00000	0.00000	0.00000	0.00060
3	0.00000	0.00106	0.00008	0.00000	0.00005	0.00000	0.00000	0.00001	0.00120
4	0.00000	0.00053	0.00004	0.00000	0.00002	0.00000	0.00000	0.00000	0.00060
5	0.00000	0.00056	0.00005	0.00000	0.00003	0.00000	0.00000	0.00000	0.00064
6	0.00000	0.00103	0.00017	0.00000	0.00005	0.00000	0.00000	0.00001	0.00127
7	0.00000	0.00054	0.00005	0.00000	0.00002	0.00000	0.00000	0.00000	0.00062
8	0.00000	0.00059	0.00006	0.00000	0.00003	0.00000	0.00000	0.00000	0.00069
9	0.00000	0.00056	0.00006	0.00000	0.00003	0.00000	0.00000	0.00000	0.00065
10	0.00000	0.00058	0.00012	0.00000	0.00003	0.00000	0.00000	0.00000	0.00075
11	0.00000	0.00055	0.00007	0.00000	0.00003	0.00000	0.00000	0.00000	0.00065
12	0.00000	0.00056	0.00007	0.00000	0.00003	0.00000	0.00000	0.00000	0.00067
13	0.00000	0.00058	0.00007	0.00000	0.00003	0.00000	0.00000	0.00000	0.00069
14	0.00000	0.00057	0.00010	0.00000	0.00003	0.00000	0.00000	0.00000	0.00072
15	0.00000	0.00062	0.00015	0.00000	0.00004	0.00000	0.00000	0.00000	0.00081
16	0.00000	0.00057	0.00009	0.00000	0.00003	0.00000	0.00000	0.00000	0.00071
17	0.00001	0.00070	0.00025	0.00001	0.00005	0.00000	0.00001	0.00000	0.00105
18	0.00000	0.00059	0.00009	0.00000	0.00003	0.00000	0.00000	0.00000	0.00072
19	0.00000	0.00061	0.00013	0.00000	0.00004	0.00000	0.00000	0.00000	0.00080
20	0.00000	0.00066	0.00020	0.00001	0.00004	0.00000	0.00000	0.00000	0.00092
21	0.00000	0.00061	0.00009	0.00000	0.00003	0.00000	0.00000	0.00000	0.00074

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
22	0.00001	0.00072	0.00027	0.00002	0.00005	0.00000	0.00001	0.00001	0.00109
23	0.00000	0.00116	0.00022	0.00001	0.00007	0.00000	0.00000	0.00001	0.00147
24	0.00000	0.00065	0.00016	0.00000	0.00004	0.00000	0.00000	0.00000	0.00086
25	0.00000	0.00062	0.00011	0.00000	0.00004	0.00000	0.00000	0.00000	0.00078
26	0.00001	0.00070	0.00027	0.00002	0.00005	0.00000	0.00001	0.00001	0.00107
27	0.00001	0.00068	0.00022	0.00001	0.00005	0.00000	0.00001	0.00000	0.00097
28	0.00000	0.00064	0.00017	0.00001	0.00004	0.00000	0.00000	0.00000	0.00087
29	0.00001	0.00069	0.00027	0.00002	0.00005	0.00000	0.00001	0.00001	0.00107
30	0.00001	0.00069	0.00023	0.00001	0.00005	0.00000	0.00001	0.00000	0.00101
31	0.00000	0.00064	0.00014	0.00000	0.00004	0.00000	0.00000	0.00000	0.00084
32	0.00001	0.00068	0.00024	0.00001	0.00005	0.00000	0.00001	0.00000	0.00101
33	0.00000	0.00063	0.00013	0.00000	0.00004	0.00000	0.00000	0.00000	0.00082
34	0.00000	0.00066	0.00019	0.00001	0.00005	0.00000	0.00000	0.00000	0.00092
35	0.00001	0.00066	0.00026	0.00002	0.00005	0.00000	0.00002	0.00001	0.00103
36	0.00001	0.00065	0.00024	0.00002	0.00005	0.00000	0.00001	0.00000	0.00099
37	0.00001	0.00067	0.00027	0.00002	0.00005	0.00000	0.00001	0.00001	0.00104
38	0.00000	0.00065	0.00018	0.00001	0.00004	0.00000	0.00000	0.00000	0.00090
39	0.00002	0.00059	0.00023	0.00001	0.00004	0.00000	0.00002	0.00001	0.00093
40	0.00000	0.00065	0.00017	0.00000	0.00004	0.00000	0.00000	0.00000	0.00088
41	0.00000	0.00067	0.00021	0.00001	0.00005	0.00000	0.00000	0.00000	0.00094
42	0.00001	0.00063	0.00026	0.00002	0.00005	0.00000	0.00002	0.00001	0.00100
43	0.00003	0.00047	0.00020	0.00001	0.00003	0.00001	0.00003	0.00001	0.00079

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
44	0.00002	0.00062	0.00025	0.00002	0.00005	0.00001	0.00002	0.00001	0.00098
45	0.00000	0.00065	0.00021	0.00001	0.00005	0.00000	0.00000	0.00000	0.00094
46	0.00003	0.00050	0.00021	0.00001	0.00003	0.00001	0.00003	0.00001	0.00084
47	0.00000	0.00065	0.00019	0.00001	0.00005	0.00000	0.00000	0.00000	0.00091
48	0.00001	0.00063	0.00021	0.00001	0.00005	0.00000	0.00001	0.00000	0.00092
49	0.00003	0.00042	0.00018	0.00002	0.00003	0.00001	0.00003	0.00001	0.00072
50	0.00003	0.00041	0.00016	0.00002	0.00003	0.00001	0.00003	0.00001	0.00069
51	0.00002	0.00056	0.00022	0.00001	0.00004	0.00001	0.00003	0.00001	0.00090
52	0.00001	0.00062	0.00024	0.00001	0.00005	0.00000	0.00001	0.00000	0.00095
53	0.00000	0.00065	0.00018	0.00001	0.00004	0.00000	0.00000	0.00000	0.00089
54	0.00002	0.00058	0.00024	0.00002	0.00004	0.00001	0.00002	0.00001	0.00093
55	0.00002	0.00059	0.00025	0.00002	0.00005	0.00001	0.00002	0.00001	0.00096
56	0.00003	0.00048	0.00021	0.00001	0.00003	0.00001	0.00003	0.00001	0.00080
57	0.00002	0.00037	0.00013	0.00002	0.00003	0.00002	0.00002	0.00001	0.00061
58	0.00000	0.00065	0.00019	0.00001	0.00005	0.00000	0.00000	0.00000	0.00091
59	0.00003	0.00052	0.00022	0.00001	0.00004	0.00001	0.00003	0.00001	0.00086
60	0.00001	0.00057	0.00021	0.00001	0.00004	0.00000	0.00001	0.00000	0.00086
61	0.00001	0.00059	0.00024	0.00002	0.00005	0.00000	0.00001	0.00001	0.00093
62	0.00000	0.00062	0.00019	0.00001	0.00005	0.00000	0.00000	0.00000	0.00088
63	0.00002	0.00038	0.00015	0.00002	0.00003	0.00001	0.00002	0.00001	0.00064
64	0.00001	0.00060	0.00021	0.00001	0.00005	0.00000	0.00001	0.00000	0.00089
65	0.00003	0.00044	0.00020	0.00002	0.00003	0.00001	0.00003	0.00001	0.00075

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
66	0.00002	0.00055	0.00024	0.00002	0.00004	0.00001	0.00002	0.00001	0.00090
67	0.00002	0.00040	0.00018	0.00002	0.00003	0.00001	0.00003	0.00001	0.00069
68	0.00002	0.00033	0.00012	0.00003	0.00002	0.00002	0.00002	0.00000	0.00057
69	0.00001	0.00031	0.00009	0.00003	0.00002	0.00002	0.00001	0.00000	0.00052
70	0.00002	0.00047	0.00022	0.00002	0.00003	0.00001	0.00003	0.00001	0.00081
71	0.00003	0.00050	0.00023	0.00002	0.00004	0.00001	0.00003	0.00001	0.00086
72	0.00001	0.00030	0.00008	0.00004	0.00002	0.00003	0.00001	0.00000	0.00049
73	0.00002	0.00056	0.00025	0.00002	0.00004	0.00001	0.00002	0.00001	0.00093
74	0.00002	0.00042	0.00021	0.00002	0.00003	0.00001	0.00003	0.00001	0.00075
75	0.00003	0.00050	0.00025	0.00002	0.00004	0.00001	0.00003	0.00001	0.00089
76	0.00002	0.00035	0.00015	0.00002	0.00003	0.00002	0.00002	0.00001	0.00061
77	0.00003	0.00045	0.00024	0.00002	0.00004	0.00001	0.00003	0.00001	0.00082
78	0.00002	0.00056	0.00025	0.00002	0.00004	0.00001	0.00002	0.00001	0.00092
79	0.00001	0.00027	0.00007	0.00004	0.00002	0.00003	0.00001	0.00000	0.00047
80	0.00001	0.00027	0.00006	0.00006	0.00002	0.00004	0.00001	0.00000	0.00047
81	0.00002	0.00037	0.00018	0.00002	0.00003	0.00001	0.00003	0.00001	0.00067
82	0.00002	0.00029	0.00010	0.00003	0.00002	0.00003	0.00002	0.00000	0.00051
83	0.00002	0.00032	0.00016	0.00003	0.00003	0.00002	0.00002	0.00001	0.00059
84	0.00002	0.00030	0.00012	0.00003	0.00002	0.00002	0.00002	0.00000	0.00054
85	0.00002	0.00053	0.00025	0.00002	0.00004	0.00001	0.00003	0.00001	0.00091
86	0.00001	0.00025	0.00008	0.00006	0.00002	0.00004	0.00001	0.00000	0.00046
87	0.00001	0.00024	0.00005	0.00008	0.00002	0.00006	0.00001	0.00000	0.00047

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
88	0.00001	0.00024	0.00006	0.00007	0.00002	0.00005	0.00001	0.00000	0.00046
89	0.00001	0.00025	0.00005	0.00009	0.00002	0.00007	0.00001	0.00000	0.00050
90	0.00001	0.00022	0.00005	0.00009	0.00002	0.00007	0.00001	0.00000	0.00047
91	0.00001	0.00026	0.00010	0.00004	0.00002	0.00003	0.00001	0.00000	0.00048
92	0.00002	0.00053	0.00025	0.00002	0.00004	0.00001	0.00002	0.00001	0.00091
93	0.00001	0.00023	0.00005	0.00011	0.00002	0.00009	0.00001	0.00000	0.00052
94	0.00001	0.00021	0.00006	0.00008	0.00002	0.00006	0.00001	0.00000	0.00045
95	0.00001	0.00022	0.00005	0.00011	0.00002	0.00008	0.00001	0.00000	0.00049
96	0.00001	0.00018	0.00005	0.00011	0.00002	0.00008	0.00001	0.00000	0.00047
97	0.00001	0.00019	0.00005	0.00011	0.00002	0.00009	0.00001	0.00000	0.00049
98	0.00001	0.00021	0.00005	0.00014	0.00002	0.00010	0.00001	0.00000	0.00053
99	0.00001	0.00021	0.00005	0.00014	0.00002	0.00011	0.00001	0.00000	0.00056
100	0.00001	0.00021	0.00007	0.00007	0.00002	0.00005	0.00001	0.00000	0.00045
101	0.00003	0.00023	0.00005	0.00015	0.00002	0.00011	0.00002	0.00000	0.00060
102	0.00003	0.00022	0.00005	0.00019	0.00002	0.00014	0.00002	0.00000	0.00068
103	0.00002	0.00020	0.00005	0.00016	0.00002	0.00013	0.00002	0.00000	0.00060
104	0.00001	0.00019	0.00005	0.00015	0.00002	0.00012	0.00001	0.00000	0.00055
105	0.00001	0.00018	0.00004	0.00015	0.00002	0.00011	0.00001	0.00000	0.00052
106	0.00001	0.00016	0.00005	0.00015	0.00002	0.00011	0.00001	0.00000	0.00051
107	0.00002	0.00019	0.00005	0.00021	0.00002	0.00016	0.00002	0.00000	0.00067
108	0.00002	0.00018	0.00005	0.00020	0.00002	0.00016	0.00002	0.00000	0.00064
109	0.00004	0.00021	0.00006	0.00021	0.00002	0.00016	0.00003	0.00000	0.00072

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
110	0.00001	0.00016	0.00004	0.00018	0.00002	0.00014	0.00001	0.00000	0.00057
111	0.00003	0.00018	0.00006	0.00020	0.00002	0.00017	0.00002	0.00000	0.00069
112	0.00002	0.00016	0.00005	0.00022	0.00002	0.00017	0.00002	0.00000	0.00068
113	0.00006	0.00017	0.00007	0.00019	0.00002	0.00014	0.00004	0.00000	0.00069
114	0.00004	0.00020	0.00006	0.00022	0.00002	0.00017	0.00003	0.00000	0.00075
115	0.00003	0.00017	0.00006	0.00023	0.00002	0.00017	0.00003	0.00000	0.00071
116	0.00007	0.00022	0.00007	0.00019	0.00002	0.00016	0.00004	0.00000	0.00079
117	0.00005	0.00019	0.00007	0.00022	0.00002	0.00016	0.00004	0.00000	0.00075
118	0.00002	0.00015	0.00005	0.00022	0.00002	0.00017	0.00002	0.00000	0.00065
119	0.00003	0.00015	0.00005	0.00023	0.00002	0.00018	0.00003	0.00000	0.00070
120	0.00008	0.00021	0.00007	0.00022	0.00002	0.00016	0.00005	0.00000	0.00082
121	0.00003	0.00015	0.00006	0.00023	0.00002	0.00017	0.00003	0.00000	0.00069
122	0.00004	0.00016	0.00006	0.00022	0.00002	0.00016	0.00003	0.00000	0.00070
123	0.00005	0.00015	0.00006	0.00018	0.00002	0.00013	0.00004	0.00000	0.00063
124	0.00008	0.00020	0.00008	0.00021	0.00002	0.00016	0.00005	0.00000	0.00081
125	0.00005	0.00014	0.00006	0.00014	0.00002	0.00010	0.00004	0.00000	0.00056
126	0.00005	0.00016	0.00007	0.00017	0.00002	0.00013	0.00004	0.00000	0.00064
127	0.00007	0.00017	0.00007	0.00017	0.00002	0.00012	0.00005	0.00000	0.00067
128	0.00017	0.00022	0.00008	0.00020	0.00003	0.00014	0.00008	0.00000	0.00091
129	0.00007	0.00015	0.00006	0.00013	0.00002	0.00009	0.00004	0.00000	0.00057
130	0.00008	0.00019	0.00008	0.00017	0.00002	0.00013	0.00005	0.00000	0.00072
131	0.00005	0.00013	0.00006	0.00015	0.00002	0.00011	0.00004	0.00000	0.00057

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
132	0.00007	0.00013	0.00005	0.00010	0.00002	0.00007	0.00004	0.00000	0.00048
133	0.00015	0.00020	0.00008	0.00019	0.00002	0.00013	0.00008	0.00000	0.00085
134	0.00015	0.00017	0.00007	0.00016	0.00002	0.00011	0.00007	0.00000	0.00077
135	0.00005	0.00012	0.00006	0.00011	0.00002	0.00007	0.00004	0.00000	0.00047
136	0.00007	0.00010	0.00004	0.00005	0.00002	0.00003	0.00004	0.00000	0.00034
137	0.00007	0.00011	0.00004	0.00007	0.00002	0.00004	0.00004	0.00000	0.00040
138	0.00014	0.00015	0.00006	0.00013	0.00002	0.00009	0.00007	0.00000	0.00067
139	0.00013	0.00012	0.00004	0.00007	0.00002	0.00004	0.00006	0.00000	0.00049
140	0.00013	0.00013	0.00005	0.00010	0.00002	0.00006	0.00006	0.00000	0.00057
141	0.00013	0.00010	0.00004	0.00005	0.00002	0.00003	0.00006	0.00000	0.00043
142	0.00005	0.00011	0.00005	0.00008	0.00002	0.00005	0.00003	0.00000	0.00039
143	0.00013	0.00009	0.00003	0.00004	0.00002	0.00002	0.00006	0.00000	0.00039
144	0.00030	0.00016	0.00006	0.00014	0.00002	0.00009	0.00012	0.00000	0.00091
145	0.00007	0.00009	0.00003	0.00004	0.00002	0.00002	0.00003	0.00000	0.00030
146	0.00043	0.00027	0.00010	0.00018	0.00005	0.00011	0.00018	0.00000	0.00132
147	0.00023	0.00017	0.00006	0.00006	0.00004	0.00002	0.00010	0.00000	0.00067
148	0.00053	0.00016	0.00006	0.00014	0.00003	0.00007	0.00021	0.00000	0.00121
149	0.00047	0.00014	0.00006	0.00012	0.00003	0.00005	0.00019	0.00000	0.00106
Total	0.00581	0.05981	0.01853	0.01010	0.00462	0.00706	0.00367	0.00055	0.11016

Table E-27 Case 1 Drifting Allision Accident Frequencies (per year) for Each Project Installation

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
1	0.00001	0.00171	0.00021	0.00000	0.00003	0.00000	0.00000	0.00001	0.00198
2	0.00001	0.00215	0.00024	0.00000	0.00004	0.00000	0.00001	0.00001	0.00247
3	0.00001	0.00371	0.00039	0.00001	0.00007	0.00000	0.00001	0.00002	0.00422
4	0.00001	0.00214	0.00026	0.00000	0.00004	0.00000	0.00001	0.00001	0.00247
5	0.00001	0.00214	0.00026	0.00001	0.00004	0.00000	0.00001	0.00001	0.00248
6	0.00003	0.00191	0.00036	0.00001	0.00004	0.00001	0.00001	0.00001	0.00239
7	0.00001	0.00142	0.00022	0.00000	0.00003	0.00000	0.00001	0.00001	0.00171
8	0.00001	0.00147	0.00024	0.00001	0.00003	0.00001	0.00001	0.00001	0.00177
9	0.00001	0.00136	0.00021	0.00001	0.00003	0.00000	0.00001	0.00001	0.00163
10	0.00002	0.00096	0.00025	0.00001	0.00002	0.00001	0.00001	0.00001	0.00129
11	0.00001	0.00114	0.00022	0.00000	0.00003	0.00000	0.00001	0.00001	0.00141
12	0.00001	0.00111	0.00022	0.00001	0.00003	0.00000	0.00001	0.00001	0.00139
13	0.00001	0.00115	0.00023	0.00001	0.00003	0.00000	0.00001	0.00001	0.00144
14	0.00001	0.00099	0.00023	0.00001	0.00002	0.00000	0.00001	0.00001	0.00128
15	0.00002	0.00087	0.00026	0.00001	0.00002	0.00000	0.00001	0.00001	0.00120
16	0.00001	0.00097	0.00023	0.00001	0.00002	0.00000	0.00001	0.00001	0.00126
17	0.00004	0.00097	0.00056	0.00002	0.00004	0.00001	0.00002	0.00001	0.00166
18	0.00001	0.00099	0.00023	0.00001	0.00002	0.00000	0.00001	0.00001	0.00128
19	0.00001	0.00086	0.00025	0.00001	0.00002	0.00001	0.00001	0.00001	0.00117
20	0.00002	0.00085	0.00033	0.00001	0.00003	0.00001	0.00001	0.00001	0.00127
21	0.00001	0.00102	0.00025	0.00001	0.00003	0.00001	0.00001	0.00001	0.00133
22	0.00003	0.00075	0.00041	0.00002	0.00003	0.00001	0.00002	0.00001	0.00128

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
23	0.00001	0.00153	0.00040	0.00001	0.00004	0.00001	0.00001	0.00001	0.00202
24	0.00001	0.00083	0.00030	0.00001	0.00003	0.00001	0.00001	0.00001	0.00120
25	0.00001	0.00090	0.00026	0.00001	0.00002	0.00001	0.00001	0.00001	0.00121
26	0.00003	0.00069	0.00038	0.00002	0.00003	0.00001	0.00002	0.00001	0.00119
27	0.00002	0.00082	0.00040	0.00002	0.00003	0.00001	0.00001	0.00001	0.00131
28	0.00001	0.00080	0.00028	0.00001	0.00002	0.00000	0.00001	0.00001	0.00115
29	0.00005	0.00069	0.00039	0.00003	0.00003	0.00001	0.00003	0.00001	0.00124
30	0.00002	0.00085	0.00051	0.00002	0.00003	0.00001	0.00001	0.00001	0.00146
31	0.00001	0.00079	0.00026	0.00001	0.00002	0.00001	0.00001	0.00001	0.00112
32	0.00002	0.00069	0.00037	0.00002	0.00003	0.00001	0.00001	0.00001	0.00115
33	0.00001	0.00080	0.00026	0.00001	0.00002	0.00001	0.00001	0.00001	0.00113
34	0.00001	0.00083	0.00038	0.00001	0.00003	0.00001	0.00001	0.00001	0.00129
35	0.00004	0.00063	0.00034	0.00002	0.00003	0.00002	0.00002	0.00001	0.00110
36	0.00002	0.00063	0.00034	0.00002	0.00002	0.00001	0.00001	0.00001	0.00106
37	0.00003	0.00062	0.00035	0.00002	0.00003	0.00001	0.00002	0.00001	0.00108
38	0.00001	0.00075	0.00030	0.00001	0.00002	0.00001	0.00001	0.00001	0.00112
39	0.00006	0.00058	0.00031	0.00003	0.00002	0.00002	0.00003	0.00001	0.00105
40	0.00001	0.00074	0.00030	0.00001	0.00002	0.00001	0.00001	0.00001	0.00110
41	0.00001	0.00081	0.00045	0.00002	0.00003	0.00001	0.00001	0.00001	0.00135
42	0.00003	0.00069	0.00048	0.00003	0.00003	0.00002	0.00003	0.00001	0.00133
43	0.00008	0.00059	0.00044	0.00004	0.00002	0.00003	0.00006	0.00001	0.00128
44	0.00004	0.00058	0.00032	0.00003	0.00002	0.00002	0.00002	0.00001	0.00104

