Sunrise Wind Farm Project

Appendix X
Navigation Safety Risk Assessment

Prepared for:

Sunrise Wind | Powered by Ørsted & Eversource

August 23, 2021

Revision 1 – October 28, 2021

Revision 2 – August 19, 2022

SUNRISE WIND FARM

Navigation Safety Risk Assessment

Stantec Consulting Services Inc.

Document No.: 10203007-HOU-R-01
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Abbreviation	Meaning
ACOE	Army Corps of Engineers
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
CFR	Code of Federal Regulations
COLREGs	International Regulations for Preventing Collisions at Sea
COP	Construction and Operations Plan
DSC	Digital Select Calling
DWT	Dead Weight Tonnage
ECA	Emission Control Area
ECDIS	Electronic Chart Display and Information System
EEZ	Exclusive Economic Zone
EU	European Union
FR	Federal Register
FSA	Formal Safety Assessment
GC	Gain Control
GPS	Global Positioning System
HF	High Frequency
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ICAO	International Civil Aviation Organization
IMO	International Maritime Organization
LOA	Length Overall
LOS	Line of Sight
LPG	Liquified Petroleum Gas
MARCO	Mid-Atlantic Ocean Data Portal
MARCS	Marine Accident Risk Calculation System
MARI PARS	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
MHW	Mean High Water
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MRASS	Mariner Radio-Activated Sound Signals
MSL	Mean sea level
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
NYSERDA	New York State Energy Research and Development
OCS	Outer Continental Shelf
OCS-DC	Direct Current Offshore Converter Station
OREI	Offshore Renewable Energy Installations
PARS	Port Access Route Study
PATON	Private Aids to Navigation
PDE	Project Design Envelope
PPU	Portable Pilotage Unit

Abbreviation	Meaning
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
VMD	Virtual Meteorological Data
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
dB	decibels
dB(A)	A-weighted decibels
ft	feet
GHz	gigahertz or 10^9 hertz
Hz	hertz
km	kilometers
km^2	square kilometers
kt	knots
m	meters
mi	miles
MJ	megajoules
MW	megawatts
nm	nautical miles
m/s	meters per second

EXECUTIVE SUMMARY

This document presents the Navigation Safety Risk Assessment (NSRA) for the Sunrise Wind Farm (the Project). The Project will be located approximately 26 Nautical Miles (nm) (48 kilometers [km]) east of Montauk Point on Long Island, New York, under lease for Renewable Energy Development on the Outer Continental Shelf (OCS).

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

This assessment covers the following elements:

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

Key findings for each area are listed in Section 18 of this report. The NSRA did not identify any major areas of concern regarding the Project's impact on marine navigation.

Figure ES-1 shows the boundaries of the NSRA Marine Traffic Study Area and the Project Assessment Area (defined in Section 1).

The proposed layout has 1 nm between Project structures sited in a uniform east-west/north-south grid. The study assessed conservative "maximum risk" parameters as relevant to each hazard. For example, a layout with the largest potential footprint (shown in Figure ES-2) was used to assess collision risk from passing vessels. The risk evaluated in this NSRA represents the maximum risk from any design/layout within the maximum risk parameters. The NSRA's maximum risk parameters are within the Project Design Envelope (PDE). When the Project layout and turbine selection are finalized, if the layout is outside the NSRA maximum risk parameters, the Project has advised that it will update this NSRA if necessary.

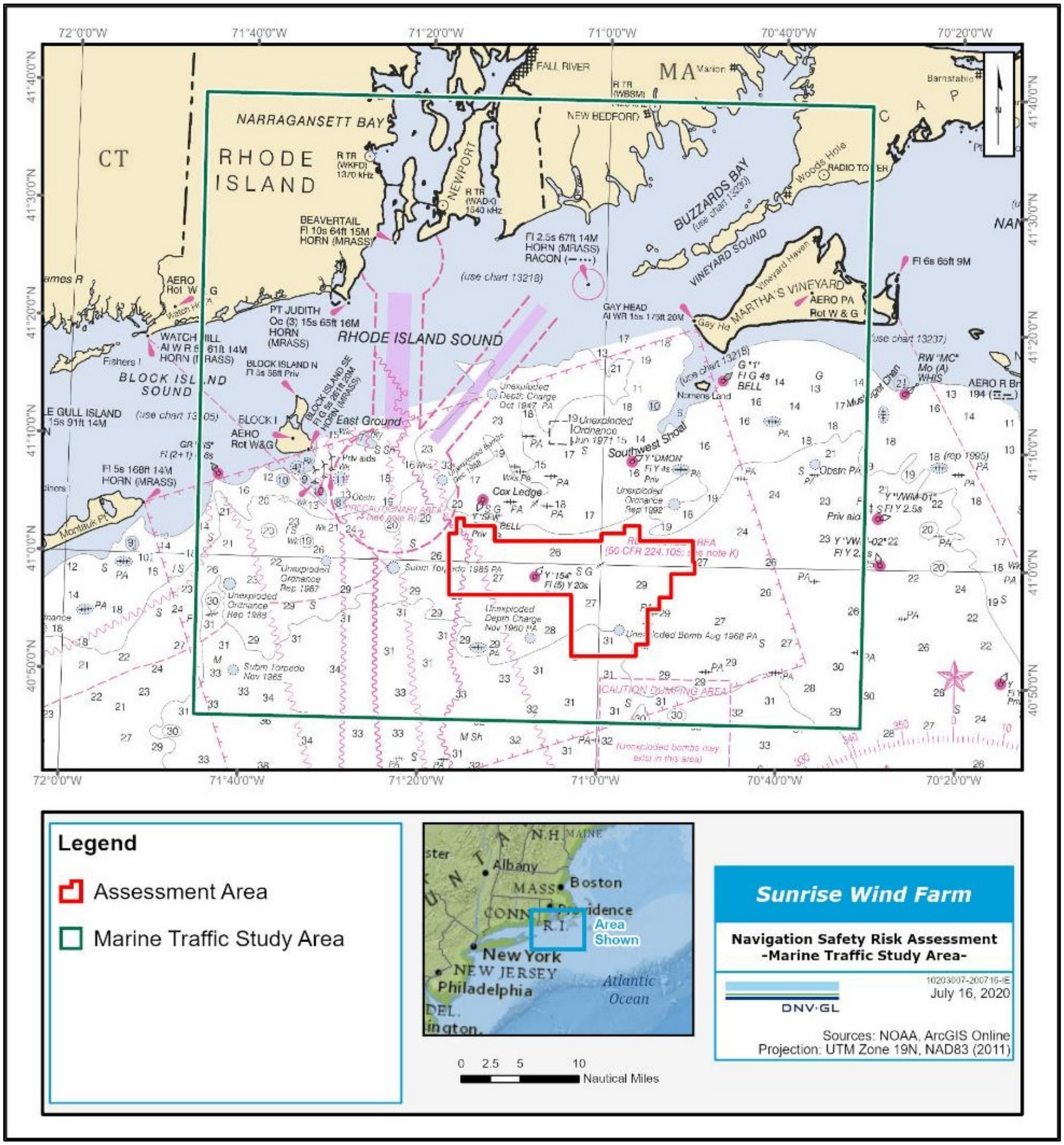

Figure ES-1 Project Location

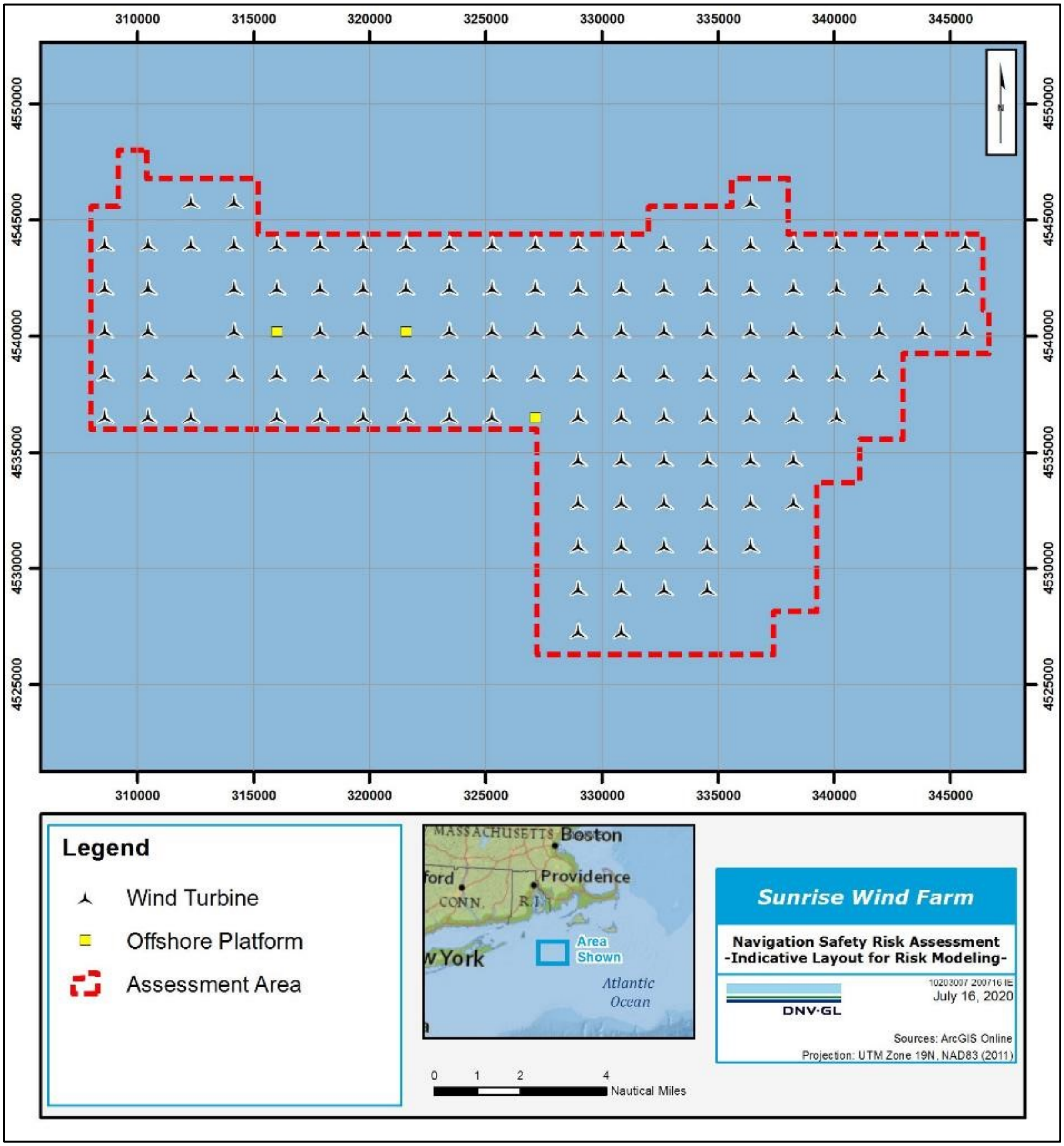

Figure ES-2 Indicative Layout used for Risk Modeling

Marine risk modeling was used to estimate the increase in the number of accidents as a result of the Project. This study attempts to balance the need to accurately estimate risk with the uncertainty accompanying the data and assumptions and assure that any error is on the side of overestimating the risk. The quantified assessment of the effect of the Project on navigation risk concludes that almost all of the risk increase due to the Project lies within the Assessment 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.

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

One year of Automatic Identification System (AIS) data was the primary marine traffic input to the model. Additional vessel transits were added to account for both current and future traffic not represented in AIS (hereafter "non-AIS"). Commercial fishing[1] is one such vessel type that is important in the Marine Traffic Study Area. The number of non-AIS commercial fishing transits was estimated by scaling port departures of AIS-carrying commercial fishing vessels per the ratio of registered commercial fishing vessels not required to carry AIS (shorter than 65 feet [ft]) to those that are required to carry AIS (65 ft in length or longer).

Conservatively, all 19,611 inbound and outbound transits estimated for non-AIS commercial fishing vessels were assumed to either fish in the Assessment Area or transit through it. The modeling shows that the Project has no significant effect on collision risk or grounding risk. In this assessment, the modeled risk increase is 1.6 accidents per year, 98 percent of which are allisions. This is a conservative and reasonable maximum estimate of the additional risk that could result from the presence of the Project assuming all non-AIS commercial fishing vessel transit to or through the Assessment Area. If the number of transits were half of the estimate, the risk would reduce by at least half. The Project poses very little risk outside the Assessment Area.

Additional risk mitigation measures whose benefits were not quantified in the model may be employed by the Project, including use of best available Automatic Identification System (AIS) technology within the wind farm. The Project will comply with Coast Guard requirements for lighting, sound signals, and marking of structures, as applicable and as determined in consultation with the Coast Guard (Sunrise Wind LLC, 2020).

Radar operations on commercial vessels are not anticipated to be impacted by the Project. Smaller vessels operating in the vicinity of the wind turbine generators may experience radar clutter and shadowing. Most instances of interference can be mitigated through the use of radar gain controls.

[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.

1 INTRODUCTION AND PROJECT DESCRIPTION

DNV Energy USA Inc. (DNV GL) conducted this independent Navigation Safety Risk Assessment (NSRA) of the proposed Sunrise Wind Farm Project (the Project). The Project's offshore structures will be located within Commercial Leases of Submerged Lands for Renewable Energy Development on the Outer Continental Shelf OCS-A 0487 and OCS-A 0500.[2]

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

1.1 Objective

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

The turbine size and layout have yet to be finalized, and several alternatives are being considered for the Project. To facilitate comprehensive and resilient analyses of the Project, this NSRA identified a maximum-risk design relevant to each analysis herein, such that the accuracy of the analyses would not be affected by potential changes to the layout that are within the maximum-risk design parameters described herein. The maximum risk parameters are within the PDE. The primary goal of applying a PDE is to allow for meaningful assessments by the jurisdictional agencies of the proposed project elements and activities while concurrently providing the Project reasonable flexibility to make prudent development and design decisions prior to construction.

1.2 Project components

The NSRA evaluated up to 123 offshore structures[3] in the NSRA Assessment Area defined in Section 1.3. The 123 structures were a combination of:

- 120 wind turbine generator (WTG) locations
- 3 potential offshore platform locations. At the time of issuance of this report, the Project is proposing only one platform for the Direct Current Offshore Converter Station (OCS-DC)

The parameters that define the maximum risk envelope for the purposes of the NSRA are shown Table 1-1.

Array cables will be laid connecting the WTGs to the offshore platform. One submarine export cable will convey power from the OCS-DC to shore located within an up to 106-mile [mi] (170 km)-long corridor.

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[2] A portion of Lease Area OCS-A 0500 (Bay State Wind LLC) and the entirety of Lease Area OCS-A 0487 (formerly Deepwater Wind New England LLC) were assigned to Sunrise Wind LLC on September 3, 2020, and the two areas will be merged and a revised Lease OCS-A 0487 will be issued. Thus, in this report, the term "Lease Area" refers to the new merged Lease Area.

[3] 'Since the time the analysis herein was conducted, Sunrise Wind has elected to reduce the number of turbines from 122 to up to 94 at 102 potential positions and has chosen a WTG model with defined measurements. This reduction is anticipated to result in the same or lower levels of impact than those presented in this report.

Table 1-1 Project offshore structure parameters defining the NSRA maximum risk envelope for visual navigation (Sunrise Wind, LLC, 2020)

Design with largest potential effect	Maximum foundation diameter at mean sea level (MSL)	
	Feet	Meters
WTG monopile	50	15
Platform monopile	50	15

Table 1-2 Project offshore structure parameters defining the NSRA maximum risk envelope for Marine Accident Risk Calculation System (MARCS) modeling (Sunrise Wind LLC, 2020)

Design with largest potential effect	Maximum foundation dimensions at MSL	
	Feet	Meters
WTG jacket	82 x 82	25 x 25
Platform jacket	220 x 220	67 x 67

Table 1-3 Project offshore structure parameters defining the NSRA maximum risk envelope for air clearance (Sunrise Wind LLC, 2020)

Design with largest potential effect	Minimum height from Mean Higher High Water (MHHW)	
	Feet	Meters
WTG blade	95	29
Platform Effective size of platform at minimum height is 328 x 295 ft (100 x 90 m)	78	24

Table 1-4 Project offshore structure parameters defining the NSRA maximum risk envelope for aviation clearance (Sunrise Wind LLC, 2020)

Parameter	WTG	Platform
Minimum air gap (from MHHW)	95 ft (29 m)	78 ft (23.8 m)
Maximum total structure height (from LAT)	968 ft (295 m)	295 ft (90 m) excluding lightning protection

The study assessed maximum risk Project characteristics relevant to each evaluated hazard, which are specified in relevant sections of this report. For example:

- For risk evaluation, the Project was modeled as having 123 offshore structures. 120 of the structure locations were modeled as potential WTG positions and 3 were modeled as potential platform positions. Only 1 platform position will be used; therefore, this approach accounts for the largest possible size of structural hazards. When built, the Project may have fewer structures in the array or consist of smaller structures than assessed, so where uncertainty exists in the final design, the assessment over-estimates the risk.
- For visual navigation, the foundation type with the largest potential for visual blockage was evaluated.
- For sailing vessel clearance, the foundation type with the smallest air gap was analyzed.

1.3 Site location and installation coordinates

The evaluated Project Assessment Area for the NSRA comprises approximately 458 km^2 (113,079 acres) and is shown in Figure 1-1. For the purpose of this NSRA, the Assessment Area is defined as the largest practical footprint of Sunrise Wind offshore structures within the Bureau of Ocean Energy Management (BOEM) lease. The Marine Traffic Study Area was defined for the purpose of analyzing marine traffic patterns and AIS data.

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

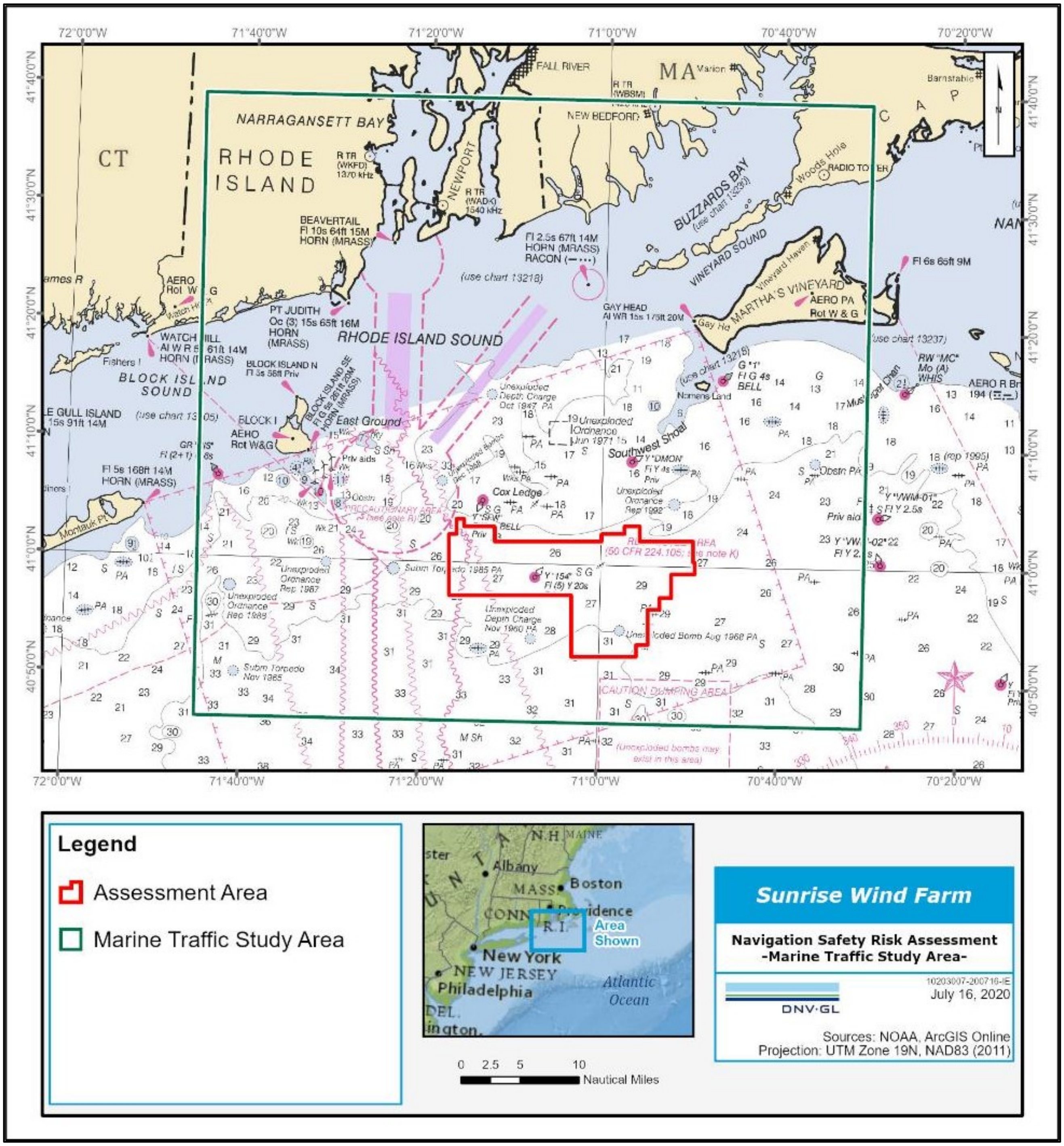


Figure 1-1 NSRA Wind Farm Assessment Area

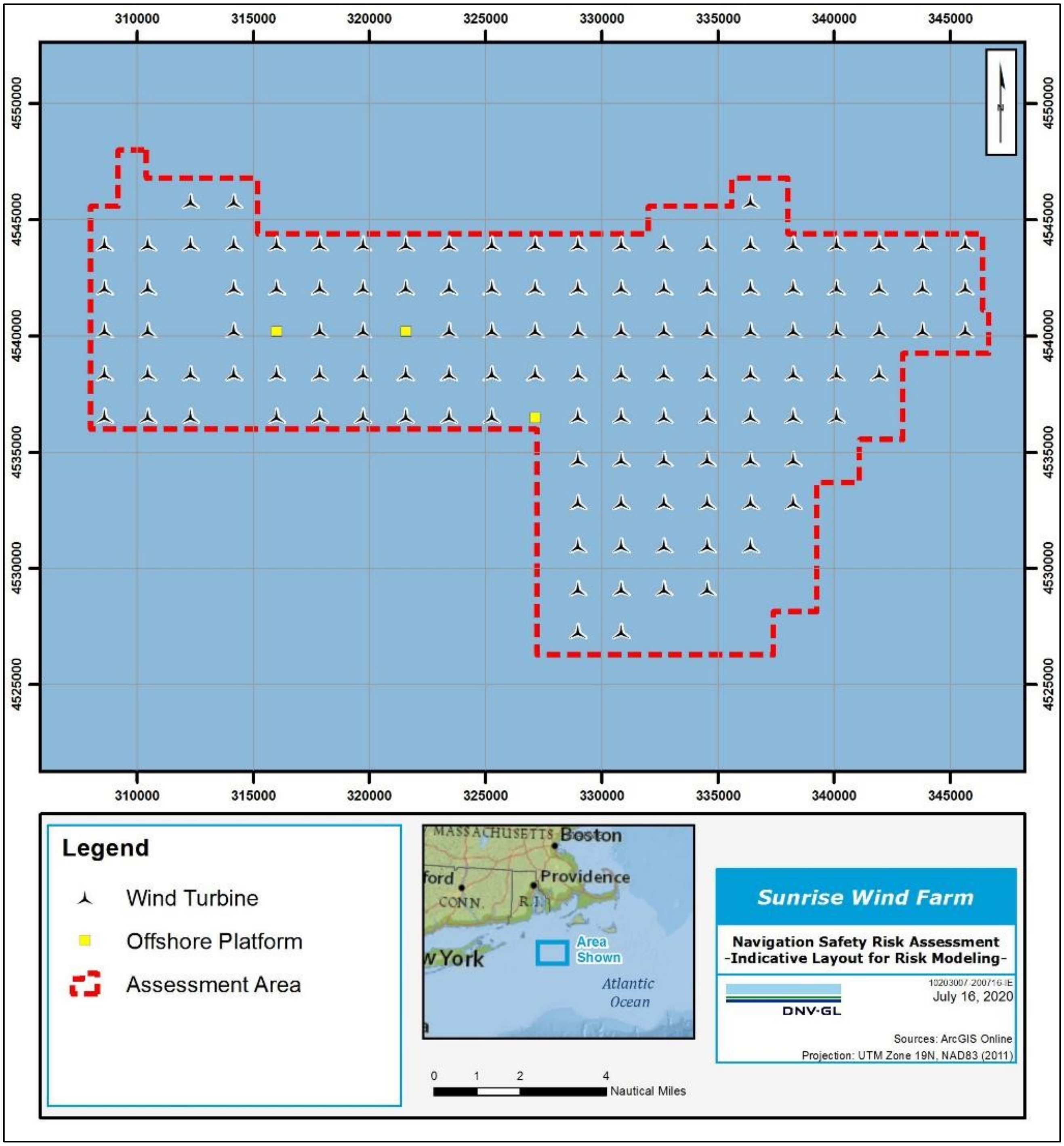


Figure 1-2 Indicative layout used for risk modeling

Figure 1-3 shows the evaluated export cable route.

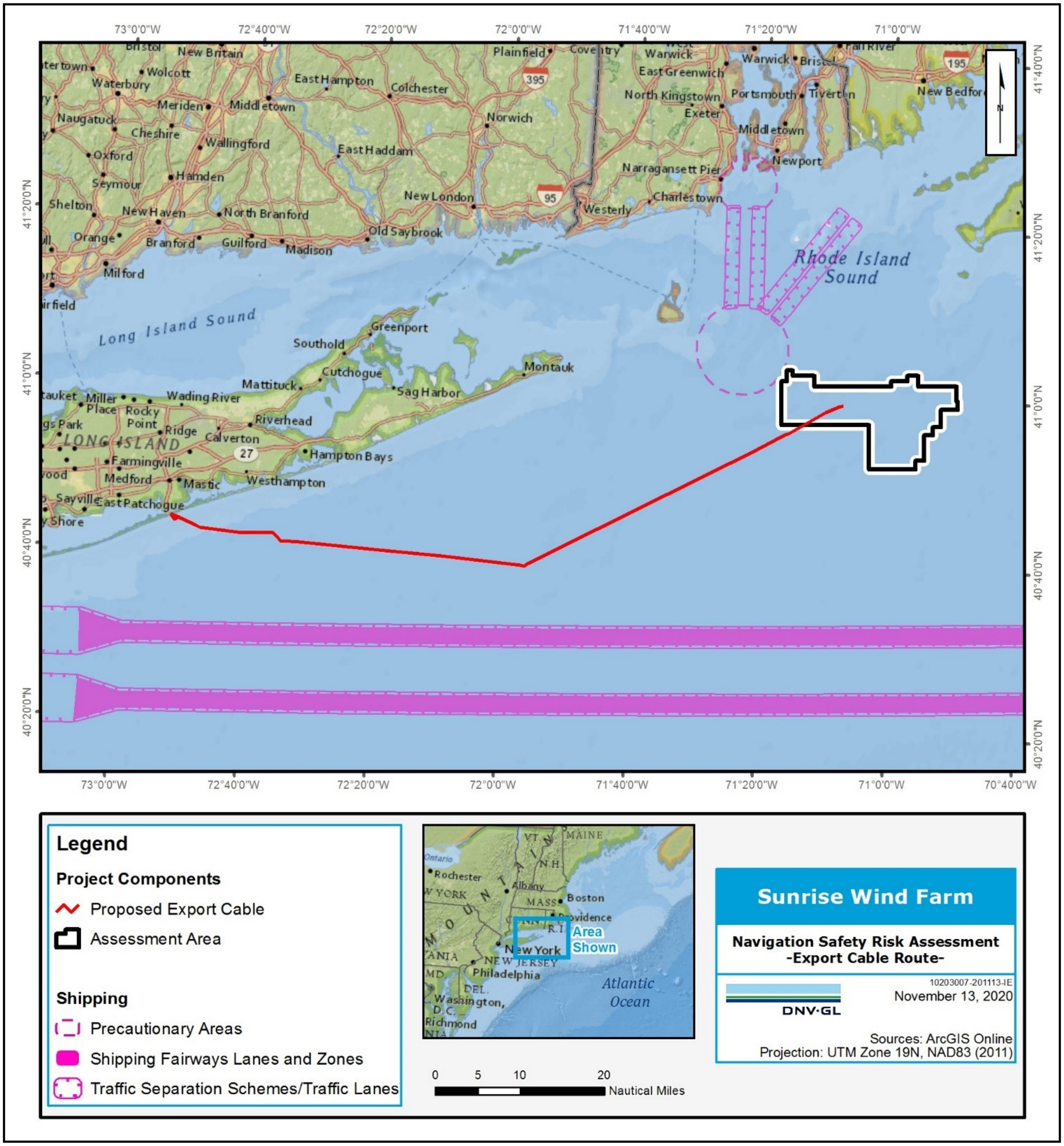


Figure 1-3 Indicative export cable route

2 TRAFFIC SURVEY

This section describes marine traffic in the vicinity of the Assessment Area. The following data sources were used to identify traffic patterns:

- Automatic Identification System (AIS) data for one year, 1 July 2018 to 30 June 2019 (MarineTraffic, 2019).
- The Mid-Atlantic Ocean Data Portal, which is used for ocean planning throughout the northeastern U.S. and provides a source of local information (Mid-Atlantic Ocean Data Portal [MARCO], 2020). Specific information used in this analysis included:
    - Commercial fishing transits inferred from Vessel Monitoring System (VMS) data, which were provided to the portal by National Marine Fisheries Service (NMFS). The most recent data products from NMFS provide processed geospatial statistics through the year 2016.
    - Density maps from Northeast Ocean Data (VMS and recreational survey data).
- The final report published by the Coast Guard for The Areas off Massachusetts and Rhode Island Port Access Route Study, referred to as MARI PARS (Coast Guard, 2020a).
- Ongoing dialogue with recreational boating and fishing industry organizations including the Responsible Offshore Development Alliance (RODA); pilot organizations; commercial maritime industry representatives; port authorities; state advisory groups (such as the New York State Fisheries Technical Working Group, the Massachusetts Fisheries Working Group and the Rhode Island Fisheries Advisory Board); and the Coast Guard. See Appendix B and Appendix C for additional detail.

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

Section 2.1	Traffic patterns, density, and statistics
Section 2.2	Location of the Project in relation to other uses
Section 2.3	Anticipated changes in traffic from the Project
Section 2.4	Effect of vessel emission requirements on traffic
Section 2.5	Seasonal variations in traffic

Figure 2-1 shows the location of the Assessment Area and the Marine Traffic Study Area.

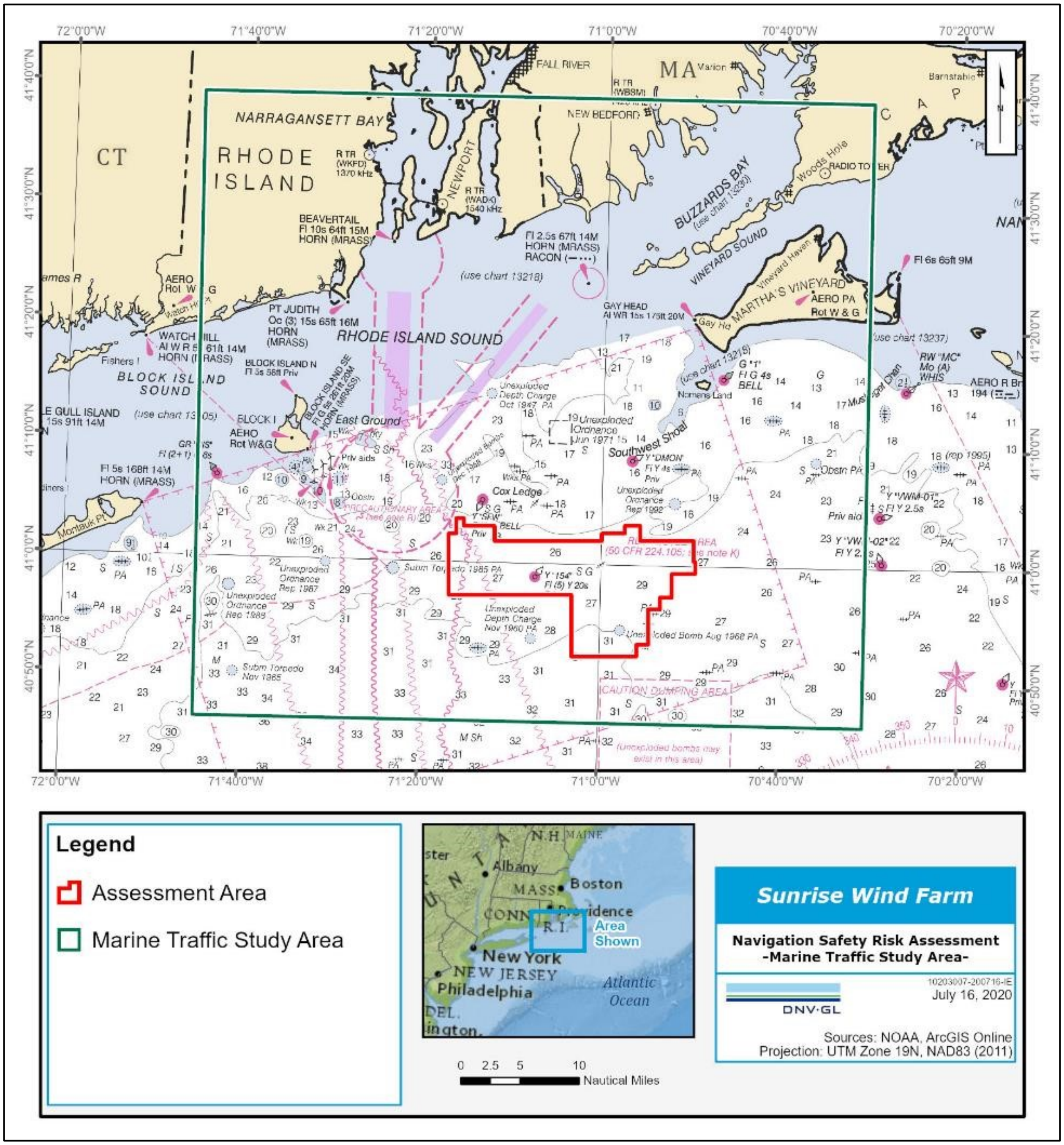


Figure 2-1 Marine Traffic Study Area

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

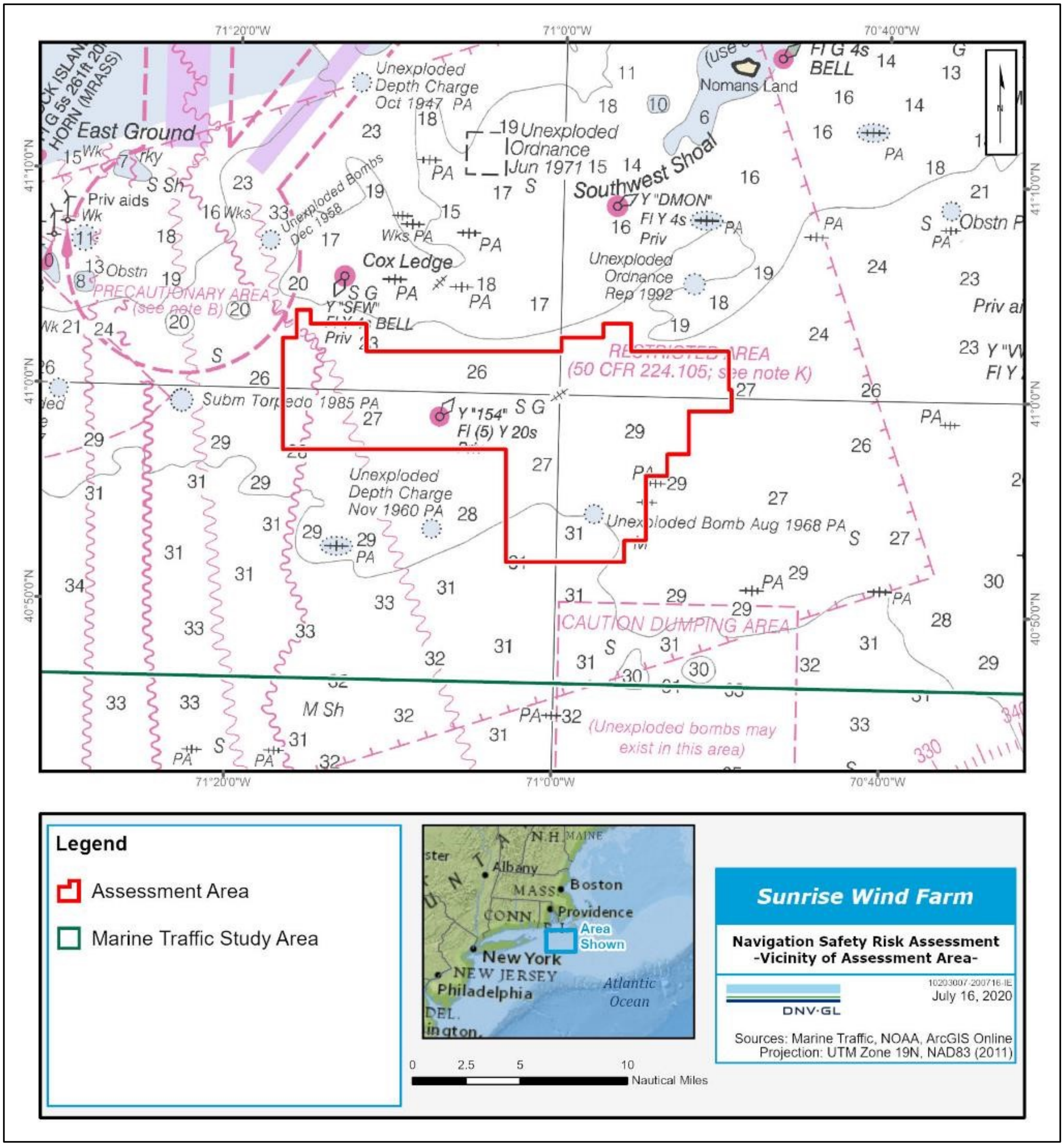


Figure 2-2 Navigation chart in the vicinity of the Project

2.1 Traffic patterns, density, and statistics

Traffic patterns, traffic density, and statistics were developed from one year of AIS data for the period 1 July 2018 through 30 June 2019. The data were spatially analyzed based on timestamp and proximity to create vessel tracks. Each vessel track represents one transit of a single vessel in the Marine Traffic Study Area.