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
45	0.00002	0.00074	0.00043	0.00002	0.00003	0.00001	0.00001	0.00001	0.00126
46	0.00008	0.00054	0.00034	0.00003	0.00002	0.00002	0.00004	0.00001	0.00109
47	0.00001	0.00072	0.00033	0.00001	0.00002	0.00001	0.00001	0.00001	0.00112
48	0.00001	0.00067	0.00037	0.00002	0.00003	0.00001	0.00001	0.00001	0.00113
49	0.00006	0.00051	0.00030	0.00005	0.00002	0.00004	0.00004	0.00001	0.00103
50	0.00008	0.00048	0.00026	0.00004	0.00002	0.00003	0.00004	0.00001	0.00096
51	0.00005	0.00054	0.00029	0.00003	0.00002	0.00002	0.00003	0.00001	0.00098
52	0.00002	0.00060	0.00033	0.00002	0.00002	0.00001	0.00001	0.00001	0.00102
53	0.00001	0.00072	0.00033	0.00002	0.00003	0.00001	0.00001	0.00001	0.00114
54	0.00003	0.00055	0.00030	0.00003	0.00002	0.00002	0.00002	0.00001	0.00097
55	0.00003	0.00062	0.00041	0.00004	0.00003	0.00002	0.00002	0.00001	0.00118
56	0.00005	0.00054	0.00034	0.00003	0.00002	0.00002	0.00004	0.00001	0.00104
57	0.00007	0.00049	0.00025	0.00005	0.00002	0.00004	0.00004	0.00001	0.00095
58	0.00001	0.00088	0.00057	0.00002	0.00004	0.00001	0.00001	0.00001	0.00155
59	0.00005	0.00053	0.00031	0.00003	0.00002	0.00002	0.00003	0.00001	0.00099
60	0.00002	0.00062	0.00034	0.00003	0.00003	0.00002	0.00002	0.00001	0.00108
61	0.00002	0.00058	0.00033	0.00002	0.00003	0.00001	0.00002	0.00001	0.00102
62	0.00002	0.00074	0.00045	0.00003	0.00003	0.00002	0.00001	0.00001	0.00130
63	0.00005	0.00053	0.00028	0.00004	0.00002	0.00003	0.00003	0.00001	0.00100
64	0.00002	0.00062	0.00034	0.00002	0.00002	0.00002	0.00001	0.00001	0.00106
65	0.00005	0.00060	0.00038	0.00003	0.00002	0.00002	0.00004	0.00001	0.00115
66	0.00004	0.00054	0.00031	0.00003	0.00002	0.00002	0.00003	0.00001	0.00099

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
67	0.00004	0.00061	0.00034	0.00004	0.00003	0.00003	0.00003	0.00001	0.00112
68	0.00005	0.00050	0.00027	0.00005	0.00002	0.00004	0.00003	0.00001	0.00097
69	0.00006	0.00052	0.00024	0.00004	0.00002	0.00003	0.00003	0.00000	0.00096
70	0.00004	0.00062	0.00041	0.00003	0.00003	0.00002	0.00003	0.00001	0.00119
71	0.00004	0.00057	0.00035	0.00003	0.00002	0.00002	0.00003	0.00001	0.00106
72	0.00010	0.00055	0.00024	0.00006	0.00002	0.00004	0.00004	0.00000	0.00106
73	0.00003	0.00058	0.00036	0.00003	0.00003	0.00002	0.00002	0.00001	0.00109
74	0.00004	0.00063	0.00041	0.00004	0.00003	0.00003	0.00003	0.00001	0.00121
75	0.00004	0.00100	0.00047	0.00004	0.00004	0.00003	0.00003	0.00001	0.00166
76	0.00004	0.00048	0.00030	0.00004	0.00002	0.00003	0.00003	0.00001	0.00094
77	0.00006	0.00065	0.00056	0.00006	0.00004	0.00004	0.00005	0.00001	0.00146
78	0.00002	0.00060	0.00036	0.00003	0.00003	0.00002	0.00002	0.00001	0.00110
79	0.00006	0.00041	0.00022	0.00006	0.00002	0.00005	0.00003	0.00000	0.00086
80	0.00008	0.00045	0.00021	0.00005	0.00002	0.00004	0.00004	0.00000	0.00090
81	0.00004	0.00051	0.00041	0.00005	0.00003	0.00004	0.00003	0.00001	0.00111
82	0.00004	0.00040	0.00025	0.00004	0.00002	0.00003	0.00003	0.00000	0.00083
83	0.00004	0.00038	0.00028	0.00006	0.00002	0.00005	0.00003	0.00001	0.00086
84	0.00004	0.00044	0.00034	0.00005	0.00003	0.00004	0.00002	0.00000	0.00096
85	0.00003	0.00058	0.00036	0.00003	0.00003	0.00002	0.00002	0.00001	0.00107
86	0.00004	0.00038	0.00027	0.00005	0.00002	0.00004	0.00002	0.00000	0.00084
87	0.00008	0.00036	0.00020	0.00007	0.00002	0.00006	0.00004	0.00000	0.00082
88	0.00006	0.00035	0.00021	0.00005	0.00002	0.00004	0.00003	0.00000	0.00077

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
89	0.00011	0.00038	0.00019	0.00007	0.00002	0.00005	0.00005	0.00000	0.00088
90	0.00006	0.00035	0.00025	0.00008	0.00002	0.00007	0.00003	0.00000	0.00087
91	0.00004	0.00033	0.00023	0.00006	0.00002	0.00005	0.00003	0.00000	0.00077
92	0.00003	0.00072	0.00045	0.00004	0.00003	0.00003	0.00003	0.00001	0.00133
93	0.00011	0.00033	0.00018	0.00010	0.00002	0.00008	0.00005	0.00000	0.00086
94	0.00004	0.00029	0.00020	0.00007	0.00002	0.00006	0.00003	0.00000	0.00071
95	0.00008	0.00032	0.00020	0.00007	0.00002	0.00006	0.00004	0.00000	0.00078
96	0.00004	0.00025	0.00017	0.00009	0.00001	0.00008	0.00003	0.00000	0.00068
97	0.00006	0.00027	0.00018	0.00007	0.00002	0.00006	0.00003	0.00000	0.00069
98	0.00008	0.00033	0.00024	0.00010	0.00002	0.00008	0.00004	0.00000	0.00090
99	0.00009	0.00030	0.00019	0.00010	0.00002	0.00009	0.00004	0.00000	0.00084
100	0.00005	0.00028	0.00020	0.00008	0.00002	0.00007	0.00003	0.00000	0.00073
101	0.00012	0.00031	0.00017	0.00009	0.00002	0.00008	0.00005	0.00000	0.00084
102	0.00014	0.00030	0.00019	0.00013	0.00002	0.00011	0.00006	0.00000	0.00094
103	0.00010	0.00032	0.00024	0.00012	0.00002	0.00010	0.00005	0.00000	0.00095
104	0.00007	0.00025	0.00017	0.00009	0.00002	0.00008	0.00003	0.00000	0.00071
105	0.00006	0.00024	0.00016	0.00011	0.00001	0.00009	0.00003	0.00000	0.00071
106	0.00005	0.00023	0.00017	0.00011	0.00001	0.00009	0.00003	0.00000	0.00071
107	0.00011	0.00026	0.00017	0.00017	0.00002	0.00015	0.00005	0.00000	0.00092
108	0.00007	0.00023	0.00016	0.00014	0.00001	0.00012	0.00004	0.00000	0.00078
109	0.00013	0.00033	0.00024	0.00018	0.00002	0.00015	0.00006	0.00000	0.00113
110	0.00006	0.00022	0.00015	0.00012	0.00001	0.00011	0.00004	0.00000	0.00072

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
111	0.00009	0.00024	0.00015	0.00023	0.00002	0.00019	0.00005	0.00000	0.00098
112	0.00008	0.00025	0.00016	0.00027	0.00002	0.00023	0.00005	0.00000	0.00106
113	0.00016	0.00020	0.00014	0.00011	0.00001	0.00009	0.00007	0.00000	0.00078
114	0.00013	0.00024	0.00016	0.00017	0.00002	0.00014	0.00006	0.00000	0.00091
115	0.00011	0.00022	0.00015	0.00019	0.00002	0.00016	0.00006	0.00000	0.00090
116	0.00019	0.00034	0.00021	0.00032	0.00002	0.00028	0.00009	0.00001	0.00145
117	0.00014	0.00022	0.00015	0.00017	0.00002	0.00014	0.00006	0.00000	0.00090
118	0.00008	0.00022	0.00015	0.00018	0.00002	0.00016	0.00004	0.00000	0.00085
119	0.00009	0.00023	0.00015	0.00026	0.00002	0.00022	0.00005	0.00000	0.00102
120	0.00018	0.00034	0.00025	0.00026	0.00003	0.00022	0.00008	0.00000	0.00137
121	0.00011	0.00020	0.00014	0.00018	0.00001	0.00015	0.00006	0.00000	0.00086
122	0.00012	0.00019	0.00014	0.00015	0.00001	0.00012	0.00005	0.00000	0.00078
123	0.00012	0.00018	0.00013	0.00011	0.00001	0.00009	0.00005	0.00000	0.00070
124	0.00017	0.00024	0.00017	0.00016	0.00002	0.00013	0.00008	0.00000	0.00096
125	0.00017	0.00018	0.00013	0.00008	0.00001	0.00005	0.00007	0.00000	0.00069
126	0.00015	0.00019	0.00014	0.00011	0.00001	0.00008	0.00007	0.00000	0.00076
127	0.00020	0.00019	0.00014	0.00011	0.00001	0.00008	0.00008	0.00000	0.00082
128	0.00031	0.00034	0.00030	0.00017	0.00003	0.00012	0.00013	0.00001	0.00141
129	0.00018	0.00017	0.00012	0.00010	0.00001	0.00007	0.00008	0.00000	0.00074
130	0.00019	0.00021	0.00015	0.00011	0.00001	0.00009	0.00008	0.00000	0.00085
131	0.00015	0.00018	0.00015	0.00011	0.00001	0.00008	0.00007	0.00000	0.00076
132	0.00020	0.00016	0.00011	0.00008	0.00001	0.00005	0.00008	0.00000	0.00070

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
133	0.00027	0.00022	0.00016	0.00011	0.00002	0.00008	0.00011	0.00000	0.00097
134	0.00025	0.00019	0.00013	0.00011	0.00001	0.00008	0.00010	0.00000	0.00088
135	0.00016	0.00016	0.00012	0.00009	0.00001	0.00006	0.00007	0.00000	0.00067
136	0.00021	0.00015	0.00010	0.00008	0.00001	0.00005	0.00008	0.00000	0.00069
137	0.00020	0.00015	0.00010	0.00007	0.00001	0.00005	0.00008	0.00000	0.00067
138	0.00027	0.00018	0.00012	0.00009	0.00001	0.00006	0.00010	0.00000	0.00083
139	0.00027	0.00016	0.00010	0.00009	0.00001	0.00005	0.00010	0.00000	0.00079
140	0.00026	0.00016	0.00011	0.00008	0.00001	0.00005	0.00010	0.00000	0.00078
141	0.00029	0.00016	0.00010	0.00009	0.00002	0.00005	0.00011	0.00000	0.00082
142	0.00016	0.00015	0.00011	0.00007	0.00001	0.00005	0.00007	0.00000	0.00064
143	0.00029	0.00017	0.00011	0.00008	0.00002	0.00004	0.00011	0.00000	0.00082
144	0.00033	0.00019	0.00012	0.00011	0.00001	0.00007	0.00012	0.00000	0.00095
145	0.00023	0.00018	0.00011	0.00008	0.00002	0.00005	0.00009	0.00000	0.00077
146	0.00041	0.00029	0.00017	0.00011	0.00002	0.00007	0.00016	0.00001	0.00123
147	0.00036	0.00027	0.00015	0.00009	0.00003	0.00005	0.00014	0.00001	0.00110
148	0.00045	0.00019	0.00012	0.00011	0.00002	0.00006	0.00016	0.00000	0.00112
149	0.00048	0.00018	0.00011	0.00011	0.00002	0.00005	0.00017	0.00000	0.00112
Total	0.01259	0.08731	0.03861	0.00964	0.00340	0.00733	0.00599	0.00084	0.16570

E.3.3 Future Case with the Project (Case 2)

The Case 2 results show the average annual frequencies of marine accidents using modified Base Case traffic data and incorporating the Project structures.

Table E-28 presents the corresponding results for the MARCS Study Area and Table E-29 through Table E-37 present the results for the sub-areas.

The results for Case 2 are compared with the other case results and discussed in Section E.4 below.

Table E-28 Case 2 Accident Frequencies (per year) With the Project in the MARCS Study Area[16]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00047	0.00000	0.00000	0.00134	0.01053	0.01235
Fishing	0.00602	0.01517	0.03863	0.09979	0.14490	0.30451
Other/Undefined	0.00054	0.00114	0.00367	0.01850	0.03861	0.06246
Passenger	0.00012	0.00001	0.00001	0.00044	0.00272	0.00331
Pleasure	0.00026	0.00034	0.00059	0.01654	0.01210	0.02982
Tanker	0.00008	0.00000	0.00000	0.00021	0.00159	0.00188
Tanker – Oil Product	0.00020	0.00000	0.00000	0.00066	0.00441	0.00527
Tug/Service	0.00001	0.00001	0.00004	0.00013	0.00053	0.00073
Total	0.00770	0.01667	0.04295	0.13762	0.21539	0.42033

[16] 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-29 Case 2 Accident Frequencies (per year) With the Project in Project Area Section 1

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00011	0.00011
Fishing	0.00010	0.00000	0.00000	0.02114	0.04090	0.06214
Other/Undefined	0.00001	0.00000	0.00000	0.00191	0.00542	0.00733
Passenger	0.00000	0.00000	0.00000	0.00000	0.00003	0.00003
Pleasure	0.00001	0.00000	0.00000	0.00233	0.00182	0.00415
Tanker	0.00000	0.00000	0.00000	0.00000	0.00002	0.00002
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00005	0.00005
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00002	0.00002
Total	0.00011	0.00000	0.00000	0.02538	0.04836	0.07385

Table E-30 Case 2 Accident Frequencies (per year) With the Project in Project Area Section 2

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00049	0.00049
Fishing	0.00025	0.00000	0.00000	0.04204	0.04573	0.08802
Other/Undefined	0.00003	0.00000	0.00000	0.00763	0.01287	0.02053
Passenger	0.00000	0.00000	0.00000	0.00000	0.00013	0.00013
Pleasure	0.00002	0.00000	0.00000	0.00523	0.00315	0.00839
Tanker	0.00000	0.00000	0.00000	0.00000	0.00008	0.00008
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00022	0.00022
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00005	0.00005
Total	0.00030	0.00000	0.00000	0.05490	0.06273	0.11792

Table E-31 Case 2 Accident Frequencies (per year) With the Project in Project Area Section 3

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00001	0.00000	0.00000	0.00134	0.00992	0.01127
Fishing	0.00009	0.00000	0.00000	0.03662	0.05832	0.09504
Other/Undefined	0.00001	0.00000	0.00000	0.00896	0.02031	0.02929
Passenger	0.00000	0.00000	0.00000	0.00044	0.00255	0.00300
Pleasure	0.00001	0.00000	0.00000	0.00899	0.00714	0.01614
Tanker	0.00000	0.00000	0.00000	0.00021	0.00149	0.00170
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00066	0.00413	0.00480
Tug/Service	0.00000	0.00000	0.00000	0.00013	0.00046	0.00059
Total	0.00012	0.00000	0.00000	0.05736	0.10434	0.16182

Table E-32 Case 2 Accident Frequencies (per year) With the Project in the Northwest Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00030	0.00000	0.00000	0.00000	0.00000	0.00030
Other/Undefined	0.00003	0.00000	0.00000	0.00000	0.00000	0.00003
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00035	0.00000	0.00000	0.00000	0.00000	0.00035

Table E-33 Case 2 Accident Frequencies (per year) With the Project in the Northeast Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00011	0.00000	0.00000	0.00000	0.00000	0.00011
Other/Undefined	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00012	0.00000	0.00000	0.00000	0.00000	0.00012

Table E-34 Case 2 Accident Frequencies (per year) With the Project in the Southwest Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Fishing	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Other/Undefined	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002

Table E-35 Case 2 Accident Frequencies (per year) With the Project in the Southeast Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Fishing	0.00026	0.00000	0.00000	0.00000	0.00000	0.00026
Other/Undefined	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00034	0.00000	0.00000	0.00000	0.00000	0.00034

Table E-36 Case 2 Accident Frequencies (per year) With the Project in the Fairway Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00035	0.00000	0.00000	0.00000	0.00000	0.00035
Fishing	0.00101	0.00000	0.00000	0.00000	0.00000	0.00101
Other/Undefined	0.00005	0.00000	0.00000	0.00000	0.00000	0.00005
Passenger	0.00009	0.00000	0.00000	0.00000	0.00000	0.00009
Pleasure	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Tanker	0.00006	0.00000	0.00000	0.00000	0.00000	0.00006
Tanker – Oil Product	0.00015	0.00000	0.00000	0.00000	0.00000	0.00015
Tug/Service	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Total	0.00176	0.00000	0.00000	0.00000	0.00000	0.00176

Table E-37 Case 2 Accident Frequencies (per year) With the Project in the Other sub-area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00009	0.00000	0.00000	0.00000	0.00000	0.00010
Fishing	0.00390	0.01517	0.03863	-0.00001	-0.00005	0.05763
Other/Undefined	0.00036	0.00114	0.00367	0.00000	0.00001	0.00518
Passenger	0.00002	0.00001	0.00001	0.00000	0.00000	0.00005
Pleasure	0.00014	0.00034	0.00059	0.00000	0.00000	0.00107
Tanker	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Tanker – Oil Product	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Tug/Service	0.00000	0.00001	0.00004	0.00000	0.00000	0.00005
Total	0.00457	0.01667	0.04295	-0.00001	-0.00004	0.06414

Table E-38 and Table E-39 present the results for each individual project structure respectively for powered and drifting allisions.

Table E-38 Case 2 Powered Allision Accident Frequencies (per year) for Each Project Installation

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
1	0.00000	0.00067	0.00004	0.00000	0.00006	0.00000	0.00000	0.00000	0.00077
2	0.00000	0.00068	0.00004	0.00000	0.00006	0.00000	0.00000	0.00000	0.00078
3	0.00000	0.00147	0.00008	0.00000	0.00017	0.00000	0.00000	0.00000	0.00172
4	0.00000	0.00069	0.00004	0.00000	0.00006	0.00000	0.00000	0.00000	0.00079
5	0.00000	0.00080	0.00005	0.00000	0.00009	0.00000	0.00000	0.00000	0.00094
6	0.00000	0.00140	0.00017	0.00000	0.00009	0.00000	0.00000	0.00000	0.00166
7	0.00000	0.00073	0.00005	0.00000	0.00007	0.00000	0.00000	0.00000	0.00086
8	0.00000	0.00094	0.00006	0.00000	0.00012	0.00000	0.00000	0.00000	0.00112
9	0.00000	0.00084	0.00006	0.00000	0.00010	0.00000	0.00000	0.00000	0.00100
10	0.00000	0.00089	0.00012	0.00000	0.00007	0.00000	0.00000	0.00000	0.00108
11	0.00000	0.00080	0.00007	0.00000	0.00008	0.00000	0.00000	0.00000	0.00095
12	0.00000	0.00088	0.00007	0.00000	0.00011	0.00000	0.00000	0.00000	0.00106
13	0.00000	0.00097	0.00007	0.00000	0.00013	0.00000	0.00000	0.00000	0.00117
14	0.00000	0.00091	0.00010	0.00000	0.00009	0.00000	0.00000	0.00000	0.00110
15	0.00000	0.00106	0.00015	0.00000	0.00010	0.00000	0.00000	0.00000	0.00131
16	0.00000	0.00095	0.00009	0.00000	0.00011	0.00000	0.00000	0.00000	0.00115
17	0.00000	0.00130	0.00025	0.00000	0.00012	0.00000	0.00000	0.00000	0.00167
18	0.00000	0.00103	0.00009	0.00000	0.00013	0.00000	0.00000	0.00000	0.00125
19	0.00000	0.00110	0.00013	0.00000	0.00012	0.00000	0.00000	0.00000	0.00135

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
20	0.00000	0.00120	0.00020	0.00000	0.00011	0.00000	0.00000	0.00000	0.00151
21	0.00000	0.00106	0.00009	0.00000	0.00014	0.00000	0.00000	0.00000	0.00129
22	0.00000	0.00138	0.00027	0.00000	0.00015	0.00000	0.00000	0.00000	0.00180
23	0.00000	0.00213	0.00022	0.00000	0.00027	0.00000	0.00000	0.00000	0.00262
24	0.00000	0.00124	0.00016	0.00000	0.00015	0.00000	0.00000	0.00000	0.00155
25	0.00000	0.00113	0.00011	0.00000	0.00015	0.00000	0.00000	0.00000	0.00139
26	0.00000	0.00136	0.00027	0.00000	0.00017	0.00000	0.00000	0.00000	0.00180
27	0.00000	0.00132	0.00022	0.00000	0.00014	0.00000	0.00000	0.00000	0.00168
28	0.00000	0.00122	0.00017	0.00000	0.00013	0.00000	0.00000	0.00000	0.00152
29	0.00000	0.00130	0.00027	0.00000	0.00016	0.00000	0.00000	0.00000	0.00174
30	0.00000	0.00138	0.00023	0.00000	0.00016	0.00000	0.00000	0.00000	0.00177
31	0.00000	0.00122	0.00014	0.00000	0.00015	0.00000	0.00000	0.00000	0.00151
32	0.00000	0.00135	0.00024	0.00000	0.00016	0.00000	0.00000	0.00000	0.00174
33	0.00000	0.00116	0.00013	0.00000	0.00014	0.00000	0.00000	0.00000	0.00144
34	0.00000	0.00132	0.00019	0.00000	0.00015	0.00000	0.00000	0.00000	0.00166
35	0.00000	0.00125	0.00026	0.00000	0.00018	0.00000	0.00000	0.00000	0.00169
36	0.00000	0.00123	0.00024	0.00000	0.00014	0.00000	0.00000	0.00000	0.00161
37	0.00000	0.00127	0.00027	0.00000	0.00017	0.00000	0.00000	0.00000	0.00171
38	0.00000	0.00130	0.00018	0.00000	0.00015	0.00000	0.00000	0.00000	0.00163
39	0.00000	0.00109	0.00023	0.00000	0.00022	0.00000	0.00000	0.00000	0.00153
40	0.00000	0.00124	0.00017	0.00000	0.00014	0.00000	0.00000	0.00000	0.00155
41	0.00000	0.00135	0.00021	0.00000	0.00015	0.00000	0.00000	0.00000	0.00171

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
42	0.00000	0.00112	0.00026	0.00000	0.00016	0.00000	0.00000	0.00000	0.00154
43	0.00000	0.00074	0.00020	0.00000	0.00025	0.00000	0.00000	0.00000	0.00119
44	0.00000	0.00113	0.00025	0.00000	0.00019	0.00000	0.00000	0.00000	0.00158
45	0.00000	0.00128	0.00021	0.00000	0.00014	0.00000	0.00000	0.00000	0.00163
46	0.00000	0.00086	0.00021	0.00000	0.00026	0.00000	0.00000	0.00000	0.00133
47	0.00000	0.00128	0.00019	0.00000	0.00014	0.00000	0.00000	0.00000	0.00161
48	0.00000	0.00118	0.00021	0.00000	0.00012	0.00000	0.00000	0.00000	0.00151
49	0.00000	0.00062	0.00018	0.00000	0.00021	0.00000	0.00000	0.00000	0.00101
50	0.00000	0.00065	0.00016	0.00000	0.00021	0.00000	0.00000	0.00000	0.00102
51	0.00000	0.00098	0.00022	0.00000	0.00023	0.00000	0.00000	0.00000	0.00144
52	0.00000	0.00109	0.00024	0.00000	0.00013	0.00000	0.00000	0.00000	0.00146
53	0.00000	0.00121	0.00018	0.00000	0.00013	0.00000	0.00000	0.00000	0.00151
54	0.00000	0.00098	0.00024	0.00000	0.00019	0.00000	0.00000	0.00000	0.00142
55	0.00000	0.00098	0.00025	0.00000	0.00016	0.00000	0.00000	0.00000	0.00139
56	0.00000	0.00071	0.00021	0.00000	0.00023	0.00000	0.00000	0.00000	0.00115
57	0.00000	0.00055	0.00013	0.00000	0.00017	0.00000	0.00000	0.00000	0.00084
58	0.00000	0.00122	0.00019	0.00000	0.00012	0.00000	0.00000	0.00000	0.00153
59	0.00000	0.00084	0.00022	0.00000	0.00024	0.00000	0.00000	0.00000	0.00130
60	0.00000	0.00095	0.00021	0.00000	0.00011	0.00000	0.00000	0.00000	0.00128
61	0.00000	0.00097	0.00024	0.00000	0.00013	0.00000	0.00000	0.00000	0.00134
62	0.00000	0.00112	0.00019	0.00000	0.00011	0.00000	0.00000	0.00000	0.00142
63	0.00000	0.00053	0.00015	0.00000	0.00018	0.00000	0.00000	0.00000	0.00086

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
64	0.00000	0.00106	0.00021	0.00000	0.00011	0.00000	0.00000	0.00000	0.00138
65	0.00000	0.00062	0.00020	0.00000	0.00021	0.00000	0.00000	0.00000	0.00103
66	0.00000	0.00085	0.00024	0.00000	0.00020	0.00000	0.00000	0.00000	0.00128
67	0.00000	0.00055	0.00018	0.00000	0.00019	0.00000	0.00000	0.00000	0.00092
68	0.00000	0.00047	0.00012	0.00000	0.00015	0.00000	0.00000	0.00000	0.00074
69	0.00000	0.00045	0.00009	0.00000	0.00012	0.00000	0.00000	0.00000	0.00067
70	0.00000	0.00065	0.00022	0.00000	0.00021	0.00000	0.00000	0.00000	0.00108
71	0.00000	0.00073	0.00023	0.00000	0.00021	0.00000	0.00000	0.00000	0.00117
72	0.00000	0.00047	0.00008	0.00000	0.00011	0.00000	0.00000	0.00000	0.00066
73	0.00000	0.00086	0.00025	0.00000	0.00017	0.00000	0.00000	0.00000	0.00128
74	0.00000	0.00059	0.00021	0.00000	0.00021	0.00000	0.00000	0.00000	0.00101
75	0.00000	0.00071	0.00025	0.00000	0.00020	0.00000	0.00000	0.00000	0.00116
76	0.00000	0.00049	0.00015	0.00000	0.00017	0.00000	0.00000	0.00000	0.00082
77	0.00000	0.00063	0.00024	0.00000	0.00021	0.00000	0.00000	0.00000	0.00109
78	0.00000	0.00088	0.00025	0.00000	0.00014	0.00000	0.00000	0.00000	0.00127
79	0.00000	0.00040	0.00007	0.00000	0.00009	0.00000	0.00000	0.00000	0.00057
80	0.00000	0.00041	0.00006	0.00000	0.00008	0.00000	0.00000	0.00000	0.00056
81	0.00000	0.00052	0.00018	0.00000	0.00020	0.00000	0.00000	0.00000	0.00091
82	0.00000	0.00042	0.00010	0.00000	0.00012	0.00000	0.00000	0.00000	0.00065
83	0.00000	0.00047	0.00016	0.00000	0.00018	0.00000	0.00000	0.00000	0.00080
84	0.00000	0.00044	0.00012	0.00000	0.00015	0.00000	0.00000	0.00000	0.00072
85	0.00000	0.00078	0.00025	0.00000	0.00018	0.00000	0.00000	0.00000	0.00122

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
86	0.00000	0.00038	0.00008	0.00000	0.00010	0.00000	0.00000	0.00000	0.00055
87	0.00000	0.00036	0.00005	0.00000	0.00007	0.00000	0.00000	0.00000	0.00048
88	0.00000	0.00037	0.00006	0.00000	0.00008	0.00000	0.00000	0.00000	0.00051
89	0.00001	0.00038	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00050
90	0.00000	0.00034	0.00005	0.00000	0.00007	0.00000	0.00000	0.00000	0.00046
91	0.00000	0.00039	0.00010	0.00000	0.00012	0.00000	0.00000	0.00000	0.00062
92	0.00000	0.00080	0.00025	0.00000	0.00016	0.00000	0.00000	0.00000	0.00122
93	0.00000	0.00035	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00046
94	0.00000	0.00034	0.00006	0.00000	0.00008	0.00000	0.00000	0.00000	0.00048
95	0.00000	0.00034	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00045
96	0.00000	0.00031	0.00005	0.00000	0.00007	0.00000	0.00000	0.00000	0.00043
97	0.00000	0.00032	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00043
98	0.00000	0.00033	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00043
99	0.00000	0.00033	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00044
100	0.00000	0.00034	0.00007	0.00000	0.00009	0.00000	0.00000	0.00000	0.00051
101	0.00001	0.00035	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00046
102	0.00000	0.00033	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00045
103	0.00000	0.00032	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00043
104	0.00000	0.00031	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00042
105	0.00000	0.00029	0.00004	0.00000	0.00006	0.00000	0.00000	0.00000	0.00040
106	0.00000	0.00028	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00039
107	0.00000	0.00031	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00042

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
108	0.00000	0.00029	0.00005	0.00000	0.00006	0.00000	0.00000	0.00000	0.00040
109	0.00000	0.00032	0.00006	0.00000	0.00006	0.00000	0.00000	0.00000	0.00044
110	0.00000	0.00027	0.00004	0.00000	0.00005	0.00000	0.00000	0.00000	0.00037
111	0.00000	0.00030	0.00006	0.00000	0.00006	0.00000	0.00000	0.00000	0.00041
112	0.00000	0.00027	0.00005	0.00000	0.00005	0.00000	0.00000	0.00000	0.00038
113	0.00000	0.00028	0.00007	0.00000	0.00005	0.00000	0.00000	0.00000	0.00041
114	0.00000	0.00031	0.00006	0.00000	0.00006	0.00000	0.00000	0.00000	0.00044
115	0.00000	0.00028	0.00006	0.00000	0.00005	0.00000	0.00000	0.00000	0.00039
116	0.00002	0.00034	0.00007	0.00000	0.00006	0.00000	0.00001	0.00000	0.00049
117	0.00000	0.00030	0.00007	0.00000	0.00006	0.00000	0.00000	0.00000	0.00042
118	0.00000	0.00025	0.00005	0.00000	0.00005	0.00000	0.00000	0.00000	0.00035
119	0.00000	0.00025	0.00005	0.00000	0.00005	0.00000	0.00000	0.00000	0.00036
120	0.00001	0.00033	0.00007	0.00000	0.00006	0.00000	0.00000	0.00000	0.00047
121	0.00000	0.00023	0.00006	0.00000	0.00005	0.00000	0.00000	0.00000	0.00034
122	0.00000	0.00026	0.00006	0.00000	0.00005	0.00000	0.00000	0.00000	0.00037
123	0.00000	0.00023	0.00006	0.00000	0.00005	0.00000	0.00000	0.00000	0.00035
124	0.00001	0.00032	0.00007	0.00000	0.00006	0.00000	0.00000	0.00000	0.00046
125	0.00000	0.00023	0.00006	0.00000	0.00004	0.00000	0.00000	0.00000	0.00034
126	0.00000	0.00025	0.00007	0.00000	0.00005	0.00000	0.00000	0.00000	0.00038
127	0.00000	0.00027	0.00007	0.00000	0.00005	0.00000	0.00000	0.00000	0.00040
128	0.00005	0.00033	0.00008	0.00002	0.00006	0.00001	0.00002	0.00000	0.00057
129	0.00000	0.00024	0.00006	0.00000	0.00005	0.00000	0.00000	0.00000	0.00036

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
130	0.00001	0.00030	0.00007	0.00000	0.00005	0.00000	0.00000	0.00000	0.00044
131	0.00001	0.00021	0.00006	0.00000	0.00004	0.00000	0.00000	0.00000	0.00033
132	0.00001	0.00021	0.00005	0.00000	0.00004	0.00000	0.00000	0.00000	0.00032
133	0.00004	0.00031	0.00008	0.00001	0.00006	0.00001	0.00002	0.00000	0.00051
134	0.00003	0.00028	0.00007	0.00001	0.00005	0.00000	0.00001	0.00000	0.00046
135	0.00000	0.00020	0.00006	0.00000	0.00004	0.00000	0.00001	0.00000	0.00031
136	0.00001	0.00016	0.00004	0.00001	0.00004	0.00000	0.00002	0.00000	0.00027
137	0.00001	0.00018	0.00004	0.00000	0.00004	0.00000	0.00000	0.00000	0.00029
138	0.00002	0.00025	0.00006	0.00001	0.00005	0.00000	0.00001	0.00000	0.00041
139	0.00002	0.00020	0.00004	0.00001	0.00004	0.00000	0.00001	0.00000	0.00033
140	0.00002	0.00023	0.00005	0.00001	0.00005	0.00000	0.00001	0.00000	0.00037
141	0.00002	0.00018	0.00004	0.00001	0.00004	0.00000	0.00001	0.00000	0.00030
142	0.00001	0.00017	0.00005	0.00000	0.00004	0.00000	0.00001	0.00000	0.00029
143	0.00002	0.00016	0.00003	0.00001	0.00004	0.00000	0.00001	0.00001	0.00028
144	0.00012	0.00027	0.00006	0.00004	0.00005	0.00002	0.00005	0.00000	0.00061
145	0.00004	0.00014	0.00003	0.00001	0.00003	0.00000	0.00002	0.00001	0.00029
146	0.00013	0.00046	0.00010	0.00004	0.00010	0.00002	0.00006	0.00000	0.00091
147	0.00004	0.00026	0.00005	0.00002	0.00007	0.00001	0.00007	0.00001	0.00054
148	0.00037	0.00026	0.00006	0.00011	0.00006	0.00006	0.00016	0.00000	0.00107
149	0.00028	0.00024	0.00006	0.00008	0.00005	0.00004	0.00012	0.00000	0.00089
Total	0.00134	0.09979	0.01850	0.00044	0.01654	0.00021	0.00066	0.00013	0.13762

Table E-39 Case 2 Drifting Allision Accident Frequencies (per year) for Each Project Installation

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
1	0.00000	0.00203	0.00021	0.00000	0.00007	0.00000	0.00000	0.00000	0.00230
2	0.00000	0.00247	0.00024	0.00000	0.00008	0.00000	0.00000	0.00000	0.00280
3	0.00000	0.00434	0.00039	0.00000	0.00014	0.00000	0.00000	0.00000	0.00487
4	0.00000	0.00247	0.00026	0.00000	0.00008	0.00000	0.00000	0.00000	0.00281
5	0.00000	0.00253	0.00026	0.00000	0.00009	0.00000	0.00000	0.00000	0.00288
6	0.00002	0.00248	0.00036	0.00001	0.00010	0.00000	0.00001	0.00000	0.00299
7	0.00000	0.00178	0.00022	0.00000	0.00007	0.00000	0.00000	0.00000	0.00208
8	0.00000	0.00195	0.00024	0.00000	0.00009	0.00000	0.00000	0.00000	0.00228
9	0.00000	0.00177	0.00021	0.00000	0.00008	0.00000	0.00000	0.00000	0.00207
10	0.00002	0.00137	0.00025	0.00000	0.00006	0.00000	0.00001	0.00000	0.00171
11	0.00001	0.00152	0.00022	0.00000	0.00007	0.00000	0.00000	0.00000	0.00181
12	0.00000	0.00156	0.00022	0.00000	0.00008	0.00000	0.00000	0.00000	0.00187
13	0.00000	0.00169	0.00023	0.00000	0.00009	0.00000	0.00000	0.00000	0.00201
14	0.00001	0.00139	0.00023	0.00000	0.00007	0.00000	0.00000	0.00000	0.00170
15	0.00001	0.00134	0.00026	0.00000	0.00007	0.00000	0.00001	0.00000	0.00169
16	0.00000	0.00144	0.00023	0.00000	0.00007	0.00000	0.00000	0.00000	0.00175
17	0.00003	0.00184	0.00056	0.00001	0.00009	0.00000	0.00001	0.00000	0.00255
18	0.00000	0.00158	0.00023	0.00000	0.00009	0.00000	0.00000	0.00000	0.00191
19	0.00001	0.00138	0.00025	0.00000	0.00008	0.00000	0.00000	0.00000	0.00172
20	0.00002	0.00142	0.00033	0.00000	0.00008	0.00000	0.00001	0.00000	0.00186
21	0.00000	0.00164	0.00025	0.00000	0.00010	0.00000	0.00000	0.00000	0.00200
22	0.00002	0.00147	0.00041	0.00001	0.00010	0.00000	0.00001	0.00000	0.00203

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
23	0.00000	0.00269	0.00040	0.00000	0.00017	0.00000	0.00000	0.00000	0.00328
24	0.00001	0.00167	0.00030	0.00000	0.00012	0.00000	0.00000	0.00000	0.00211
25	0.00000	0.00147	0.00026	0.00000	0.00009	0.00000	0.00000	0.00000	0.00182
26	0.00002	0.00146	0.00038	0.00001	0.00012	0.00000	0.00001	0.00000	0.00200
27	0.00002	0.00153	0.00040	0.00000	0.00009	0.00000	0.00001	0.00000	0.00205
28	0.00001	0.00136	0.00028	0.00000	0.00008	0.00000	0.00000	0.00000	0.00174
29	0.00004	0.00134	0.00039	0.00001	0.00011	0.00001	0.00002	0.00000	0.00191
30	0.00001	0.00187	0.00051	0.00000	0.00012	0.00000	0.00001	0.00000	0.00252
31	0.00000	0.00134	0.00026	0.00000	0.00008	0.00000	0.00000	0.00000	0.00170
32	0.00001	0.00128	0.00037	0.00000	0.00008	0.00000	0.00001	0.00000	0.00176
33	0.00000	0.00127	0.00026	0.00000	0.00007	0.00000	0.00000	0.00000	0.00162
34	0.00001	0.00182	0.00038	0.00000	0.00013	0.00000	0.00000	0.00000	0.00234
35	0.00003	0.00121	0.00034	0.00001	0.00010	0.00000	0.00001	0.00000	0.00171
36	0.00001	0.00110	0.00034	0.00000	0.00008	0.00000	0.00000	0.00000	0.00154
37	0.00002	0.00109	0.00035	0.00001	0.00009	0.00000	0.00001	0.00000	0.00156
38	0.00001	0.00132	0.00030	0.00000	0.00008	0.00000	0.00000	0.00000	0.00172
39	0.00005	0.00106	0.00031	0.00001	0.00011	0.00001	0.00002	0.00000	0.00156
40	0.00000	0.00125	0.00030	0.00000	0.00007	0.00000	0.00000	0.00000	0.00162
41	0.00001	0.00156	0.00045	0.00000	0.00008	0.00000	0.00000	0.00000	0.00210
42	0.00001	0.00110	0.00048	0.00000	0.00009	0.00000	0.00001	0.00000	0.00170
43	0.00005	0.00090	0.00044	0.00001	0.00018	0.00001	0.00002	0.00000	0.00162
44	0.00003	0.00099	0.00032	0.00001	0.00009	0.00000	0.00001	0.00000	0.00146

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
45	0.00001	0.00138	0.00043	0.00000	0.00008	0.00000	0.00000	0.00000	0.00191
46	0.00006	0.00088	0.00034	0.00001	0.00013	0.00001	0.00002	0.00000	0.00145
47	0.00000	0.00127	0.00033	0.00000	0.00007	0.00000	0.00000	0.00000	0.00169
48	0.00000	0.00122	0.00037	0.00000	0.00008	0.00000	0.00000	0.00000	0.00168
49	0.00005	0.00082	0.00030	0.00001	0.00011	0.00001	0.00002	0.00000	0.00132
50	0.00007	0.00077	0.00026	0.00002	0.00009	0.00001	0.00003	0.00000	0.00125
51	0.00004	0.00091	0.00029	0.00001	0.00009	0.00001	0.00002	0.00000	0.00137
52	0.00001	0.00103	0.00033	0.00000	0.00008	0.00000	0.00000	0.00000	0.00146
53	0.00000	0.00126	0.00033	0.00000	0.00007	0.00000	0.00000	0.00000	0.00167
54	0.00002	0.00091	0.00030	0.00001	0.00009	0.00000	0.00001	0.00000	0.00134
55	0.00001	0.00101	0.00041	0.00000	0.00009	0.00000	0.00001	0.00000	0.00154
56	0.00003	0.00086	0.00034	0.00001	0.00013	0.00000	0.00001	0.00000	0.00139
57	0.00006	0.00078	0.00025	0.00001	0.00009	0.00001	0.00002	0.00000	0.00121
58	0.00000	0.00176	0.00057	0.00000	0.00008	0.00000	0.00000	0.00000	0.00242
59	0.00003	0.00086	0.00031	0.00001	0.00011	0.00001	0.00001	0.00000	0.00134
60	0.00001	0.00109	0.00034	0.00000	0.00009	0.00000	0.00000	0.00000	0.00155
61	0.00001	0.00101	0.00033	0.00000	0.00009	0.00000	0.00000	0.00000	0.00145
62	0.00001	0.00141	0.00045	0.00000	0.00009	0.00000	0.00000	0.00000	0.00195
63	0.00004	0.00084	0.00028	0.00001	0.00010	0.00001	0.00002	0.00000	0.00129
64	0.00001	0.00111	0.00034	0.00000	0.00008	0.00000	0.00000	0.00000	0.00154
65	0.00002	0.00093	0.00038	0.00001	0.00014	0.00000	0.00001	0.00000	0.00150
66	0.00003	0.00089	0.00031	0.00001	0.00010	0.00000	0.00001	0.00000	0.00134

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
67	0.00002	0.00096	0.00034	0.00000	0.00012	0.00000	0.00001	0.00000	0.00146
68	0.00004	0.00084	0.00027	0.00001	0.00010	0.00001	0.00002	0.00000	0.00129
69	0.00005	0.00082	0.00024	0.00001	0.00008	0.00001	0.00002	0.00000	0.00124
70	0.00002	0.00099	0.00041	0.00000	0.00015	0.00000	0.00001	0.00000	0.00158
71	0.00002	0.00092	0.00035	0.00000	0.00012	0.00000	0.00001	0.00000	0.00142
72	0.00009	0.00082	0.00024	0.00002	0.00008	0.00001	0.00004	0.00000	0.00130
73	0.00001	0.00097	0.00036	0.00000	0.00010	0.00000	0.00001	0.00000	0.00145
74	0.00001	0.00105	0.00041	0.00000	0.00016	0.00000	0.00001	0.00000	0.00164
75	0.00001	0.00146	0.00047	0.00000	0.00015	0.00000	0.00001	0.00000	0.00211
76	0.00002	0.00090	0.00030	0.00001	0.00011	0.00000	0.00001	0.00000	0.00135
77	0.00002	0.00146	0.00056	0.00000	0.00025	0.00000	0.00001	0.00000	0.00230
78	0.00001	0.00104	0.00036	0.00000	0.00010	0.00000	0.00000	0.00000	0.00152
79	0.00005	0.00073	0.00022	0.00001	0.00008	0.00001	0.00002	0.00000	0.00114
80	0.00008	0.00073	0.00021	0.00002	0.00007	0.00001	0.00003	0.00000	0.00116
81	0.00002	0.00130	0.00041	0.00000	0.00019	0.00000	0.00001	0.00000	0.00193
82	0.00003	0.00080	0.00025	0.00001	0.00010	0.00001	0.00001	0.00000	0.00121
83	0.00002	0.00068	0.00028	0.00001	0.00010	0.00000	0.00001	0.00000	0.00111
84	0.00002	0.00121	0.00034	0.00000	0.00016	0.00000	0.00001	0.00000	0.00175
85	0.00001	0.00098	0.00036	0.00000	0.00011	0.00000	0.00001	0.00000	0.00147
86	0.00002	0.00102	0.00027	0.00001	0.00013	0.00000	0.00001	0.00000	0.00147
87	0.00007	0.00068	0.00020	0.00002	0.00008	0.00001	0.00003	0.00000	0.00108
88	0.00005	0.00074	0.00021	0.00001	0.00009	0.00001	0.00002	0.00000	0.00113