AIS carriage requirements

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

Not all vessels are required to carry AIS. In particular, foreign vessels not destined for or departing from a location under U.S. jurisdiction and some self-propelled vessels of less than 1600 gross tonnage are not required to carry AIS under U.S. law. However, international law (International Maritime Organization [IMO], 1974), which applies to all vessels in international trade, requires an AIS class A device on:

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

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

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

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

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

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

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

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

(i) Fishing industry vessels;

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

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

The relevant Coast Guard Captain Of The Port may also determine that voluntary installation of AIS by a vessel would mitigate a safety concern due to specific circumstances.

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

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

Overview of Vessel Tracks

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

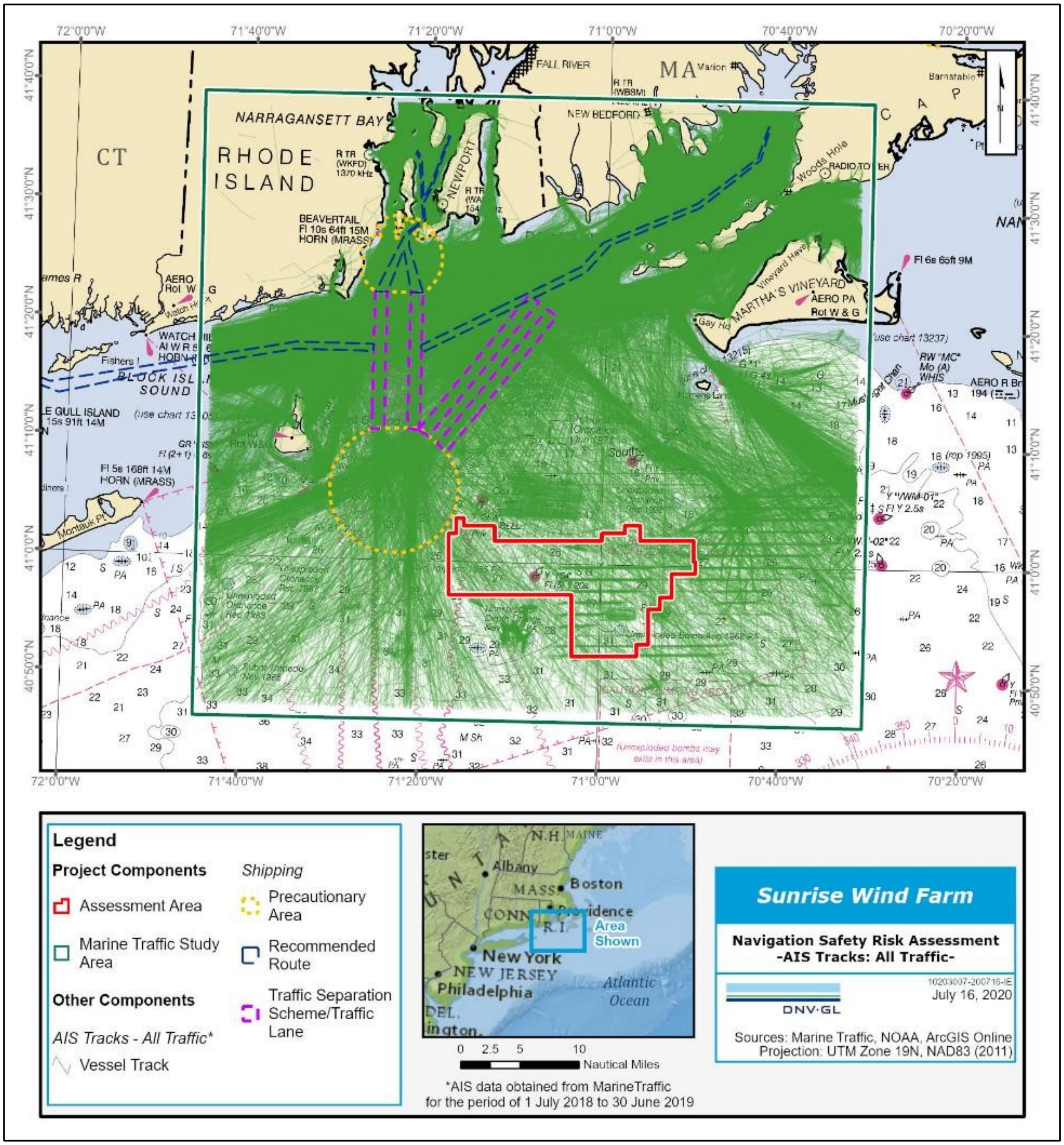


Figure 2-3 All AIS tracks in the Marine Traffic Study Area[4]

[4] AIS data for the period 1 July 2018 to 30 June 2019 (MarineTraffic, 2019)

A closer view in Figure 2-4 shows three broad traffic patterns in the Assessment Area: north-south, east-west, and southeast-northwest[5].

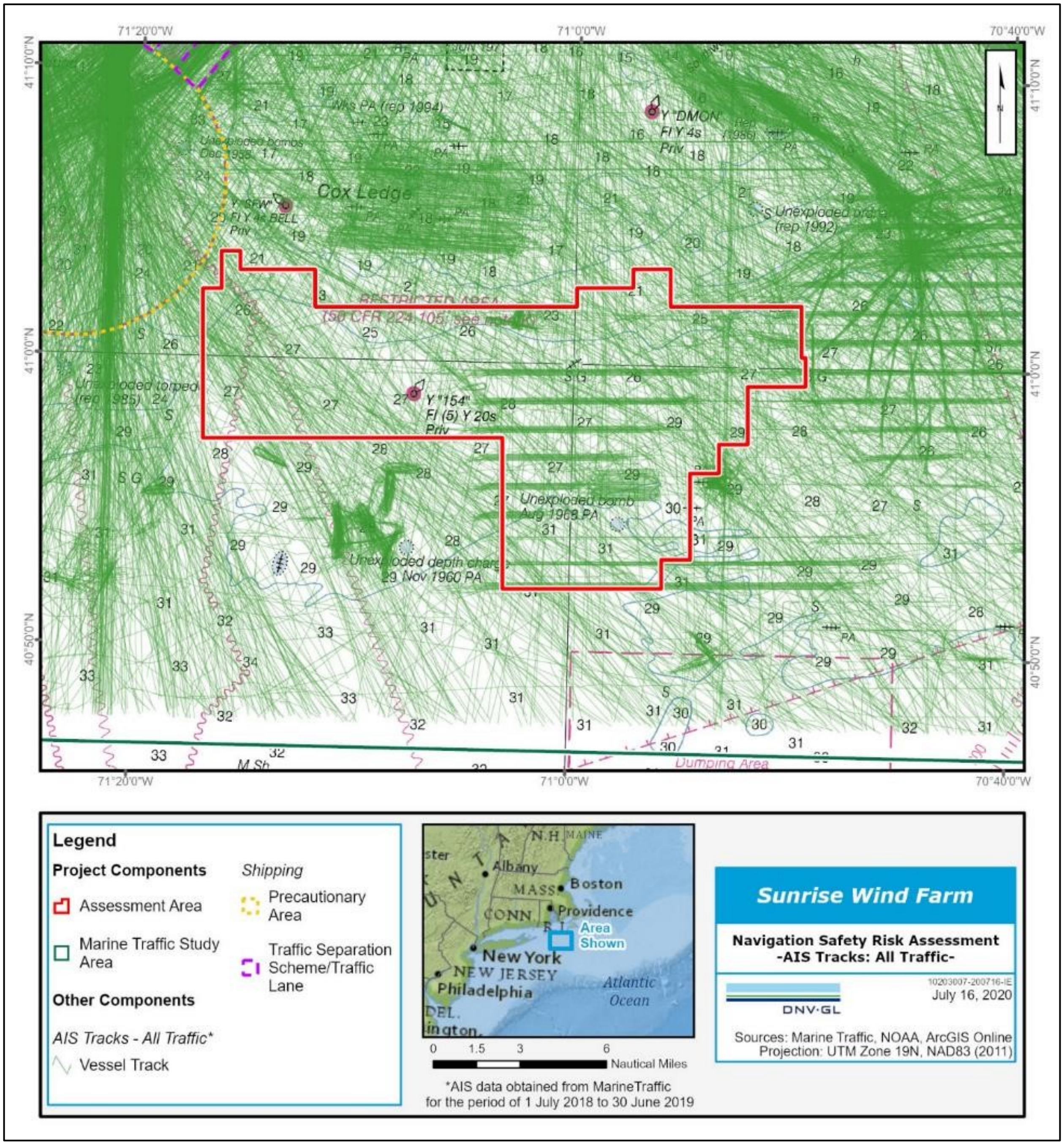


Figure 2-4 All AIS tracks in the vicinity of the Project Assessment Area[4]

[5] The order of the cardinal directions is not indicative of the traffic direction.

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

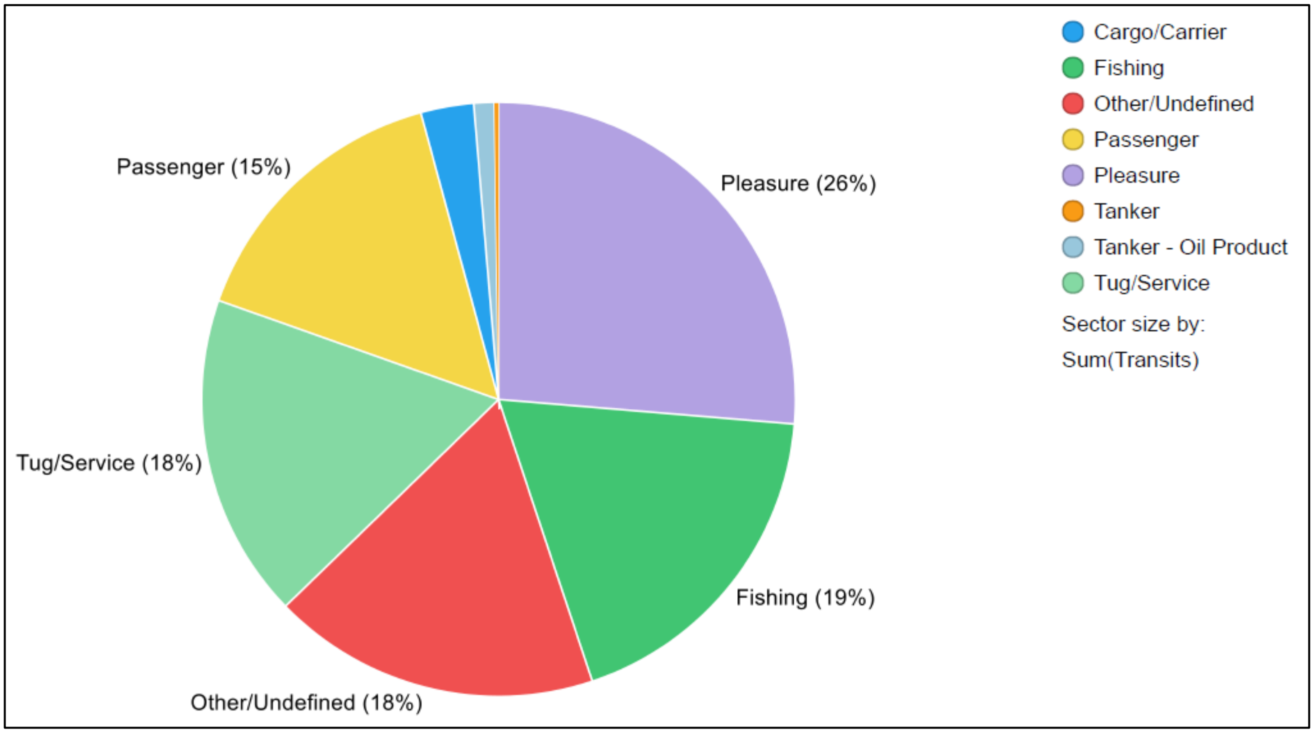


Figure 2-5 Distribution of vessel tracks in the Marine Traffic Study Area[4]

2.1.1 Traffic patterns

Below are discussions of traffic patterns for each of the vessel types:

- Deep draft vessels
- Fishing vessels
- Passenger vessels
- Pleasure and recreational vessels
- Tugs
- Other vessels

Maps of AIS vessel tracks for each vessel type are presented in Appendix A.

2.1.1.1 Deep draft commercial vessel traffic

Cargo, carrier, and tanker vessels transport goods such as petroleum products, coal, commodities, and food to/from ports in the area. They transit the main shipping routes in the designated Traffic Separation Schemes. The AIS data show fewer than one cargo vessel and one tanker per day transited the Wind Farm Assessment Area. These vessels predominantly transit two main courses through the larger NSRA Study Area:

- South-north and vice versa via the Narragansett Bay Traffic lanes or just west of them. The route transits to the west of the Wind Farm Assessment Area.
- East-west and vice versa between Buzzards Bay and Block Island Sound. The route transits to the north and northwest of the Wind Farm Assessment Area.

Figure 2-6 presents the tracks for cargo/carriers and tankers (those that carry hydrocarbon cargo and those that carry other cargoes). On a nautical chart, traffic separation zones are illustrated as purple rectangles.

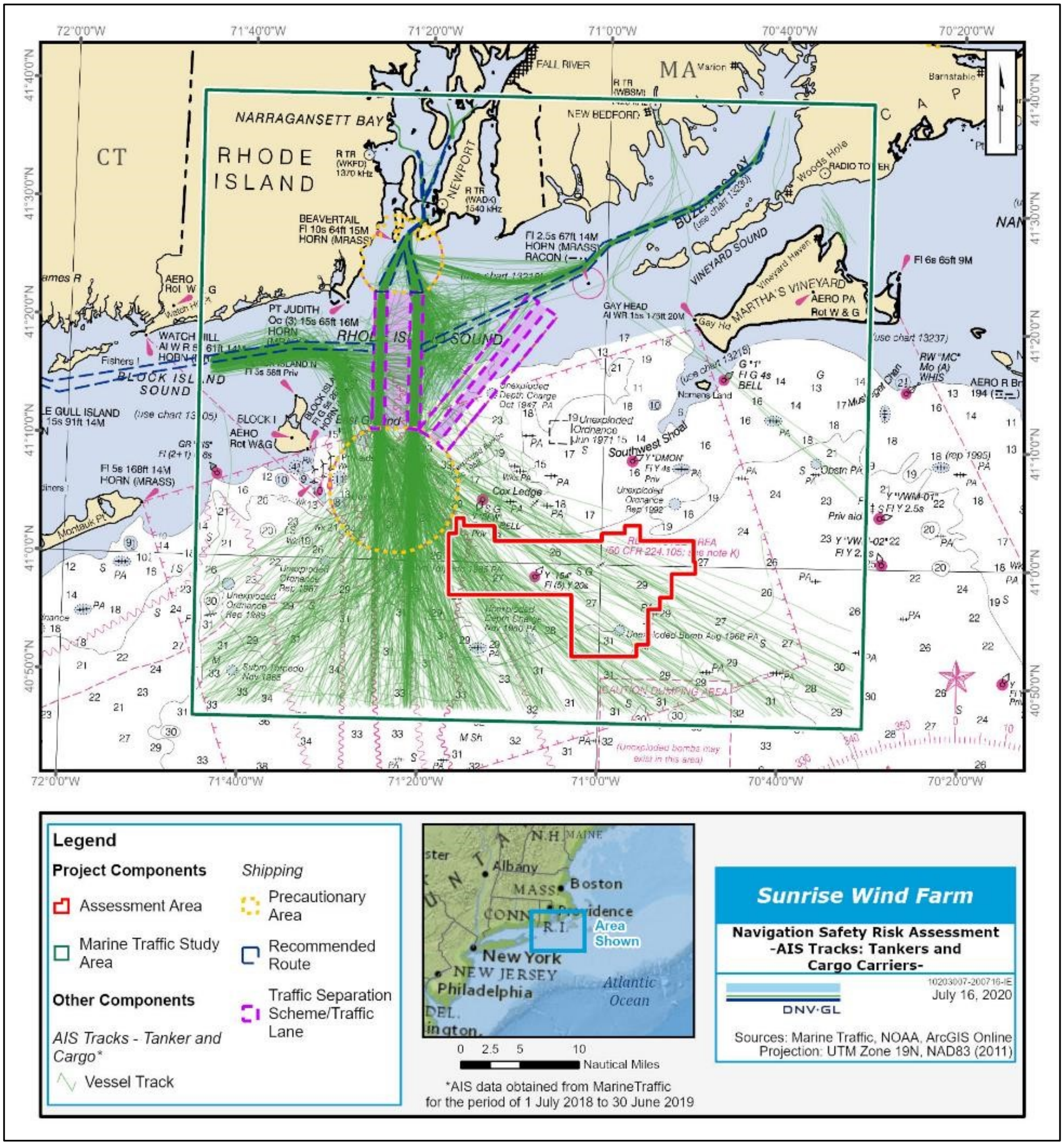


Figure 2-6 AIS tracks for tankers and cargo carriers[4]

2.1.1.2 Commercial fishing vessel traffic

Summary

Figure 2-7 presents the AIS tracks for fishing vessels in the Marine Traffic Study Area. The fishing vessel tracks captured in the AIS data show a higher traffic density in the vicinity of the coastline (north of the Project Assessment Area) and in the eastern portion of the Assessment Area. The AIS data show comparatively fewer fishing vessel transits south of the Assessment Area. A few major commercial fishing ports in New England berth the majority of vessels that fish in the vicinity of the Assessment Area.

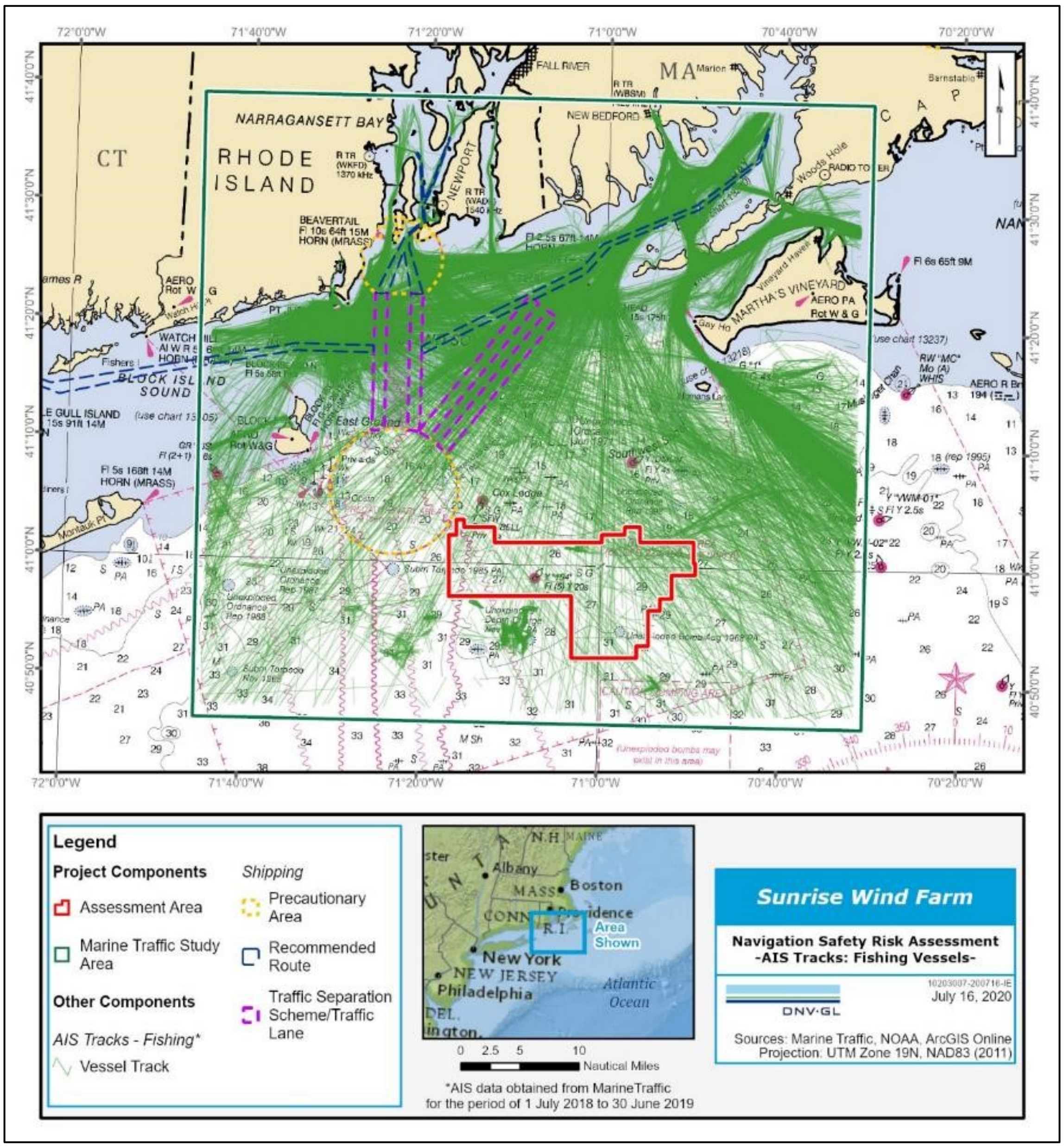


Figure 2-7 AIS tracks for fishing vessels[4]

The Coast Guard examined its own AIS data for the MARI PARS to identify fishing vessel traffic characteristics in the Wind Energy Area (WEA) that includes the Project (Coast Guard, 2020a). The following Coast Guard information relevant to this NSRA is based on the density of fishing vessel traffic (Figure 2-8), a review of U.S. National Oceanic and Atmospheric Administration (NOAA) fishing licenses, and input offered at workshops: (Coast Guard, 2020a)

- The densest fishing vessel traffic takes a northwest to southeast route from Gay Head, Massachusetts and vice-versa.
- The majority of the commercial fishing vessels in the area originate at one of five locations:
    - New Bedford, Massachusetts: This fleet generally transits from New Bedford, Massachusetts, across Buzzards Bay and through or around the Elizabeth Islands to the vicinity of Nomans Land, then southeasterly to fishing grounds east of the study area. This fleet follows a reciprocal track to return to port. [Note that this fleet transits far east of the Project Assessment Area.]
    - Pt. Judith, Rhode Island: This fleet generally transits from Pt. Judith, Rhode Island, to fishing grounds south and east of the [MARI PARS] study area. This fleet follows a reciprocal track to return to port. Some members of this fleet fish within the WEA.
    - Quonset, Rhode Island: This fleet generally transits from Quonset, Rhode Island, south through the West Passage of Narragansett Bay then southeasterly to fishing grounds south and east of the [MARI PARS] study area. This fleet follows a reciprocal track to return to port.
    - Montauk, New York: This fleet generally transits from Montauk, New York, east/southeast through the study area to fishing grounds further east. This fleet follows a reciprocal track to return to port.
    - Connecticut ports (Stonington, New London, and several smaller ports): This fleet generally transits from Connecticut ports east/southeast through the study area to fishing grounds further east. This fleet flows a reciprocal track to return to port.

The Coast Guard MARI PARS informs this NSRA with the following:

- Commercial fishing vessels transiting through the BOEM leases in the WEA originate from ports in Connecticut, Montauk, New York, and ports further south.
- Commercial fishing vessels transiting along the eastern boundary of the BOEM leases in the WEA originate from Pt. Judith and Quonset, Rhode Island.

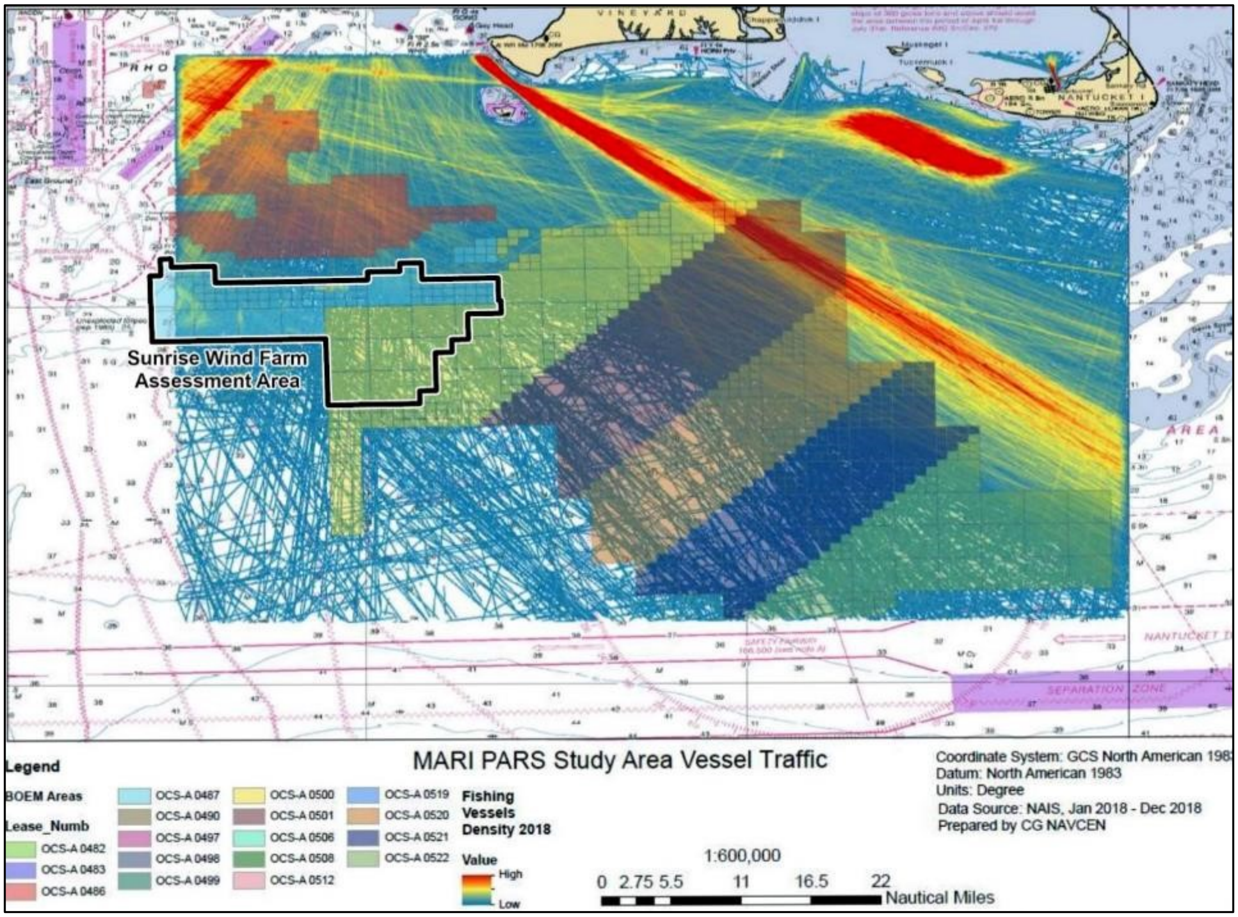


Figure 2-8 Fishing vessel density (taken from Coast Guard, 2020a)

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

To provide an improved estimate of commercial fishing vessel transits for modeling of navigation risk, a maximum reasonable number of transits of non-AIS commercial fishing vessels was estimated. According to the Coast Guard's analysis of fishing vessel activity discussed above, the states that are most likely to have registered commercial fishing vessels that transit the in the vicinity of the Project are Connecticut, Rhode Island, and New York. Based on the traffic statistics in Section 2.1.3.1, there are comparably few vessels from New York transiting from the coast to the vicinity of the Project.

An analysis of ship lengths for commercial fishing vessels registered in Rhode Island and Connecticut showed that 17.5% of the registered commercial fishing vessels have lengths greater than 65 ft and hence are required to use AIS.

The number of additional commercial fishing vessel trips for vessels shorter than 65 ft was estimated as:

$$\textit{Number of trips} = N / 0.175$$

where:

N is 3,432, the number of trips for fishing vessels longer than 65 ft obtained from the AIS data.

Key assumptions in the estimate are:

- All of the commercial fishing vessels with lengths of at least 65 ft are represented in the AIS dataset on departure from or approach to port, and fishing vessels under 65 ft are assumed to not be represented in the data at all.
- Fishing vessels properly self-identify as type "fishing" in AIS.
- According to more than ten years of vessel registration records in Rhode Island and Connecticut[6] ranging from 2008 to 2019 (NOAA, 2020), an average of 17.5% of all registered vessels are at least 65 ft in length, therefore must use AIS. This study assumes that AIS data represent only 17.5% of the commercial vessel traffic at port entries/exits. The number of transits is scaled up appropriately.
- Regardless of vessel size, the number of transits per vessel is assumed to be the same. The number of transits per year taken by an average fishing vessel *longer* than 65 ft is the same as the number of transits per year taken by an average fishing vessel *shorter* than 65 ft.
- Regardless of vessel size, the routes taken are assumed to be the same. The port of departure and fishing grounds of an average fishing vessel *longer* than 65 ft is the same as the port of departure and fishing grounds of an average fishing vessel *shorter* than 65 ft. This resulted in a maximum boundary estimate of 19,611 additional commercial fishing vessel trips inbound and outbound from ports in the Marine Traffic Study Area.

Approach

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

[6] A larger proportion of vessels registered in Massachusetts are longer than 65 ft, and based on the available AIS data for fishing vessels, the majority of the vessels originating at Massachusetts ports do not fish in or transit through the Assessment Area.

Therefore, this NSRA evaluated the level of commercial fishing activity in three ways:

- VMS data that indicate which types of fish were caught in the Marine Traffic Study Area. VMS data are collected by NOAA National Marine Fisheries Service (NMFS) via type-approved transmitters that automatically transmit a vessel's position for relay to NMFS.
- Combined permit / Vessel Trip Report (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.
- Additional information provided in the MARI PARS report (Coast Guard, 2020a).

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

Figure 2-9 to Figure 2-15 show commercial fishing vessel activity available for specific fish species. The scale is based on relative values rather than absolute values. The categories are "Low," "Med-Low," "Med-Hi," "High," and "Very High." Therefore, an area defined as "High" means that the fishing activity in this area is higher than average in the Mid-Atlantic region (approximately Virginia to Maine); the fishing activity is not higher than a specific value.

Fishing activity by catch (VMS data)

This section summarizes fishing activity based on VMS data for:

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

Figure 2-9 presents monkfish commercial fishing vessel activity at less than 4 knots (kt). Monkfish fishing activity occurred throughout most of the Project Assessment Area, though the density varied significantly. A couple of small "Very High" areas fell in the central portion of the Assessment Area. Most of the "Very High" fishing activities in the Mid-Atlantic region were either southwest or northeast of the Assessment Area.

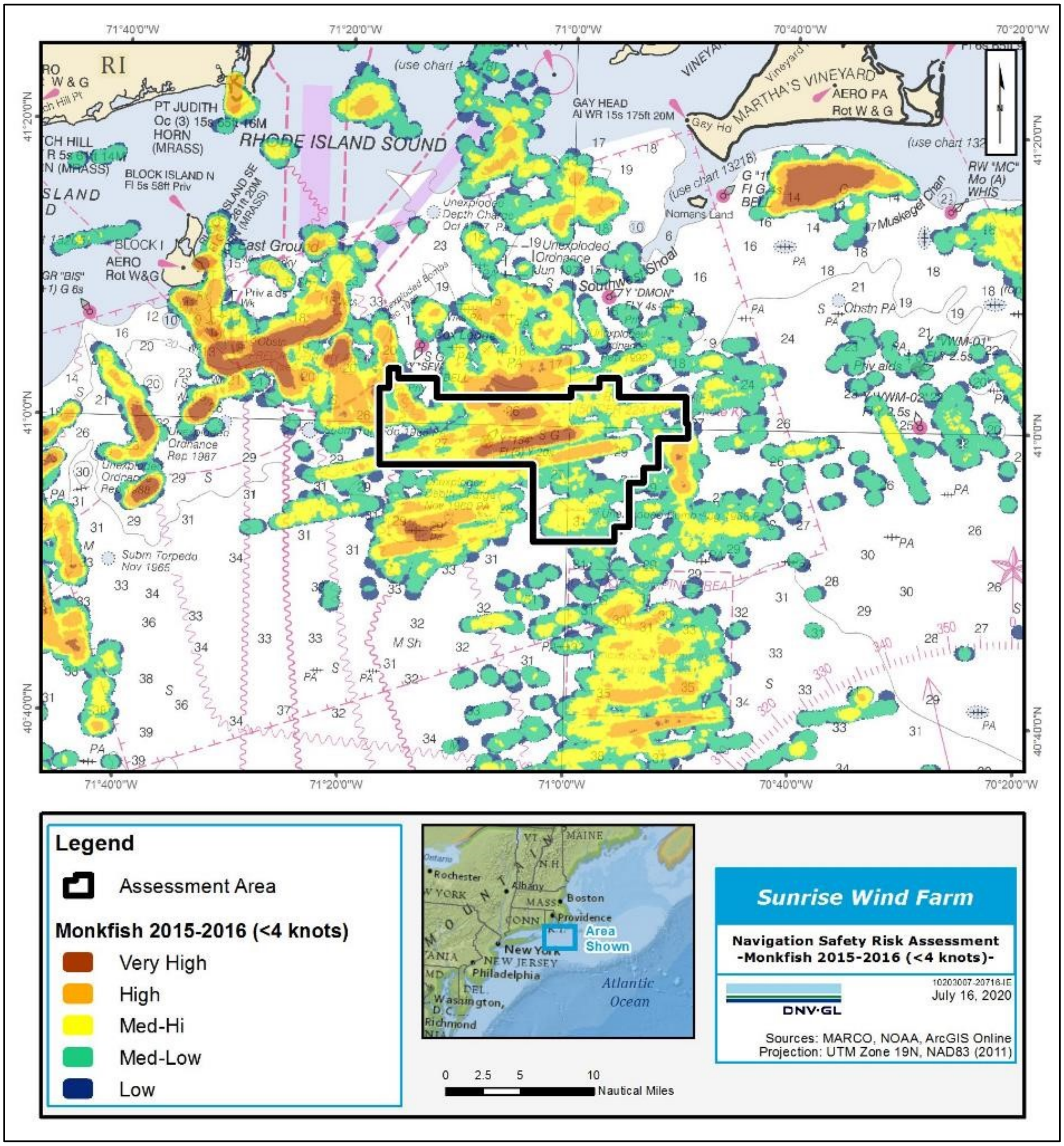


Figure 2-9 Commercial fishing vessel density - monkfish fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-10 presents pelagics (herring/mackerel/squid) commercial fishing vessel activity at less than 4 kt. The eastern and western sections of the Project Assessment Area had pelagics fishing activity primarily ranging from medium to very high. However, the central part of the Assessment Area had no recorded VMS pelagics fishing during this time period.

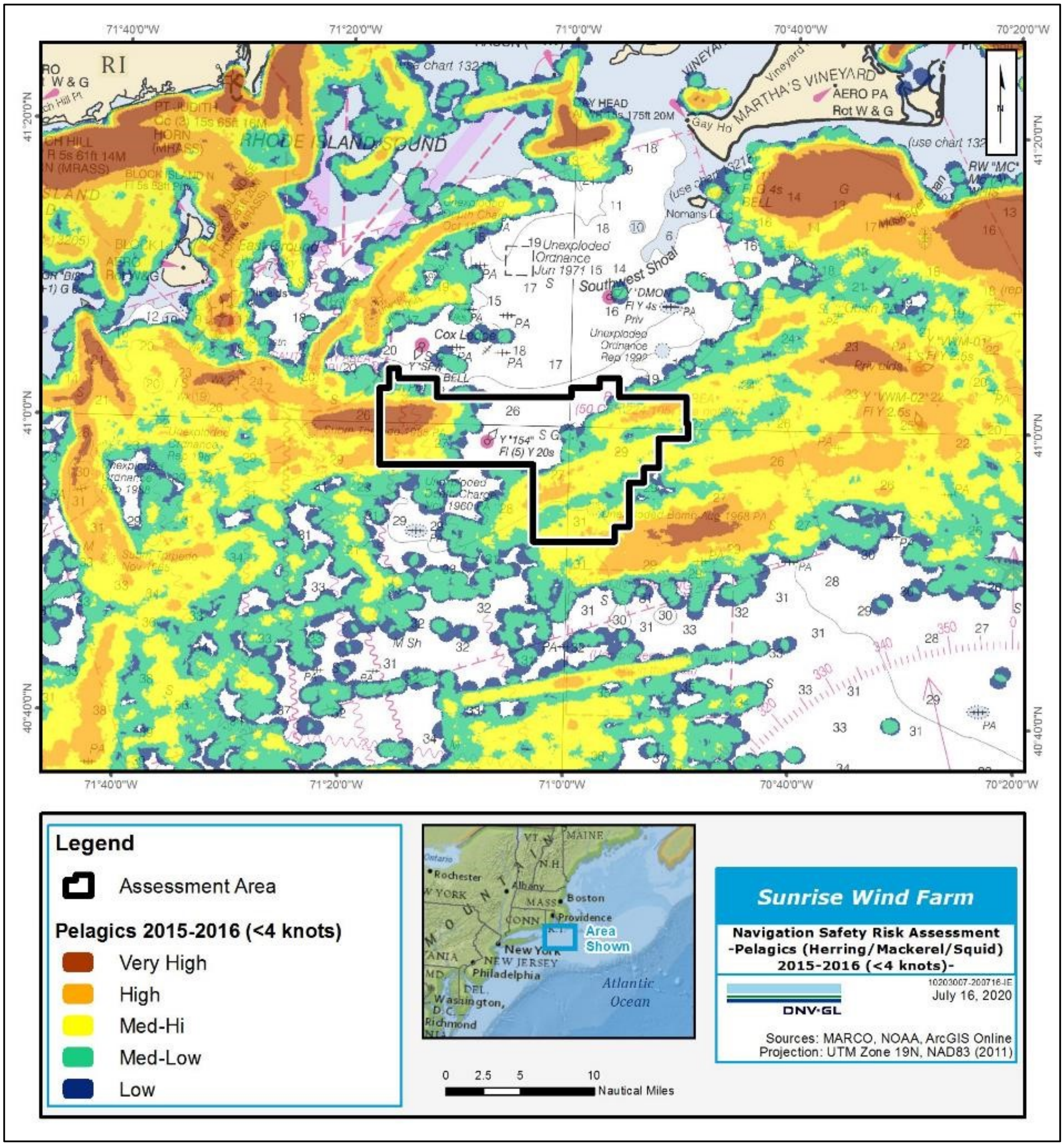


Figure 2-10 Commercial fishing vessel density - pelagics (herring/mackerel/squid) fishing, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-11 shows scallop commercial fishing vessel activity at less than 5 kt. In the central part of the Project Assessment Area scallop fishing activity ranged from low to very high, while the southern part of the Assessment Area had no scallop fishing activity.

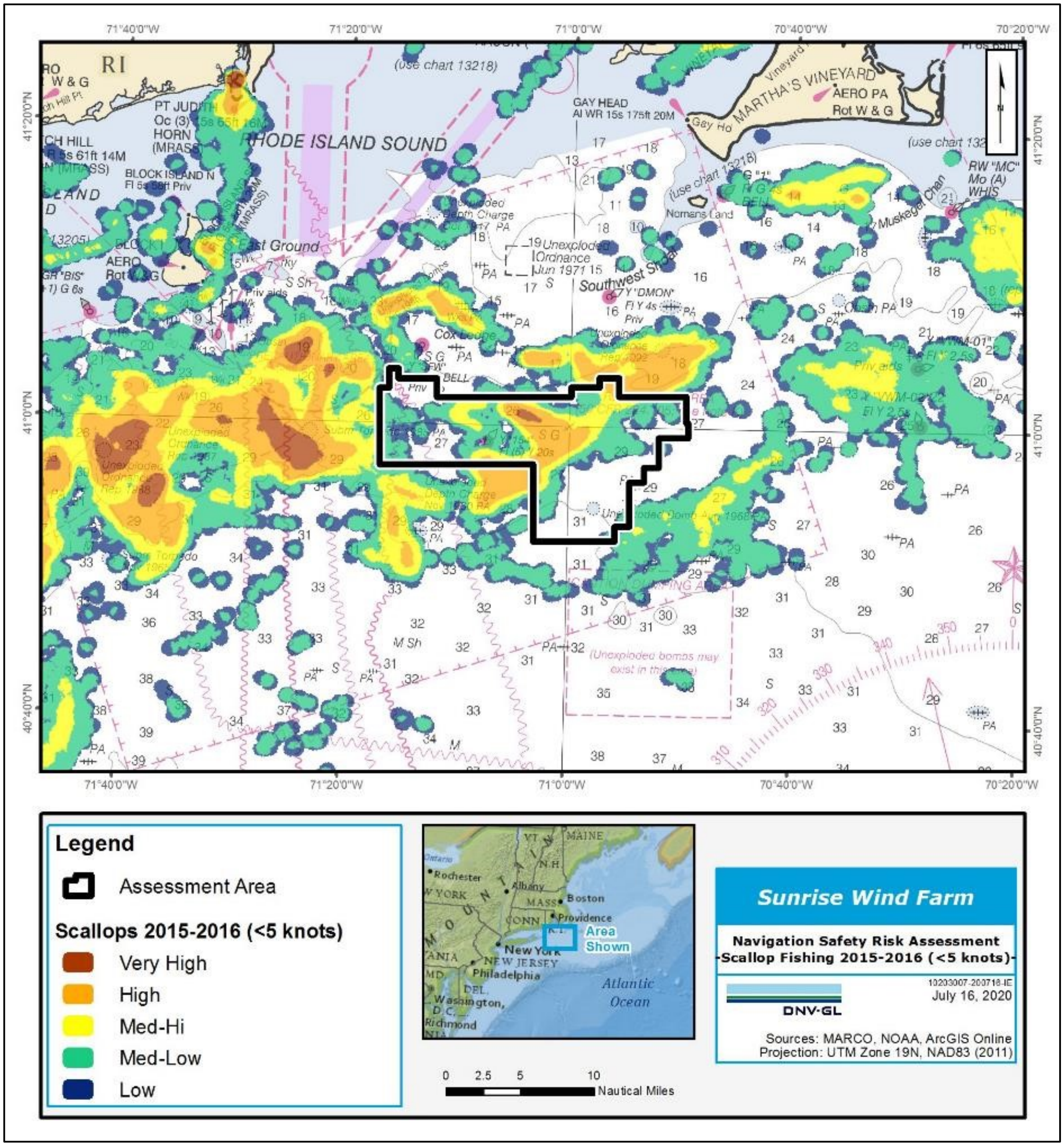


Figure 2-11 Commercial fishing vessel density - scallop fishing at less than 5 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-12 presents squid commercial fishing vessel activity at less than 4 kt. The western part of the Project Assessment Area had medium to very high squid fishing, and activity in the eastern and southern sections ranged from low to high. The central part of the Assessment Area did not have any recorded squid fishing activity.

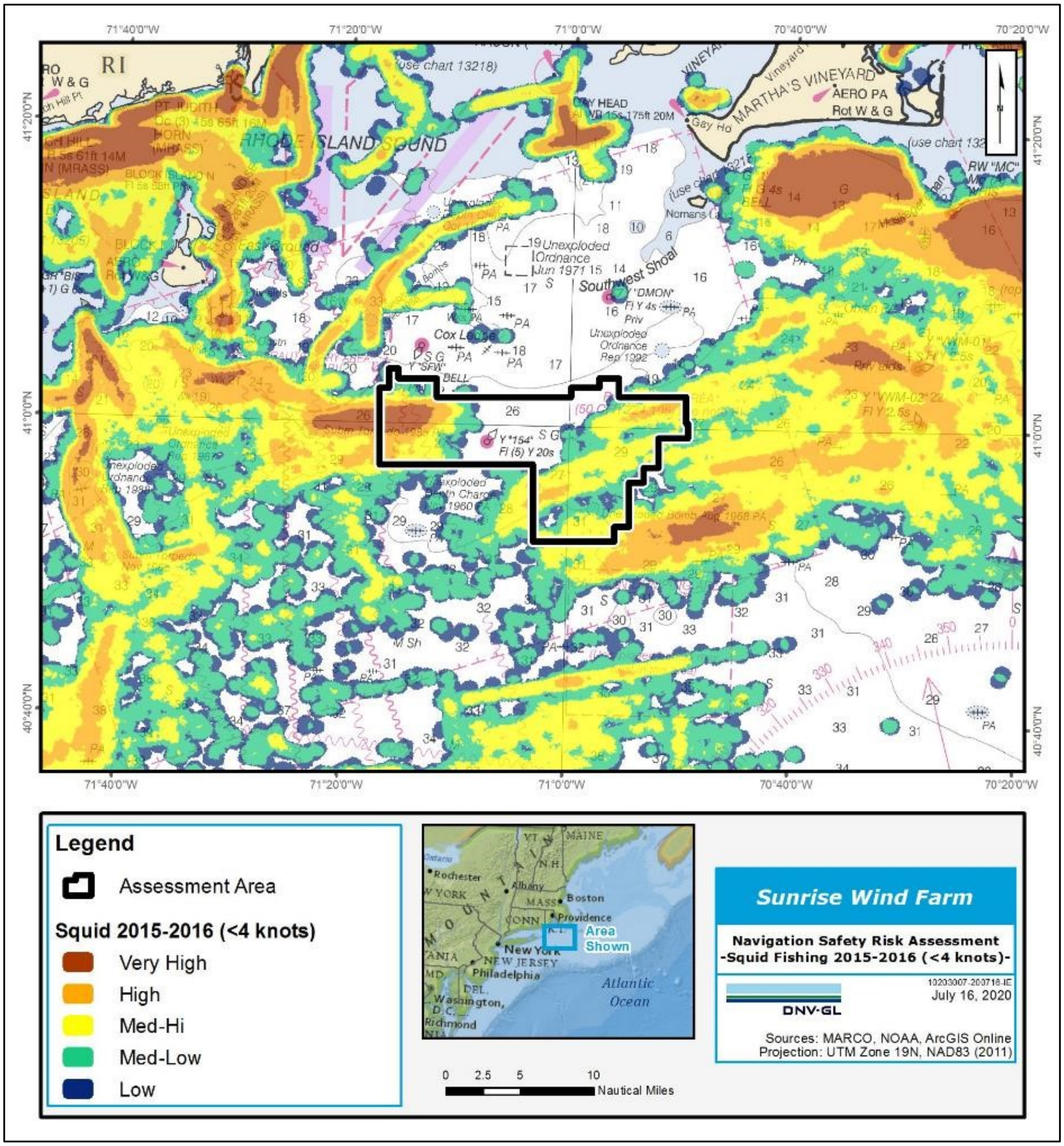


Figure 2-12 Commercial fishing vessel density - squid fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-13 shows surfclam/ocean quahog commercial fishing vessel activity at less than 4 kt. The western and central potions of the Project Assessment Area showed low to high surfclam/ocean quahog fishing activity, while the southern and eastern parts of the Assessment Area had no activity.

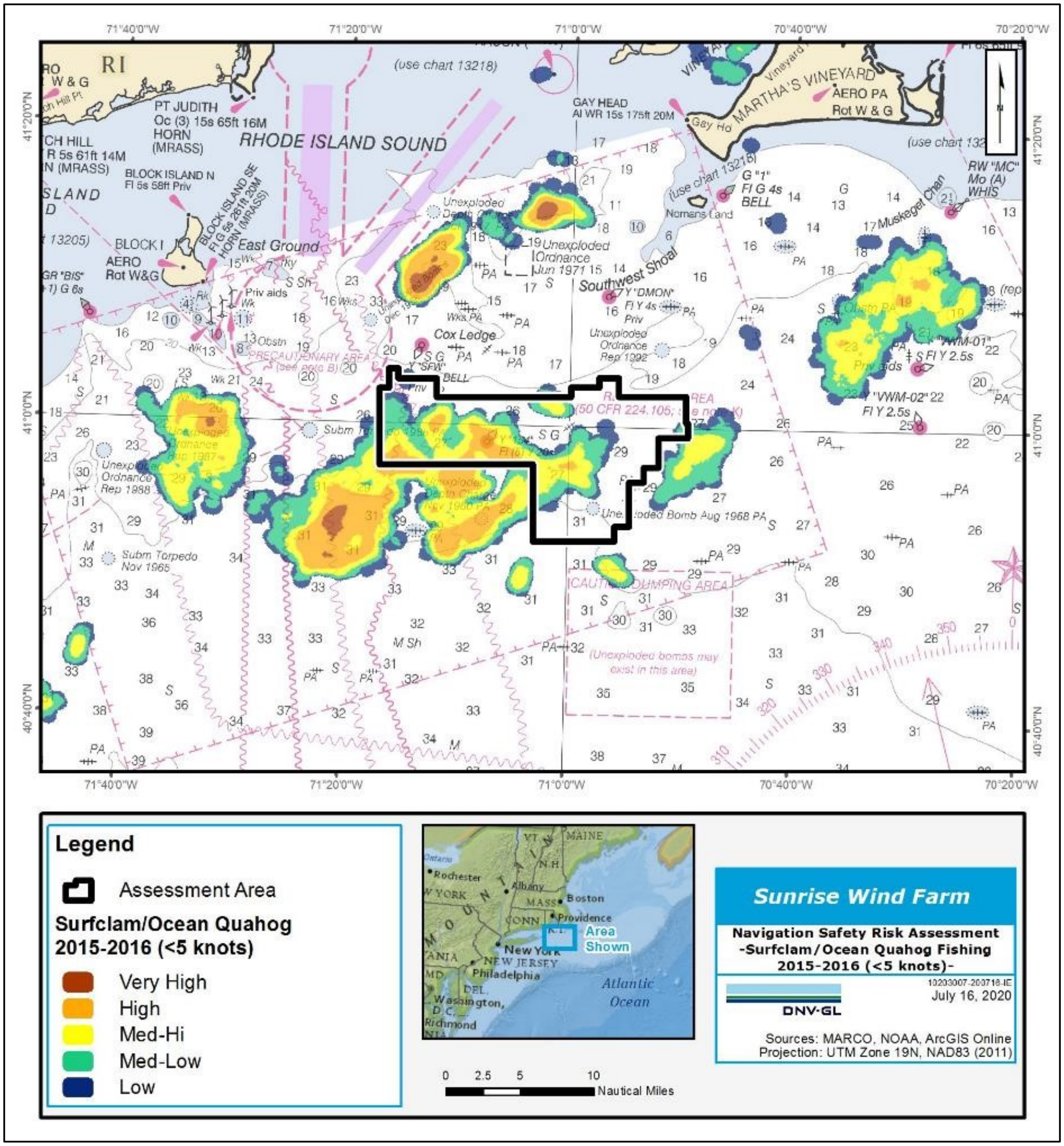


Figure 2-13 Commercial fishing vessel density - surfclam/ocean quahog fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-14 shows multispecies (groundfish) commercial fishing vessel activity at less than 4 kt. The central part of the Project Assessment Area had no recorded VMS groundfish fishing. However, the eastern and western ends of the Assessment Area had activity ranging from low to high during this period.

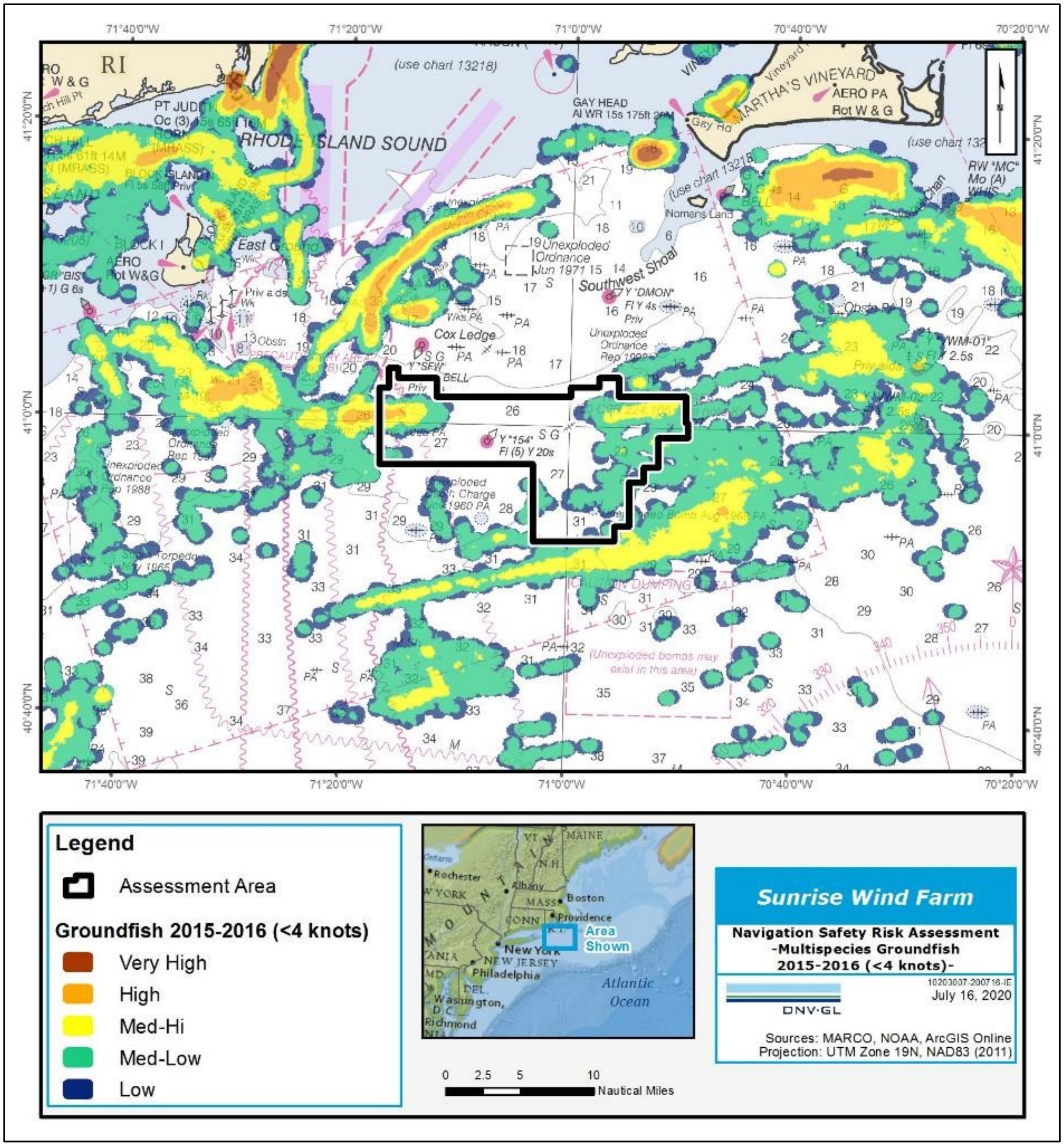


Figure 2-14 Commercial fishing vessel density - multispecies groundfish fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Figure 2-15 shows herring commercial fishing vessel activity at less than 4 kt. Most of the Project Assessment Area had no recorded VMS herring fishing from 2015 to 2016, though the southern section of the Assessment Area showed low to medium levels of fishing activity.

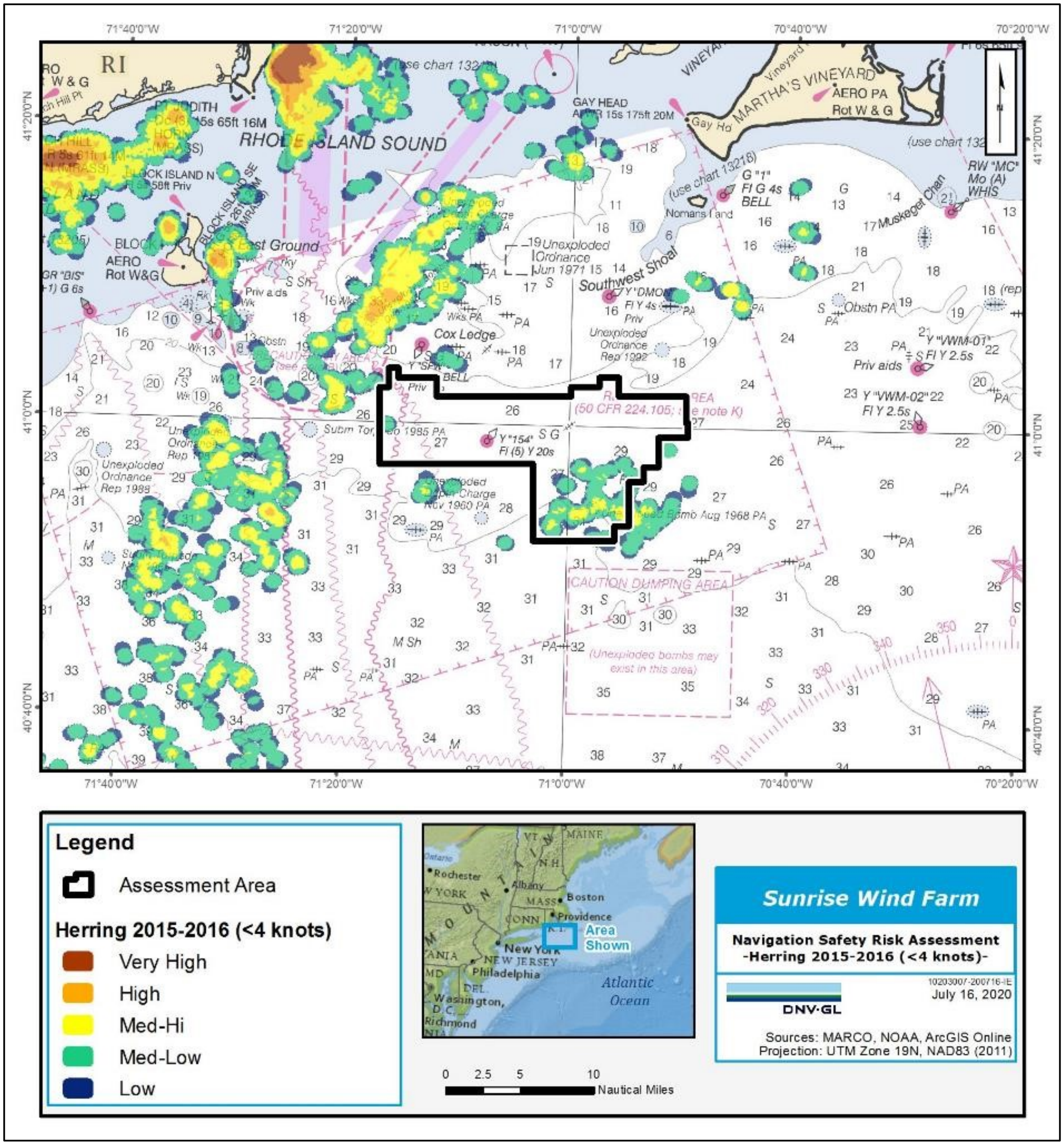


Figure 2-15 Commercial fishing vessel density - herring fishing at less than 4 kt, 2015-2016 (VMS) (MARCO, 2020)

Fishing activity by permitted gear (VTR data)

The most recent publicly available data were obtained for fishing gear use in the Marine Traffic Study Area. The data cover the period 2011 through 2015 and were obtained from Communities at Sea (MARCO, 2020). Figure 2-16 to Figure 2-21 show activity level by fishing gear type, in order of relative activity in the Project Assessment Area. The principal ports of the registered vessels using the specified fishing gear are labeled in each figure.

The data show that:

- Gillnet activity and bottom trawl activity (greater than 65 ft in length) were generally less in the Assessment Area than other parts of the region, with more activity in the center of the Assessment Area.
- Sparse less-than-average bottom trawl (less than 65 ft in length) and dredging activity occurred in the Assessment Area.
- Below average pots and traps activity occurred in a small portion of the Assessment Area.
- No longline activity occurred in the Assessment Area during the evaluated five-year period.

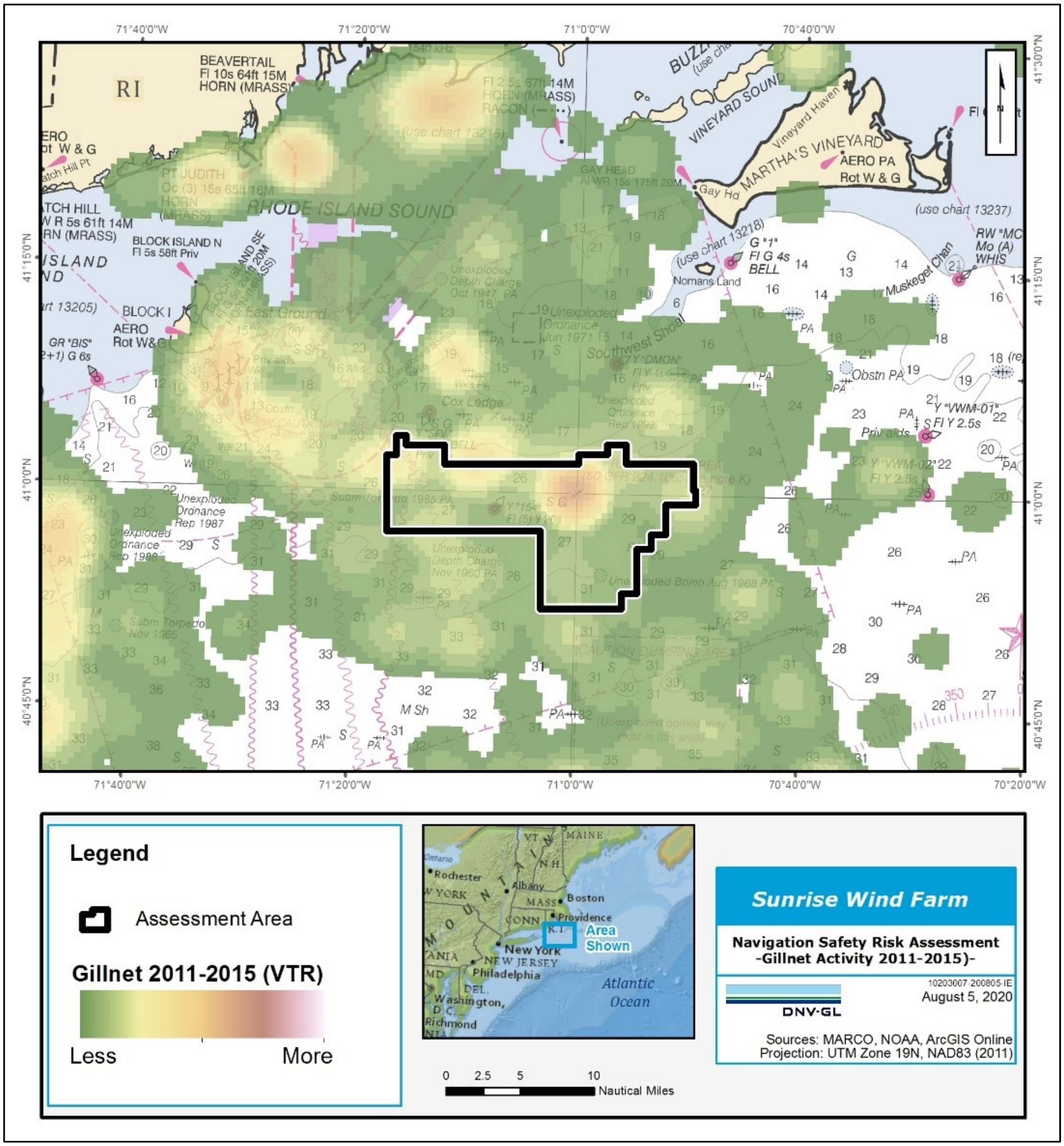


Figure 2-16 Total gillnet activity, 2011-2015 (MARCO, 2020)

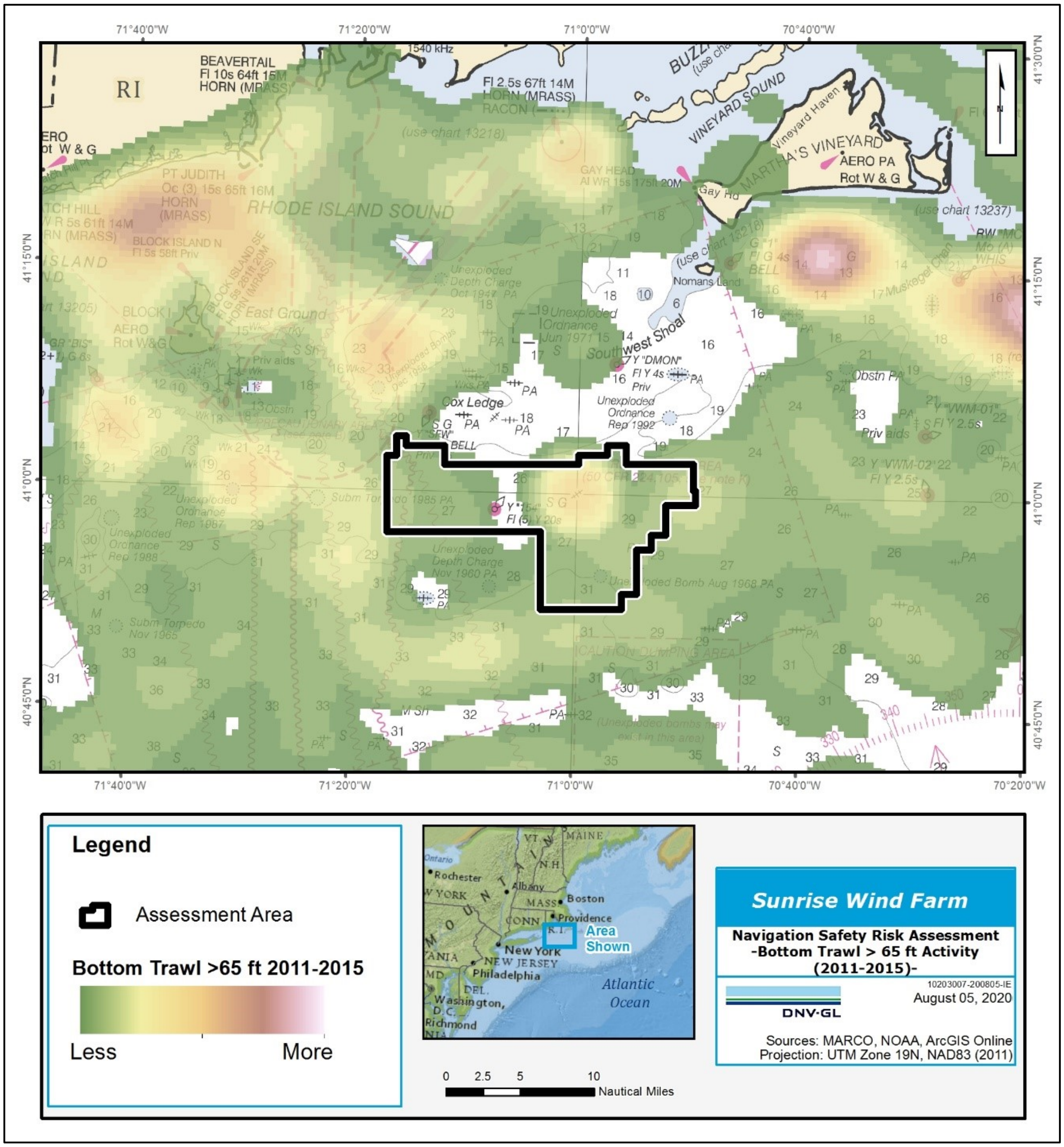


Figure 2-17 Total bottom trawl (>65 ft) activity, 2011-2015 (MARCO, 2020)

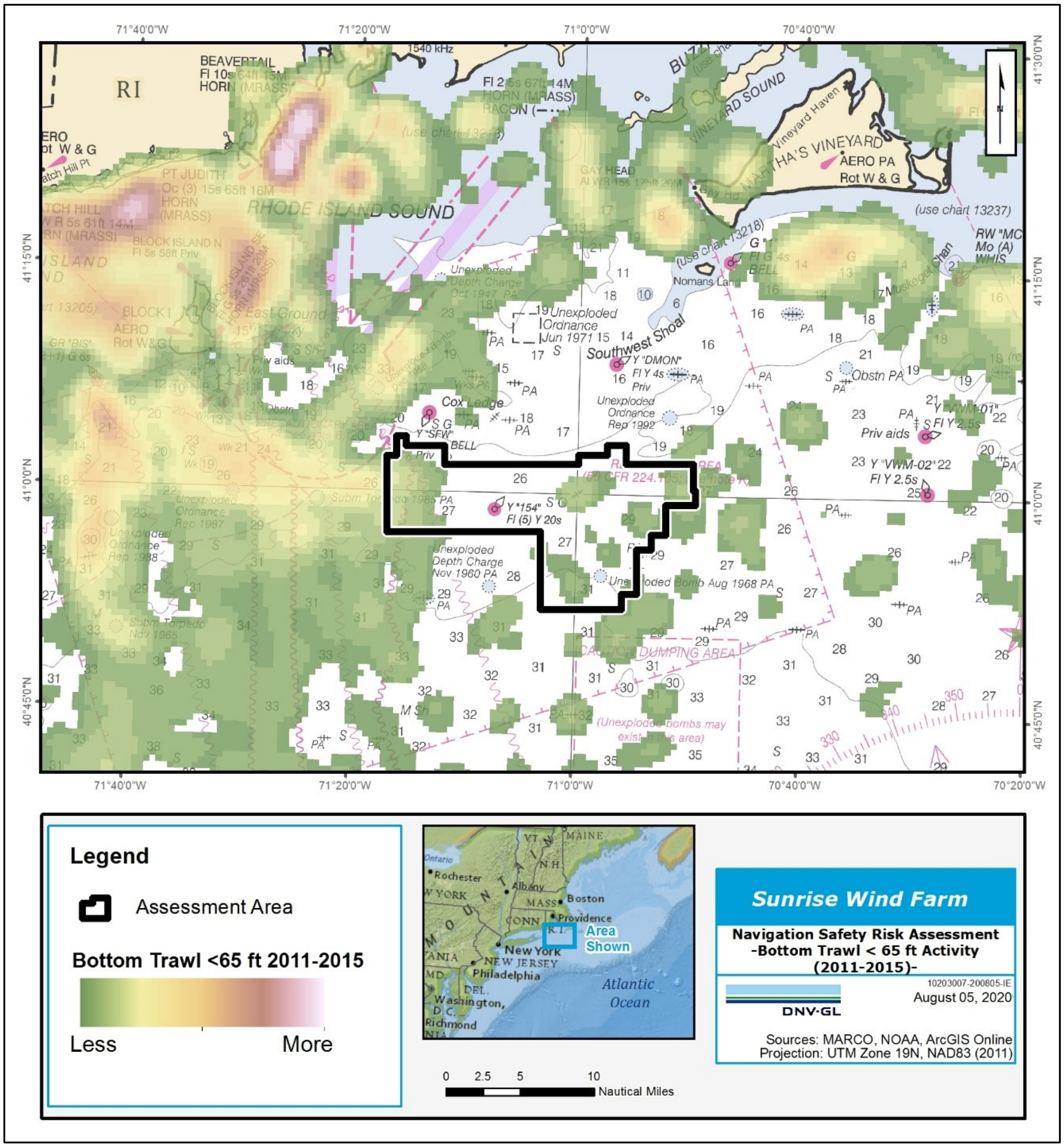


Figure 2-18 Total bottom trawl (<65 ft) activity, 2011-2015 (MARCO, 2020)