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
89	0.00011	0.00066	0.00019	0.00003	0.00007	0.00002	0.00004	0.00000	0.00111
90	0.00005	0.00099	0.00025	0.00001	0.00012	0.00001	0.00002	0.00000	0.00145
91	0.00002	0.00062	0.00023	0.00001	0.00009	0.00000	0.00001	0.00000	0.00099
92	0.00001	0.00121	0.00045	0.00000	0.00013	0.00000	0.00001	0.00000	0.00180
93	0.00010	0.00064	0.00018	0.00003	0.00007	0.00001	0.00004	0.00000	0.00107
94	0.00003	0.00056	0.00020	0.00001	0.00007	0.00000	0.00001	0.00000	0.00089
95	0.00007	0.00070	0.00020	0.00002	0.00008	0.00001	0.00003	0.00000	0.00112
96	0.00003	0.00045	0.00017	0.00001	0.00006	0.00001	0.00002	0.00000	0.00075
97	0.00005	0.00056	0.00018	0.00001	0.00007	0.00001	0.00002	0.00000	0.00090
98	0.00007	0.00096	0.00024	0.00002	0.00012	0.00001	0.00003	0.00000	0.00145
99	0.00009	0.00067	0.00019	0.00002	0.00008	0.00001	0.00004	0.00000	0.00110
100	0.00003	0.00050	0.00020	0.00001	0.00007	0.00000	0.00002	0.00000	0.00083
101	0.00011	0.00060	0.00017	0.00003	0.00006	0.00002	0.00005	0.00000	0.00105
102	0.00013	0.00067	0.00019	0.00003	0.00007	0.00002	0.00005	0.00000	0.00117
103	0.00009	0.00096	0.00024	0.00002	0.00012	0.00001	0.00004	0.00000	0.00148
104	0.00005	0.00053	0.00017	0.00001	0.00006	0.00001	0.00002	0.00000	0.00087
105	0.00005	0.00043	0.00016	0.00001	0.00005	0.00001	0.00002	0.00000	0.00074
106	0.00004	0.00040	0.00017	0.00001	0.00005	0.00001	0.00002	0.00001	0.00070
107	0.00009	0.00052	0.00017	0.00002	0.00006	0.00001	0.00004	0.00000	0.00092
108	0.00005	0.00042	0.00016	0.00001	0.00005	0.00001	0.00002	0.00000	0.00072
109	0.00012	0.00097	0.00024	0.00003	0.00011	0.00002	0.00005	0.00000	0.00154
110	0.00005	0.00038	0.00015	0.00001	0.00005	0.00001	0.00002	0.00001	0.00067

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
111	0.00008	0.00043	0.00015	0.00002	0.00005	0.00001	0.00004	0.00000	0.00078
112	0.00006	0.00040	0.00016	0.00002	0.00005	0.00001	0.00003	0.00001	0.00073
113	0.00013	0.00034	0.00014	0.00003	0.00004	0.00002	0.00005	0.00001	0.00075
114	0.00011	0.00050	0.00016	0.00003	0.00006	0.00002	0.00005	0.00000	0.00092
115	0.00009	0.00036	0.00015	0.00002	0.00004	0.00001	0.00004	0.00001	0.00071
116	0.00016	0.00071	0.00021	0.00004	0.00008	0.00002	0.00006	0.00000	0.00130
117	0.00013	0.00040	0.00015	0.00003	0.00005	0.00002	0.00005	0.00001	0.00083
118	0.00006	0.00035	0.00015	0.00002	0.00004	0.00001	0.00003	0.00001	0.00067
119	0.00007	0.00035	0.00015	0.00002	0.00004	0.00001	0.00003	0.00001	0.00068
120	0.00016	0.00097	0.00025	0.00004	0.00011	0.00002	0.00007	0.00000	0.00164
121	0.00009	0.00030	0.00014	0.00002	0.00004	0.00001	0.00004	0.00001	0.00065
122	0.00010	0.00030	0.00014	0.00002	0.00004	0.00001	0.00004	0.00001	0.00066
123	0.00011	0.00027	0.00013	0.00003	0.00003	0.00002	0.00004	0.00001	0.00063
124	0.00015	0.00049	0.00017	0.00004	0.00006	0.00002	0.00006	0.00001	0.00100
125	0.00013	0.00027	0.00013	0.00003	0.00003	0.00002	0.00005	0.00001	0.00067
126	0.00012	0.00030	0.00014	0.00003	0.00003	0.00002	0.00005	0.00001	0.00070
127	0.00016	0.00033	0.00014	0.00004	0.00004	0.00002	0.00007	0.00001	0.00081
128	0.00024	0.00100	0.00030	0.00006	0.00012	0.00003	0.00010	0.00001	0.00185
129	0.00016	0.00027	0.00012	0.00004	0.00003	0.00002	0.00007	0.00001	0.00073
130	0.00016	0.00039	0.00015	0.00004	0.00004	0.00002	0.00007	0.00001	0.00088
131	0.00012	0.00026	0.00015	0.00003	0.00003	0.00002	0.00005	0.00001	0.00065
132	0.00019	0.00024	0.00011	0.00005	0.00003	0.00003	0.00007	0.00001	0.00072

Turbine / OSP	Cargo Carrier	Fishing	Other Undefined	Passenger	Pleasure	Tanker	Tanker - Oil	Tug Service	Total
133	0.00024	0.00047	0.00016	0.00006	0.00005	0.00003	0.00010	0.00001	0.00113
134	0.00023	0.00036	0.00013	0.00006	0.00004	0.00003	0.00009	0.00001	0.00096
135	0.00014	0.00023	0.00012	0.00004	0.00003	0.00002	0.00006	0.00001	0.00063
136	0.00020	0.00021	0.00010	0.00005	0.00003	0.00003	0.00008	0.00001	0.00071
137	0.00019	0.00022	0.00010	0.00005	0.00003	0.00003	0.00008	0.00001	0.00070
138	0.00025	0.00031	0.00012	0.00006	0.00004	0.00004	0.00010	0.00001	0.00092
139	0.00026	0.00024	0.00010	0.00007	0.00003	0.00004	0.00010	0.00001	0.00085
140	0.00025	0.00027	0.00011	0.00006	0.00003	0.00004	0.00010	0.00001	0.00086
141	0.00027	0.00023	0.00010	0.00007	0.00003	0.00004	0.00011	0.00001	0.00086
142	0.00015	0.00022	0.00011	0.00004	0.00003	0.00002	0.00006	0.00001	0.00063
143	0.00028	0.00023	0.00011	0.00007	0.00003	0.00004	0.00011	0.00001	0.00088
144	0.00032	0.00036	0.00012	0.00008	0.00004	0.00005	0.00013	0.00001	0.00111
145	0.00022	0.00023	0.00011	0.00006	0.00003	0.00003	0.00009	0.00001	0.00078
146	0.00039	0.00051	0.00017	0.00010	0.00006	0.00006	0.00016	0.00001	0.00146
147	0.00035	0.00035	0.00015	0.00009	0.00004	0.00005	0.00015	0.00002	0.00120
148	0.00044	0.00036	0.00012	0.00011	0.00004	0.00006	0.00017	0.00001	0.00132
149	0.00045	0.00031	0.00011	0.00011	0.00003	0.00006	0.00018	0.00001	0.00127
Total	0.01053	0.14495	0.03861	0.00272	0.01210	0.00159	0.00441	0.00053	0.21543

E.3.4 Model verification

Several checks and cross-checks were conducted to assure the model is self-consistent, and provides valid, credible results.

The difference between Case 1 and Case 0 provides an estimate of the maximum risk increase that could result from the presence of the Project if none of the traffic varied their routes or increased their activity 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 Project Area.

E.3.5 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 0.28 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 0.11 and 0.17 for powered and drift allision respectively. The sum of the allision frequencies represents the difference in the total accident frequency between Case 1 and Case 0.

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.3.6 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 and drift allisions are reduced for Cargo/Carrier, Passenger, Tanker (including Oil Tanker) and Tug/Service traffic. This is because these ship types are re-routed around the Project Area in the Future Case.
- Allisions are increased for the Fishing and Pleasure ships. This is because of the additional pleasure tour ships, the recreational fishing ships and the new fishing activities included in the Future Case (Case 2).
- Collision frequency increases because there are 20% more ship-miles in the MARCS Study Area in the Future Case.

E.4 Results and discussion

E.4.1 Project risk difference: comparing Case 2 to Case 0

The Future Case (Case 2) includes the Project structures and the modified traffic data. The Base Case (Case 0) is without the Project structures and without the modifications to the traffic data.

Table E-40 shows 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-41 to Table E-43 show the same for each of the three Project Area sections. Differences in frequency less than 0.00010 per year are highlighted in grey.

Table E-40 Case 2 Minus Case 0 Accident Frequencies (per year) in the MARCS Study Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00017	-0.00001	-0.00001	0.00134	0.01053	0.01202
Fishing	0.00200	0.00003	0.00167	0.09979	0.14490	0.24839
Other/Undefined	0.00013	0.00000	0.00000	0.01850	0.03861	0.05724
Passenger	0.00003	0.00000	-0.00001	0.00044	0.00272	0.00317
Pleasure	0.00022	0.00000	0.00016	0.01654	0.01210	0.02902
Tanker	0.00000	0.00000	-0.00001	0.00021	0.00159	0.00179
Tanker – Oil Product	0.00008	-0.00001	-0.00001	0.00066	0.00441	0.00513
Tug/Service	0.00000	0.00000	-0.00003	0.00013	0.00053	0.00064
Total	0.00263	0.00001	0.00177	0.13762	0.21539	0.35742

Table E-41 Case 2 Minus Case 0 Accident Frequencies (per year) in Project Area Section 1

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00011	0.00011
Fishing	0.00006	0.00000	0.00000	0.02114	0.04090	0.06210
Other/Undefined	0.00000	0.00000	0.00000	0.00191	0.00542	0.00733
Passenger	0.00000	0.00000	0.00000	0.00000	0.00003	0.00003
Pleasure	0.00001	0.00000	0.00000	0.00233	0.00182	0.00415
Tanker	0.00000	0.00000	0.00000	0.00000	0.00002	0.00002
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00005	0.00005
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00002	0.00002
Total	0.00006	0.00000	0.00000	0.02538	0.04836	0.07381

Table E-42 Case 2 Minus Case 0 Accident Frequencies (per year) in Project Area Section 2

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00049	0.00049
Fishing	0.00018	0.00000	0.00000	0.04204	0.04573	0.08795
Other/Undefined	0.00002	0.00000	0.00000	0.00763	0.01287	0.02051
Passenger	0.00000	0.00000	0.00000	0.00000	0.00013	0.00013
Pleasure	0.00002	0.00000	0.00000	0.00523	0.00315	0.00839
Tanker	0.00000	0.00000	0.00000	0.00000	0.00008	0.00008
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00022	0.00022
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00005	0.00005
Total	0.00022	0.00000	0.00000	0.05490	0.06273	0.11784

Table E-43 Case 2 Minus Case 0 Accident Frequencies (per year) in Project Area Section 3

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00134	0.00992	0.01127
Fishing	0.00006	0.00000	0.00000	0.03662	0.05832	0.09501
Other/Undefined	0.00001	0.00000	0.00000	0.00896	0.02031	0.02928
Passenger	0.00000	0.00000	0.00000	0.00044	0.00255	0.00300
Pleasure	0.00001	0.00000	0.00000	0.00899	0.00714	0.01614
Tanker	0.00000	0.00000	0.00000	0.00021	0.00149	0.00170
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00066	0.00413	0.00480
Tug/Service	0.00000	0.00000	0.00000	0.00013	0.00046	0.00059
Total	0.00008	0.00000	0.00000	0.05736	0.10434	0.16177

The main difference between Case 0 and Case 2 is the powered and drift allision frequency. Fishing ships dominate (69%) the total allision frequency, followed by the Other/Undefined vessels (16%). This is partly because of the increase in fishing ships assumed in the Future Case and the fact that these ship types did not get re-routed.

E.4.2 Discussion of the sub-area results

The sub-area accident frequency differences between Case 0 and Case 2 are presented in Table E-44 through Table E-49 and discussed below. These are conservative estimates of the risk increase from the Project.

Table E-44 Case 2 Minus Case 0 Accident Frequencies (per year) in the Northwest Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00020	0.00000	0.00000	0.00000	0.00000	0.00020
Other/Undefined	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00023	0.00000	0.00000	0.00000	0.00000	0.00023

Table E-45 Case 2 Minus Case 0 Accident Frequencies (per year) in the Northeast Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Fishing	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Other/Undefined	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002

Table E-46 Case 2 Minus Case 0 Accident Frequencies (per year) in the Southwest Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Fishing	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Other/Undefined	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001

Table E-47 Case 2 Minus Case 0 Accident Frequencies (per year) in the Southeast Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Fishing	0.00016	0.00000	0.00000	0.00000	0.00000	0.00016
Other/Undefined	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Passenger	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Pleasure	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Tanker	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tanker – Oil Product	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00020	0.00000	0.00000	0.00000	0.00000	0.00020

Table E-48 Case 2 Minus Case 0 Accident Frequencies (per year) in the Fairway Area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00012	0.00000	0.00000	0.00000	0.00000	0.00012
Fishing	0.00034	0.00000	0.00000	0.00000	0.00000	0.00034
Other/Undefined	0.00001	0.00000	0.00000	0.00000	0.00000	0.00001
Passenger	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Pleasure	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
Tanker	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
Tanker – Oil Product	0.00006	0.00000	0.00000	0.00000	0.00000	0.00006
Tug/Service	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Total	0.00064	0.00000	0.00000	0.00000	0.00000	0.00064

Table E-49 Case 2 Minus Case 0 Accident Frequencies (per year) in the Other Sub-area

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.00003	-0.00001	-0.00001	0.00000	0.00000	0.00002
Fishing	0.00097	0.00003	0.00167	-0.00001	-0.00005	0.00261
Other/Undefined	0.00006	0.00000	0.00000	0.00000	0.00001	0.00007
Passenger	-0.00001	0.00000	-0.00001	0.00000	0.00000	-0.00003
Pleasure	0.00011	0.00000	0.00016	0.00000	0.00000	0.00027
Tanker	-0.00001	0.00000	-0.00001	0.00000	0.00000	-0.00002
Tanker – Oil Product	0.00001	-0.00001	-0.00001	0.00000	0.00000	0.00000
Tug/Service	0.00000	0.00000	-0.00003	0.00000	0.00000	-0.00003
Total	0.00116	0.00001	0.00177	-0.00001	-0.00004	0.00289

In general, the differences in accident frequencies observed reflect the differences in the amount of shipping traffic of each ship type in each sub-area.

The largest change in accident frequency due to the Project occurs in the Other and the Fairway sub-areas. This is because some traffic is either re-routed into these sub-areas in the Future Case. The increase in accident frequency is mainly due to increased drift grounding and collision risks in the Other sub-area and to collision risk in the Fairway sub-area.

The changes in accident frequency for the remaining sub-areas are minor or judged to be insignificant.

E.5 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, or Case 1) and for the Future Case (Case 2) with the addition of the Project (and additional vessel traffic caused by the presence of Project structures and assumes 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 the Mayflower Wind Project.

Per NVIC 01-19 recommendations, this NSRA addresses the difference in collision and grounding due to the implementation of the Project, in addition to the risk of allision with Project structures. In this assessment, the difference in accident frequency between Case 2 and Case 0 is 0.36 accidents per year across the entire MARCS Study Area. This is our best estimate of the incremental risk that results from the presence of the Project.

This modeling included an 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 GL during development of this NSRA and updated after issuance of a draft of Appendix G in August 2021.

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 Appendix A. The precise locations of the structures and the ECC 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	Coordinates of the structures in the Lease Area as evaluated in the NSRA are provided in Appendix A. GIS data and accompanying metadata for relevant Project components will be provided to the USCG.
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 selected 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. The draft traffic survey was submitted for comment to BOEM in early 2021.
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 and Appendix G Section G.2.1 for the Brayton Point ECC.

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 and Appendix G Section G.2.1 for the Brayton Point ECC.
Does the survey include consultation with recreational vessel organizations?	Yes	Consultation with recreational organizations was undertaken and is summarized in Section 1.2 of the Mayflower COP. See the NSRA, Appendix C for the list of engagements and topics discussed.
Does the survey include consultation with fishing vessel organizations?	Yes	Consultation with recreational organizations was undertaken and is summarized in Section 1.2 of the Mayflower COP. See the NSRA, Appendix C for the list of engagements and topics discussed.
Does the survey include consultation with pilot organizations?	Yes	Consultation with maritime safety and security organizations were undertaken and are summarized in Section 1.2 of the Mayflower COP. See the NSRA, Appendix C for the list of engagements and topics discussed.
Does the survey include consultation with commercial vessel organizations?	Yes	Consultation with commercial organizations was undertaken at The Southeastern New England Port Safety & Security Forum and is summarized in Section 1.2 of the Mayflower COP. See the NSRA, Appendix C for the list of engagements and topics discussed.
Does the survey include consultation with port authorities?	Yes	Consultation with port authorities was undertaken and is summarized in Section 1.2 of the Mayflower COP. See the NSRA, Appendix B for the list of engagements and topics discussed.
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. Additional routes and patterns relative to the Brayton Point ECC are provided in Appendix G Section G.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, Section 2.2.2 for transit-related uses, and in Appendix G Section G.2 for the Brayton Point ECC.
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 with additional information relevant to the Brayton Point ECC provided in Appendix G Section G.2.

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 Marine Traffic Study Area with additional information relevant to the Brayton Point ECC provided in Appendix G Section G.2.
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 Marine Traffic Study Area are assessed in Section 2.2.1 with additional information relevant to the Brayton Point ECC provided in Appendix G Section G.2.
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 2.1.1.5 (tugs), 2.1.1.1 (cargo/tanker vessels), and 2.1.1.3 (passenger vessels). Fishing vessel routes are presented in Section 2.2.2.2 (which also refers to Section 2.1.1.2). Additional information relevant to the Brayton Point ECC is provided in Appendix G Section G.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 risk evaluated in Section 11. Additional information relevant to the Brayton Point ECC is provided in Appendix G Section G.2.
Does the survey include whether the nearby area contains prescribed or recommended routing measures or precautionary areas?	Yes	Section 2.2.2.4 describes routing measures, precautionary areas, separation zones, and TSS in the Marine Traffic Study Area. Additional information relevant to the Brayton Point ECC is provided in Appendix G Section G.2.
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 Marine Traffic Study Area are presented in Section 2.2.2.4. Additional information relevant to the Brayton Point ECC is provided in Appendix G Section G.2.
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 Marine Traffic Study Area are presented in Section 2.2.3. Project impacts on anchorages is discussed in Section 5.4. Information relevant to the Brayton Point ECC is provided in Appendix G Section G.2.
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 2.2.3.4 with additional information relevant to the Brayton Point ECC provided in Appendix G Section G.2.

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. Appendix G Section G.2 provides additional information relevant to the Brayton Point ECC.
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. Appendix G Section G.2 provides additional information relevant to the Brayton Point ECC.
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. Appendix G Section G.2 provides additional information relevant to the Brayton Point ECC.
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. Appendix G Section G.2 provides additional information relevant to the Brayton Point ECC.
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 and 2.2.4.4. Appendix G Section 2 provides additional information relevant to the Brayton Point ECC.
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 2.2.4.4. Appendix G Section G.2 provides additional information relevant to the Brayton Point ECC.
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 2.2.4.5. Appendix G Section G.2 provides additional information relevant to the Brayton Point ECC.
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. No changes in traffic are anticipated from operation of the Brayton Point ECC. 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.
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. The same analysis applies to the Brayton Point ECC.

ISSUE	Covered in the NSRA?	COMMENTS
Does the survey include seasonal variations in traffic?	Yes	Seasonal variations in traffic are presented in Section 2.5. Appendix G Section G.2 provides additional information relevant to the Brayton Point ECC.
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 assessed 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 from the Project are assessed in Section 3.1.
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.

<table>
<tr><th>ISSUE</th><th>Covered in the NSRA?</th><th>COMMENTS</th></tr>
<tr><td colspan="3">4. OFFSHORE UNDER WATER STRUCTURES</td></tr>
<tr><td>Does the NSRA denote whether minimum safe clearance over underwater devices has been determined for the deepest draft of vessels that could transit the area?</td><td>Yes</td><td>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. Appendix G Section G.4 provides additional information relevant to the Brayton Point ECC.</td></tr>
<tr><td>Has the developer demonstrated an evidence-based, case- by-case approach which will include dynamic draft modeling in relation to charted water depth to ascertain the safe clearance over a device?</td><td>NA</td><td>Underkeel clearance hazards were evaluated and determined not to be relevant to the Project. No Project components will rise above the seabed to pose a hazard to passing vessels.
Charted water depths are a minimum of 35 m (115 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. Appendix G Section G.4 provides additional information relevant to the Brayton Point ECC.</td></tr>
<tr><td>To establish a minimum clearance depth over devices, has the developer identified from the traffic survey the deepest draft of observed traffic?
This will then require modeling to assess impacts of all external dynamic influences giving a calculated dynamic draft. A 30% factor of safety for under keel clearance (UKC) should then be applied to the dynamic draft, giving an overall calculated safe clearance depth to be used in calculations.</td><td>NA</td><td>Not applicable. No underwater devices are planned other than subsea cables.
See above and Section 4 for assessment of hazards related to Project components buried in the seabed. Appendix G Section G.4 provides additional information relevant to the Brayton Point ECC.</td></tr>
<tr><td colspan="3">5. ASSESSMENT OF ACCESS TO AND NAVIGATION WITHIN, OR CLOSE TO, A STRUCTURE.
Has the developer determined the extent to which navigation would be feasible within the structure site itself by assessing whether:</td></tr>
<tr><td>Navigation within the site would be safe?
• By all vessels or
• By specified vessel types, operations and/or sizes?
• In all directions or areas; or
• In specified directions or areas?
• In specified tidal, weather or other conditions; and
• At any time, day or night?</td><td>Yes</td><td>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.</td></tr>
</table>

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 and tides, 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. Appendix G Section G.6 provides additional information relevant to the Brayton Point ECC.
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	Section 6.2 describes tidal streams and 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 tidal streams and currents, which are not anticipated to significantly affect navigation risk in proximity to the Project.
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.

ISSUE	Covered in the NSRA?	COMMENTS
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 discusses a future scour study, Section 6.2 describes the relative low level of tidal influence in the Lease Area, and Appendix G Section G.6 provides additional information relevant to the Brayton Point ECC.
Structures would cause danger and/or severely affect the air column, water column, seabed and sub-seabed in the general vicinity of the structure?	Yes	No danger or severe effects are anticipated at this time based on the available data. See Section 6.2 and relevant sections of the COP. Appendix G Section G.6 provides additional information relevant to the Brayton Point ECC.
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?	Y	Risk to vessels under sail is assessed in Section 7.2.
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.

ISSUE	Covered in the NSRA?	COMMENTS
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 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.
Each OREI layout design will be assessed on a case-by-case basis.	Yes	The layout assessed in this NSRA is considered the maximum risk layout for navigation as noted in Section 1.1.