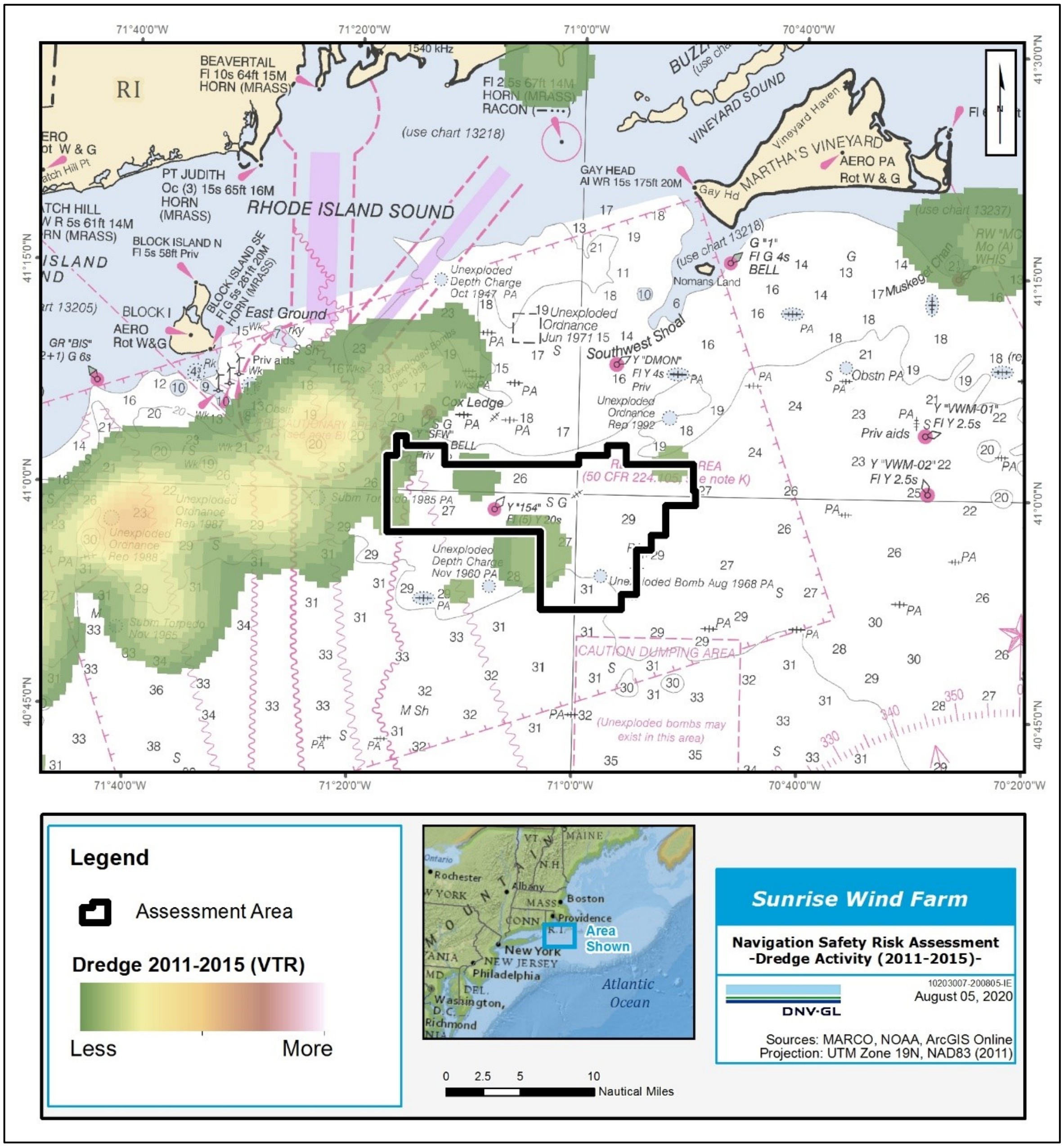


Figure 2-19 Total dredge activity, 2011-2015 (MARCO, 2020)

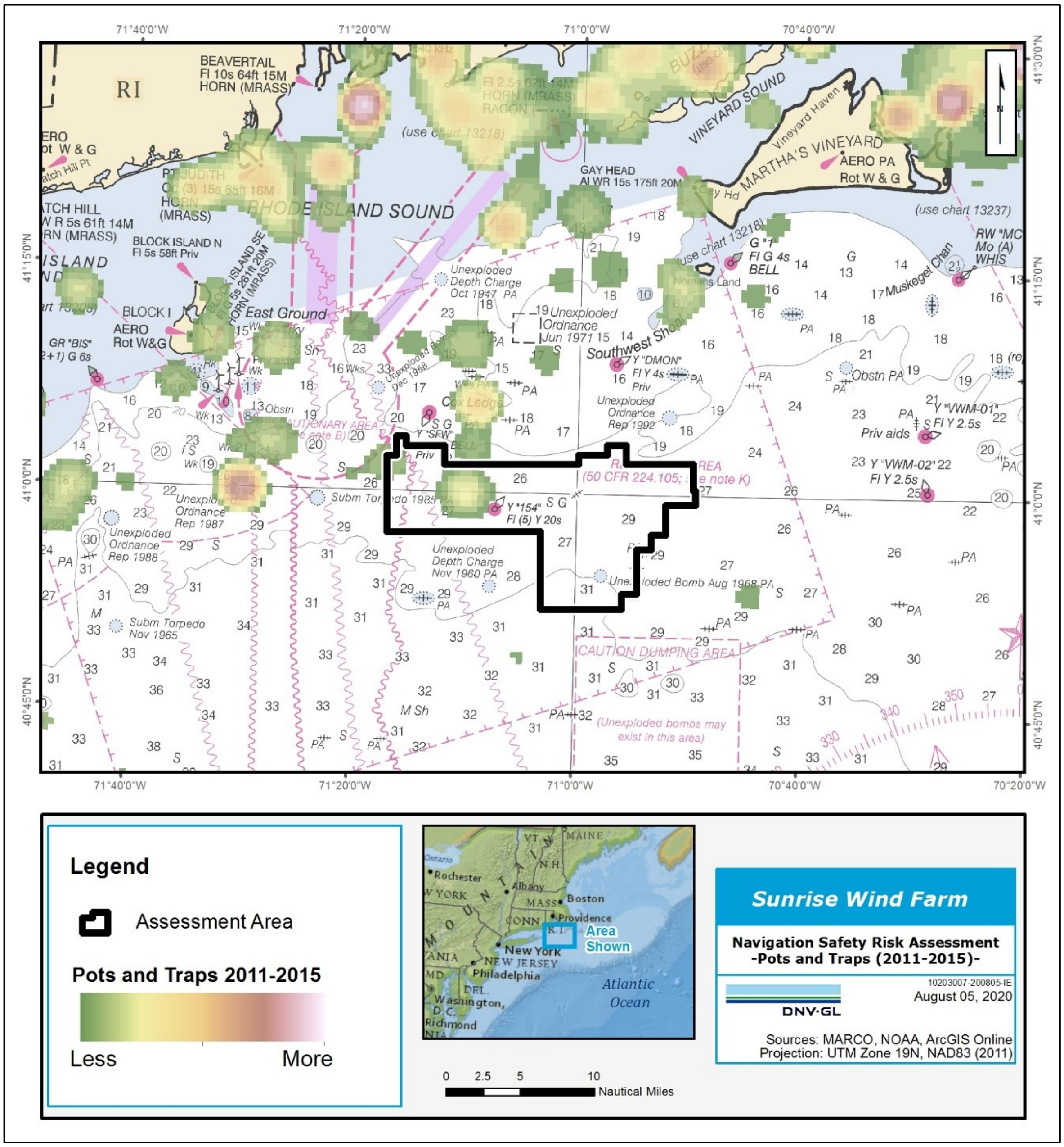


Figure 2-20 Total pots and traps activity, 2011-2015 (MARCO, 2020)

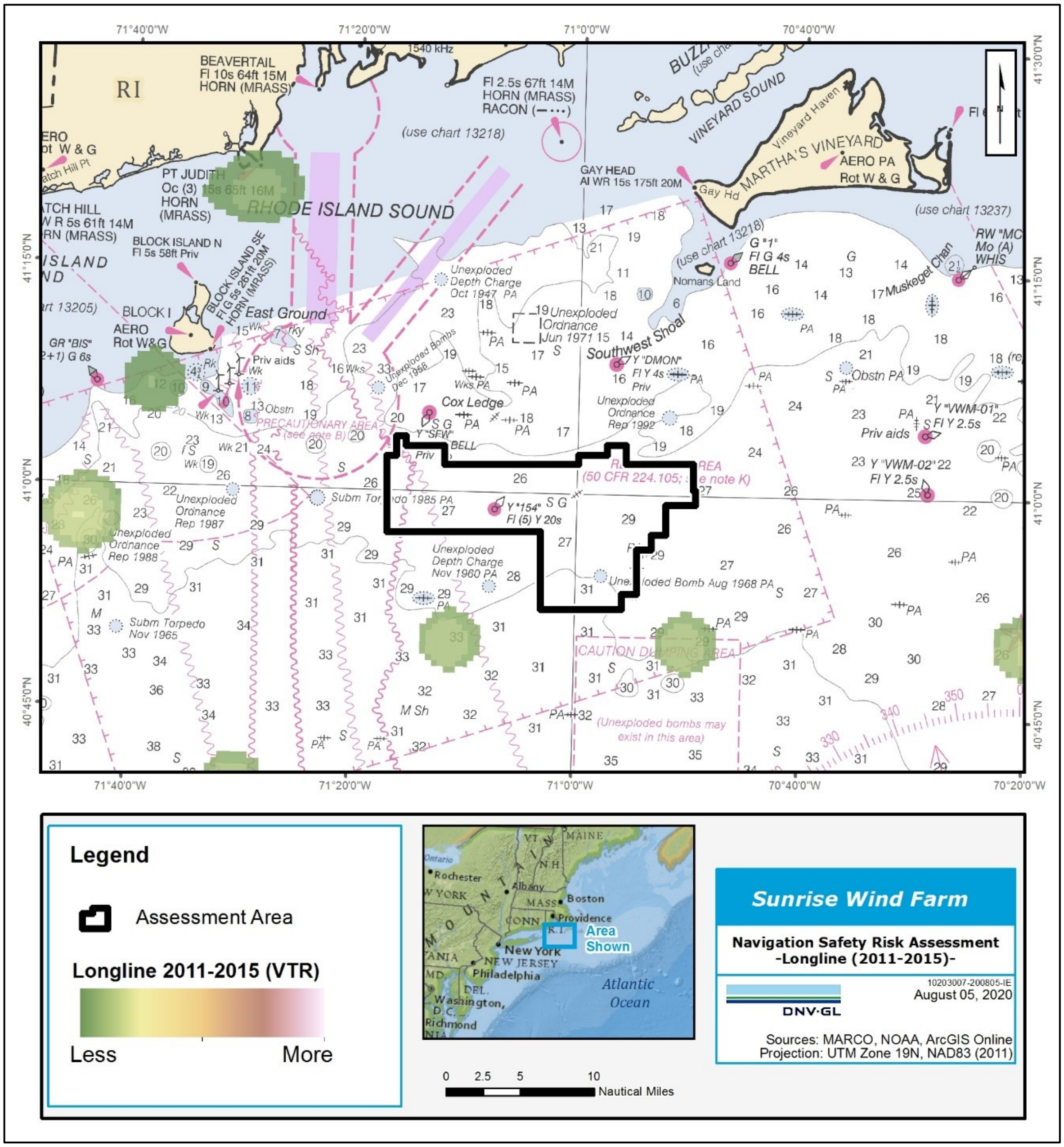


Figure 2-21 Total longline activity, 2011-2015 (MARCO, 2020)

Information from Coast Guard MARI PARS

The Coast Guard MARI PARS report (Coast Guard, 2020a) provides additional information about commercial fishing activity. The report shows vessel traffic fishing for squid, mackerel, butterfish, and lobster following an east-west pattern for vessels less than 65 ft in length. This activity is highest in August and September.

2.1.1.3 Passenger vessel traffic

Figure 2-22 shows that passenger vessels (including ferries and cruise ships) largely follow established routes near the coast and within the Narragansett Bay Traffic Separation Scheme (TSS).

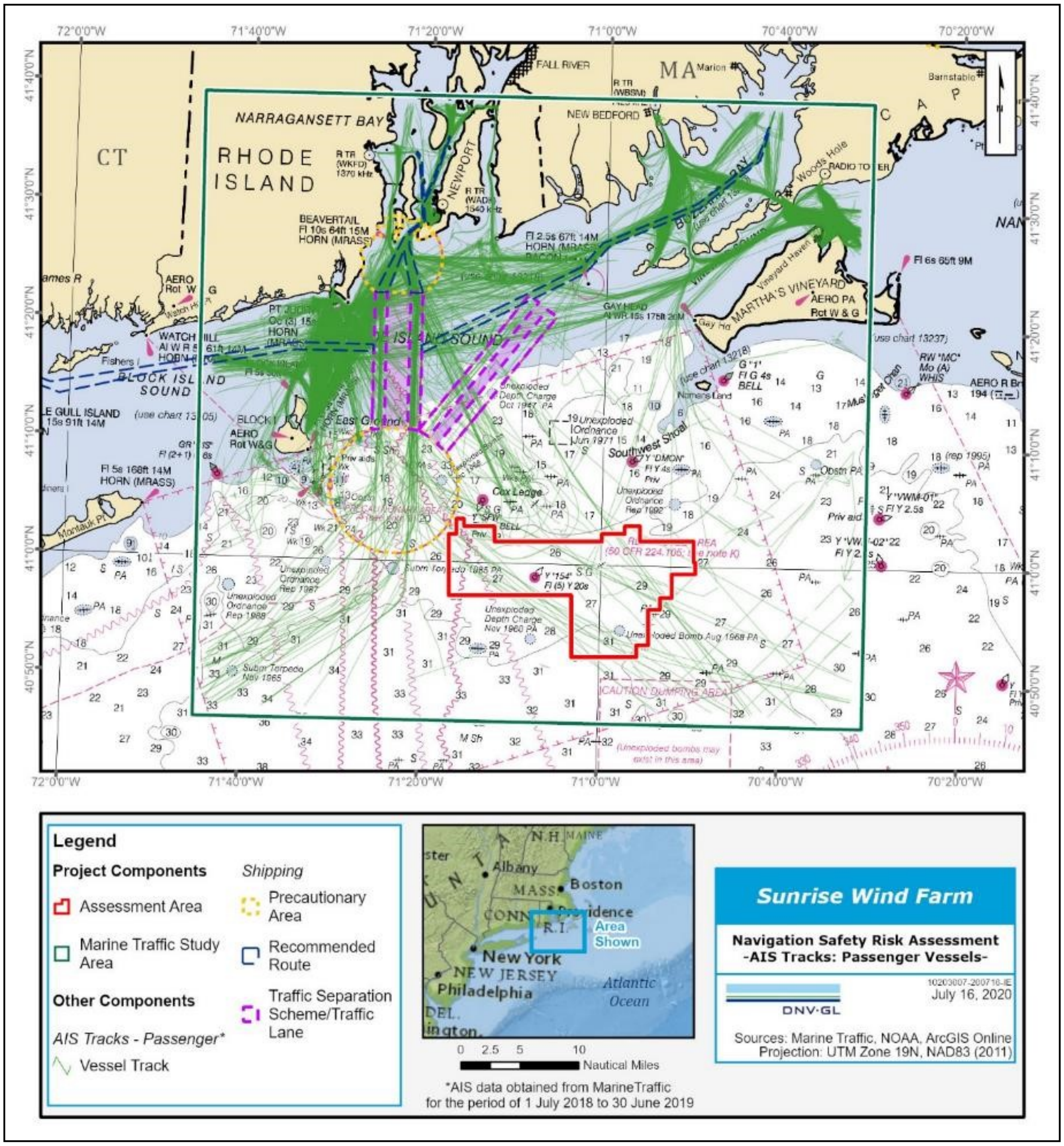


Figure 2-22 AIS tracks for passenger vessels[4]

2.1.1.4 Pleasure vessel traffic

Pleasure vessels include recreational boating and are defined for the purposes of this study as AIS ship types "Pleasure Craft", "Sailing Vessel", and "Yacht". The data show pleasure and recreation vessel traffic primarily occurs near the coast (Figure 2-23), with relatively few tracks in the Project Assessment Area. The AIS tracks that go through the Assessment Area have either northwest-southeast or southwest-northeast general directionality.

Similarly, the recreational boating density map from the Mid-Atlantic Ocean Data Portal (MARCO, 2020) (Figure 2-24) shows that there are a much greater number of AIS recreational vessel tracks near the coast than in the vicinity of the Assessment Area.

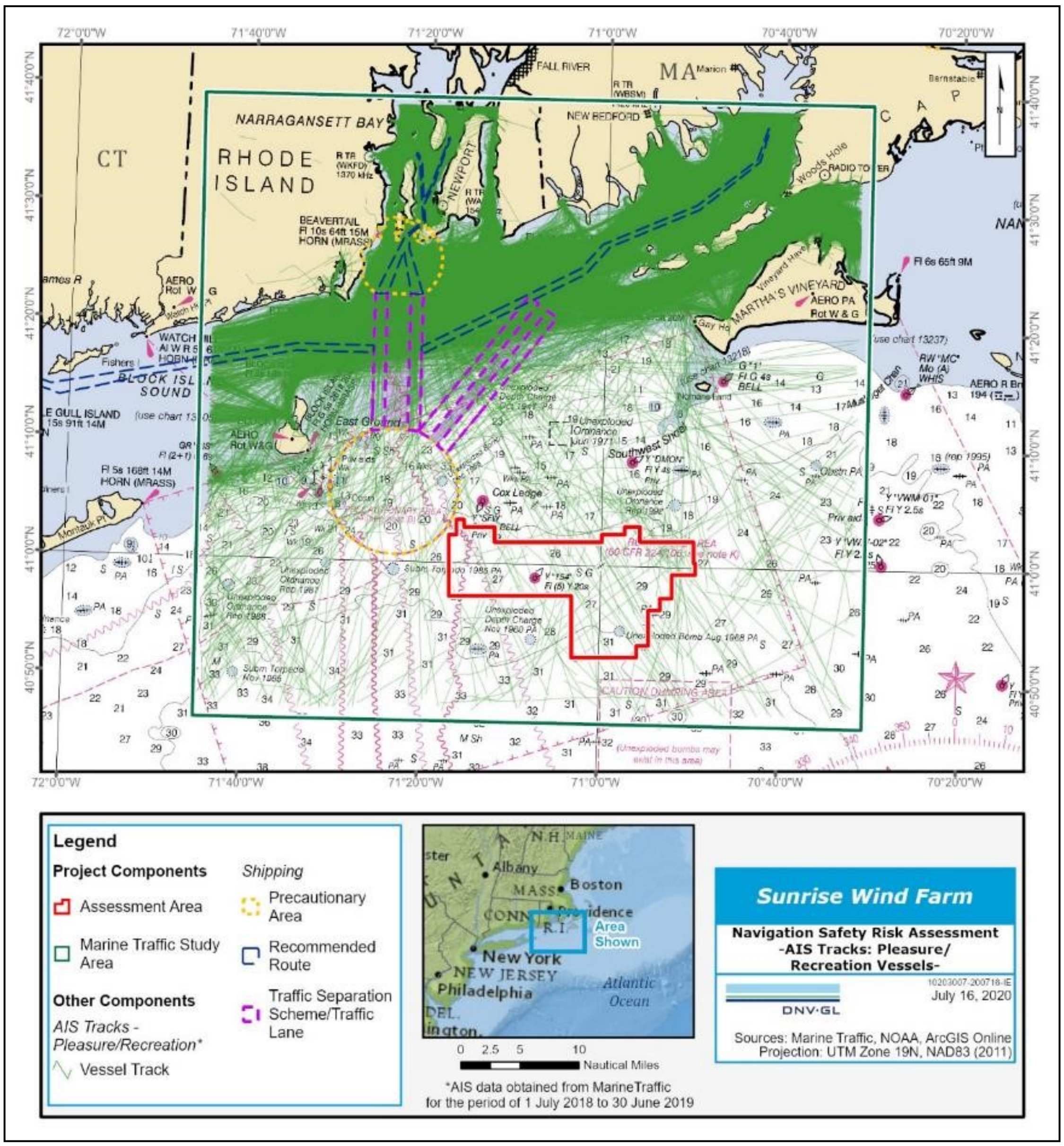


Figure 2-23 AIS tracks for pleasure/recreation vessels[4]

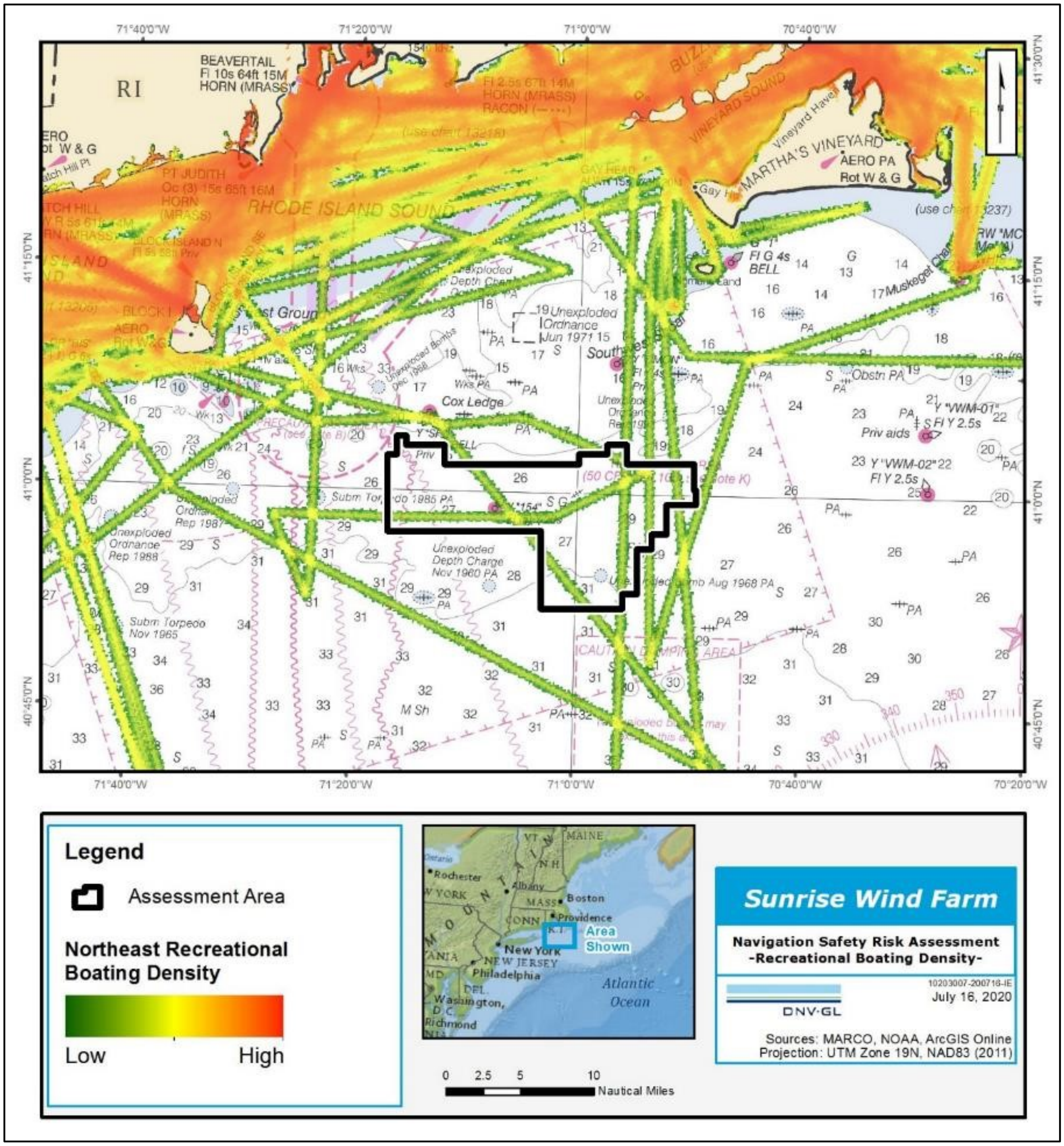


Figure 2-24 Recreational boating density (MARCO, 2020)

To ensure that the most realistic traffic is used in DNV GL's proprietary MARCS software, pleasure vessel transits were added to the transits indicated in the AIS data for the purposes of risk modeling (summarized in Section 11). The following paragraphs describe the method used and the resulting estimated number of transits.

Data on recreational boating were obtained from the Northeast Ocean Data Portal. The activities are from participants in the 2012 Northeast Recreational Boater survey, conducted by SeaPlan (2013), the Northeast Regional Ocean Council (NROC), states' coastal agencies, marine trade association of industry representatives, and the First Coast Guard District. The data are from a randomly selected survey of registered boaters in the 2012 boating season.

The data contain 760 registered activities in the defined Marine Traffic Study Area: 386 for fishing activity and 374 for other pleasure activities (such as diving and swimming). Each record was implemented in the model as an outbound and a return transit. The traffic patterns derived from the AIS analysis for fishing vessels and pleasure vessels were examined and the most densely trafficked routes closest to the Project Assessment Area were selected. The additional traffic was allocated to these routes. This represents a reasonable worst-case assessment of traffic that does not transmit AIS.

2.1.1.5 Tug/Service traffic

The AIS tracks for tugs and service vessels show distinct patterns, as seen in Figure 2-25. Most vessels transit coastwise and do not enter the Project Assessment Area. The tugs and service vessels transiting to/from open waters generally take the Buzzards Bay TSS.

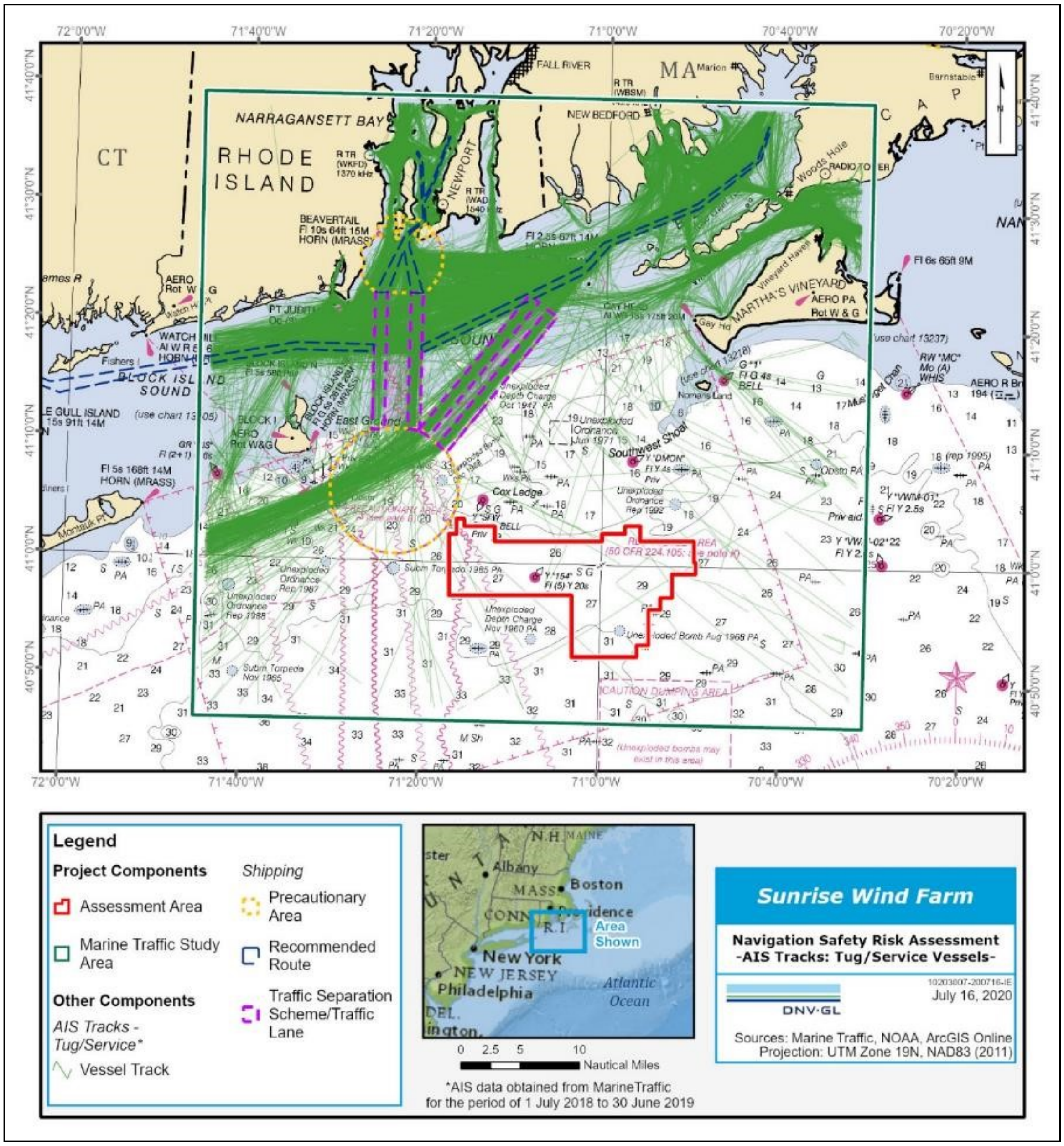


Figure 2-25 AIS tracks for tugs[4]

2.1.1.6 Other vessel traffic

AIS tracks for "Other" vessel types are presented in Figure 2-26. Other vessels are within AIS vessel sub-categories that do not clearly fit into other categories, including research vessels and military vessels. Most of these vessels generally transit near the coast and do not enter the Project Assessment Area. Vessel tracks outside the Assessment Area are likely to also include commercial fishing vessels headed to common fishing areas (Coast Guard, 2020a).

Within the Assessment Area, the majority of the tracks appear to be from research/data-gathering vessels because of the grid patterns produced by their tracks. These likely were conducting site characterization surveys for the Project.

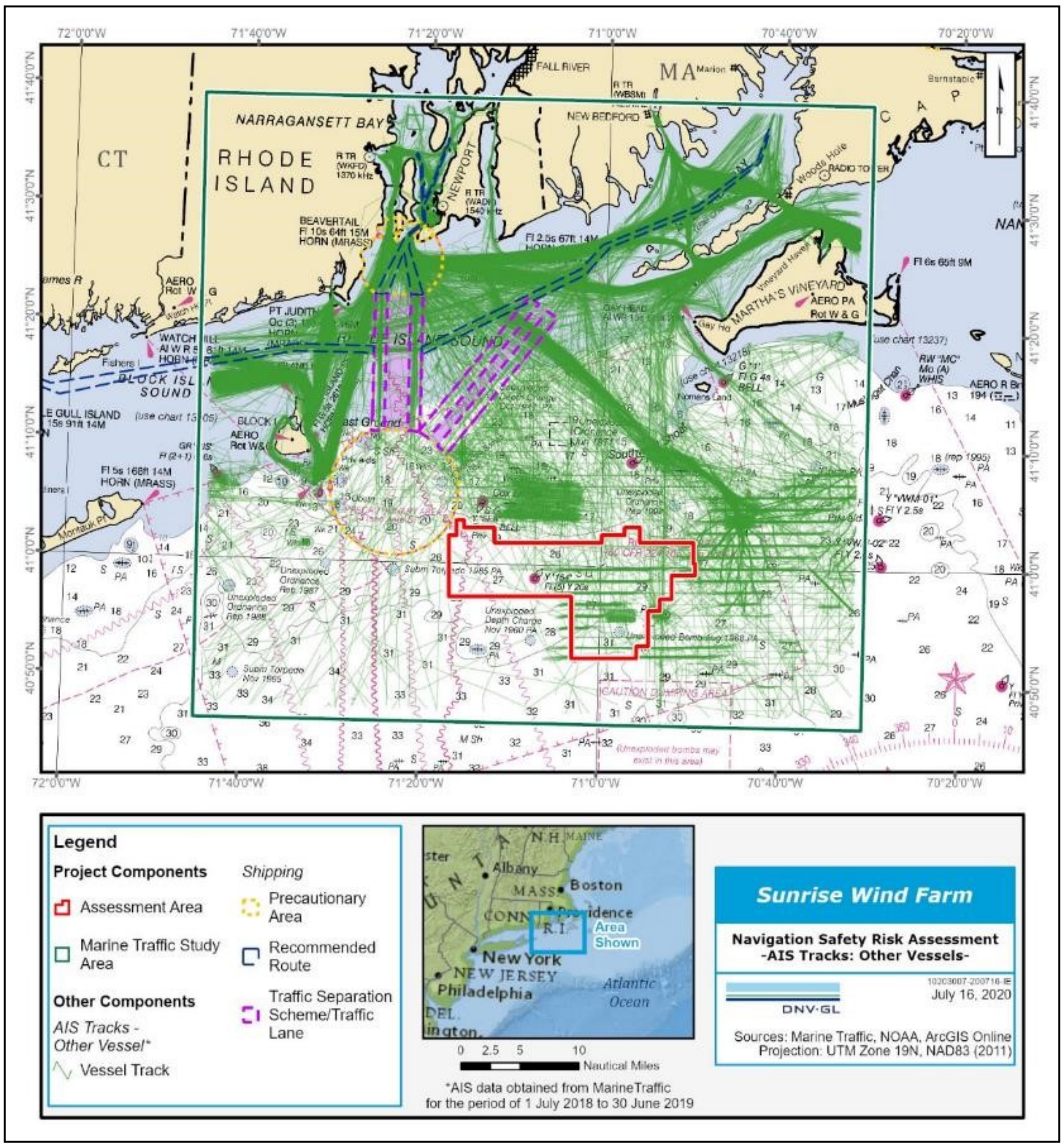


Figure 2-26 AIS tracks for other vessels[4]

2.1.2 Traffic density

Figure 2-27 presents a density heat map for all AIS points in the Marine Traffic Study Area. The traffic density shows that vessels are significantly closer together in space/time near the coast and in the TSS. Density maps for each ship type are provided in Appendix A.

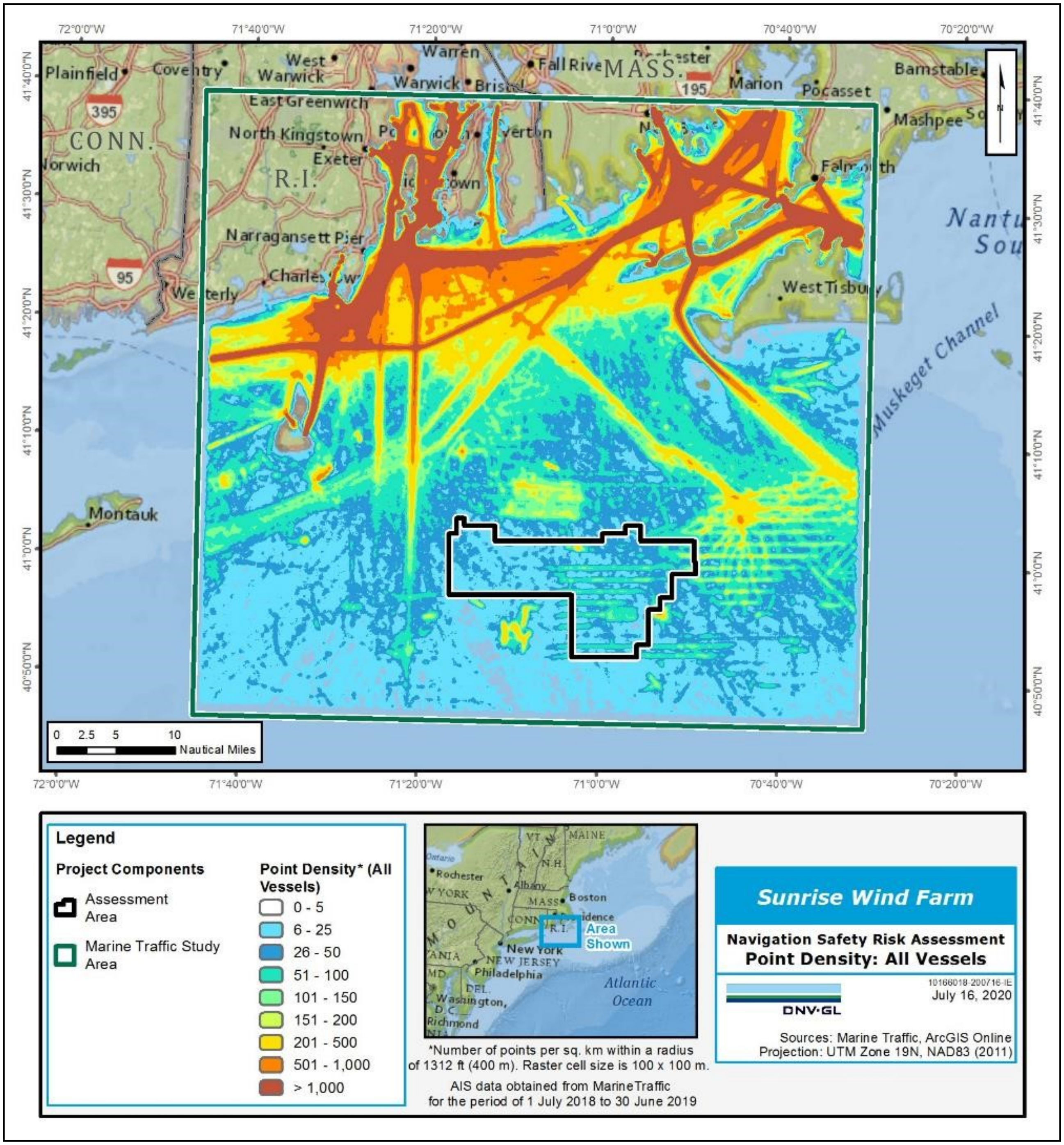


Figure 2-27 AIS point density[4]

2.1.3 Traffic statistics

This section presents the traffic statistics of the Marine Traffic Study Area. The statistics provide insight concerning how many vessels and which types transit in specific locations and allows an estimate of the distribution of transits per vessel type. The below statistics are based on AIS data; therefore, fishing a pleasure vessel counts are likely less than actual values.

2.1.3.1 Transit counts

Transit counts per transect

Figure 2-28 shows the transects defined for this traffic analysis. The locations of the transects were selected to evaluate the major routes in the Marine Traffic Study Area. The resulting number of vessels crossing each transect provides a view of marine traffic in the one year of AIS data, July 2018 through June 2019.

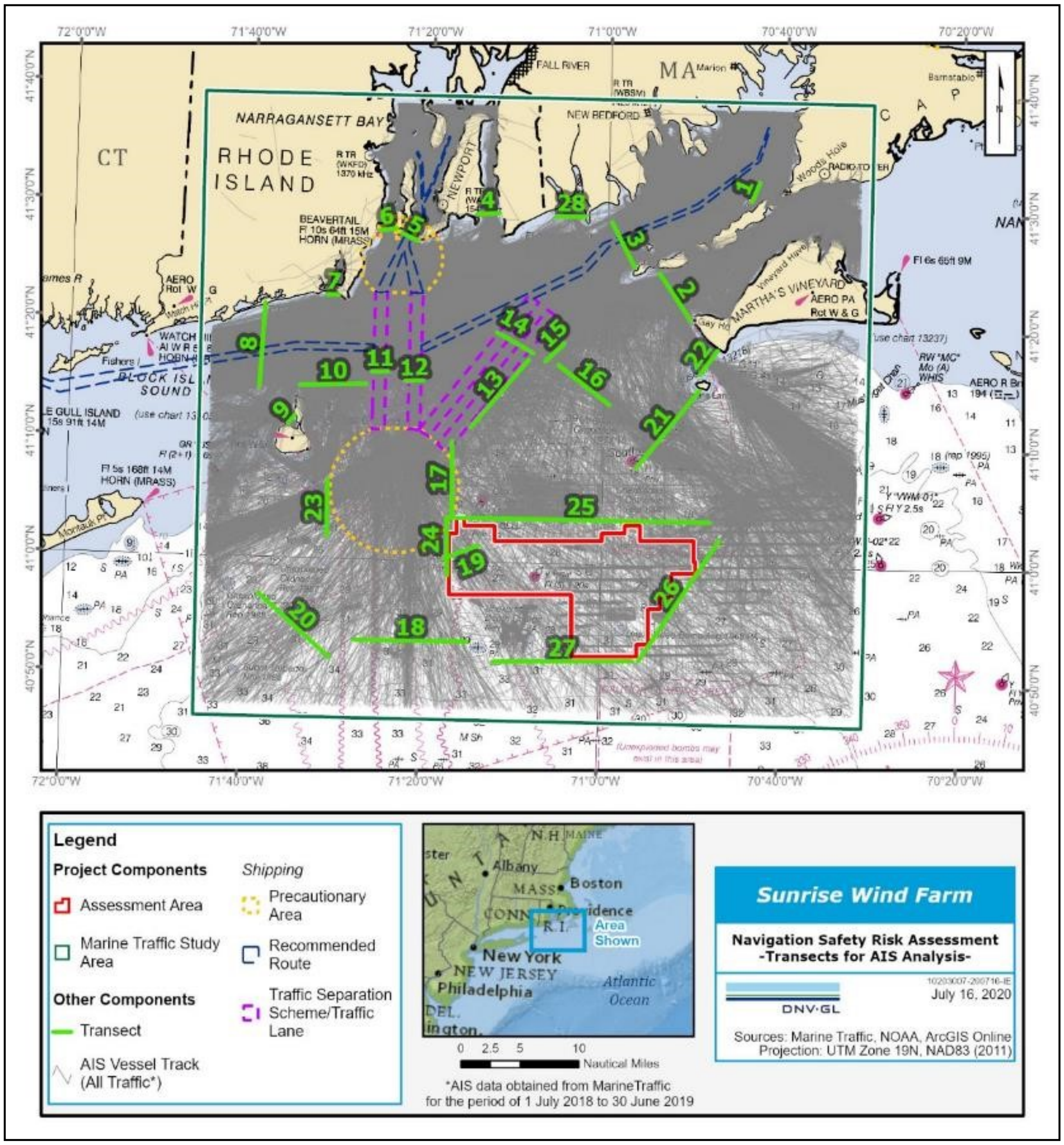


Figure 2-28 Transects used for statistical analysis of traffic[4]

Figure 2-29 presents the total number of transits per transect in the year of AIS data, July 2018 through June 2019.

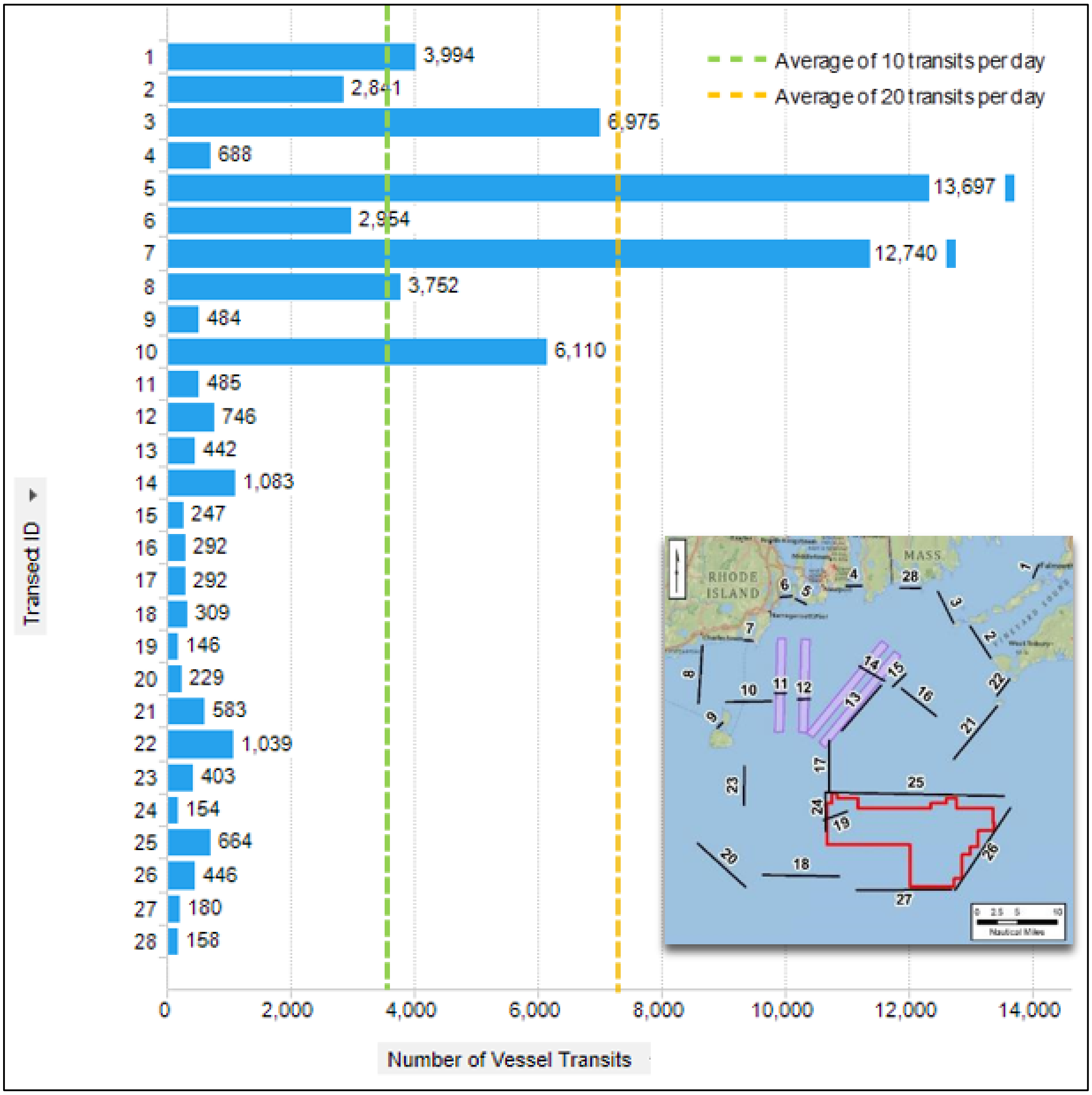


Figure 2-29 Annual number of transits per transect[4]

Most of the transects have very low traffic levels of less than 10 transits per day (less than 3,650 transits per year). Transects 5 (entrance of Narragansett Bay via East Passage) and 7 (Pt Judith) have a comparatively higher level of traffic, each with an average of 35 to 38 transits per day, 13,000 per year.

Transects 3 (entrance of Buzzards Bay) and 10 (northeast of Block Island) each have an average of slightly less than 20 transits per day, 6,000 to 7,000 per year. Transects 1 (Woods Hole Pass), 2 (entrance of Vineyard Sound), 6 (entrance of Narragansett Bay via West Passage) and 8 (entrance of Block Island Sound) average around 8 transits per day, about 3,000 transits per year.

Figure 2-30 to Figure 2-33 present the distribution of transits per vessel type for each transect. Transects near the coast show a predominance of fishing (commercial), pleasure (including recreational fishing), and other vessel types.

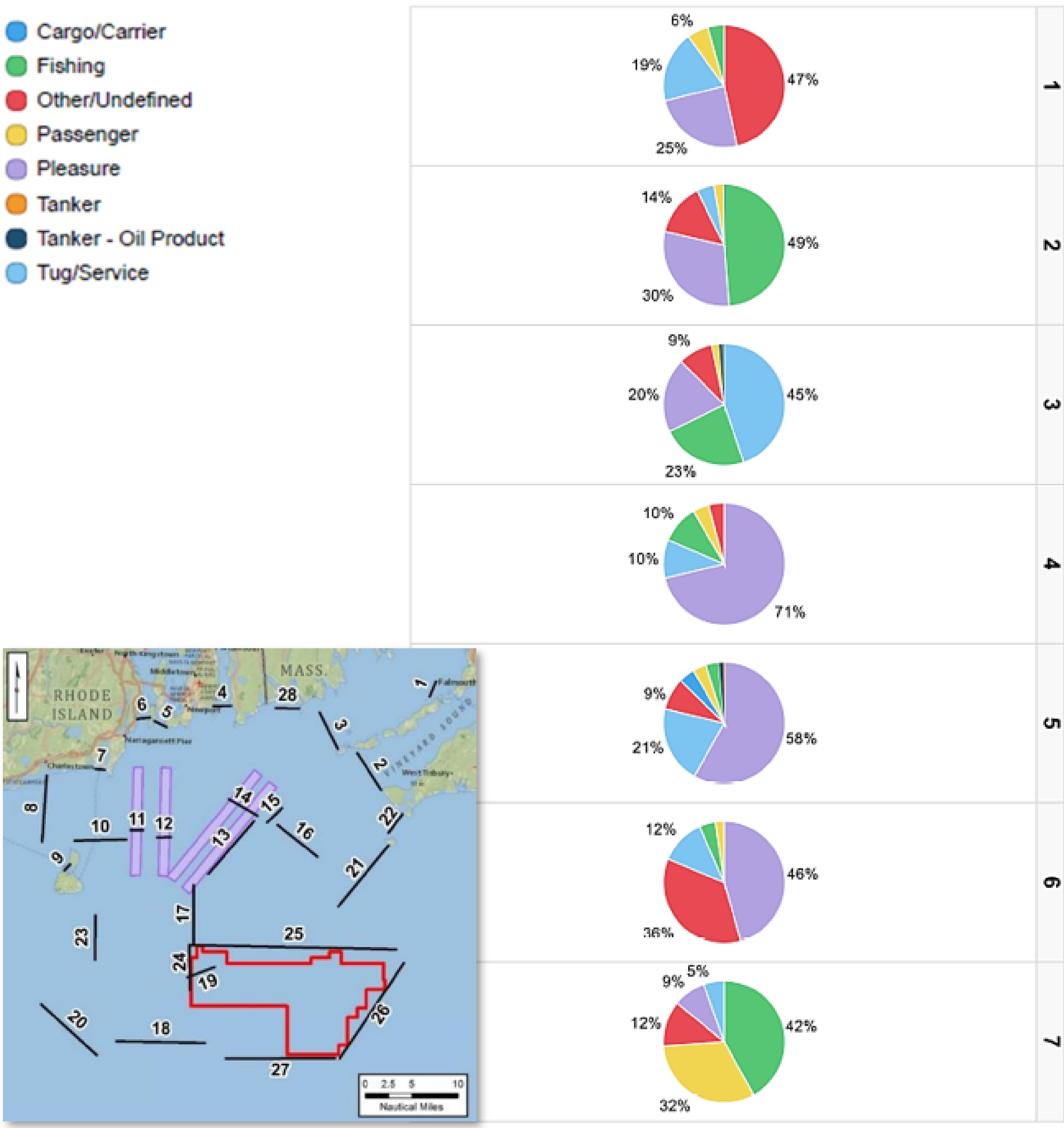


Figure 2-30 Traffic distributions for Transects 1 to 7[4]

In the TSS (transects 11, 12, and 14), cargo and carrier vessels also comprise a significant portion of the traffic. Transects 19, 25, 26, and 27 indicate that the traffic in the Project Assessment Area primarily consists of cargo, fishing, and other vessel types.

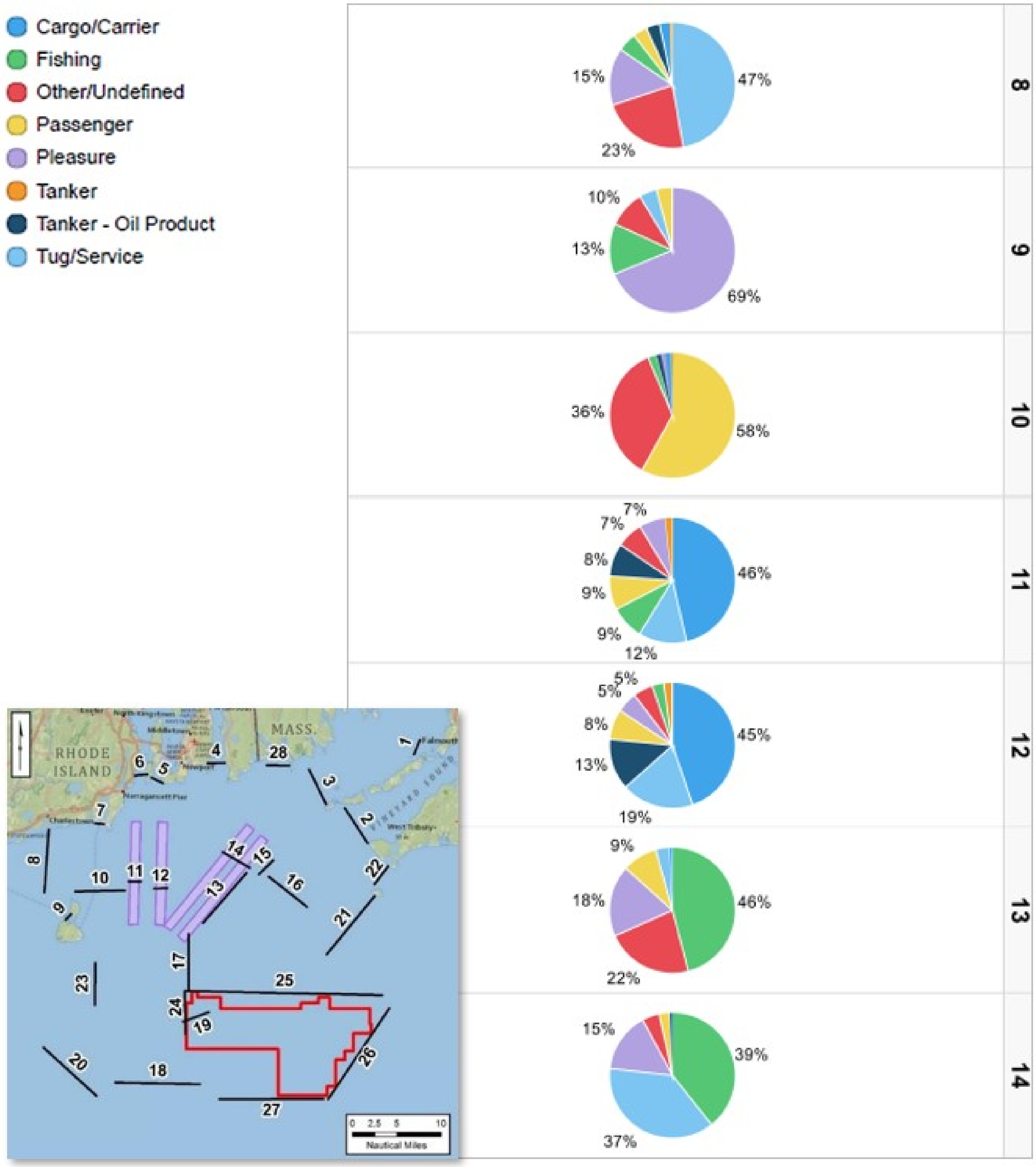


Figure 2-31 Traffic distributions for Transects 8 to 14[4]

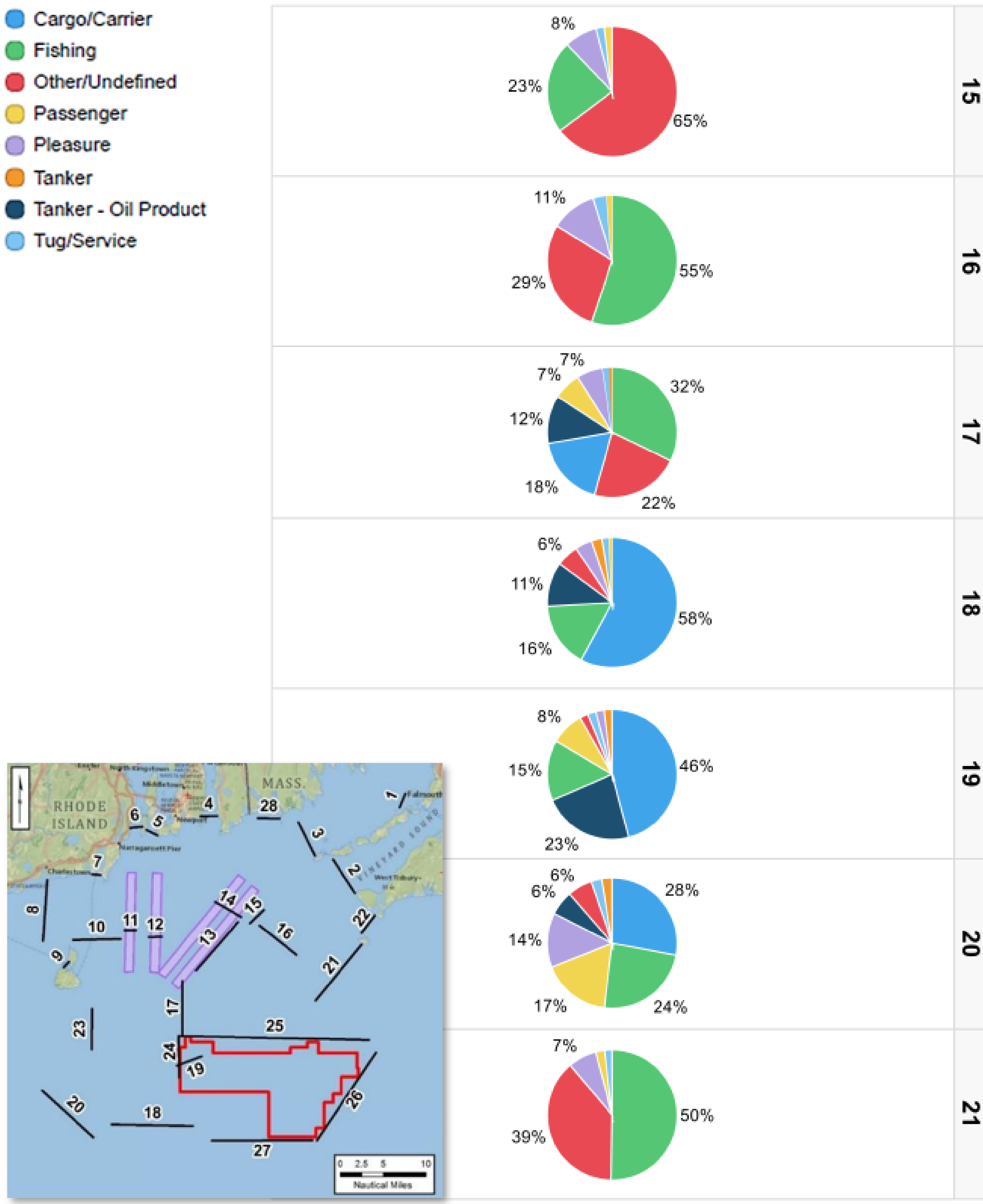


Figure 2-32 Traffic distributions for Transects 15 to 21[4]

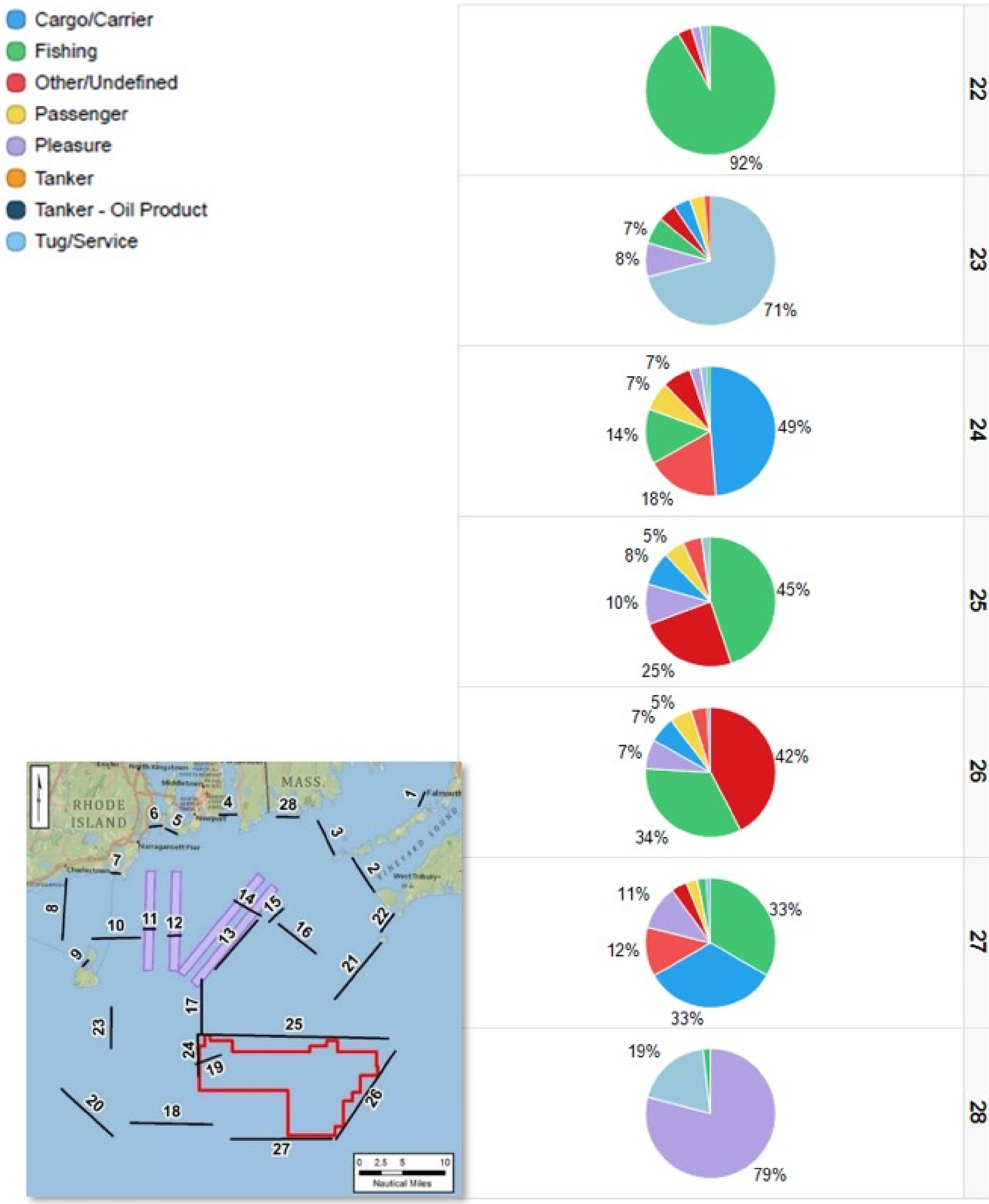


Figure 2-33 Traffic distributions for Transects 22 to 28[4]

2.1.3.2 Vessel size

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

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

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

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

Size distributions for Length Overall (LOA), beam, and DWT for vessels in the Marine Traffic Study Area are provided in Figure 2-34 to Figure 2-36.

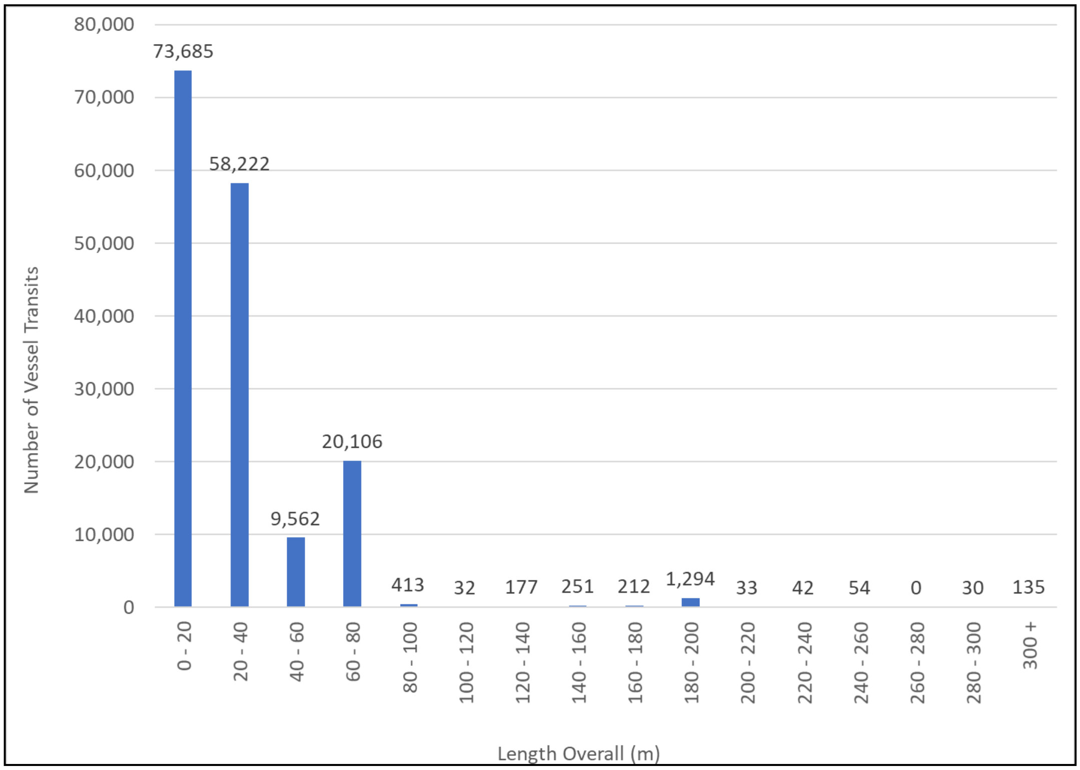


Figure 2-34 LOA distribution in Marine Traffic Study Area[4]

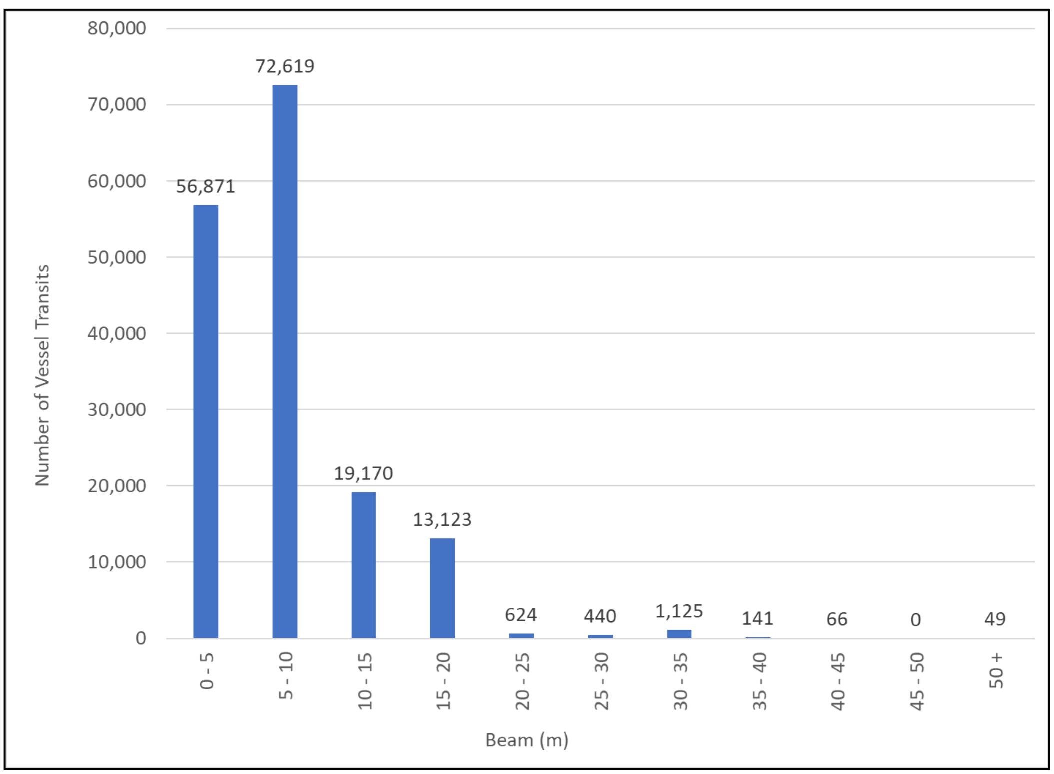


Figure 2-35 Beam distribution in Marine Traffic Study Area[4]

The data indicate that the great majority of vessels are small: less than 40 m (131 ft) LOA and 10 m (33 ft) beam. In general, all of the vessel types include data for length and beam; 95 percent of the transits included credible data in the LOA and beam fields. However, only 18 percent of the data entries included a DWT value. DWT entries were consistently present for deep draft vessels; however, only a low percentage of the data included DWT for fishing, pleasure, passenger, tug/service, and other vessel types.

The average and maximum DWT of vessels in the Marine Traffic Study Area are shown in Figure 2-36.

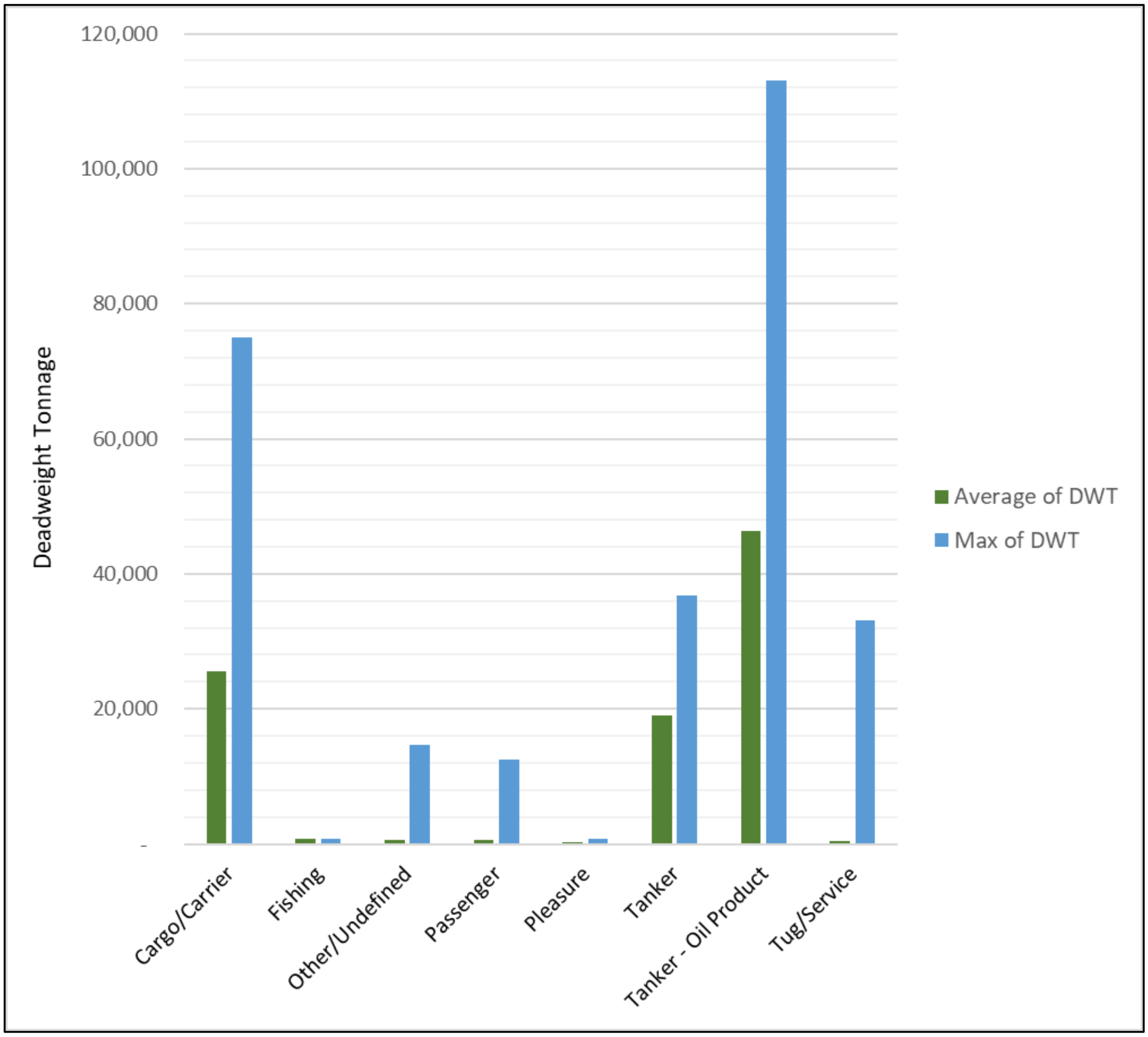


Figure 2-36 Average and maximum DWT of vessels in Marine Traffic Study Area[4]

Size distributions for vessels that entered DWT in their AIS system and transited the Marine Traffic Study Area during the 12-month period of AIS data are shown in Figure 2-37.

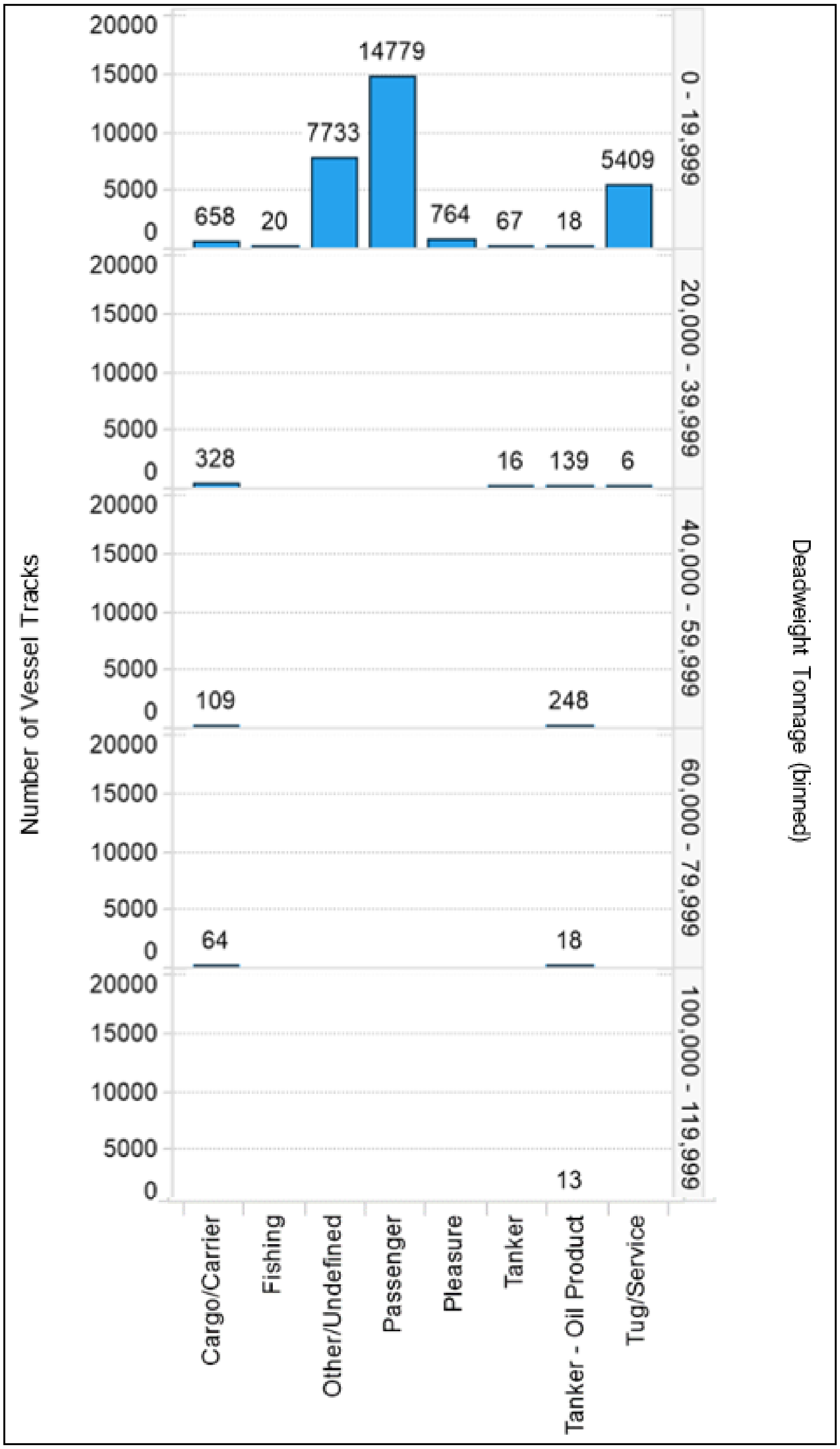


Figure 2-37 DWT distribution in Marine Traffic Study Area per vessel type[4]

Figure 2-38 through Figure 2-40 present statistics for vessels in the vicinity of the Project Assessment Area.