ISSUE	Covered in the NSRA?	COMMENTS
Risk assessments should build on any earlier work conducted as part of the NSRA and the mitigations identified as part of that process. Where possible, an original assessment should be referenced to confirm where information or the assessment remains the same or can be further refined due to the later stages of project development. Risk assessments should present information to enable the USCG to adequately understand how the risks associated with the proposed layout have been reduced to As Low As Reasonably Practicable (ALARP).	Yes	The factors evaluated during selection of offshore wind layout are described in Section 8. The 1 nm x 1 nm structure layout aligning with adjacent OREI structures is a mitigation identified in early phase work prior to undertaking the NSRA. The NSRA presents information to enable the USCG to identify 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 a comprehensive lists of risk control measures that are (1) already implemented and (2) identified but not necessarily proposed for implementation 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 and Section 12 assesses lines of orientation and distances between structures.
Packed boundaries will be considered on a case-by-case basis as part of the risk assessment process. For opposite boundaries of adjacent sites due consideration should be given to the requirement for lines of orientation which allow a continuous passage of vessels and/or SAR helicopters through both sites. Where there are packed boundaries this will affect layout decisions for any possible future adjacent sites. The definition of 'adjacent' will be assessed on a case-by-case basis.	NA	Not applicable to this Project; packed boundaries are not under consideration at this time.
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.

ISSUE	Covered in the NSRA?	COMMENTS
Structures and locations could limit the ability of vessels to maneuver in order to avoid collisions?	Yes	The USCG MARIPARS report (2020a), Section 3.1, and Section 11 assess the risks to vessels in the Lease Area.
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 10.3 present potential effects on VHF Rescue 21, DSC, and AIS), UHF, marine radar, land-based radar, and GPS. Appendix G Section G.10 provides additional information relevant to the Brayton Point ECC. 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	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 (Mayflower, 2021).
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 seabed 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. Appendix G Section G.10 provides additional information relevant to the Brayton Point ECC.
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 Section 3.1.

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 11.1. Consequences of potential of collision, allision, and grounding accidents are described in Section 11.2. 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 SAR data in the MARIPARS report is assessed in Section 12, which also presents the relevant risks 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 in the MARIPARS report is assessed in Section 12, which also presents the relevant risks 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. The Project’s final lighting and marking will be agreed in consultation with USCG and BOEM.
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 final lighting and marking 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 final lighting and marking 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’s final lighting and marking will be agreed in consultation with USCG and BOEM.
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 First 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 First 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	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, which are provided as separate appendices in the Project COP (Appendices Z and AA, respectively). 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 controls and shutdown capabilities from the Project's shore-based operations center. Section 15 refers to the Project Emergency Response Plan (outlined in COP Appendix AA). Emergency procedures will be developed and implemented in coordination with the relevant agencies, including USCG. Consultation with USCG will include 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 (outlined in COP Appendix AA). Emergency procedures will be developed and implemented in coordination with the relevant agencies, including USCG. Consultation with USCG will include 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.
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.

ISSUE	Covered in the NSRA?	COMMENTS
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 (outlined in COP Appendix AA). The Emergency Response Plan and procedures 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 (outlined in COP Appendix AA). The Emergency Response Plan and procedures will be developed and implemented in coordination with the relevant agencies, including USCG. The precise locations of the structures and the ECC 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	An outline of the Project Emergency Response Plan is provided as a separate appendix in the Project COP (Appendix AA). 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.
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.

APPENDIX G NAVIGATION SAFETY RISK ASSESSMENT OF THE BRAYTON POINT OFFSHORE EXPORT CABLE CORRIDOR

This appendix presents additional information related to the Brayton Point Offshore Export Cable Corridor (ECC) for the Mayflower Wind Offshore Wind Project (the Project). The Project will be located within the commercial Lease for Renewable Energy Development on the Outer Continental Shelf OCS-A 0521.

A Project-specific Navigation Safety Risk Assessment (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). The Project NSRA is 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. After issuance of the draft NSRA, a new ECC was added to the Project Design Envelope (PDE), and a portion of the new ECC lies outside the Marine Traffic Study Area of the NSRA.

This appendix updates the draft NSRA with a qualitative evaluation of the potential effects of the Brayton Point ECC on navigation safety for the elements specified in NVIC 01-19, specifically:

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

Summary findings for each element are listed in Section G.17.

Appendix F is an updated Checklist for NSRA Development and Review.

The numbering of the topics/sections of this appendix aligns with the numbering system in NVIC 01-19 and in the main report.

Contents

G.1 Site and Installation Coordinates

Figure G-1 shows the location of the new ECC with interconnection at Brayton Point in Somerset, Massachusetts (Brayton Point ECC). Up to six high-voltage direct current (HVDC) cables will be buried in the ECC. The target burial depth throughout the route will be 1.8 m (6 ft). The burial depth PDE range is 1 to 4 m (3.2 to 13.1 ft). The installation methods described in the main NSRA report concerning the Falmouth ECC apply to the Brayton Point ECC as well.

For the purpose of this NSRA, the “Project Area” shown in Figure G-1 is defined as the largest possible footprint of the offshore structures, and its boundaries align with the boundaries of offshore lease OCS-A 0521.

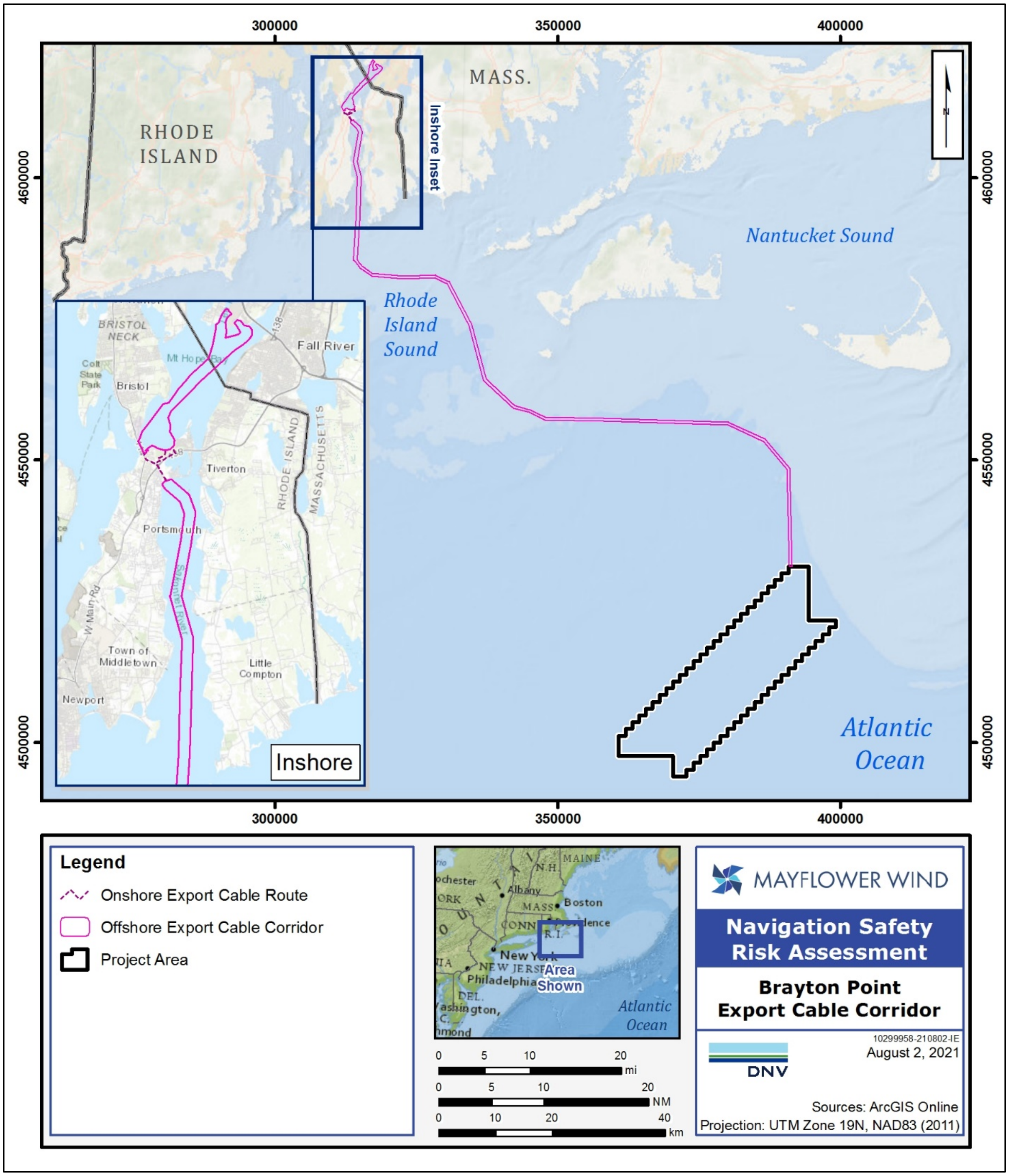


Figure G-1 Map of Brayton Point ECC (Mayflower Wind, 2021)

G.2 Traffic Survey

The marine traffic in the vicinity of the Brayton Point ECC was assessed using summary traffic data from the following sources:

- Vessel transit counts for the year 2019 based on National Automatic Identification System (AIS) data (MarineCadastre, 2021). AIS statistics for 2020 are not relied on for the purposes of the NSRA because of potential effects from COVID-19 on traffic patterns. Use of 2019 data was discussed with USCG prior to preparation of the Mayflower NSRA (see the main NSRA report, Section 2).
- Vessel Trip Reports (VTR) and recreational survey data maps from the Northeast Ocean Data Portal (NOAA, 2016) (SeaPlan, 2013).
- Vessel Monitoring System (VMS) reported vessel activity (NROC, 2018).

G.2.1 Traffic Patterns and Density

The national AIS data show the nature of the traffic in the vicinity of the Brayton Point ECC (Figure G-2).

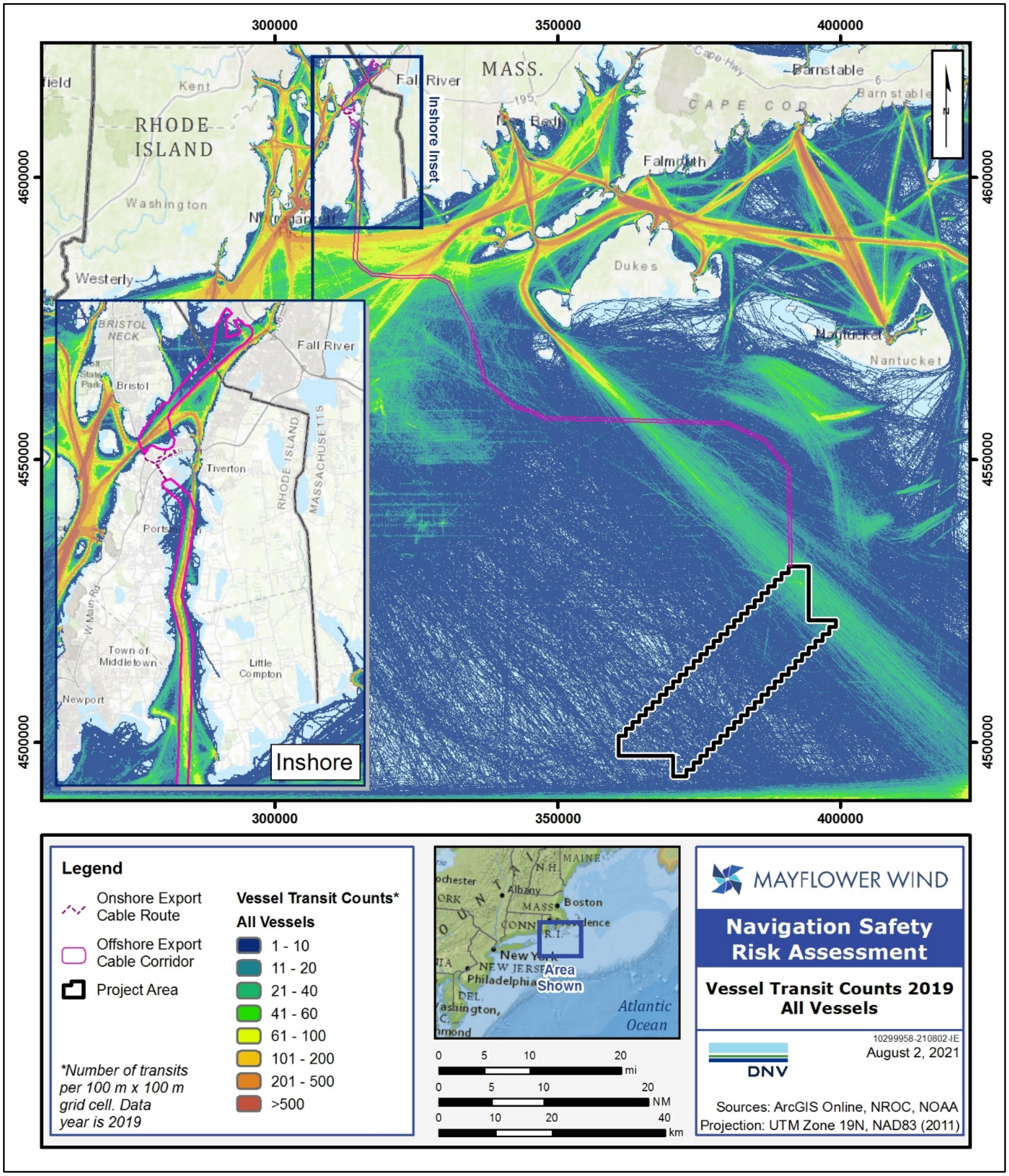


Figure G-2 All Vessel Transit Counts for 2019 (MarineCadastre, 2021)

Views of the transit counts for each vessel type are provided in Figure G-4 through Figure G-9[17].

Cargo vessel traffic in the vicinity of the Brayton Point ECC was predominantly coastwise traffic, crossing the ECC approximately 3 nm (5.5 km) south of the entrance to the Sakonnet River.

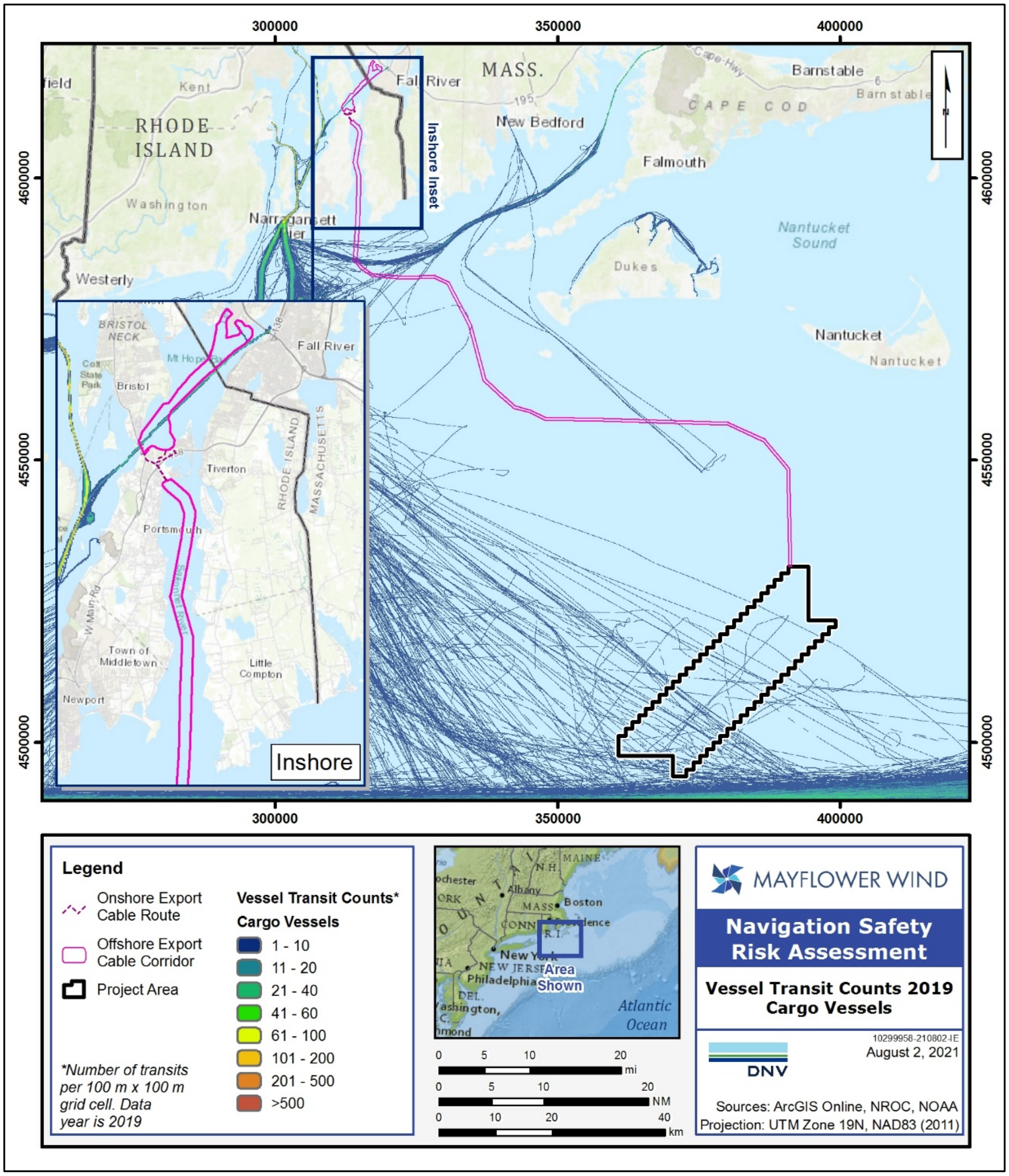


Figure G-3 Cargo Vessel Transit Counts for 2019 (MarineCadastre, 2021)

[17] The vessel types referred to in this appendix are based on the vessel types from MarineCadastre, rather than the vessel types selected for clarity in risk modeling described in the main NSRA. The differences are minor, but noted here for transparency.

The transit paths of fishing vessels cover most of the area relevant to this assessment of the Brayton Point ECC. The majority of the offshore 100 m x 100 m grid cells contain counts of 1 to 10 tracks (NROC, 2018). The highest-count routes taken by fishing vessels are from New Bedford to the southwest, crossing the ECC approximately 8.5 nm (15.7 km) south of the entrance to the Sakonnet River, and south/easterly routes around Martha's Vineyard, crossing the ECC in two locations.

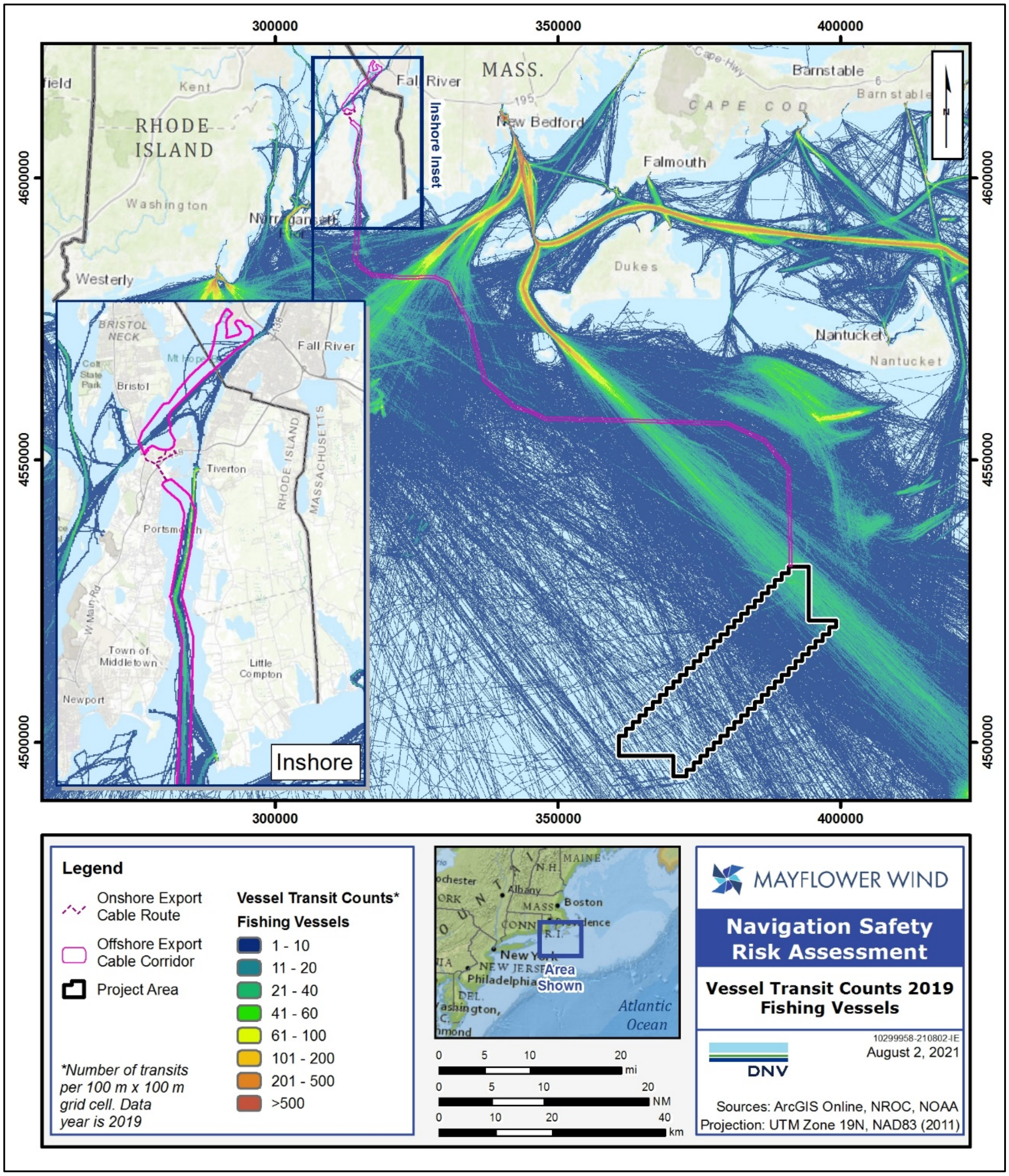


Figure G-4 Fishing Vessel Transit Counts for 2019 (MarineCadastre, 2021)

Transit counts for other vessels show patterns similar to fishing and pleasure vessels.