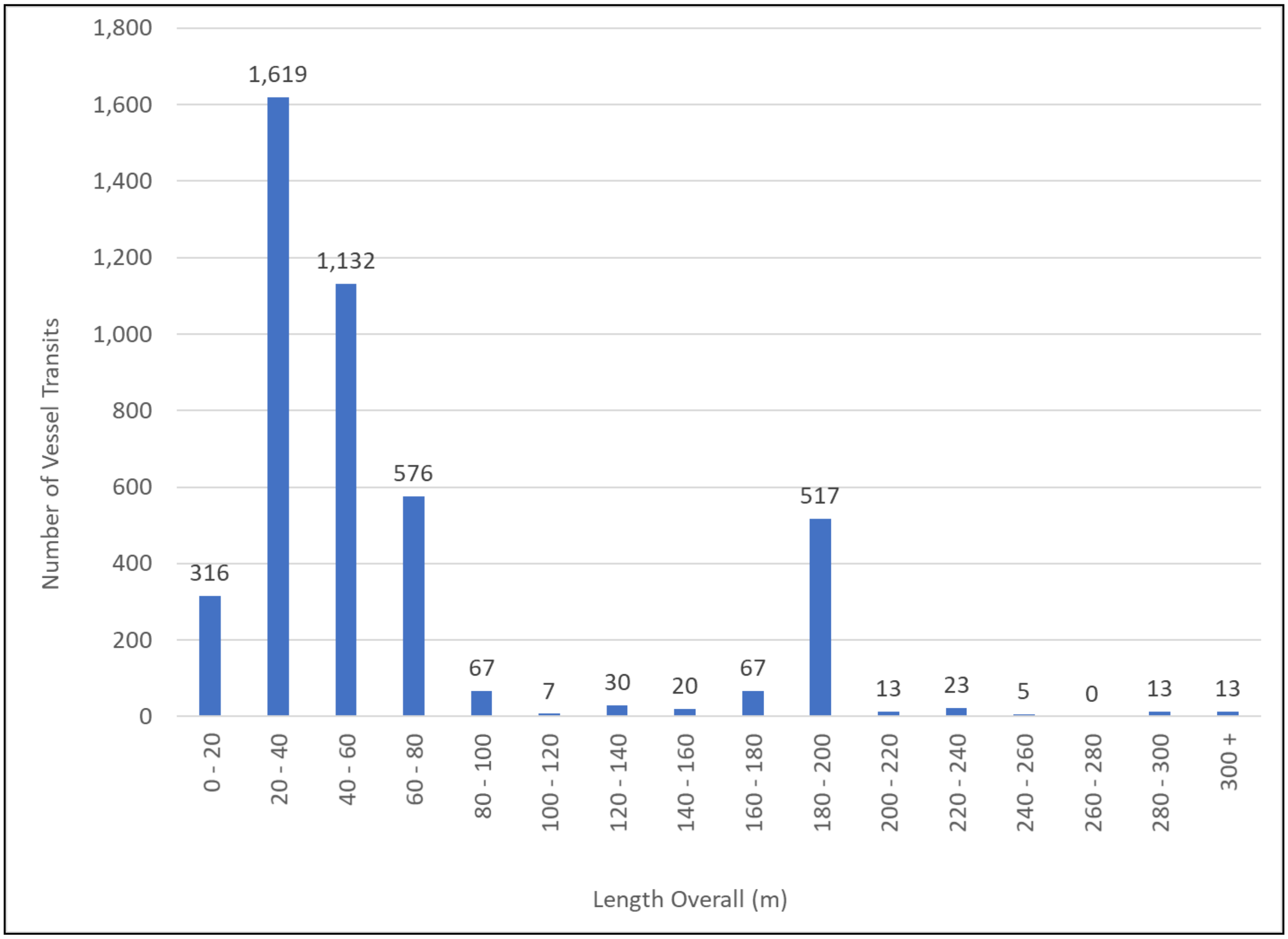


Figure 2-38 LOA distribution within 4.34 nm (8 km) of the Project Assessment Area[4]

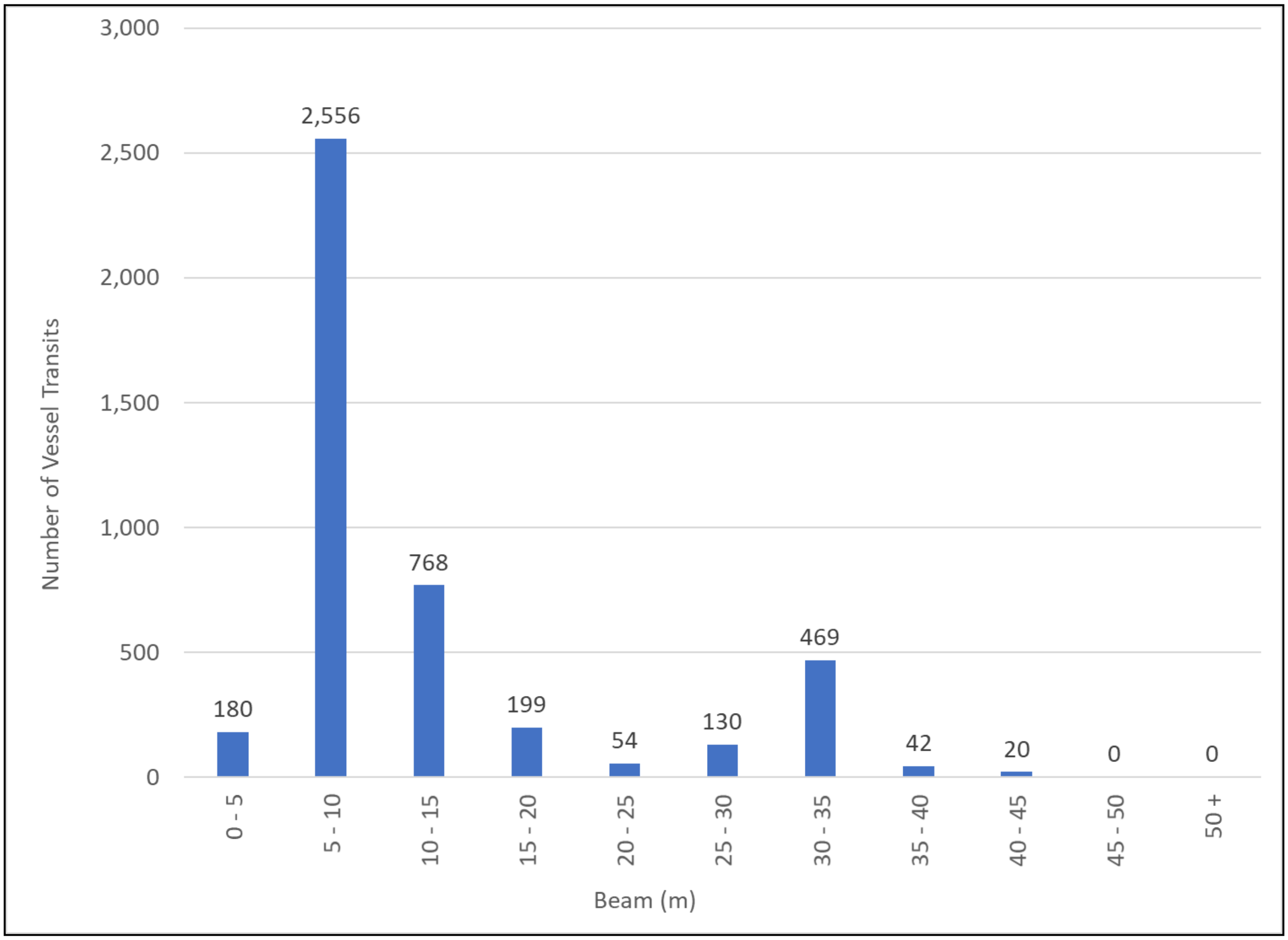


Figure 2-39 Beam distribution within 4.34 nm (8 km) of the Project Assessment Area[4]

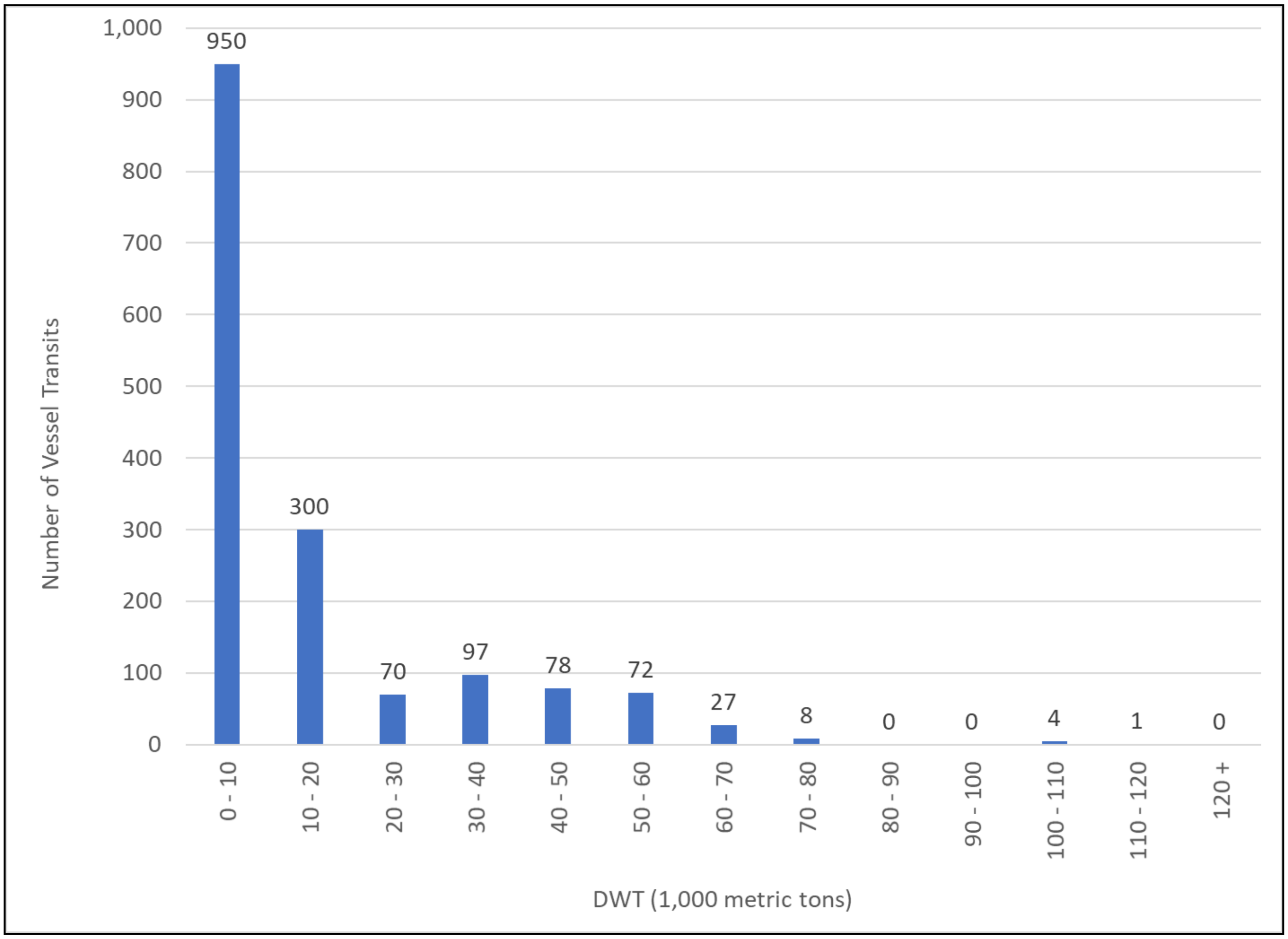


Figure 2-40 DWT distribution within 4.34 nm (8 km) of the Project Assessment Area[4]

Similar to the larger Marine Traffic Study Area, in the vicinity of the Project Assessment Area, the DWT data are less reported.

Table 2-1 presents the average, LOA, beam, and DWT for vessel types in the Marine Traffic Study Area taken from one year of AIS data (MarineTraffic, 2019). The average is based on the number of transits rather than the number of unique vessels. As expected, hydrocarbon tankers, non-hydrocarbon tankers, and cargo/carriers are the largest vessels in the Marine Traffic Study Area.

Table 2-1 Summary of vessel size and track count per vessel type in the Marine Traffic Study Area[4]

Vessel type	Count of AIS transits	Average LOA	Average beam	Average DWT
Tanker - Oil Product	436	606 ft (185 m)	100 ft (31 m)	46,315 metric tons
Cargo/Carrier	1,189	598 ft (182 m)	98 ft (30 m)	25,602 metric tons
Tanker	83	476 ft (145 m)	80 ft (24 m)	18,963 metric tons
Passenger	32,848	172 ft (52 m)	40 ft (12 m)	584 metric tons
Other/Undefined	22,045	125 ft (38 m)	32 ft (10 m)	518 metric tons
Tug/Service	22,738	83 ft (25 m)	25 ft (8 m)	421 metric tons
Fishing	34,000	83 ft (25 m)	24 ft (7 m)	742 metric tons
Pleasure	58,928	55 ft (17 m)	16 ft (5 m)	172 metric tons

Table 2-2 shows average sizes of vessels within 4.34 nm (8.0 km) of the wind farm Assessment Area. In general, the sizes of vessels in the vicinity of the Project are similar to those in the larger NSRA Marine Traffic Study Area.

Table 2-2 Summary of vessel size and track count per vessel type within 4.34 nm (8 km) of the Project Assessment Area[4]

Vessel type	Count of AIS transits	Average LOA	Average beam	Average DWT
Tanker - Oil Product	160	607 ft (185 m)	102 ft (31 m)	48,054 metric tons
Cargo/Carrier	479	618 ft (188 m)	102 ft (31 m)	25,285 metric tons
Tanker	22	509 ft (155 m)	83 ft (25 m)	21,713 metric tons
Passenger	188	312 ft (95 m)	47 ft (14 m)	7,075 metric tons
Other/Undefined	1725	185 ft (56 m)	38 ft (11 m)	1,324 metric tons
Tug/Service	48	166 ft (51 m)	43 ft (13 m)	1,925 metric tons
Fishing	1635	94 ft (29 m)	26 ft (8 m)	742 metric tons
Pleasure	224	78 ft (24 m)	21 ft (6 m)	196 metric tons

2.1.3.3 Vessel speed

This section characterizes vessel speeds in the Marine Traffic Study Area. Figure 2-41 presents speed as calculated from points in the AIS data. Speeds greater than 12 kt are visible in the more trafficked routes between islands and traffic south of the TSS.

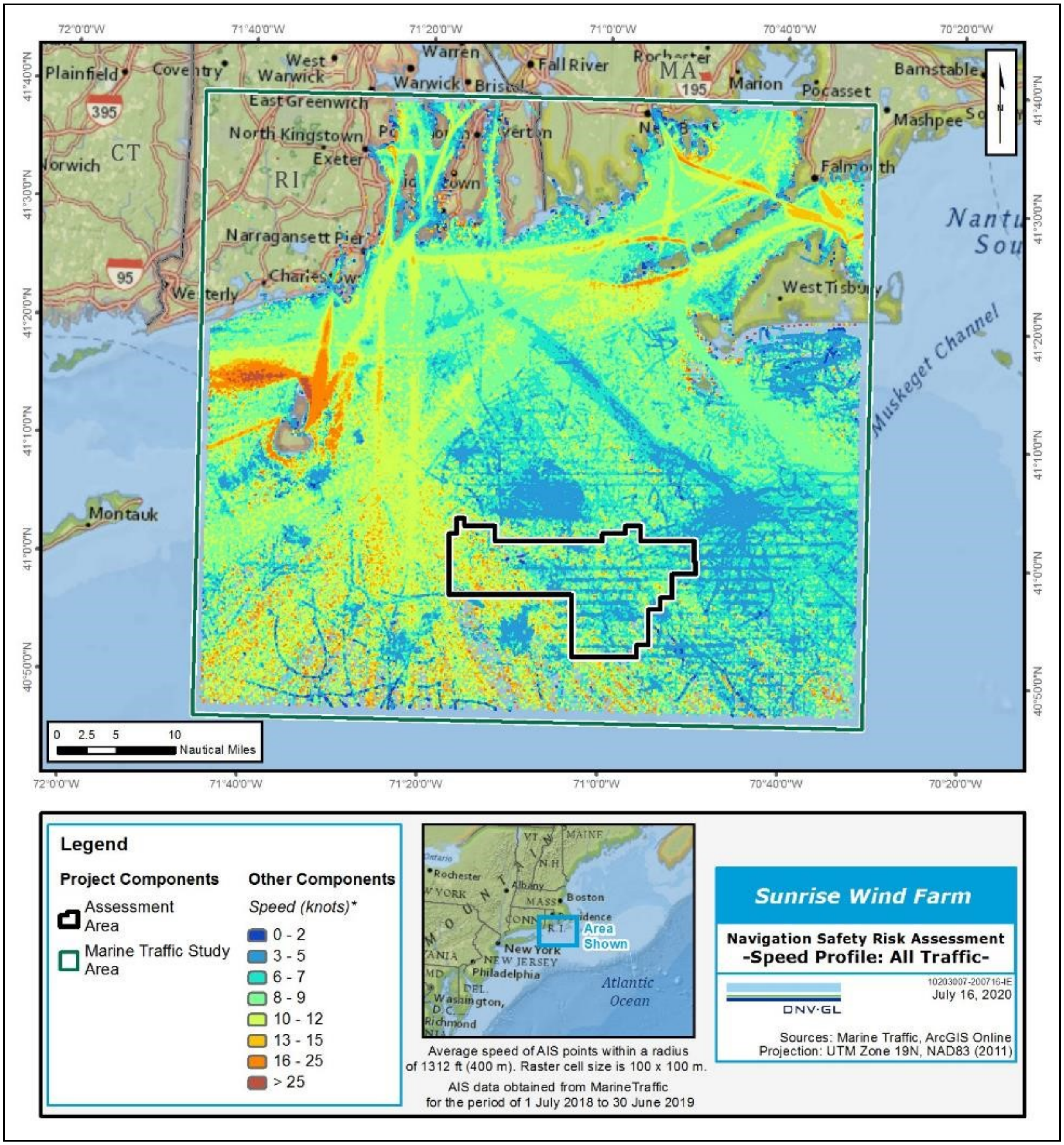


Figure 2-41 Speed profile of all vessels in the AIS data[4]

The speed of 75 percent of the vessels in the Marine Traffic Study Area is between 5 and 15 kt (between 2.6 and 7.7 meters per second [m/s]). Passenger vessels have the highest average speed. Figure 2-42 shows the traffic speed distribution for each vessel type.

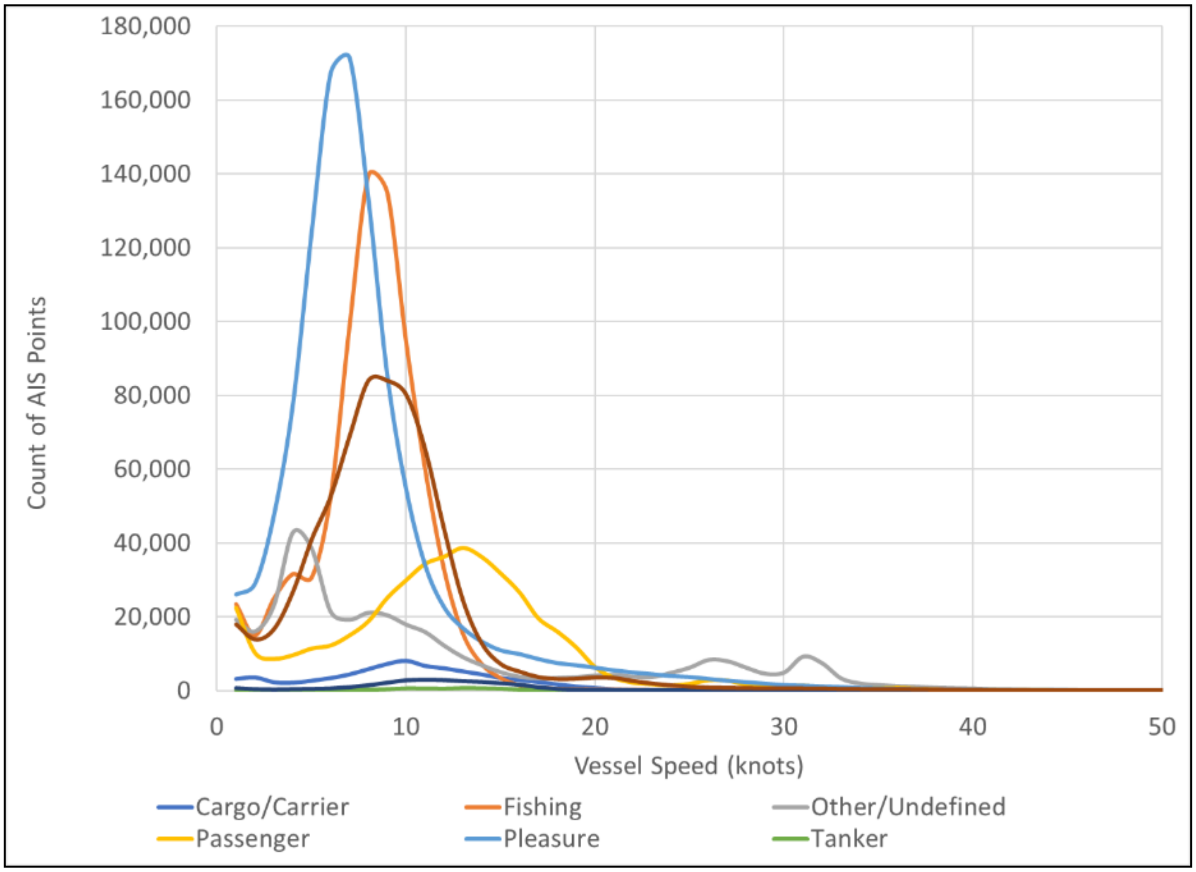


Figure 2-42 Speed profile for each vessel type in the AIS data[4]

2.1.4 Types of cargo

The cargoes arriving and departing at ports in the Marine Traffic Study Area include:

- Cars
- Liquid bulk, including fuel oil
- Bulk commodities
- Dry bulk
- Aggregate
- Break bulk (equipment, lumber, metals)
- Food

2.2 Location of the Project in relation to other activities

This section describes the proximity of the Project to navigation-related aspects. Figure 2-43 shows the navigation chart around the Project Assessment Area and Figure 2-44 shows the export cable route. Analysis of hazards related to the export cable is provided in Section 3.1 and Section 4.

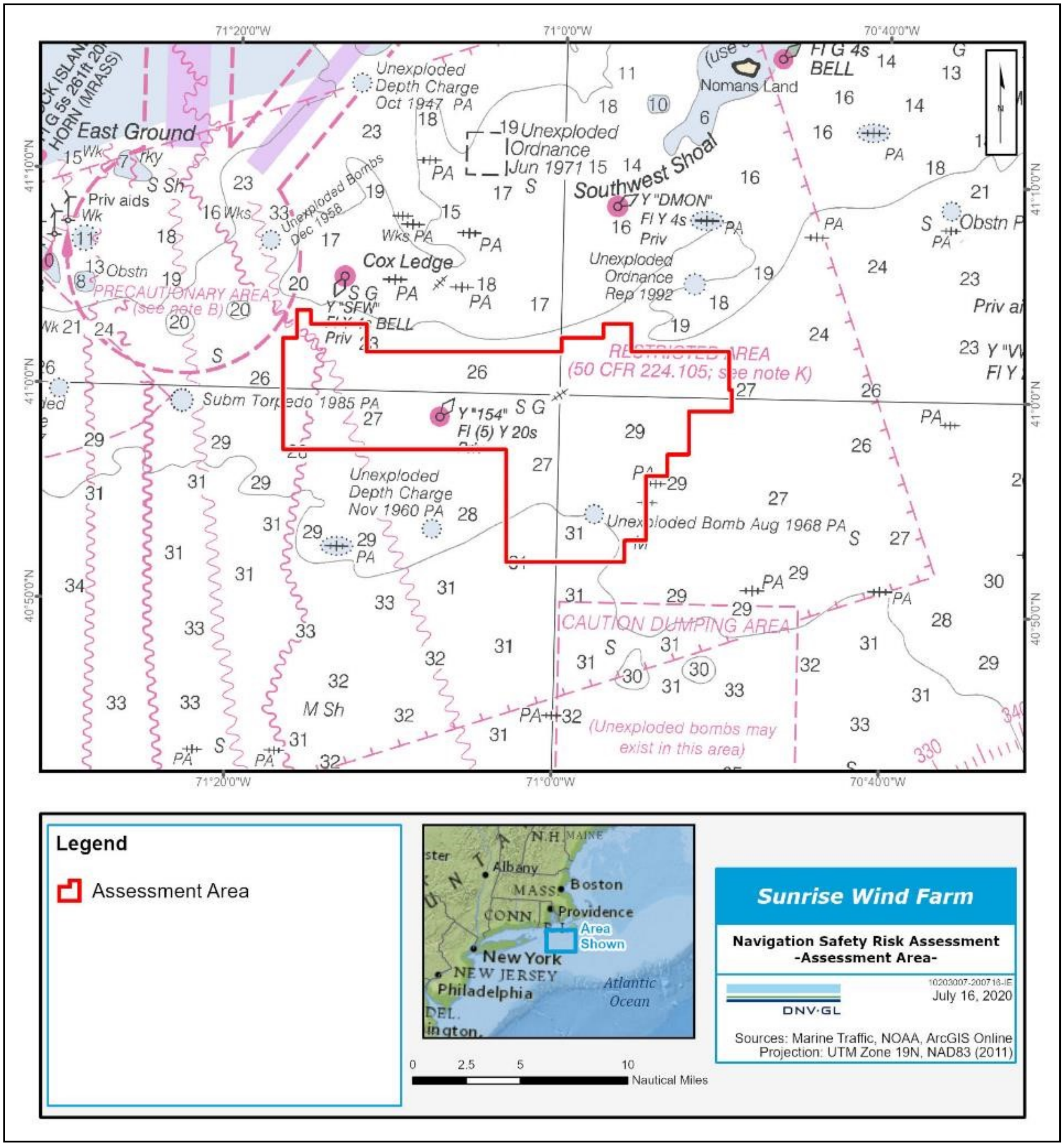


Figure 2-43 Navigation chart in the vicinity of the Project Assessment Area

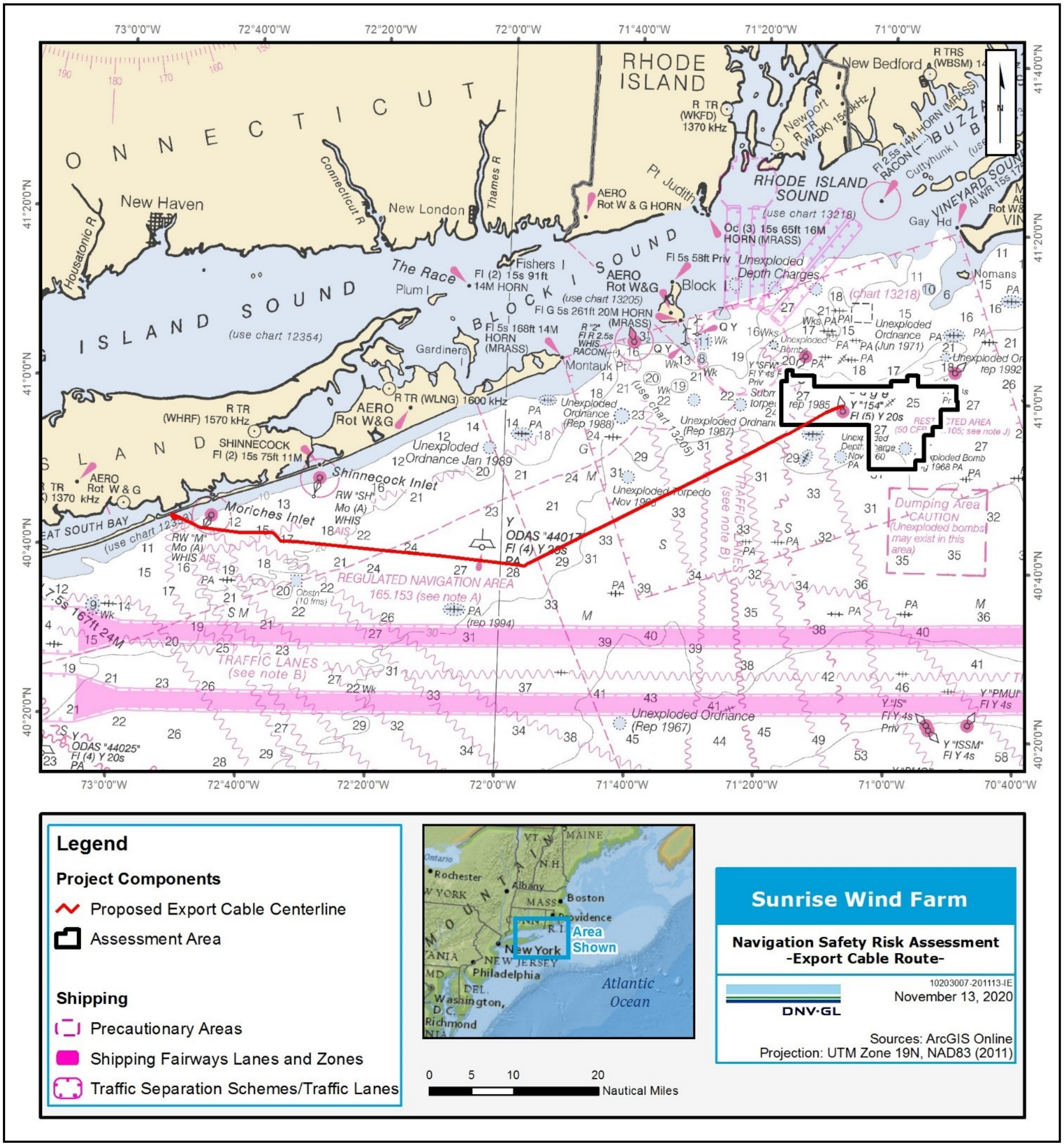


Figure 2-44 Indicative export cable route

2.2.1 Proximity to non-transit waterway uses

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

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

Section in this report	Type of waterway use	Closest proximity to the proposed maximum footprint of the Project (measured from the nearest WTG)
2.2.1.1	Fishing (recreational and commercial)	Occurs within the footprint
2.2.1.2	Day cruising of leisure craft (pleasure and passenger)	Occurs within the footprint
2.2.1.3	Racing	Occurs within the footprint
-	Aggregate mining	No offshore mining activity identified within 100 nm (185 km) of the Project
2.2.1.4	Wildlife viewing	Occurs within the footprint

2.2.1.1 Fishing

The Project is co-located with use of fixed and mobile fishing gear and with recreational fishing.

Rhode Island collects data and maps for ocean uses. Figure 2-45 illustrates the fishing grounds that are fished using commercial fixed gear (RI OceanSAMP, 2009a). Fixed gear fishing occurs year-round in at least the northern half of the Project Assessment Area. Analogous data is not available for the southern half.

Fixed gear consists of lobster pots, fish pots, and gill nets and are either placed on the bottom or kept afloat using buoys.

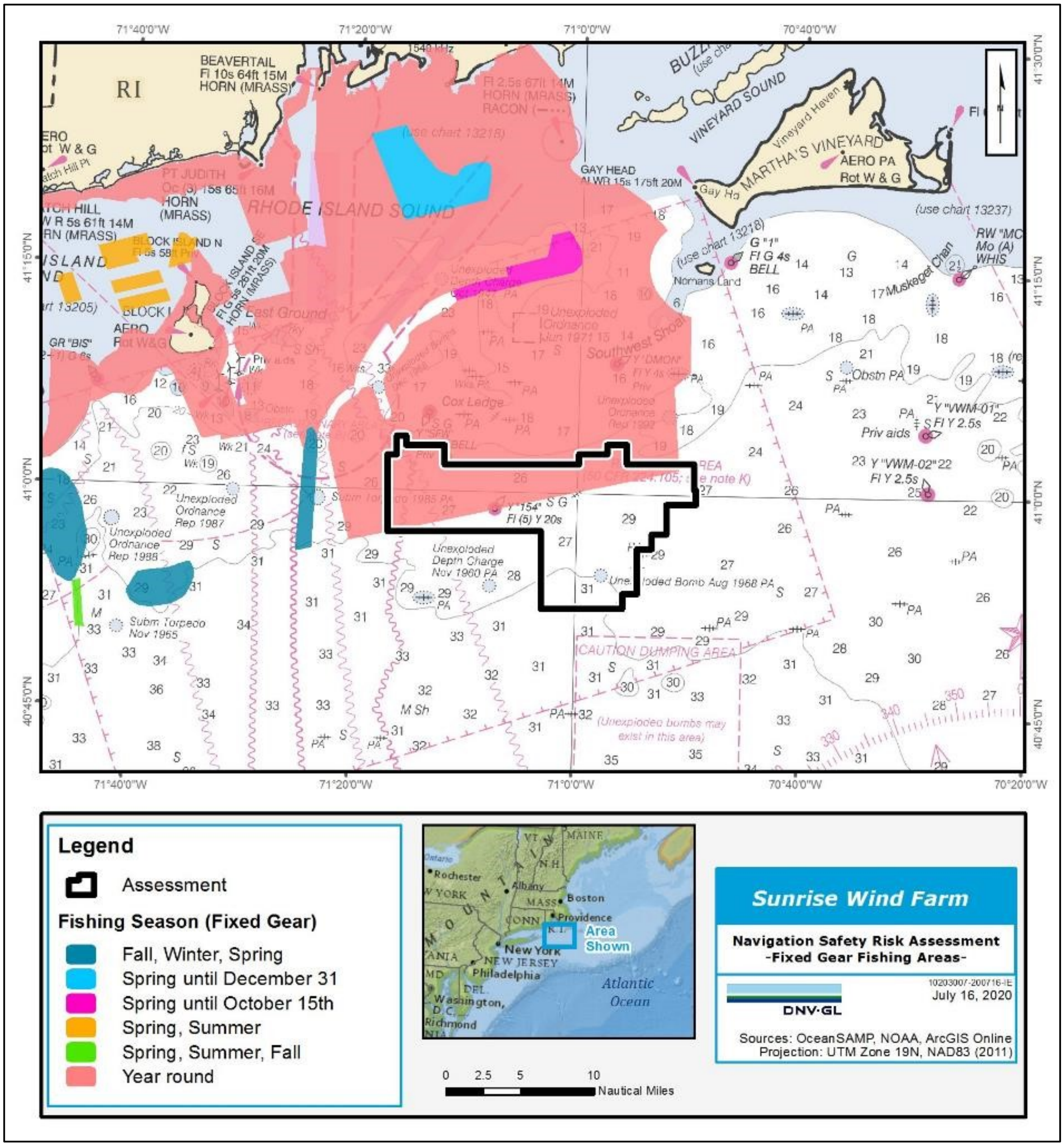


Figure 2-45 Fixed gear fishing areas by season in Rhode Island waters (RI OceanSAMP, 2009a)

Figure 2-46 illustrates the fishing grounds that are fished using mobile gear (RI OceanSAMP, 2009b). Mobile gear consists of trawling and scallop dredging (see Section 5 for further discussion on fishing gear interactions with Project components). Mobile gear fishing occurs year-round in at least the northern half of the Project Assessment Area. Analogous data is not available for the southern half.

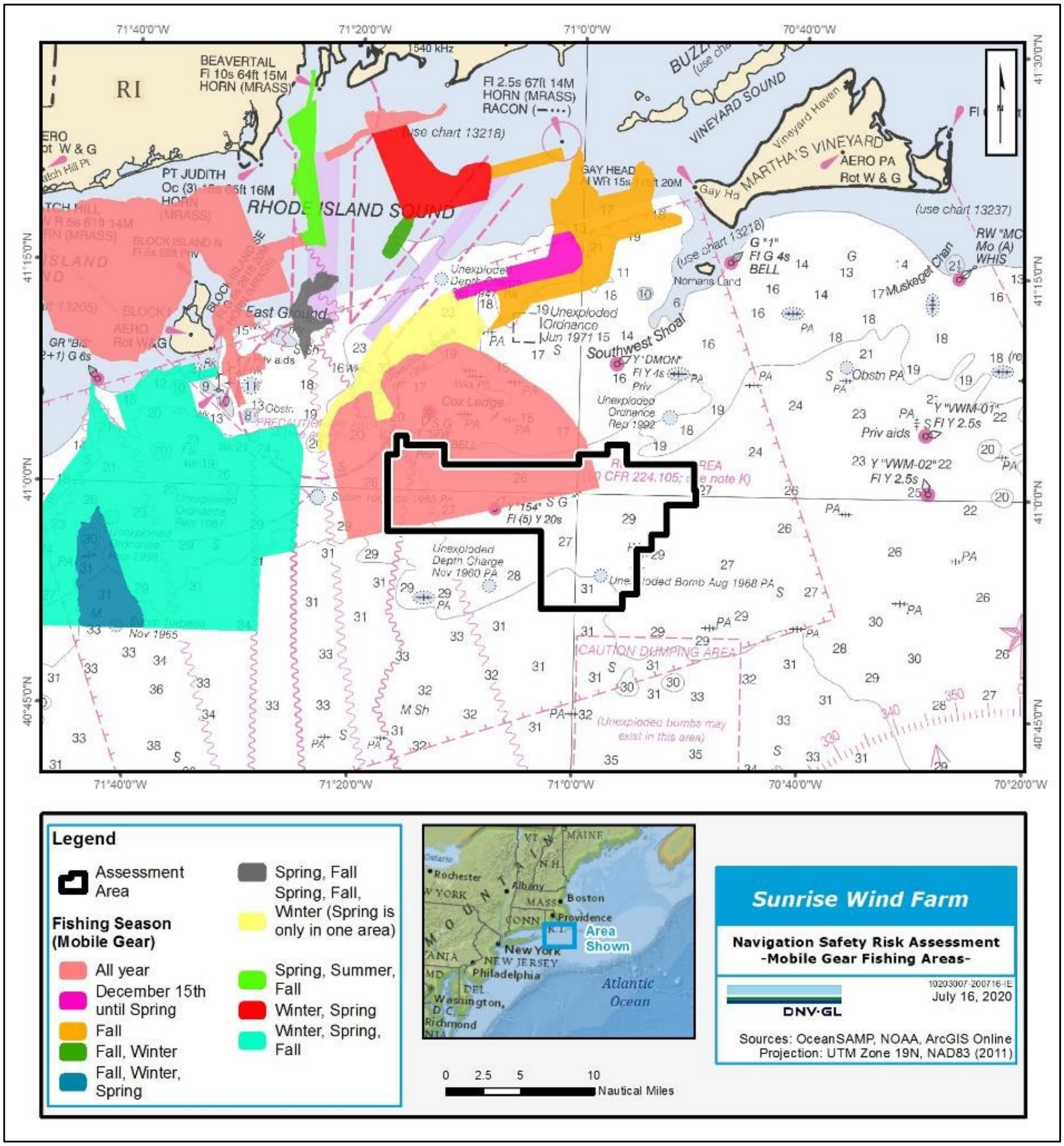


Figure 2-46 Mobile gear fishing areas by season in Rhode Island waters (RI OceanSAMP, 2009b)

Common fishing techniques for recreational fishing are line fishing and angling. This type of fishing is typically conducted from relatively small vessels, usually while drifting. Figure 2-47 illustrates the fishing grounds that are fished recreationally (RI OceanSAMP, 2009c). Recreational fishing was identified in a small portion of the northern half of the Project Assessment Area. Analogous data is not available for the southern half.

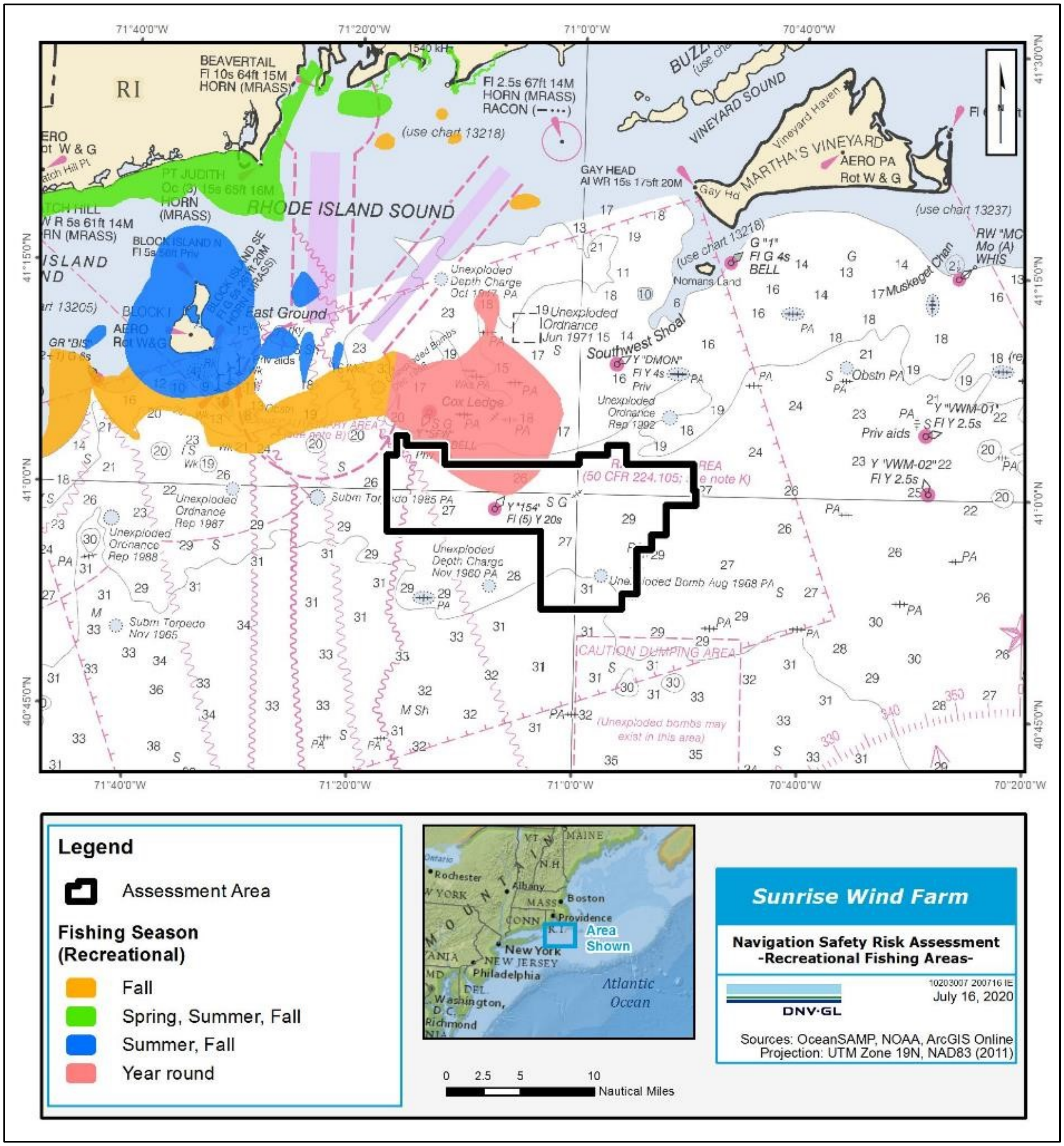


Figure 2-47 Recreational fishing areas by season in Rhode Island waters (RI OceanSAMP, 2009c)

2.2.1.2 Day cruises

Commercial day cruises in the Marine Traffic Study Area are offered by Rhode Island Fast Ferry services, including:

- Rhode Island Lighthouse Tour
- Sightseeing cruises and sunset cruises on Narragansett Bay
- Martha's Vineyard Fast Ferry service between Quonset Point, Rhode Island, Oak Bluffs, Martha's Vineyard, and Block Island, Rhode Island.
- Offshore Wind Farm Support to transfer crew and cargo during construction and operations.

Pleasure craft transit in the vicinity of the Project Assessment Area is described in Section 2.1.1.4.

2.2.1.3 Sailing and racing courses

Figure 2-48 illustrates the typical routes of distance sailing races, some of which have historically transited through the Project Assessment Area (RI OceanSAMP, 2016a). Future races will most likely route around the wind farm. Anecdotally, organizers of major marine events (such as the Newport/Bermuda, Bermuda/Marion, Annapolis/Newport regattas) which may transit in the vicinity of the Assessment Area have indicated the event tracklines would avoid the Assessment Area. Though safety is one factor, the primary reason for avoiding the Assessment Area is to promote a leisurely recreational event in open water. (Sunrise Wind LLC, 2019).

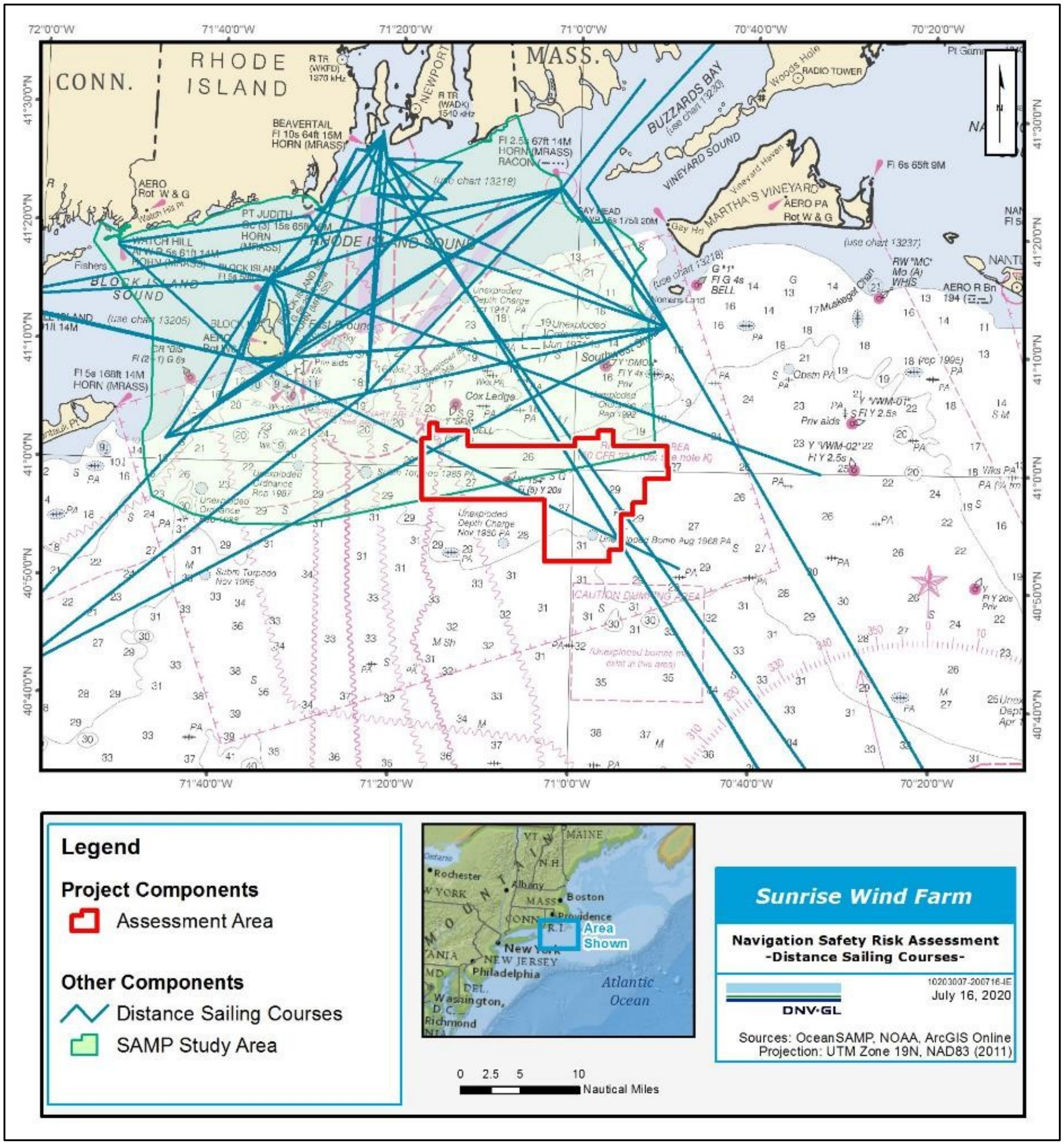


Figure 2-48 Distance sailing racecourses from Rhode Island ports (RI OceanSAMP, 2016a)

2.2.1.4 Wildlife viewing

Figure 2-49 illustrates the Rhode Island Sound Offshore Wildlife Viewing Areas in the Marine Traffic Study Area, including bird watching, shark cage diving and whale watching (RI OceanSAMP, 2016b/c/d). Vessels transiting to offshore wildlife viewing areas could take routes through the Project Assessment Area.

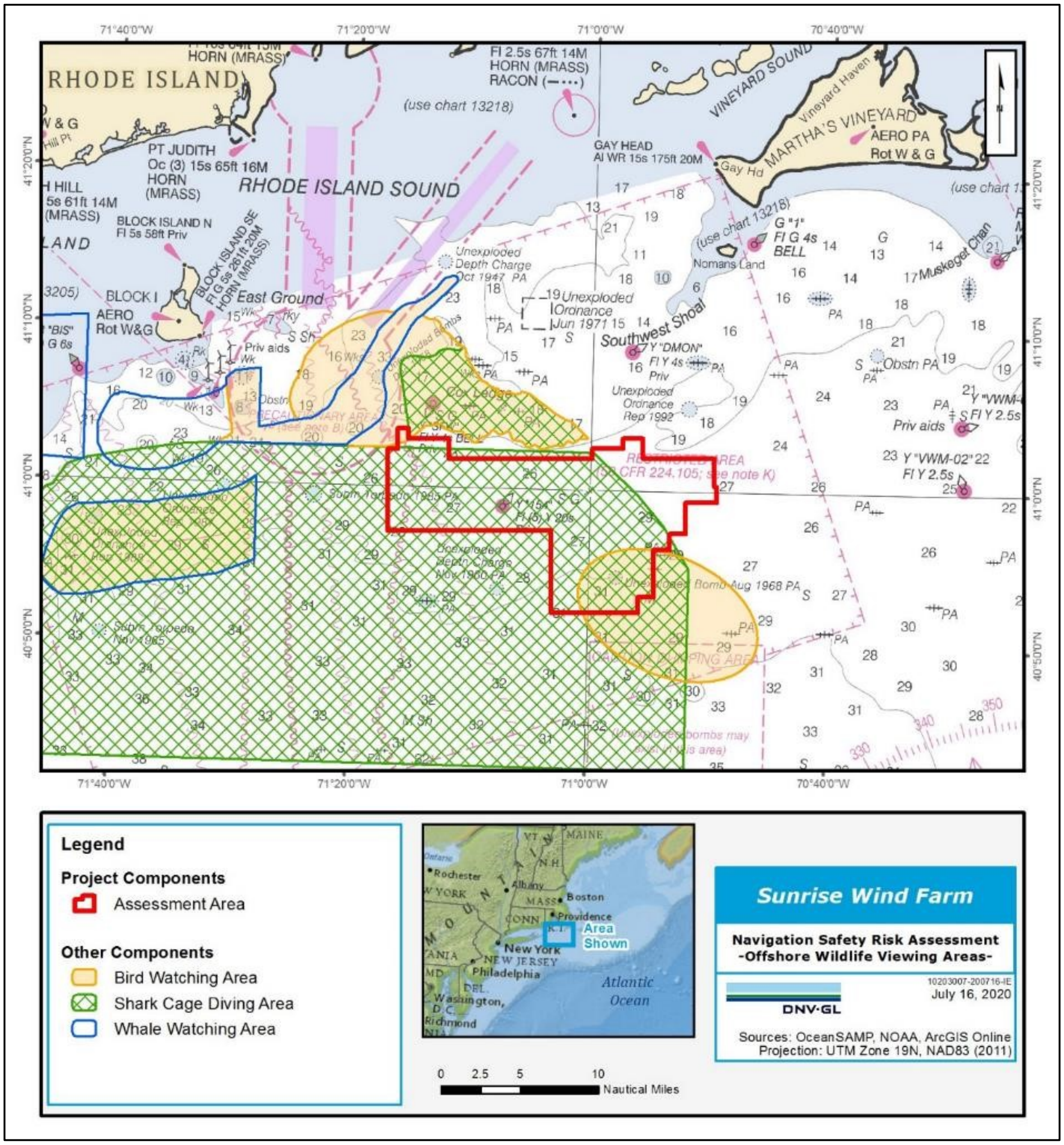


Figure 2-49 Offshore wildlife viewing areas (RI OceanSAMP, 2016b/c/d)[7]

[7] There are apparent differences in wildlife viewing areas between the above OceanSAMP GIS layers, Ocean SAMP downloadable paper maps (RI OceanSAMP, 2009d), and the 2010 OceanSAMP report (RI, 2010). This NSRA used the GIS layers.

2.2.2 Proximity to transit-related waterway uses

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

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

Type of waterway use	Closest proximity to the proposed maximum footprint of the Project (measured from the nearest WTG)
Transit routes used by coastal or deep-draft vessels, ferry routes	Deep-draft vessels transit within the footprint. Very limited coastal traffic or ferry routes occur within the footprint.
Transit routes used by fishing vessels	Occurs within the footprint.
Shipping routes	No international shipping routes identified within the footprint; the closest routes are in the TSS: 5.7 nm (10.6 km) (Inbound Buzzards Bay Traffic Lane), and 7.3 nm (13.5 km) (Outbound Buzzards Bay Traffic Lane) from the Project Assessment Area.
Routing measures or precautionary areas	None identified within the footprint; the closest routing measures are 5.7 nm (10.6 km) (Inbound Buzzards Bay Traffic Lane), and 7.3 nm (13.5 km) (Outbound Buzzards Bay Traffic Lane) from the Assessment Area. The closest precautionary areas are 0.4 nm (740 m) northwest of the Project Assessment Area.
TSS	None identified within the footprint, the closest TSS is 5.7 nm (10.6 km) (Inbound Buzzards Bay Traffic Lane), and 7.3 nm (13.5 km) (Outbound Buzzards Bay Traffic Lane) from the Project Assessment Area.
Anchorage grounds or safe havens	None identified within the footprint; the closest designated anchorage is 12 nm (22 km) (Anchorage G) northeast of the Project Assessment Area. Anchoring within the Project footprint is not advised unless an emergency situation exists.
Port approaches	None identified within 10 nm of the Project Assessment Area.
Pilot boarding or landing areas	None identified within the Project Assessment Area; closest pilot boarding area is 16 nm (30 km) from the Project.

2.2.2.1 Coastal, deep-draft, and ferry routes

Transit routes used by coastal vessels, deep-draft vessels, and ferry routes are described in Section 2.1.1. Some deep draft vessels currently transit within the Project Assessment Area.

2.2.2.2 Transit routes used by fishing vessels

Transit routes used by fishing vessels traverse the Project Assessment Area at lower densities than in the "areas of mass transit" (Coast Guard, 2020a) east of the Assessment Area (Figure 2-50).

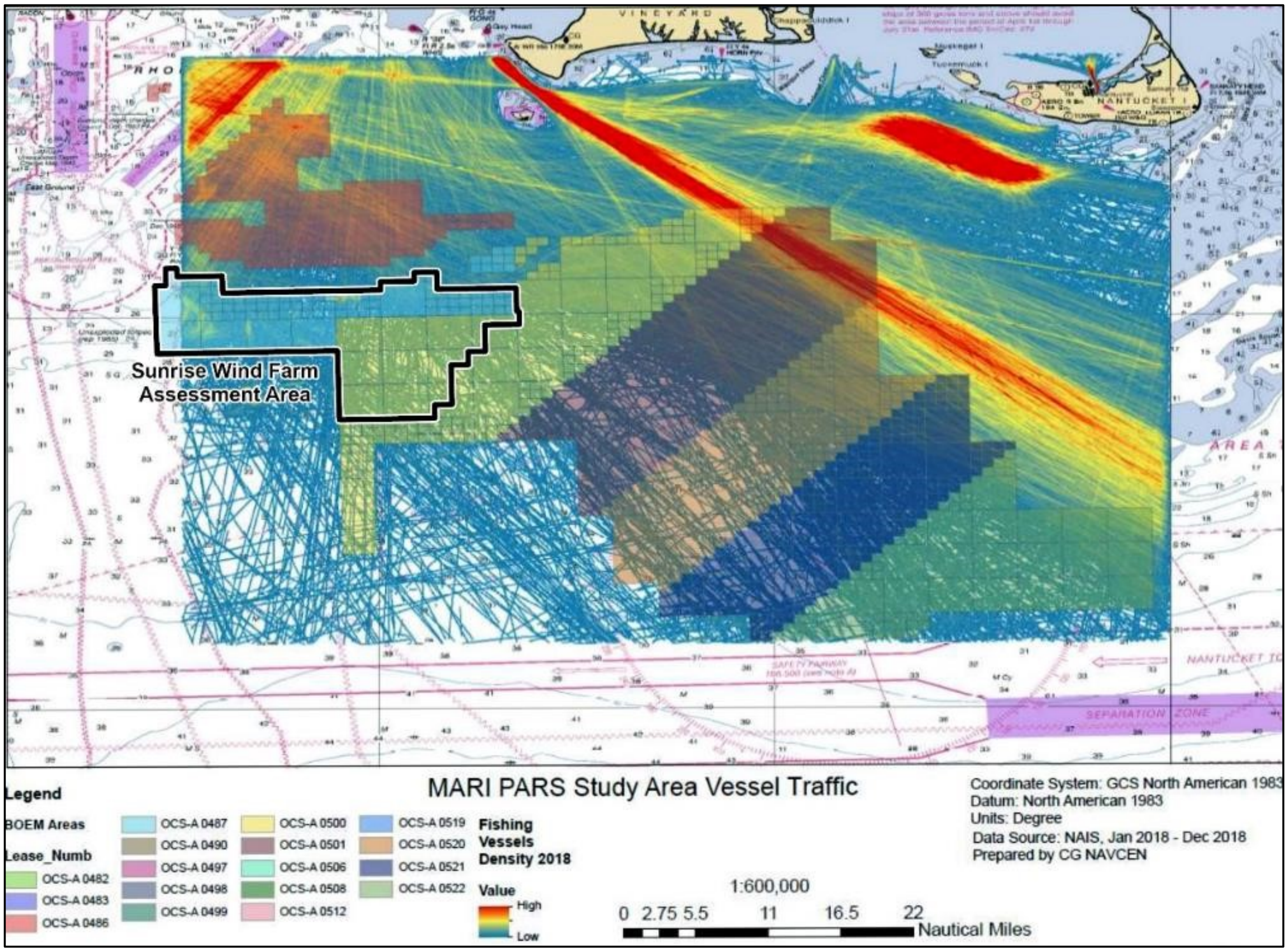


Figure 2-50 Fishing vessel density in 2018 (taken from Coast Guard, 2020a)

2.2.2.3 Shipping routes

International shipping traffic uses the established TSS:

- Buzzards Bay – inbound lane is 7.3 nm (13.5 km) from the nearest Project structure.
- Narragansett Bay – inbound lane is 10 nm (18.5 km) from the nearest Project structure.

2.2.2.4 Routing measures, precautionary areas, and separation zones

Distances from routing measures, precautionary areas, and TSS are listed in previous Table 2-4. NVIC 01-19 suggests a risk-based review of safe distances, which is provided in this section.

In NVIC 01-19 Enclosure 3: Marine Planning Guidelines, the recommended navigation safe distances for planning are:

a) 2 nm from the parallel outer or seaward boundary of a traffic lane.

b) 5 nm from the entry/exit (terminations) of a Traffic Separation System. 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 the TSS in the Marine Traffic Study Area is voluntary (Coast Guard, 2004).

The Marine Planning Guidelines 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 ways to reduce either the consequences or likelihood of the risk. Risk-informed decisions benefit from higher resolution analysis to support decision making.

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

- High density traffic areas (interpreted in the context of large international ports)
- 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 was listed in the NVIC but was not accounted for in the model. Based on the traffic survey, only a small percentage of the traffic in the vicinity of the Project is engaged in west-bound international trade and would presumably arrive at a U.S. port after being at sea for a significant duration.

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

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

(b) Low traffic density. Low traffic density will decrease vessel interactions and allow for more space for transiting vessels to maneuver;

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

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

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

The PDE provides for structures no closer than:

a) 6.5 nm (12.0 km) from the parallel outer or seaward boundary of a TSS, which is 4.5 nm more than the planning guideline.

b) 6.5 nm (12.0 km) from the entry of the TSS, which is 1.5 nm more than the guideline. Additionally, no Project WTGs are within the TSS Precautionary Area (Coast Pilot 2 §167.101); the closest WTG is 1.4 nm from the Precautionary Area.

Based on the risk assessment of collision and grounding in Section 11, the Project does not significantly increase marine navigation accident risk in the TSS or in the routes taken by vessels around the Project Assessment Area. The risk of an allision exists within the Assessment Area; however, outside the Assessment Area, the Project poses zero allision risk.

2.2.2.5 Anchorages, safe havens, approaches, or pilot areas

Figure 2-51 shows the designated anchorages in the area. The closest anchorage is Anchorage G, located 12 nm (22 km) from the Project; therefore, no measurable effects are anticipated related to anchorages. No significant anchorage activity is indicated by the AIS data in the Assessment Area. It is possible that a vessel could anchor in the Assessment Area in an emergency situation if the captain of the vessel identifies it as the safest course of action available at the time.

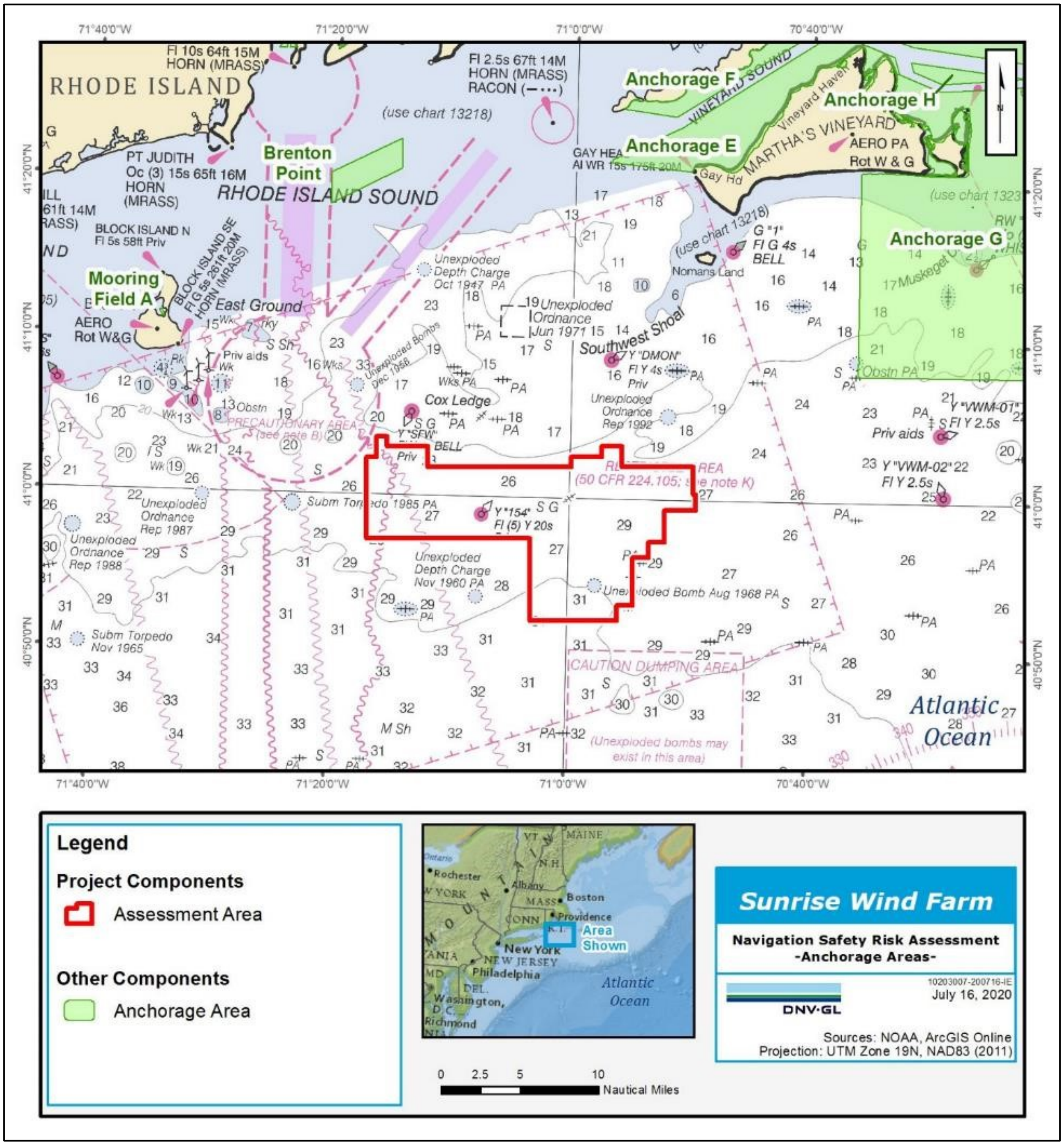


Figure 2-51 Anchorage areas

Figure 2-52 shows nearby pilot boarding areas. The Project is 16 nm (30 km) from the closest pilot boarding area.

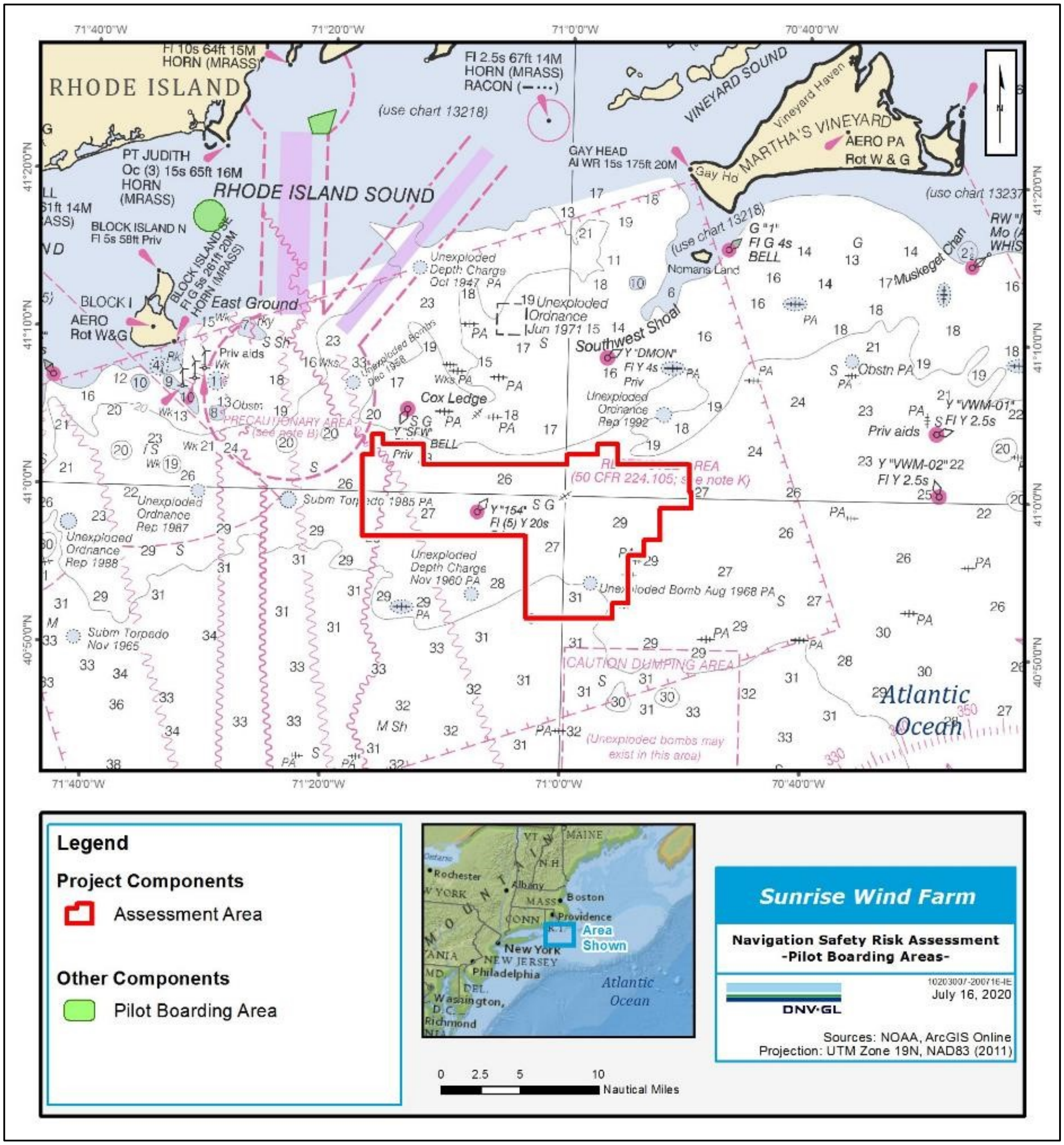


Figure 2-52 Pilot boarding areas

2.2.3 Proximity to other uses of interest

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

Table 2-5 Proximity of the Project to other uses of interest

Type of waterway use	Closest proximity to the proposed maximum footprint of the Project (measured from the Project Assessment Area boundary)
Fishing grounds or routes used by fishing vessels to fishing grounds	Occurs within the footprint. Fishing grounds lie within the Assessment Area and are discussed in Section 2.1.1.2. Routes that fishing vessels in AIS take through the wind farm, for example, to fishing areas near the edge of the Outer Continental Shelf, are sparsely distributed across the Assessment Area, and are oriented generally northwest-southeast and north-south (see previous Figure 2-7).
Within the jurisdiction of a port or navigation authority	None identified within the footprint.
Offshore firing/bombing ranges or areas used for military purposes	The Assessment Area is within the Narragansett Military Operations Area. No specific military activities have been identified within the Assessment Area; however, aircraft and submarine use occur nearby. The closest identified military use is submarine transit lanes, approximately 2.5 nm (4.6 km) from the Assessment Area.
Existing or proposed offshore renewable energy facility, gas platform, or marine aggregate mining	None identified within the footprint. Figure 2-53 shows nearby energy-related facilities. The closest identified existing renewable energy facility is Block Island Wind Farm, approximately 11 nm (21 km) from the Project. The closest proposed energy facilities are South Fork Wind Farm within about 1 nm (2 km) and Bay State Wind Farm, which borders the Project. WTGs will be installed in the adjacent wind farms in a pattern consistent with the Project. See the discussion below concerning other proposed wind farms in the area. No offshore oil and gas platforms or marine aggregate mining has been identified in the Marine Traffic Study Area.
Existing or proposed structure developments or existing designated offshore disposal areas	No other existing or proposed non-energy structures were identified within the Marine Traffic Study Area. No existing designated disposal areas identified within the footprint, the closest one is more than 11 nm (20 km) from the Assessment Area.

Type of waterway use	Closest proximity to the proposed maximum footprint of the Project (measured from the Project Assessment Area boundary)
Aids to navigation (ATON) and/or Vessel Traffic Services	Two Private Aids to Navigation (PATON) are within the Assessment Area, Army Corps of Engineers (ACOE) Block Island Lighted Research Buoy 154 and Caribbean Wind Lighted Research Buoy BW1; several other buoys are in the vicinity. The closest federal ATON is approximately 14 nm (26 km) from the Assessment Area, the G"1" Squibnocket Lighted Bell Buoy 1 east of Nomans Land, marking shoal water near Martha's Vineyard. No negative effects from the Project are anticipated on existing ATON. Section 9 provides additional discussion concerning ATON. The closest Vessel Traffic Services are Vessel Movement Reporting System (VMRS) Buzzards Bay and Cape Cod Canal Control.