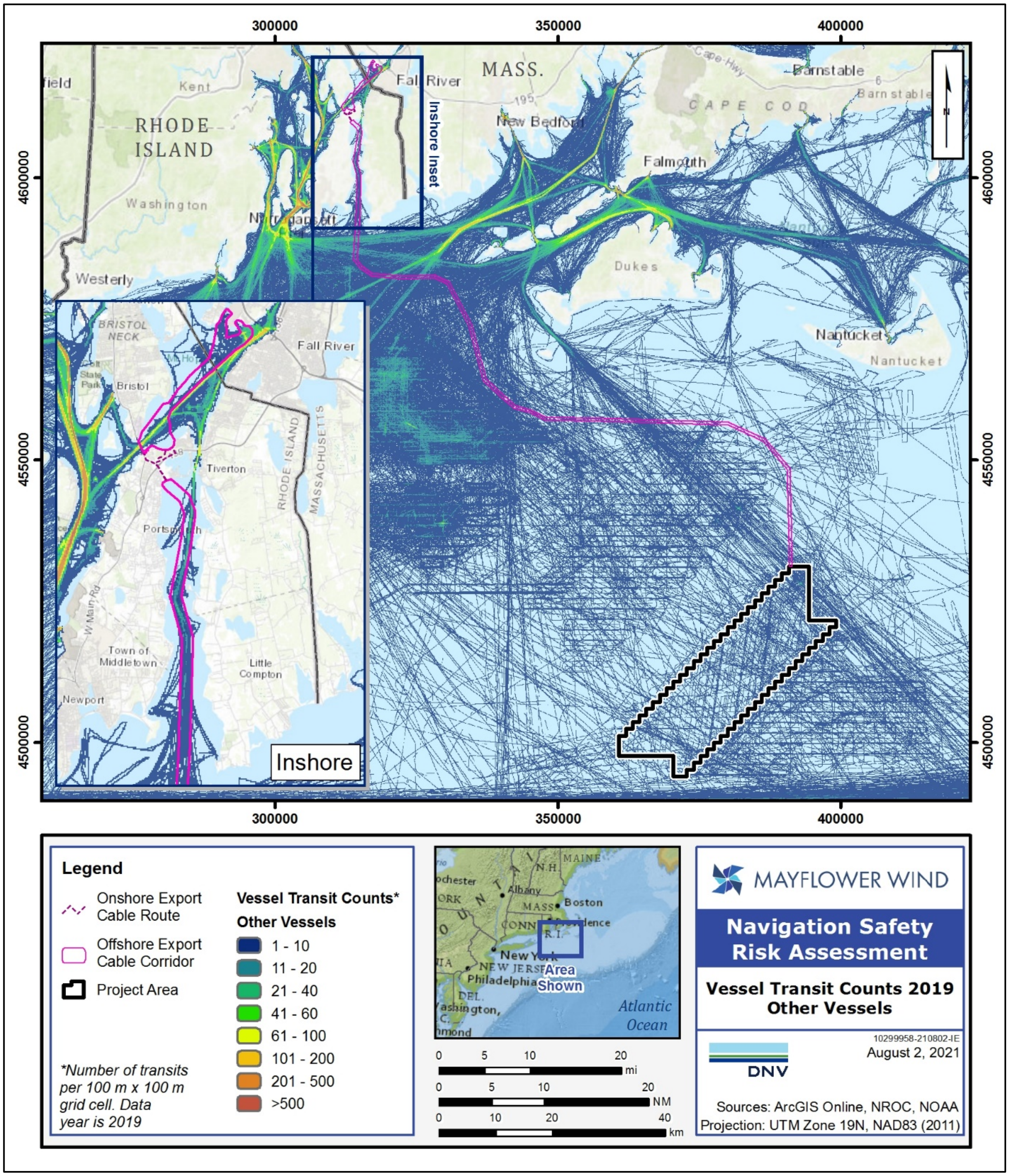


Figure G-5 Other Vessel Transit Counts for 2019 (MarineCadastre, 2021)

Passenger vessel transit counts in the vicinity of the Brayton Point ECC indicate very few grid cells with more than 10 tracks in 2019. Apparent routes include the following:

- From open water through the Sakonnet River and Mount Hope Bay to Fall River. This route contains the highest transit counts, up to 200 tracks per year
- Parallel to the coast and approximately 1.3 nm (2.4 km) south of Sakonnet Point
- From open water through the East Passage of Narragansett Bay and Mount Hope Bay to Fall River

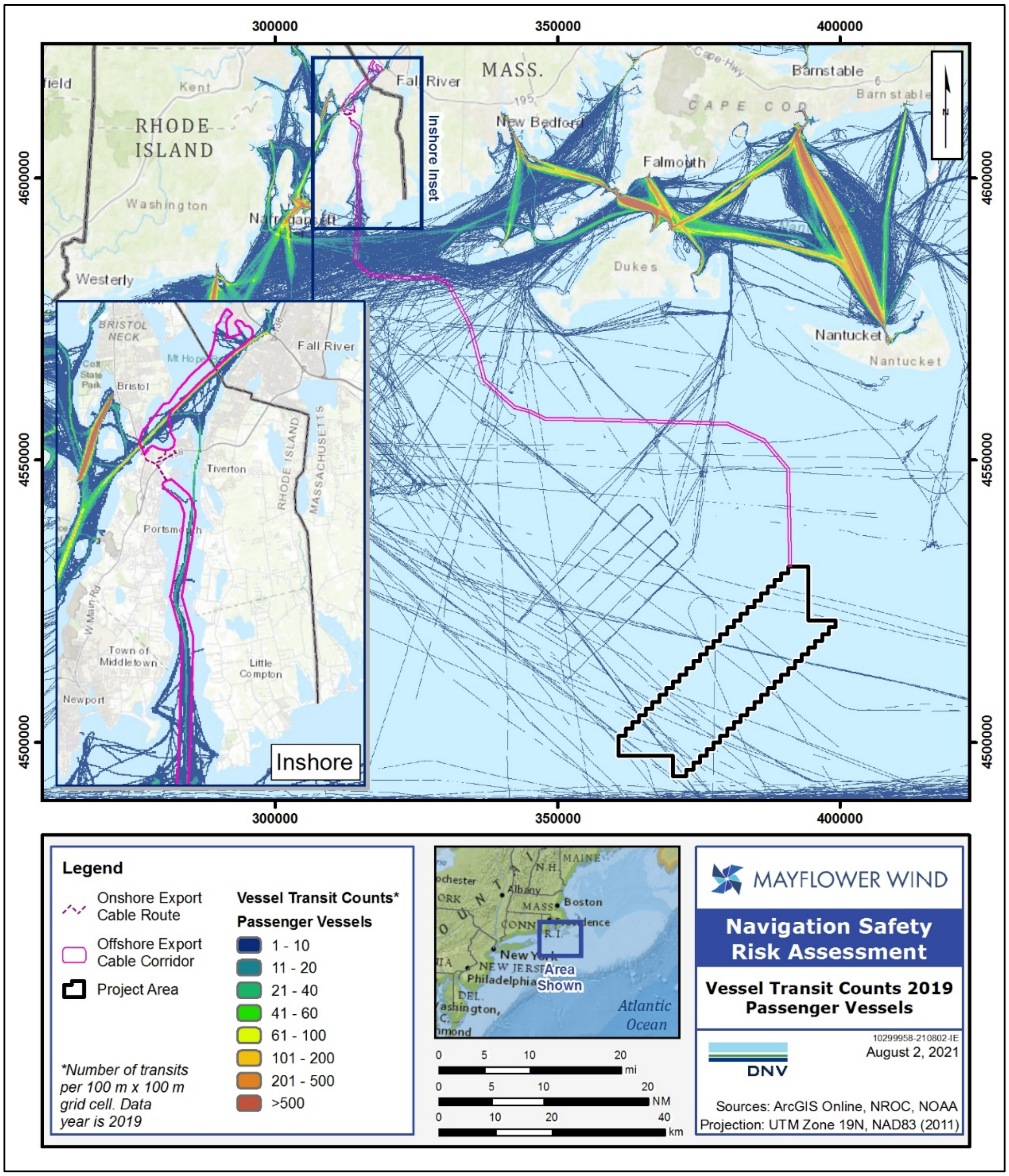


Figure G-6 Passenger Vessel Transit Counts for 2019 (MarineCadastre, 2021)

Pleasure and sailing vessel transit counts show a pattern of transits that were highest near the coast and include relatively high counts in the Sakonnet River and Mount Hope Bay of up to 500 tracks in 2019 (an average of less than 2 per year per grid cell). Very low transit counts (10 or less per grid cell) were indicated further than 10 nm (18.5 km) offshore in the vicinity of the Brayton Point ECC.

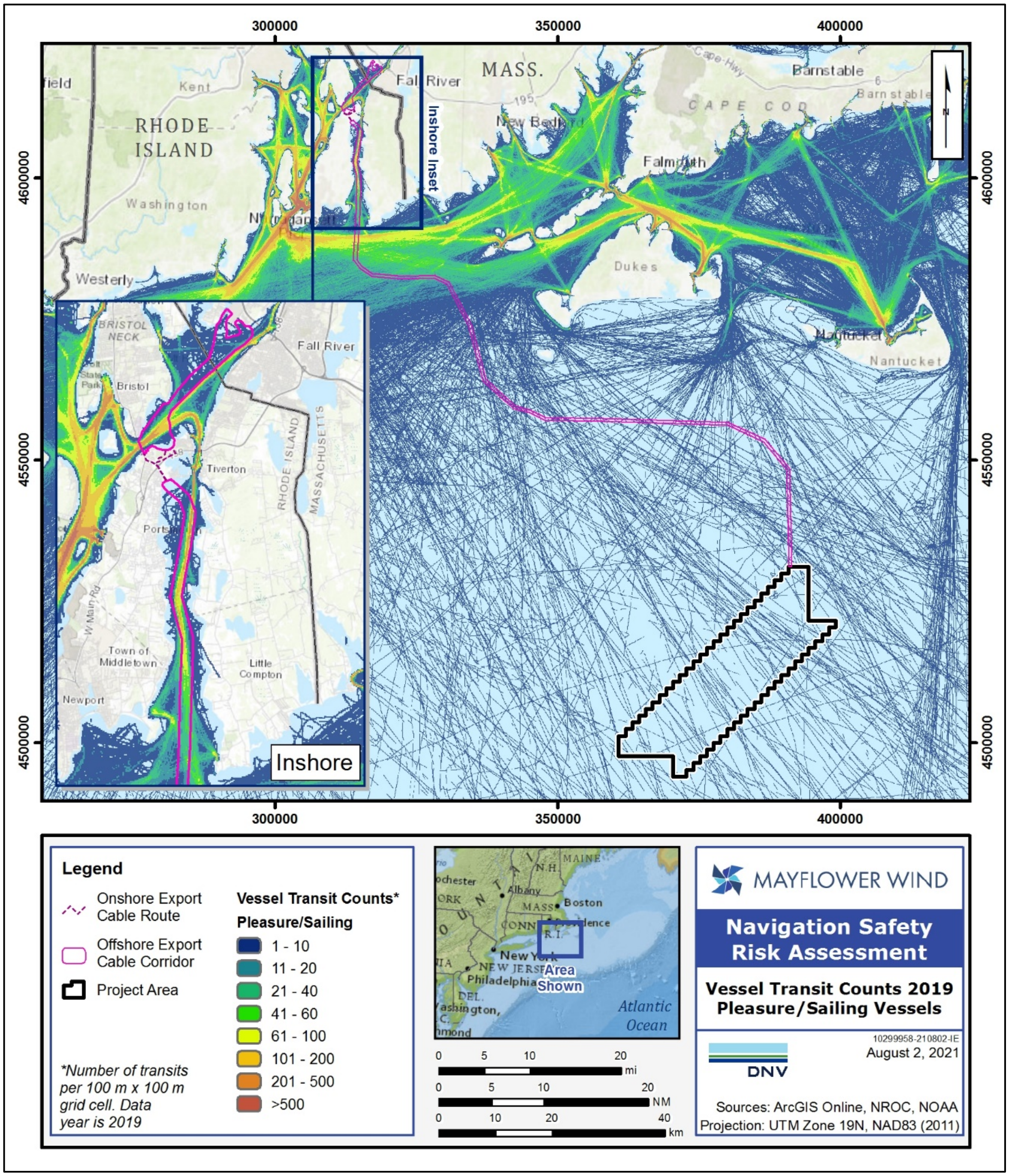


Figure G-7 Pleasure/Sailing Vessel Transit Counts for 2019 (MarineCadastre, 2021)

Tankers in the vicinity of the Brayton Point ECC crossed the ECC along a coastal route that continued through Cape Cod Canal. Very limited tanker activity occurred in Mount Hope Bay or in Sakonnet River.

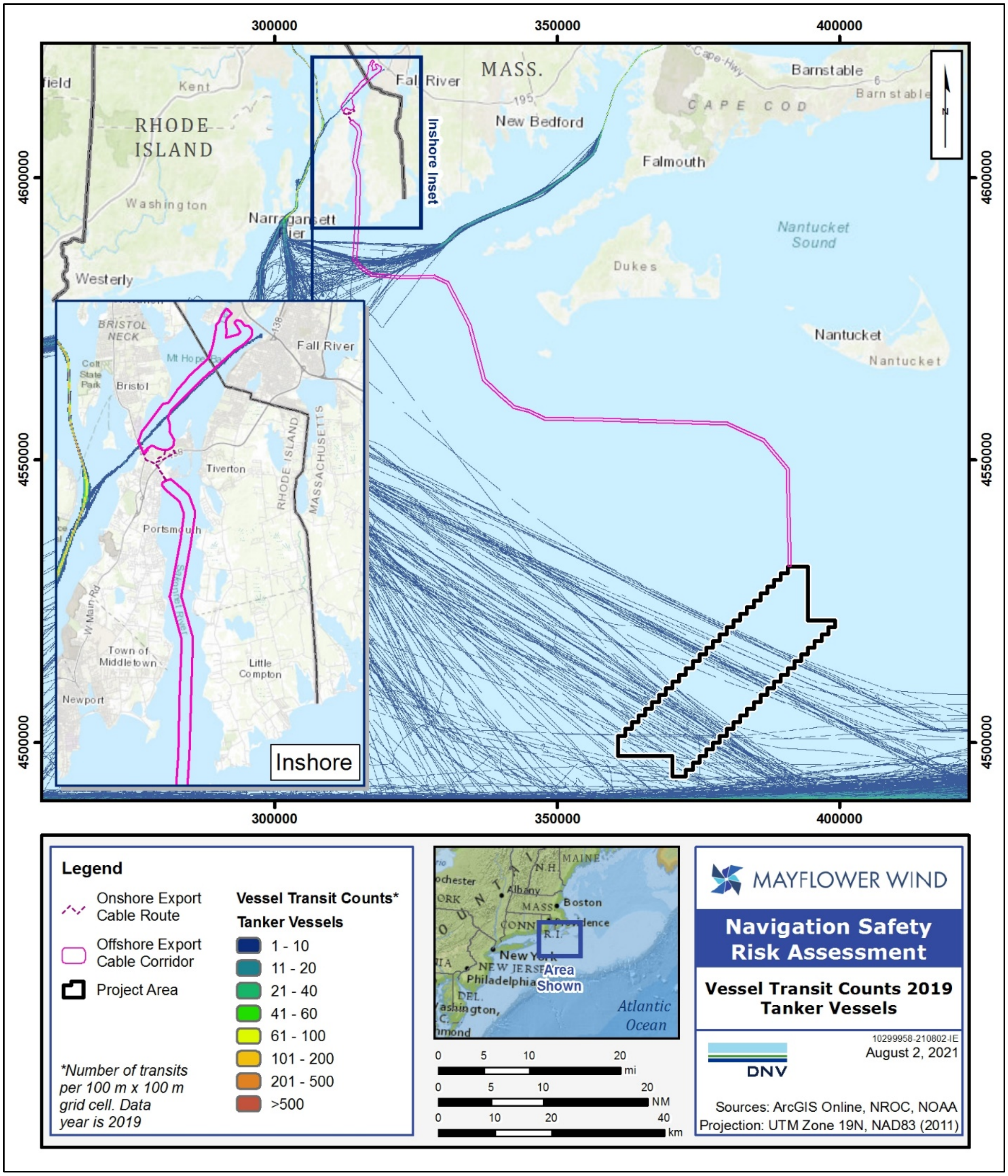


Figure G-8 Tanker Transit Counts for 2019 (MarineCadastre, 2021)

In contrast to the low transit counts for carriers and tankers, tug-tow vessels' routes near the Brayton Point ECC had comparatively higher transit counts on their coastal route in proximity to the ECC. The maximum transit counts per grid cell exceeded 500 per year (an average of less than 2 per day) in a small number of grid cells east of the ECC.

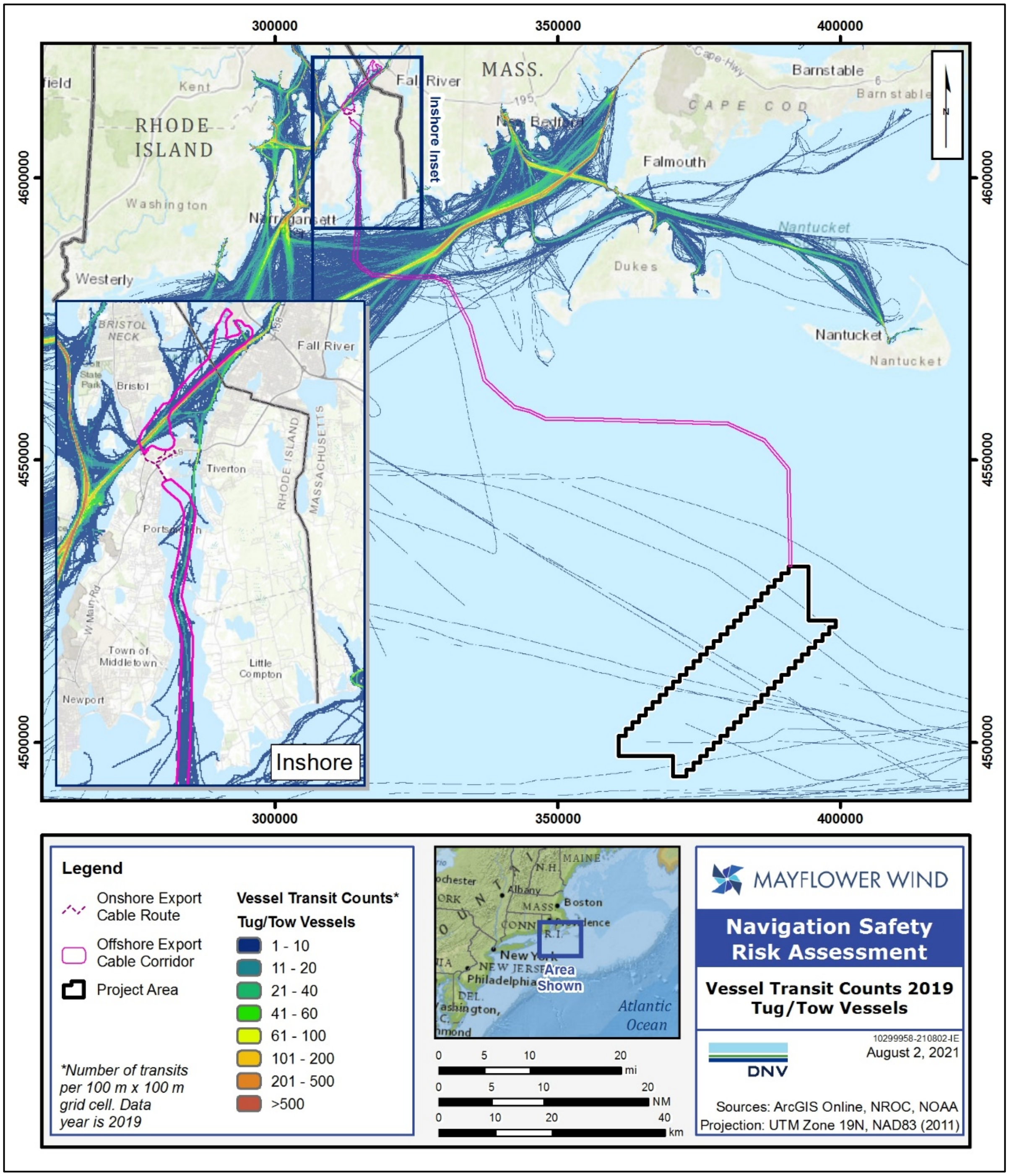


Figure G-9 Tug/Tow Vessel Transit Counts (MarineCadastre, 2021)

Figure G-10 shows the comparative level of fishing activity in the vicinity of the Brayton Point ECC based on data from National Marine Fisheries Service (NMFS) VMS.

Figure G-11 shows the comparative level of fishing gear used in the vicinity of the Brayton Point ECC based on data reported under the VTR program.

Based on the figures, the following observations can be made:

- Mount Hope Bay – Comparatively low levels of fishing for all species. Herring was the most fished, at a medium-low level.
- Sakonnet River – No indicated fishing except for high levels of monkfish fishing and limited gillnet fishing in the south.
- Rhode Island Sound – Fishing is indicated for all species in the vicinity of some portion of the Brayton Point ECC. Squid and pelagics show high levels of fishing that intersect with the ECC. Concerning fishing gear use, longline and pots and traps showed no activity in the vicinity of the ECC, while use of other gear types are indicated at comparatively lower levels. Gillnet use in Rhode Island Sound south of the entrance to the Sakonnet River was the highest of any reported gear use, at a comparatively moderate level. The use of dredge towing, which is potentially the most impacted by buried cables, has not been reported in the vicinity of the ECC.

Figures G-10 and G-11 are illustrative in showing the location and relative intensity of fishing effort for the species groups targeted and gear types utilized by the VMS and VTR fisheries represented in those figures. However, the fisheries-dependent data used to generate those figures does not represent the totality of commercial fishing. This means that there are landings of commercially targeted species that occur in the Brayton Point ECC, particularly inshore, that are not represented in these figures. In addition to the limitations of landings data, a portion of the fishing vessels with landings not represented in these figures are also not represented in AIS charts as AIS carriage is not a requirement of their fishing permits or vessel registration. While the Sakonnet River and Mount Hope Bay exhibit lower levels of fishing effort than other areas of Narragansett Bay in the data sets represented in Figures G-10 and G-11, other fisheries-dependent data, or other forms of information collected on the presence of commercial and recreational fishing, fishing does occur in these areas. Fishing occurs at higher levels in offshore portions of the Brayton Point ECC than in the inshore portions. The commercial and recreational fishing effort in the Brayton Point ECC (as well as the rest of the Project including the Lease Area and the Falmouth ECC) is discussed in Section 11 (Commercial and Recreational Fisheries and Fishing Activity) and Appendix V (Commercial and Recreational Fisheries and Fishing Activity Technical Report) of the Construction and Operation Plan (COP).

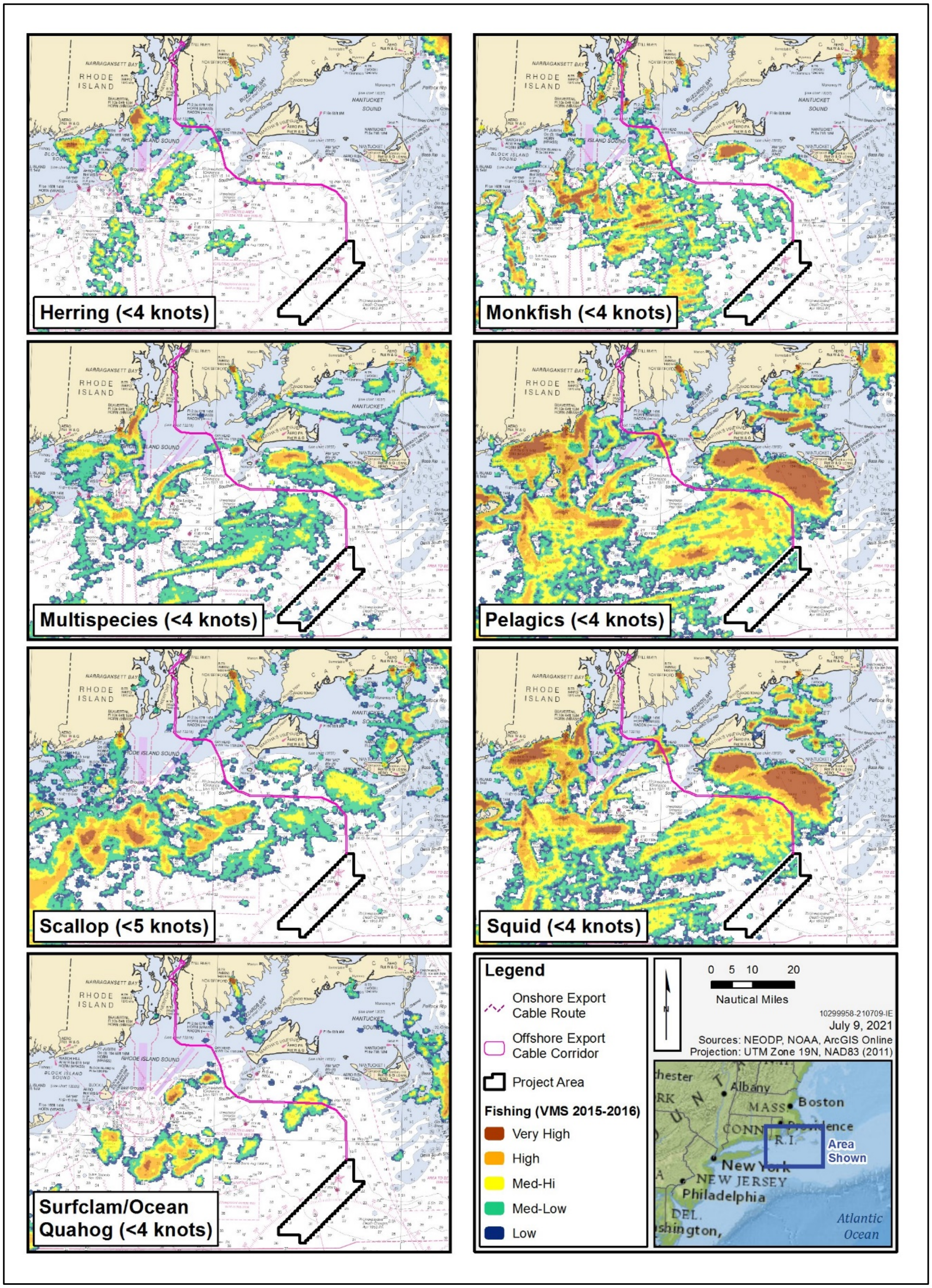


Figure G-10 Fishing Vessel Activity VMS data 2015-2016 (MarineCadastre, 2021)

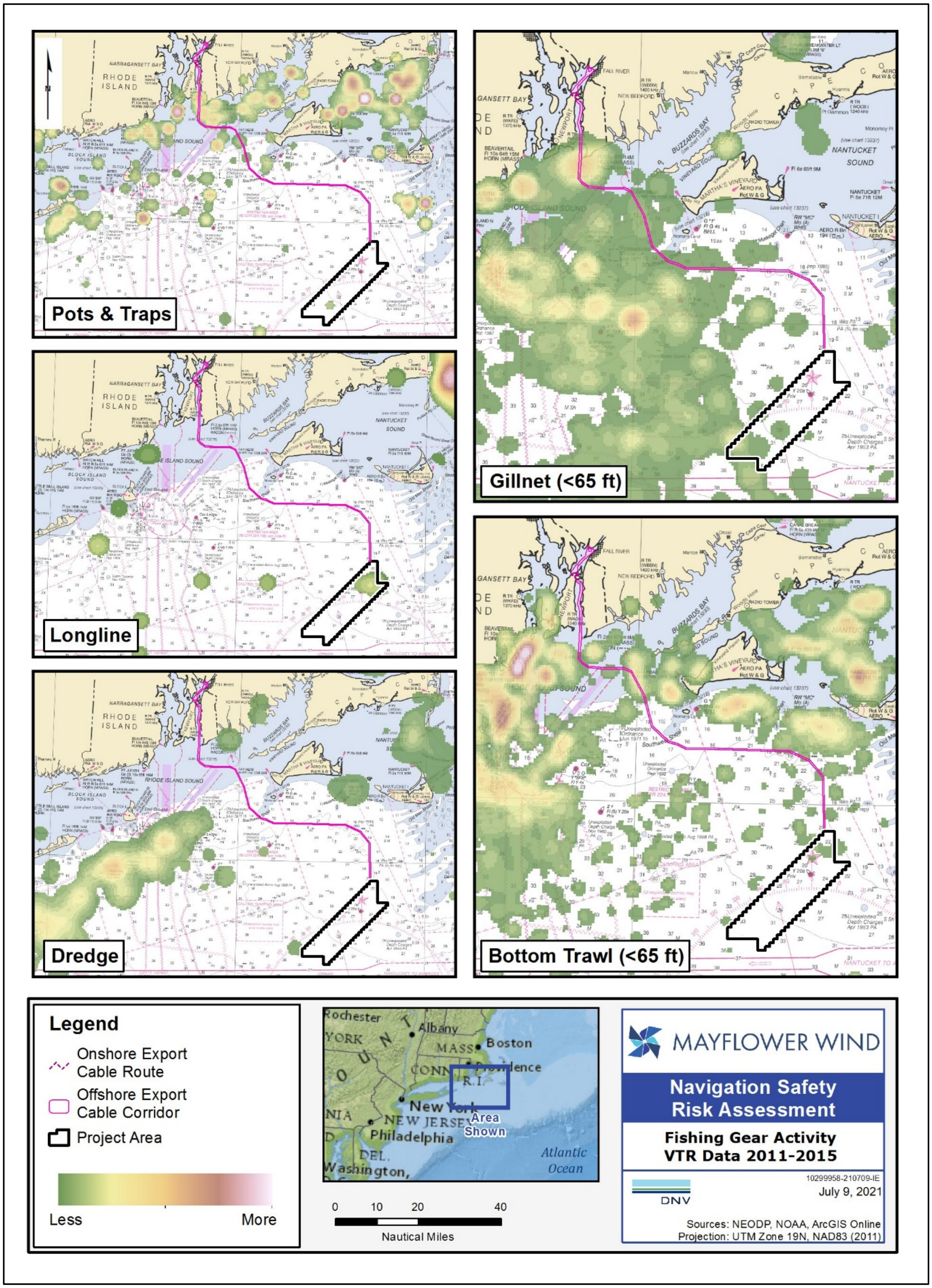


Figure G-11 Fishing Gear Activity VTR data 2011-2015 (MarineCadastre, 2021)

G.2.2 Traffic Statistics

To develop traffic statistics for the Brayton Point ECC, the data used in the traffic survey (Section G.2) was reviewed to identify the highest traffic density along portions of the ECC. The results are summarized in Table G-1, which lists the highest traffic density of any 100 m x 100 m grid cell within 5 nm (9.3 km) of the ECC.

Table G-1 2019 AIS Maximum Vessel Counts (MarineCadastre, 2021)

Vessel type	Maximum Vessel Transit Counts Per Grid Cell within 5 nm of the Brayton Point ECC			
	Mount Hope Bay	Sakonnet River	Rhode Island Sound	South of Martha's Vineyard
Cargo	40-60 (except within 200 m of the Port of Fall River)	0	1-10	1-10
Fishing	40-60	100-200 near Tiverton, 40-60 elsewhere	60-100	40-60
Other	200-500	60-100 near Tiverton, 40-60 elsewhere	100-200	20-40
Passenger	>500	40-60	40-60	1-10
Pleasure	>500	>500	>500	1-10
Tanker	10-20 (only two cells), 1-10 elsewhere	0	1-10	0
Tug-tow	200-500	40-60	100-200	1-10

In the northern portion of the Brayton Point ECC, Mount Hope Bay and the Sakonnet River, shallow draft vessels comprise most of the vessel traffic, primarily passenger and pleasure types. Cargo and tanker densities are very low, averaging a few port calls per month or fewer.

For Rhode Island Sound and south of Martha's Vineyard, the traffic densities and statistics are more completely described in the NSRA main report, Section 2.

To obtain more precise statistics, vessel counts available in Ocean Reports were reviewed for the inshore and offshore areas in the vicinity of the Brayton Point ECC. Ocean Reports is a data portal provided by a BOEM and NOAA partnership (BOEM and NOAA, 2020). It provides summary statistics for 2016 AIS data. Vessel transit counts are taken for grid cells of 100 m by 100 m. The differences between the 2016 and 2019 data are relatively minor, except for Pleasure vessels. There are two probable explanations: increased used of AIS equipment and improved capture of AIS signals.

Table G-2 2016 AIS Mean and Maximum Vessel Counts

Vessel type	Mean and Maximum Vessel Transit Counts Per Grid Cell in the Vicinity of the Brayton Point ECC							
	Mount Hope Bay		Sakonnet River		Rhode Island Sound		South of Martha's Vineyard	
	Mean	Maximum	Mean	Maximum	Mean	Maximum	Mean	Maximum
Cargo	26.46	344	0	0	2.10	12	1.08	18
Fishing	7.65	49	7.99	113	12.01	142	4.58	90
Other	NR*	NR	NR	NR	NR	NR	NR	NR
Passenger	18.96	199	5.67	49	4.81	61	1.03	3
Pleasure	20.47	619	20.38	376	9.96	117	1.21	8
Tanker	0	0	0	0	1.61	8	1.27	4
Tug-tow	29.37	441	3.69	49	11.23	291	1.12	3

* Not Reported

The southern portion of the Brayton Point ECC lies within the Marine Traffic Study Area assessed in the main NSRA report. The northern portion of the ECC follows a path northward and then westward until it aligns with the entrance of the Sakonnet River. The west-east portion of the ECC crosses the corner of the outbound lane of the Buzzards Bay TSS and the Recommended Vessel Route (in green) for deep draft vessels and tugs/barges. The risks associated with the ECC burial depth are assessed in a separate preliminary cable burial assessment (Cathie and Associates, 2021) that is in draft at the time of this NSRA update (August 2021). The relevant recommendations from that assessment are presented in Section G.4.2 and in Mayflower Wind's COP in Section 11.

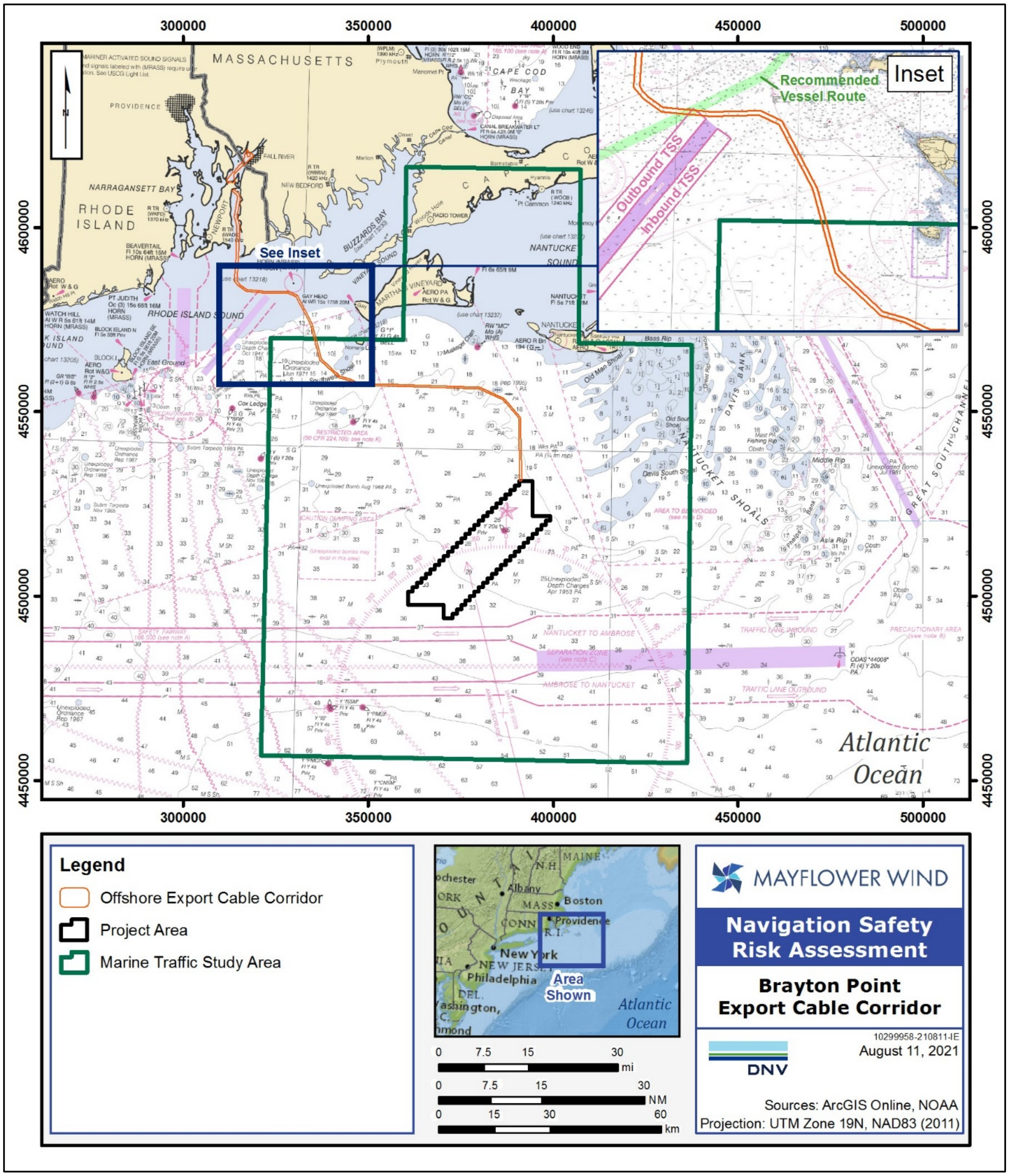


Figure G-12 Brayton Point ECC on a Navigation Chart

Marine cargoes in Mount Hope Bay and Sakonnet River include paper, latex and chemicals, fish, coal and lignite, vehicles, and equipment (World Port Source, 2021). Cargoes in Rhode Island Sound and South of Martha's Vineyard are described in Section 2.4 of the main NSRA report.

Non-transit uses of Mount Hope Bay and Sakonnet River include:

- Recreational boating
- Fishing and shell-fishing
- Public recreational uses such as swimming, wind surfing, bird watching, etc.
- Port facilities and marinas (World Port Source, 2021) The only identified port authority in the Brayton Point ECC is the Fall River Port Authority.
- Naval Undersea Warfare Center, Division Newport Testing Range, which consists of waters within Narragansett Bay, nearshore waters of Rhode Island Sound, Block Island Sound, and coastal waters of New York, Connecticut, and Massachusetts (Naval Facilities Engineering Command, Atlantic, 2016).

The following were not identified within 2 nm (3.7 km) of the Brayton Point ECC:

- Pilot boarding areas
- Anchorage areas
- Danger Zones and Restricted Areas (offshore firing/bombing ranges and areas used for other military purposes)
- Oil and gas platforms or wells, or oil and gas leases
- Sand and gravel leases
- Mining
- Ocean disposal sites

Because the offshore export cables in the Brayton Point ECC will be buried during the Project's operational phase, no cable risks are anticipated to aids to navigation; vessel traffic services; switch to low sulfur fuel; or vessel traffic patterns prior to entering the North America Emission Control Area (ECA).

Based on an evaluation of monthly 2019 AIS data (MarineCadastre, 2021), the seasonal patterns in the vicinity of the Brayton Point ECC are similar to those in the Marine Traffic Study Area discussed in Section 2 of the main NSRA report. The traffic in the AIS data is relatively higher during the summer and autumn than in the winter and spring for most vessel types. The exceptions are cargo vessels and tankers, which are more consistent throughout the year.

G.3 Offshore Above Water Structures

The offshore export cables will be buried below the seabed or covered on the seabed and will not include above-water components.

G.4 Offshore Under Water Structures

This section describes navigation hazards and risks from the export cable during construction, operations, and decommissioning phases of the Project.

G.4.1 Construction Phase

Up to six submarine cables will be installed by dedicated cable laying vessels, simultaneously trenching and laying the cables into the seabed at a target depth of 1.8 m (6 ft) (Mayflower Wind, 2021). During this phase the cable laying vessel will have a restricted ability to maneuver due to the unspooling of cable between the vessel and the seabed.

Vessels involved in cable lay activities will pose a hazard to passing vessels, whether fishing or transiting. Three primary means of reducing this risk are:

- A temporary moving safety zone surrounding the vessels laying the cable (often including a cable lay vessel and a barge) while they are engaged in cable laying operations. Unauthorized persons or vessels will be prohibited from entering into, transiting through, or remaining in the safety zone without permission of the Captain of the Port or designated representative. The vessels laying the cable will meet the requirements to exhibit lights and shapes as required in COLREGS Rule 27 (IMO, 1972), which will facilitate passing vessels to properly identify their obligation to give way. It is noted that from the entrance of the Sakonnet River and further inland vessels are subject to the Inland Navigation Rules Act of 1980 rather than COLREGS, but the requirements are similar.
- Updates to mariners from the Project, and commonly communicated via Local Notices to Mariners, updates on the Project website, and through direct outreach to the fishing community and other mariners.
- Project safety vessel(s) and/or personnel will be on scene to keep watch for vessels that are on course with the cable lay activity.

G.4.2 Operations Phase

During Project operations, the export cables in the Brayton Point ECC will be buried in or covered on the seabed, and may pose a hazard to activities that pierce the sea floor, such as fishing with specific types of bottom gear or vessel anchoring.

To better understand the risks from and to the export cable and how to mitigate them, a preliminary cable burial risk assessment (CBRA) has been completed (Cathie and Associates, 2021). The assessment was based on best industry practice methodology as recommended by Carbon Trust (2015) and DNV GL and considers vessel activity (interpreted from site-specific AIS data), seabed data (including bathymetry and soil properties), and other considerations including anchorages, dredged channels, and existing infrastructure. A probabilistic risk analysis was completed based on these factors, and a minimum depth of lowering (cable burial depth, referenced from mean seabed level to top of cable) was recommended.

The preliminary CBRA completed for the Brayton Point ECC resulted in a recommendation of a minimum depth of burial of 1 m (3.3 ft) along most of the ECC, and up to 2 m (6.6 ft) in a specific zone. This indicates that the target burial depth of the cables of 1.8 m (6 ft) is sufficient to protect the cables in most of the ECC and maintain adequate separation from any activities that pierce the sea floor, such as fishing with specific types of bottom gear or vessel anchoring (Cathie and Associates, 2021). The preliminary CBRA was completed using suitable data with conservative assumptions applied where appropriate (Cathie and Associates, 2021) and will be updated when the 2021 geophysical and geotechnical surveys of the Brayton Point ECC are complete (Mayflower, 2021). Additionally, seabed mobility will be assessed in more detail to determine whether deeper burial or seabed preparation (i.e., sand wave clearance) is required in certain areas of the ECC to maintain a stable minimum burial depth (Mayflower, 2021).

In addition to posing a hazard to bottom gear, contact with an anchor could pose a risk to the anchoring vessel and its crew and passengers. The risk to offshore vessels from the export cables is described in the NSRA report Section 4.1. The risks to vessels transiting inshore waters near the Brayton Point ECC are similar; however, the largest vessels (cargo and tanker vessels) did not transit the Sakonnet River in 2019 based on National AIS data (MarineCadastre, 2021). Cargo vessels do transit the East Passage of Narragansett Bay to Sakonnet Bay, taking a route that crosses the ECC. Based on the vessel types and indicative sizes, anchor risk is anticipated to be less on the Sakonnet River than it is in offshore waters.

Assessment of tides and currents is in Section G.6.

G.4.3 Decommissioning Phase

Prior to decommissioning, Mayflower Wind will consult with BOEM and submit a decommissioning application for review and approval in line with regulations in place at the time (Mayflower Wind, 2021). An approved decommissioning plan will dictate the removal of the export cables, and if removal is agreed upon, would essentially be a reverse of the installation process.

G.5 Navigation within or Close to a Structure

The Brayton Point ECC does not include any unburied/uncovered structures above the seabed. The risks from the ECC on navigation identified by this NSRA related to navigation are described in Section G.4.

Mobile fishing gear types are employed in the vicinity of the Brayton Point ECC. The predominant bottom-contact mobile fishing gear types utilized in this area have minimal penetration depth. However, these fishing techniques might penetrate the seabed or impact unburied cables that are not otherwise protected, potentially resulting in damage to the gear, a hazard to the vessel, and/or damage the cables. The fishing activities that pose a risk include bottom trawling and especially shellfish dredging. Both activities could occur in the vicinity of the ECC.

Important risk controls include assurance that the cable is buried at sufficient depth for any gear type, and/or adequately protecting cable that cannot be buried to target burial depth, and/or using gear that has limited penetration depth in the vicinity of the cable. To reduce the likelihood of interactions between fishing activities and the cable, BOEM recommends a minimum burial depth of 3.28 ft (1 m) and at least a single armor layer (BOEM, 2011). The CBRA completed specifically for the Brayton Point ECC (see Section G.4.2) and the planned target burial depth support the effectiveness of this risk control.

G.6 Effect of Tides, Tidal Streams, and Currents

Tides, tidal streams, and currents are not significant factors in safe navigation in the offshore portions of the Brayton Point ECC. However, within the inshore portion of the ECC, the tidal stream is significantly stronger than offshore.

Water depths in the offshore portion of the ECC range from 16 m to 41 m (52 ft to 135 ft) and inshore from 0 m to 23 m (0 ft to 75 ft) (NOAA NGDC, 1999).

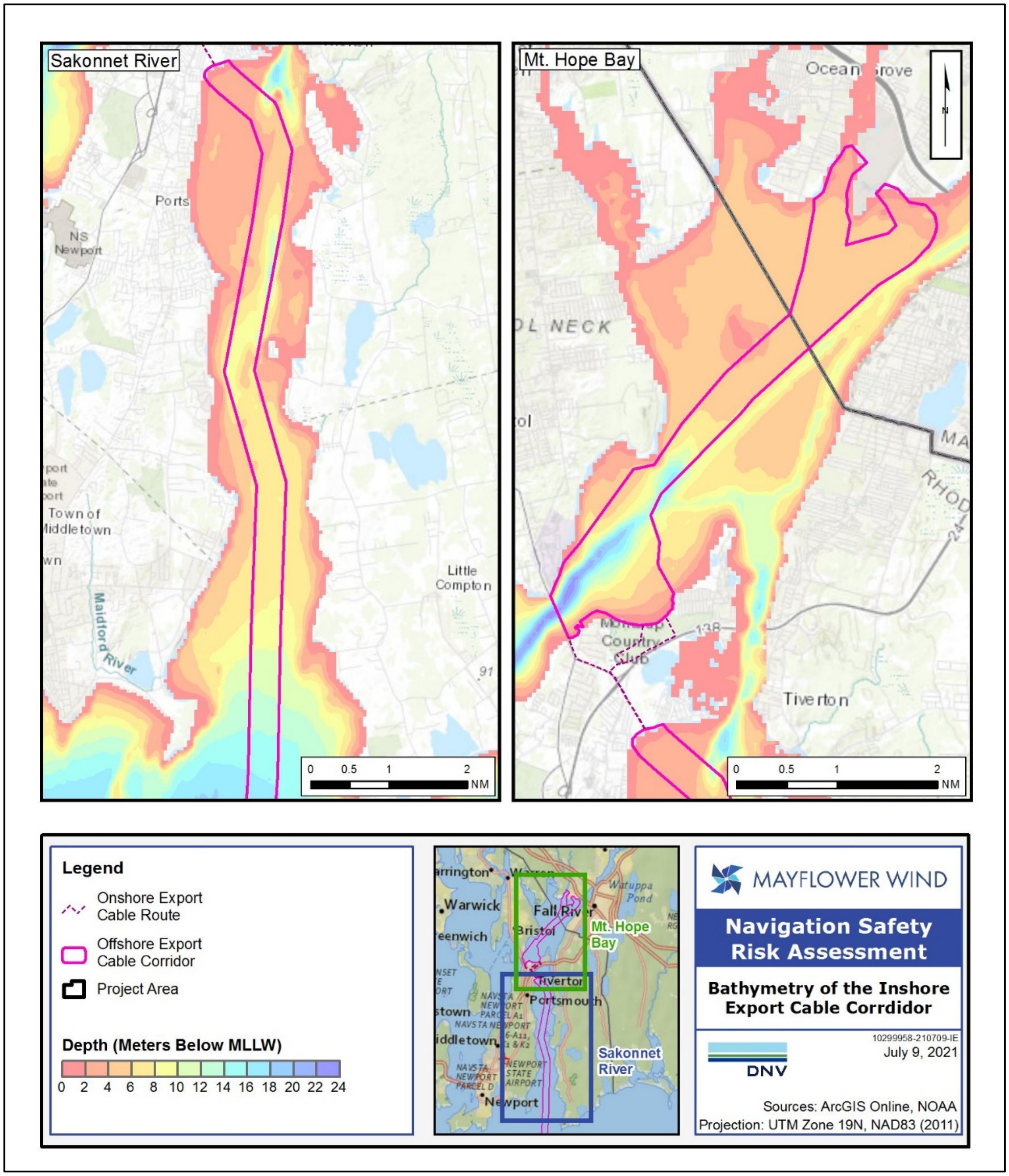


Figure G-13 Bathymetry in the inshore portion of the Brayton Point ECC

The average speed and direction of the current along the offshore portion of the Brayton Point ECC are shown in Figure G-14 and Figure G-15. The monthly average current is from 0.17 to 0.23 m/s (0.33 to 0.45 kt), with maximum recorded current in December of 1.22 m/s (2.37 kt). The preponderant direction of the current is from west-northwest to north-northwest.

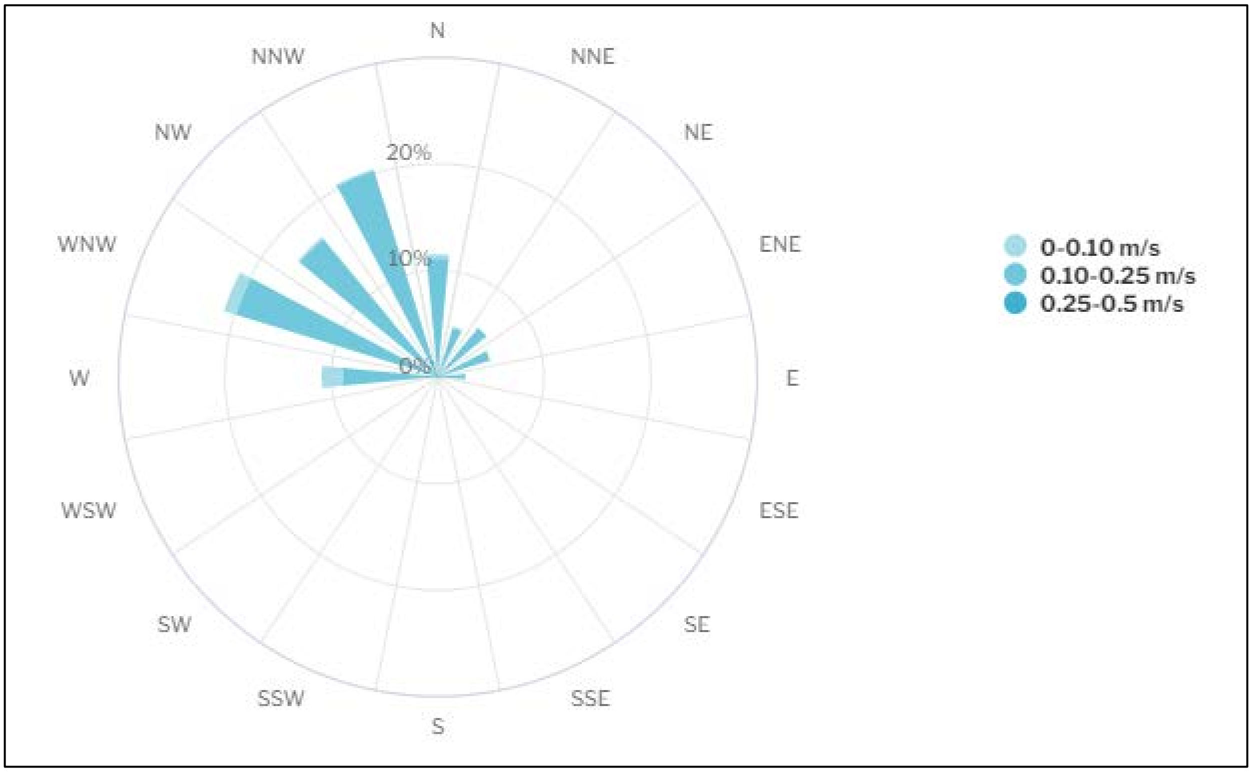


Figure G-14 Average Current Direction along the offshore portion of the Brayton Point ECC (BOEM and NOAA, 2020)

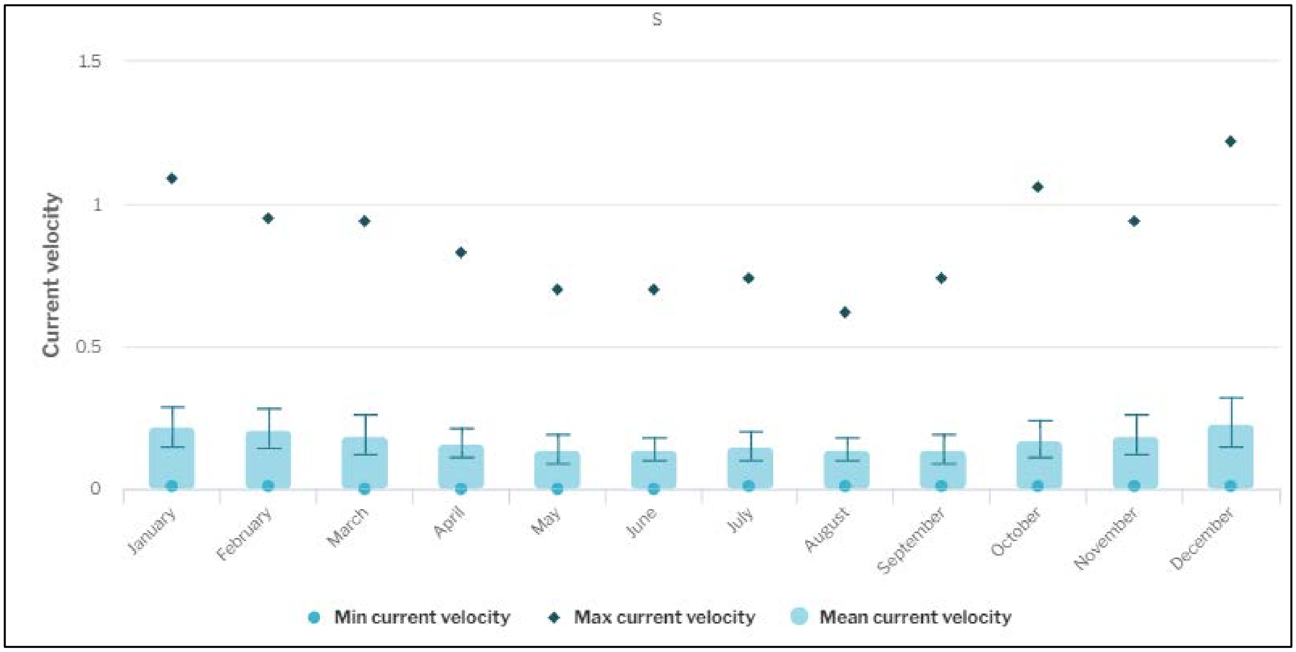


Figure G-15 Average Current Speed along the offshore portion of the Brayton Point ECC (BOEM and NOAA, 2020)

Waves in the offshore portions of the ECC are predominantly from the north and north-northeast. The average wave period is 6 seconds and the significant wave height ranges from 1 to 1.5 m (3.3 to 4.9 ft) as shown in Figure G-14. The portion of the ECC within the Sakonnet River and Mt Hope Bay are sheltered.

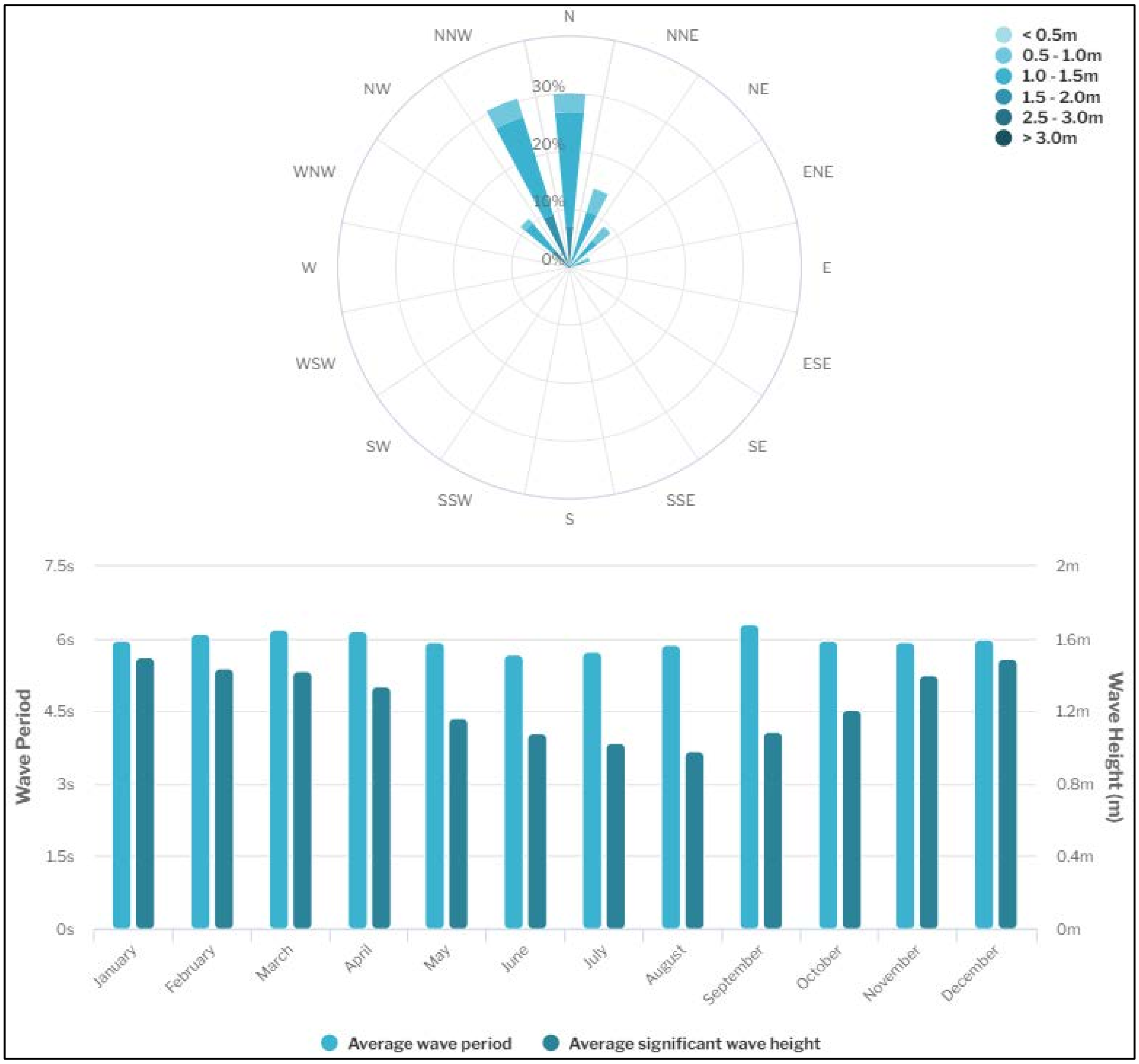


Figure G-16 average wave direction, significant height and period along the offshore portion of the Brayton Point ECC (BOEM and NOAA, 2020)

Tides and currents are not expected to have an impact on the navigation risk caused by the export cables. Over time, the current and the waves could have a scour effect and the burial depth may change. Potential movement of the cables compared to location and burial depth will be monitored during the Project's operational phase and mitigated if necessary through use of, for example, scour protection mattresses (Mayflower Wind, 2021).

G.7 Weather

With the exception of the potential scour effect mentioned in the Section G.6, weather conditions are not anticipated to affect or be affected by the buried export cables in the Brayton Point ECC.

G.8 Configuration and Collision Avoidance

The buried export cables are not anticipated to have direct effects on collision risk. Identified navigation safety risks to anchoring, which could potentially relate to collision avoidance, are described in Section G.4.

G.9 Visual Navigation

The buried export cables are not anticipated to affect visual navigation during the Project's operational phase. Section G.4 describes potential risks to navigation during the Project's construction phase.

G.10 Communications, Radar, and Positioning Systems

Traditional compasses that rely on the earth's geomagnetic field may detect a small effect on compass readings above the cables in shallow water that will diminish quickly with distance. However, compass readings and locations obtained from global positioning system (GPS) receivers would not be affected.

For trenched cables, the compass deviation could reach up to 8 degrees where the depth is lower than 3 m (10 ft) of water depth, but would quickly decrease and be less than 1 degree at 8 m (25 ft) and deeper. Therefore, all the offshore traffic, as well as most of the inland traffic, will not be affected by significant compass variations. Only smaller boats close to the coast near the cables' landing locations could be affected by significant compass variation, although visual navigation would predominantly be used in this situation. In addition, several mitigation measures such as the co-trenching of return cables can significantly reduce the compass deviation (JICABLE, 2015) (Exponent, 2014).

The buried export cables are not anticipated to affect navigation safety related to marine communications, radar, or other positioning systems such as GPS.

G.11 Risk of Collision, Allision, or Grounding

The buried export cables are not anticipated to have any direct effect on collision, allision, or grounding risk. Indirect risks to navigation safety, such as anchoring, are described in Section G.4.

G.12 Emergency Response Considerations

The buried export cables are not anticipated to affect the ability of emergency response assets or personnel to respond. It is possible but unlikely during the Project lifetime that a cable-related anchoring accident could occur and require in-water assistance.

G.13 Facility Characteristics

No effects are anticipated to Federal Aids to Navigation (ATON) or visual navigation from the export cables.

G.14 Design Requirements

Locations and details of offshore Project components such as the export cables will be provided to NOAA so they can be included on nautical charts.

G.15 Operational Requirements

The Project operations center will monitor the export cables, and the cables will be included in marking, monitoring activities, and advisories, and provision of locations of Project components to NOAA.

G.16 Operational Procedures

Project emergency procedures, described in Section 16 of the main NSRA report, will include the export cables in their scope.

G.17 Conclusions and Risk Mitigations for the Brayton Point ECC

The primary conclusions of this study are as follows:

1. Site location and coordinates	• The Brayton Point ECC will link an offshore substation platform(s) within the Project's Lease Area to the Onshore Project Area at Brayton Point in Somerset, MA.
2. Traffic survey	• Deep draft vessel (cargo and tankers) traffic is light along most of the Brayton Point ECC. Significant deep draft Traffic crosses the ECC only along the coast of Rhode Island. • In the inshore portion of the Brayton Point ECC (Sakonnet River and Mt Hope Bay), traffic primarily consists of shallow draft vessels such as Passenger and pleasure crafts. • Along the inshore portion of the Brayton Point ECC, comparatively low levels of fishing for all species were reported. • Fishing activity intersects the Brayton Point ECC in the Rhode Island Sound; however, fishing activity occurs but is limited in the inshore portions of the ECC and dredge towing, which is potentially the most impacted by buried cables, has not been reported in inshore portions of the ECC.
3. Offshore above water structures	• The offshore export cables will be buried below the seabed or covered on the seabed and will not include above-water components.
4. Offshore under water structures	• The subsea cables will be buried in the Brayton Point ECC, with a target burial depth of 1.8 m (6 ft). • During the construction phase, the vessels involved in the cable laying activities have limited maneuverability and may pose a hazard to passing vessels. This risk is planned to be mitigated by implementing a temporary safety zone around the vessels and by informing the mariners (Mayflower, 2021). • A preliminary cable burial risk assessment has been performed to assess the risk from and to the buried cables and to determine the appropriate burial depth and mitigation measures. During Project operations, the export cables in the Brayton Point ECC will be buried in or covered on the seabed, and may pose a hazard to activities that pierce the sea floor, such as fishing with specific types of bottom gear or vessel anchoring. This risk is planned to be mitigated by burying the cable at sufficient depth based on risk assessment and periodic monitoring of the cable location during Project operations. This preliminary risk assessment has recommended a minimum burial depth of 1 m (3.28 ft) along most of the ECC, and deeper burial depth in specific zones.

5. Navigation within or close to a structure	• Mobile fishing gear are employed in the vicinity of the Brayton Point ECC; however, the bottom-contacting mobile gear types used in this area have minimal penetration depths. These fishing techniques might penetrate the seabed or impact unburied cables that are otherwise protected, potentially resulting in damage to the gear, a hazard to the vessel, and/or damage the cables. • Anchors penetrating the seabed within the Brayton Point ECC may also impact the buried cables and may result in damage to the vessel and/or the cables. A Project engineering risk mitigation is routing the ECC to avoid designated anchorage areas. • Another primary risk control is burying the cable at sufficient depth based on risk assessment, covering cables that cannot be buried to target burial depth, and periodic monitoring of the cable location during Project operations. The preliminary cable burial risk assessment has recommended a minimum burial depth of 1 m (3.28 ft). The Project target burial depth is 1.8 m (6 ft).
6. Effect of tides, tidal streams, and currents	• Water depths in the offshore portion of the Brayton Point ECC range from 16 m to 41 m (52 ft to 135 ft) and inshore from 0 m to 23 m (0 ft to 75 ft). • Along the offshore portion of the Brayton Point ECC, the current is predominantly from the northwest and the waves from the north. In the long term, the current and waves may have a scour effect on the ECC and affect the burial depth. Periodic monitoring of the cable location during Project operations is planned to mitigate this risk (Mayflower, 2021). • Along the inshore portion of the Brayton Point ECC, the current is predominantly generated by the tidal stream and the waves are neglectable.
7. Weather	• Weather conditions are not anticipated to affect or be affected by the buried export cable in the Brayton Point ECC.
8. Configuration and collision avoidance	• The buried export cables are not anticipated to have direct effects on collision risk.
9. Visual navigation	• The buried export cables are not anticipated to affect visual navigation during the Project's operational phase.
10. Communications, radar, and positioning systems	• The magnetic field generated by the HVDC cables may affect navigation compasses and create a deviation of the readings. This deviation may be significant above the cables in shallow waters but is neglectable at water depths greater than 8 m (26 ft).

	• Other navigation safety related systems such as communications, radar, or other positioning systems like GPS are not anticipated to be affected by the buried cables.
11. Risk of collision, allision, or grounding	• The buried export cables are not anticipated to have any direct effect on collision, allision, or grounding risk.
12. Emergency response considerations	• The buried export cables are not anticipated to affect the ability of emergency response assets or personnel to respond. It is possible but unlikely during the Project lifetime, that a cable-related anchoring accident could occur and require in-water assistance.
13. Facility characteristics	• No effects are anticipated to Federal ATON or visual navigation from the export cables.
14. Design requirements	• Locations and details of offshore Project components such as the export cables will be provided to NOAA so they can be included on nautical charts.
15. Operational requirements	• The Project operation center will monitor the export cables' condition. • Information on the Brayton Point ECC and its location will be provided to NOAA to include on navigation charts.
16. Operational procedures	• Emergency procedures will be developed and reviewed with relevant agencies, including the Coast Guard, to ensure that response plans are adequate and properly resourced.

G.18 References

Carbon Trust (2015), “Cable Burial Risk Assessment Methodology, Guidance for the Preparation of Cable Burial: Depth of Lowering Specification”, CTC835, February 2015.

Cathie and Associates (2021), Brayton Point Preliminary Cable Burial Risk Assessment (CBRA), July 2021.

Exponent (2014), “Submarine Cable DC Magnetic Field in Lake Champlain and Marine Assessment”, November 29, 2014.

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