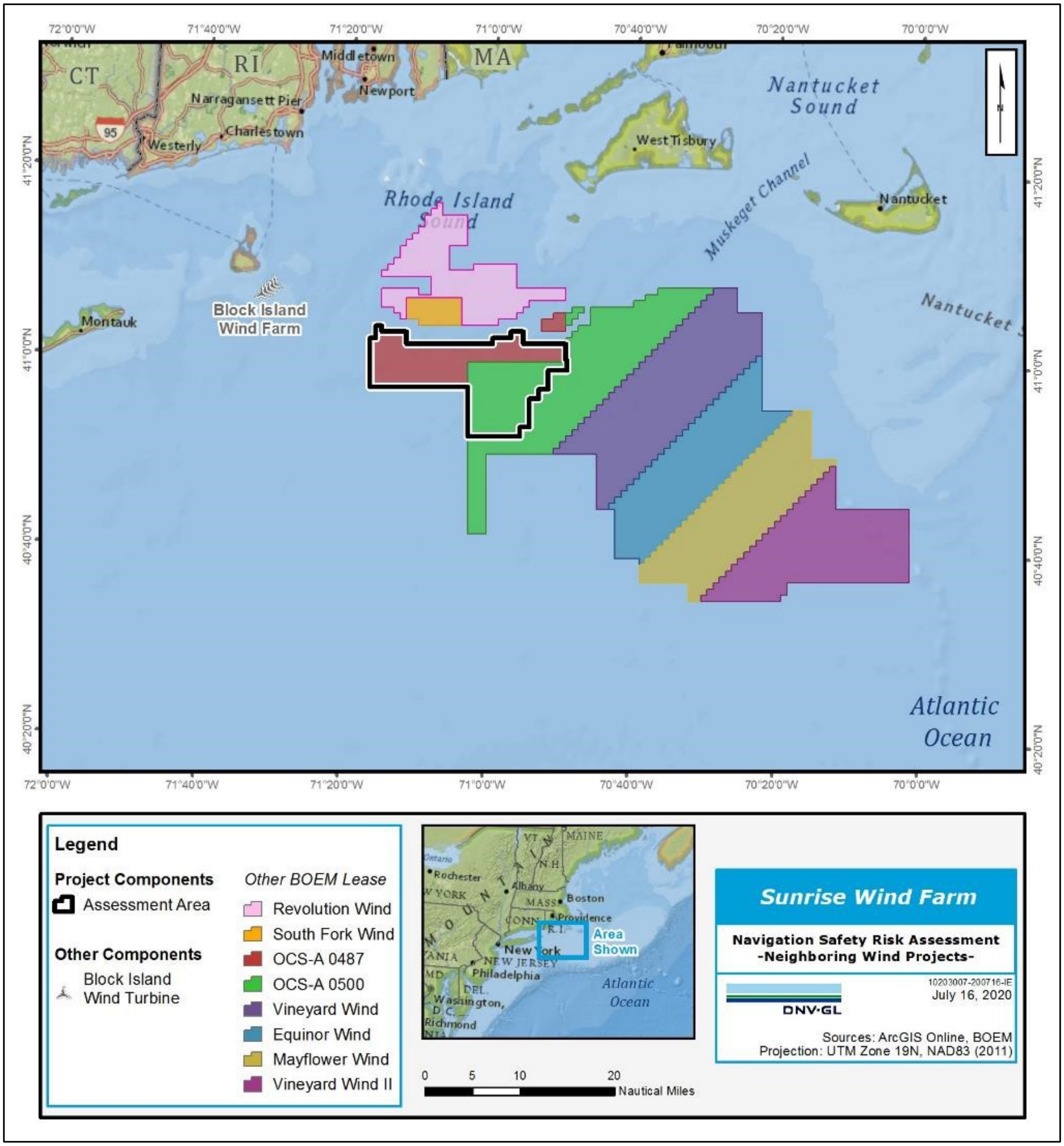


Figure 2-53 Operational and proposed neighboring wind energy projects

2.3 Anticipated changes in traffic from the Project

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

1. Additional non-Project traffic that might be generated by the presence of the wind farm.
2. The modification of traffic routes for some ship types due to the presence of wind farm structures.

Each is described below. Project-related traffic will include additional vessel transits to/from the Project for construction, maintenance, and inspections. These Project-related vessels are not added to the model as the primary focus of this study is potential effects on other waterway users.

Additional traffic added to the future case

The adjustments described in this section are implemented in the Future Case MARCS model, with the Project.

It is anticipated that there will be public interest in the Project that could potentially lead to pleasure tours of the wind farm and a potential increase of recreational traffic (including recreational fishing). It is difficult to estimate a precise number of vessels per year that will be added to local traffic patterns. To incorporate the potential tours, excursions, and recreational (including recreational fishing) traffic surrounding the Project, it is assumed that there will be 100 trips per year. This is a conservative upper estimate for the first operational year of the Project. It is anticipated that as time passes, there will be less tour traffic and the increase in vessels may diminish. This study aims to present the conservative case with the most probable traffic, as opposed to an average traffic scheme over a longer period. This additional traffic in the Future Case is included in the Pleasure vessel category and is allocated a new route from Narragansett Bay to the wind farm.

The Coast Guard MARI PARS report (2020a) reviewed the characteristics of potential future traffic 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 Coast Guard MARI PARS report comprised:

- Six to eight new Liquified Petroleum Gas (LPG) tanker transits to and from Providence. This study assumes that an additional eight LPG vessels per year enter the AIS Marine Traffic Study Area from the Nantucket-to-Ambrose Safety Fairway, take the Narragansett TSS to the Port of Providence and the reverse route on departure from the port.
- An additional 50 cruise ship visits to Newport, approximately doubling its current cruise traffic. The cruise ships in the AIS data enter the Marine Traffic Study Area from both the southwest and the southeast and take the Narragansett TSS on approach to Newport. This study assumes the southeastern route will be modified to a more north-south direction after construction of the Project, as deep draft vessels will modify their routes to navigate safely around the wind farms. The additional 100 transits are assumed to be divided equally between the two approach routes. This study assumes a reverse route is taken on departure from the port.
- New vessels and activity related to construction and maintenance of proposed wind farms. The construction traffic will be relatively short-lived in terms of the risk being assessed in this study. The maintenance and operations vessel traffic 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.

Modification of current traffic routes for the future case

The model built to assess the risk after the Project is constructed contained routes that differed from the Base Case (current situation) model. According to the AIS data, some deep draft vessels traverse the area where the wind farm is to be constructed. Many deep draft vessels (cargo, tanker, tanker oil products, and cruise ships) as well as tug/service vessels may choose not to navigate through the wind farm. At this time, the extent to which they will adjust their course is a matter of speculation.

Alternative routes are developed in the model for these vessel types to avoid the Rhode Island – Massachusetts lease areas shown in Figure 2-53 above. Deep draft ships (cargo, tanker, tanker oil products, and cruise ships) as well as tug/service vessels that transited through the lease areas are re-allocated to these modified routes outside of the BOEM lease areas for the model's Future Case. Other traffic types (fishing, other, shallow draft passenger, and pleasure) are modeled as continuing to navigate through the wind farm in the Future Case.

2.4 Effect of vessel emission requirements on traffic

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

Additional fuel restrictions came into effect on 1 January 2020. The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI (IMO, 1997) contains a global requirement regarding fuels used in ships in international trade. Ships using fuel oil must have a maximum of 0.50 percent (mass basis) sulfur content in their fuel or be fitted with an approved equivalent means of compliance, such as a scrubber. Switchover to lower sulfur fuel for inbound traffic will continue take place outside the ECA boundary. Less than one inbound deep draft vessel per day transits in the vicinity of the Project Assessment Area (see transects 18, 19, and 25 in Section 2.1.3.1). The risk of loss of propulsion near the Project due to switchover at the 200 nm ECA boundary (also the border of the Exclusive Economic Zone [EEZ]) is below a level that is reasonably quantifiable in a risk model.

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

2.5 Seasonal variations in traffic

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

Figure 2-55 and Figure 2-56 show the number of transits per season per vessel type for each of the route transects. Figure 2-57 shows the seasonality of transits in the Project Assessment Area per vessel type.

Traffic is significantly higher in the summer, more than double the traffic in any other season. In the year of AIS data, summer increases were the greatest near the coast, and were greatest for commercial fishing and pleasure vessels.

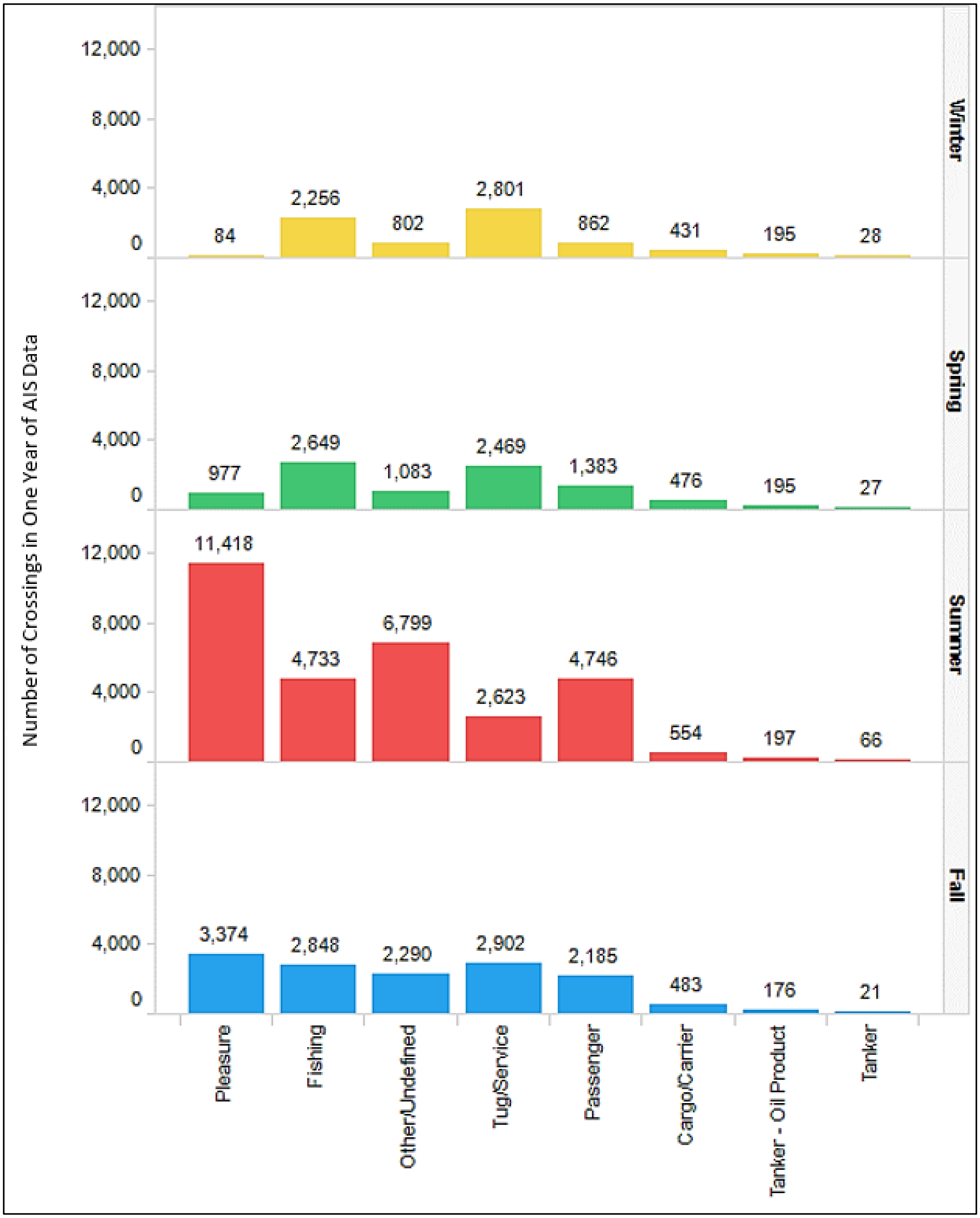


Figure 2-55 Seasonality of vessel transits per vessel type[4]

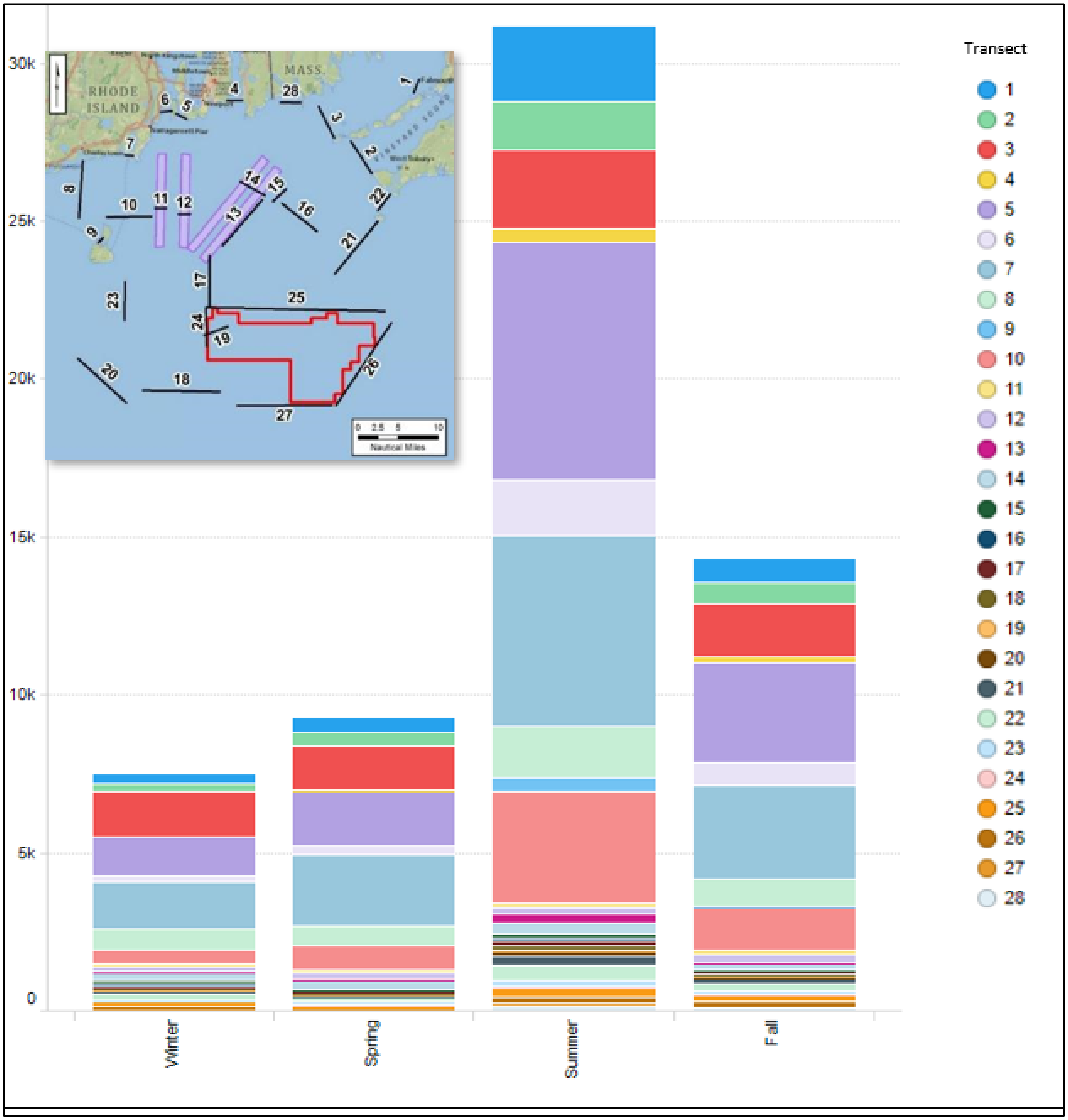
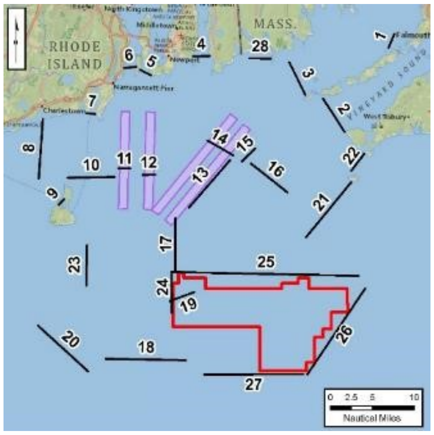


Figure 2-56 Seasonality of vessel tracks crossing all route transects[4]



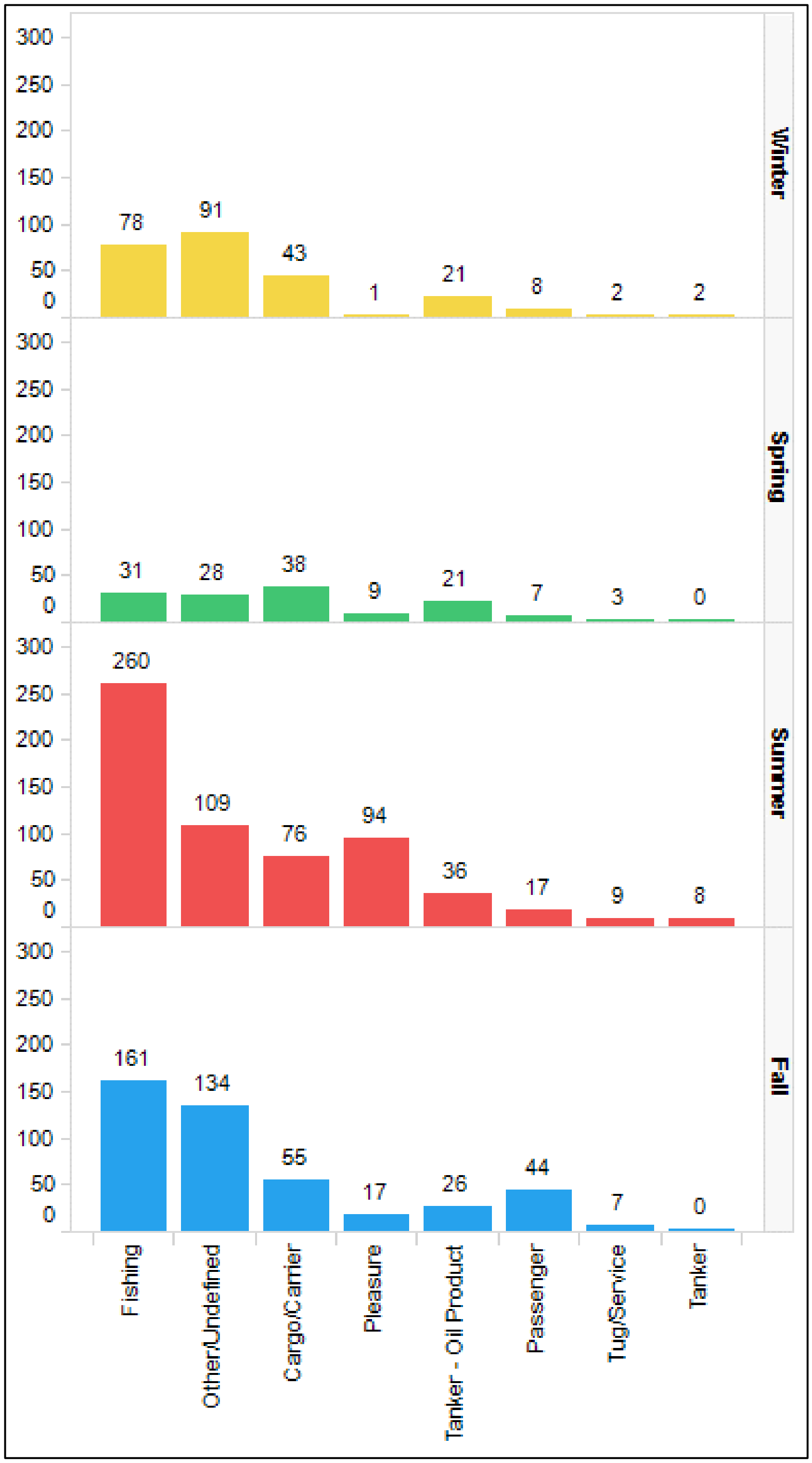


Figure 2-57 Seasonality of vessel tracks crossing the Project Assessment Area (transects 19, 25, 26, and 27)[4]

Key conclusions concerning seasonality of traffic are:

- Pleasure vessel traffic shows the strongest seasonal increase of any of the traffic types. Summer traffic across the entrance of Narragansett Bay via East Passage (transect 5) showed the greatest increase.
- Commercial fishing vessels show significantly higher traffic in the summer across nearly all the evaluated routes. The route with the largest increase in traffic is at Pt Judith (transect 5 and others). Large percentage increases are noted at Block Island (transect 9) and southbound toward the edge of the continental shelf (transect 18); however, the number of transits at these locations is low compared to highly transited lanes at large international ports.
- Similarly, vessels identified as “Other” or undefined show higher traffic levels in the summer, particularly on the western side of the Marine Traffic Study Area.
- Passenger vessel traffic is generally highest in the summer and fall, but there is no strong pattern concerning the seasonality associated with any of the routes.
- Tug and service vessels show small increases in the fall and winter.
- Cargo/carrier, oil tanker, and non-hydrocarbon tanker traffic show no distinct seasonality.
- In the Assessment Area, the level of traffic in the summer and fall is far greater than the traffic in winter and spring, primarily due to increased traffic from fishing, pleasure, and other vessels.

3 OFFSHORE ABOVE WATER STRUCTURES

This section describes:

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

3.1 Hazards to vessels

The hazards posed to vessels from the Project are:

- Air draft (clearance) – WTG blades could pose a hazard to a vessel with a mast or other structural component taller than 28 m (94 ft) above Mean Higher High Water (MHHW) from the 8 megawatt (MW) WTGs, which results in the smallest air draft compared to the other classes of WTGs in the PDE. Similarly, the Offshore Platform could pose a hazard to a vessel taller than 24 m (78 ft). Section 3.2 discusses this risk.
- Keel clearance – A jacket leg could pose a hazard to a deep draft vessel depending on the hull shape if the vessel was extremely close to the jacket leg. Vessels passing at a safe distance will be well away from the jacket legs. The primary scenario of concern for keel clearance would be allision with the jacket near the waterline. Section 6 discusses water depths.
- Subsea (buried) cable – A subsea cable could pose a hazard to a vessel if an anchor or fishing gear penetrated the seabed to the depth of the cable at a cable location or impacted cables that are otherwise protected. See further discussion below.
- Stationary object at/near the waterline – The sea level portion of monopile or jacket foundation with associated J-tubes could pose a hazard to: (1) a vessel on an allision course with the foundation or (2) a vessel adrift and being pushed (primarily by the wind) toward the foundation. Section 11.1 discusses the consequences of an allision with a Project structure and Section 11.1.1 presents an estimate of the frequency of an allision with a Project structure.
- Mobile gear fishing techniques – Mobile gear are employed in the vicinity of the Project. 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 Project submarine power cables. The fishing activities that pose a risk include bottom trawling and shellfish dredging. Both activities are expected in the vicinity of the Assessment Area and export cable. Assurance that the cable is buried at sufficient depth for any gear type, and/or adequately protecting cable that cannot be buried to target burial depth, and/or using gear that has limited penetration depth in the wind farm are important risk controls. To reduce the likelihood of interactions between fishing activities and a subsea cable, the BOEM recommends a minimum burial depth of 3.28 ft (1 m) and at least a single armor layer (BOEM, 2011).

- Radar clutter – WTGs and the movement of turbine blades can potentially interfere with communication signals from radio and radar transmitters by either blocking or reflecting the signals. See discussion in Section 10.2.
- Noise – Sound from Project components may add to background noise levels. See discussion in Section 3.4.

A study by Stostek et al. (2017) measured penetration depths of various types of fishing gear (Table 3-1). The Project will typically target a burial depth of 3 to 7 ft (1 to 2 m) and the cable includes various protective armoring and sheathing to protect the cable from external damage and keep it watertight (Sunrise Wind LLC, 2020). The target burial depth will be determined based on an assessment of seabed conditions, seabed mobility, the risk of interaction with external hazards such as fishing gear and vessel anchors, and a site-specific Cable Burial Risk Assessment. A study recently conducted in the region (Deepwater Wind, 2012) concluded that disturbance of the seabed from fishing gear was less than 1.6 ft (0.49 m) below the surface of the seabed.

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

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

3.2 Vessel clearances from project components

The air draft required by a vessel is the distance between the waterline and the highest point on the vessel. The air clearance is the additional space between the highest point on the vessel and the hazard, relevant to this assessment, a turbine blade or a platform. The minimum air clearance for Project structures are listed in Table 1-3. Figure 3-1 illustrates the minimum air clearance for the Project WTGs.

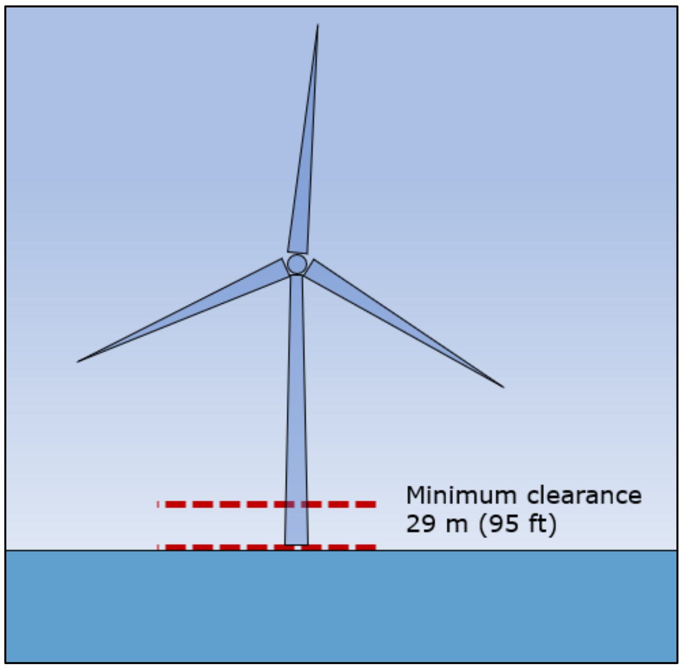


Figure 3-1 Illustration of air clearance

The tips of WTG blades on an 8 MW turbine are about 10 m to 25 m (33 to 82 ft) away from the monopile (Ostachowicz et al., 2016). Therefore, the restricted air clearance exists only within a narrow range of distance from the structure, illustrated in Figure 3-2.

All foundations will indicate the as-built air gap on the structure.

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

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

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

Figure 3-2 Illustration of blade tip distance from monopile

3.3 Emergency rescue activities and project components

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

To facilitate SAR within the Project footprint (and all potential U.S. offshore wind farms) both table-top and operational exercises were conducted with the Coast Guard at the Block Island Wind Farm. These exercises demonstrated the Coast Guard's capability to search in the vicinity of WTGs with both vessels and aircraft, and rescue (extract) an injured person from a nacelle. Additionally, Ørsted hosted Coast Guard officials, including SAR specialists, at its Marine and Helicopter Coordination Center in Grimsby, England and the nearby Race Bank offshore wind farm. The site visit included observations and discussion of United Kingdom Maritime and Coastguard Agency (UK MCA) SAR best practices, organization, and operational processes. Future field exercises during operations and additional simulation exercises are planned (Sunrise Wind LLC, 2020).

Table 3-2 presents the aviation hazard envelope based on the PDE (Sunrise Wind LLC, 2020).

Table 3-2 Maximum risk envelope for aviation clearance (Sunrise Wind LLC, 2020)

Parameter	WTG	Platform
Minimum air gap (from MHHW)	29 m (95 ft)	78 ft (23.8 m)
Maximum total structure height (from LAT)	968 ft (295 m)	295 ft (90 m) excluding lightning protection

In 2005, the UK MCA conducted trials at the UK North Hoyle Wind Farm using a Sea King Mark III helicopter (UK MCA, 2005), and with 5 MW WTGs, which are smaller and more closely spaced than those in the PDE. The study 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

Effects of varying levels were noted regarding:

1. "Radar returns from structures. Side lobes [depth estimated at less than 50 m] limited target detection when vessels were within 100 meters of turbines."
   In poor visibility, voice communications and radar are the primary means of casualty detection, whether wind turbines are present or not. Radar detection is reduced for vessels that are close to turbines.
2. "Limitations in approach distances from turbines in clear weather."
3. "Inability to effect surface rescues within wind farms in restricted visibility."
4. "Tracking, by vessel or shore-based marine radar, of helicopter movements within wind farms was generally poor."
5. "Increase of aircraft power requirements downwind of the wind farm."
   However, there was no noticeable increase in turbulence. (UK MCA, 2005)

The study identified measures that reduced risk to the rescue activity, both of which will be implemented in the Sunrise Wind Farm:

- 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 conduct SAR operations: Sunrise Wind has committed to an indicative layout scenario with WTGs and OCS-DC sited in a uniform east-west/north-south grid with 1 nm by 1 nm spacing. (Sunrise Wind LLC, 2020)

The Coast Guard MARI PARS (2020a) report examined potential navigation safety and search-and-rescue (SAR) issues associated with anticipated offshore wind farm development in the area.

The Coast Guard MARI PARS report concluded that a wind turbine array "developed along a standard and uniform grid pattern with at least three lines of orientation and standard spacing" (such as proposed for the Project) would maintain the Coast Guard's ability to conduct SAR operations within the Assessment Area.

3.4 Noise

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

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

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

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

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

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

An estimated background noise level of 68 dB is greater than the noise level of a wind farm from 1,148 ft (350 m) away (68 dB and 35-45 dB respectively), therefore noise from the Project turbines is not anticipated to pose any negative effects on navigation in the region; the background noise level is much greater than the noise from the Project.

3.5 Project structure impact analysis

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

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

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

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

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

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

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

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

Vessel type	DWT (metric tons)		
	Low	Average	High
Tanker – oil/gas products	1,241	46,315	113,005
Cargo & carrier	1,750	25,602	75,005
Tanker	9,240	18,963	36,771
Tug/Service	1	421	33,095

Vessel type	DWT (metric tons)		
	Low	Average	High
Other & undefined	20	518	14,620
Passenger	70	584	12,512
Pleasure (incl. recreational boating)	1	Insufficient data	711
Commercial fishing	1	250*	742

* Estimated based on vessel LOA and beam

The speeds in Table 3-5 are based on the speed profiles in the AIS dataset shown in order of decreasing speed. The low and high speed 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 half of the representative speed.

Table 3-5 Assumed vessel speed when allision occurs

Vessel type	Low speed (kt)	Representative speed (kt)	High speed (kt)
Passenger	5.9	11.7	14.0
Other & undefined	5.7	11.3	13.6
Tanker	5.5	11.0	13.2
Tanker - oil/gas product	5.4	10.8	13.0
Cargo & carrier	4.8	9.5	11.4
Tug & service	4.3	8.5	10.2
Commercial fishing	3.8	7.5	9.0
Pleasure & recreation	3.8	7.5	9.0

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

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

Figure 3-3 gives the resulting range of kinetic energies.

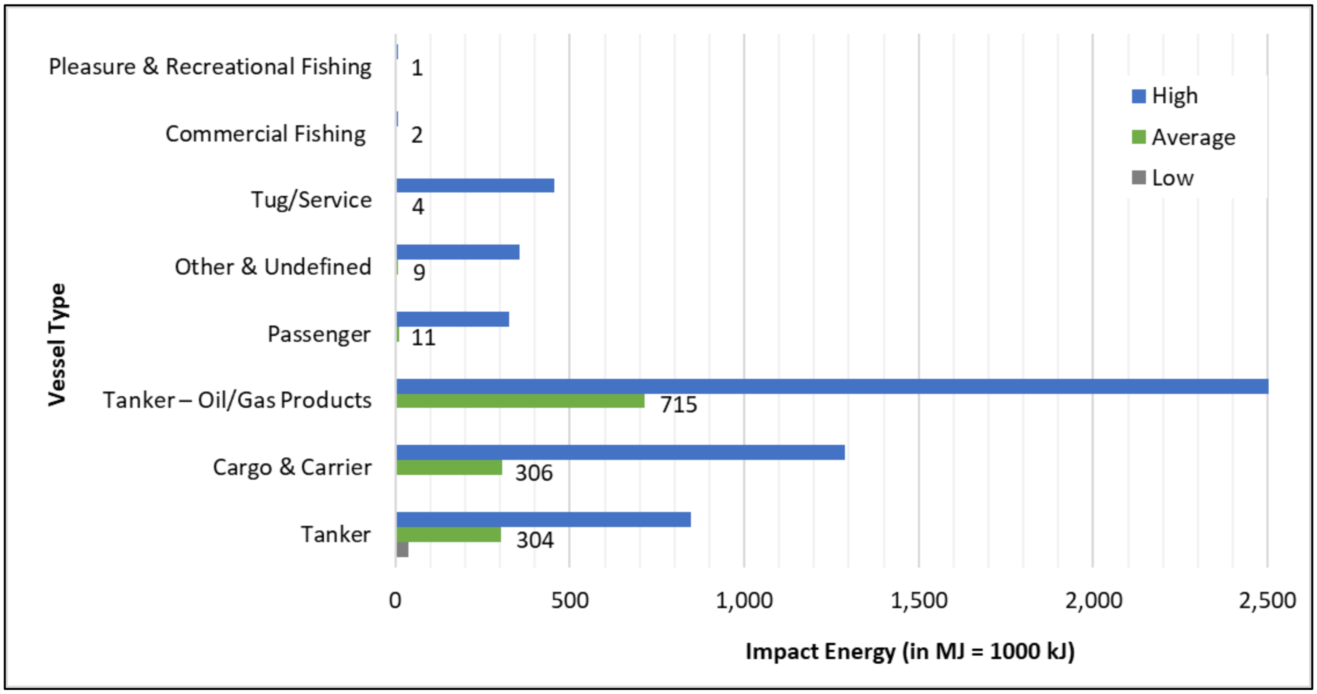


Figure 3-3 Ranges of kinetic energy per ship type

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/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 pleasure and fishing vessels are unlikely to cause extensive damage to a jacket because of their low tonnage and average speeds. Deep draft vessels such as tankers and carriers have a greater potential to cause damage to the jacket, even at lower speeds.

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

As previously stated, it is not anticipated that tankers or any deep draft / large vessel types will transit within the Project. Based on the MARCS model results, the annual frequency of a powered allision with a WTG involving a tanker (carrying oil products or not) or cargo/carrier is less than 0.0005/year; at least a 1-in-2,000-years event.

During construction, the primary risk is from an on-site construction vessel allision with a WTG while transiting through the wind farm. However, construction vessels are anticipated to be travelling at low speeds through the construction zone and are unlikely to cause significant damage in the event of an allision. Based on the low speeds that are expected in a construction zone, a drifting or direct strike from a construction or work vessel is unlikely to cause extensive enough damage to a monopile or jacket based on the WTG strength analysis discussed earlier in this section. In addition, drift allisions are typically low consequence because the allision location on the ship could be anywhere along the ship’s length, but only near the center of mass will the energy transfer be significant. If the allision location is off-center, a proportion of the energy will not go toward deformation of the vessel or Project structure, but instead will rotate the vessel around the turbine.

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

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

4 OFFSHORE UNDERWATER STRUCTURES

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

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

For commercial fisheries, the primary fishing gear in the Rhode Island and Massachusetts wind energy areas are gillnet, dredge, pot, bottom trawl, and midwater trawl (Kirkpatrick et al., 2017). As an indication of the level of activity, Figure 4-1 presents the annual revenue from these fisheries for the five-year period 2007 to 2012. Three gear types represent 59 percent of the permits and 83 percent of the revenue: dredge, bottom trawl, and gillnet. Longline and hand fishing combined represent about 8 percent of the permits and less than 1 percent of the total revenue.

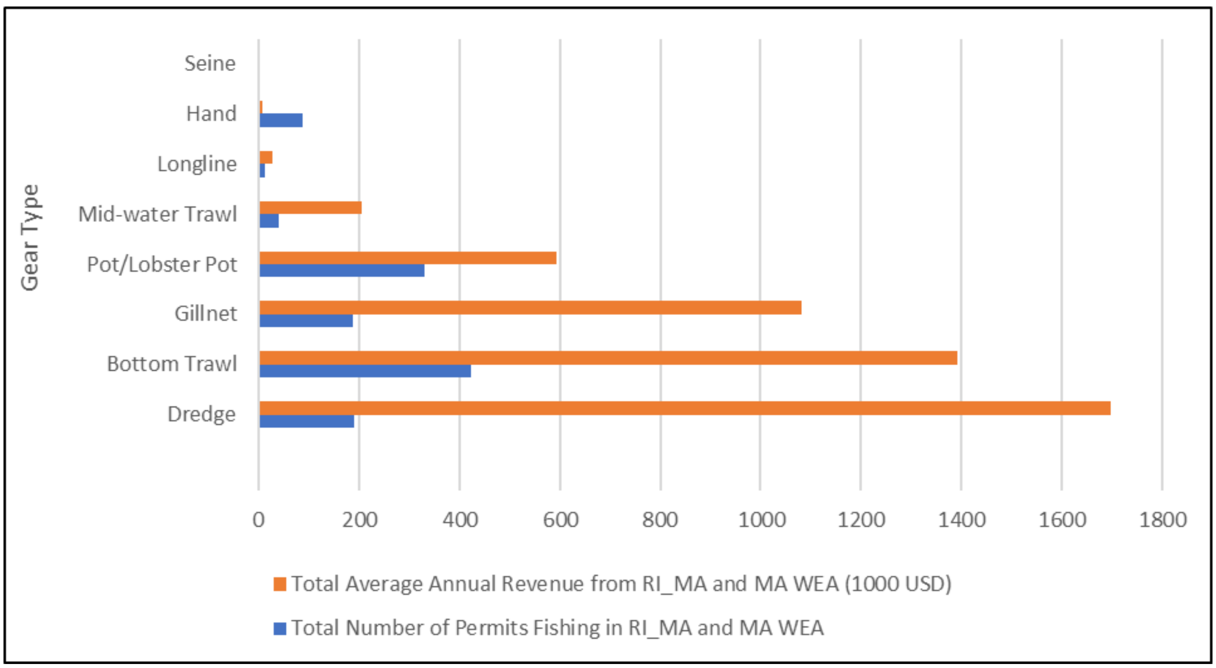


Figure 4-1 Number of commercial permits and revenue per year (2007–2012) (Kirkpatrick et al., 2017)

Anchoring, bottom trawling, and dredging pose the greatest risk of contact with a cable. The current cable target burial depth is 3 to 7 ft (1 to 2 m) and includes at least a single armor layer. In addition, and to assure the risk is sufficiently mitigated, a separate cable burial risk assessment is being conducted for the Project, and the results of that study, along with an assessment of seafloor conditions and seafloor mobility, will inform the depth of cable burial for the Project and cable protection measures where necessary.

5 NAVIGATION WITHIN OR CLOSE TO A STRUCTURE

This section assesses:

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

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

5.1 Construction and decommissioning phase navigation risks

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

Offshore construction activities could be a hazard and Project construction vessels could experience hazards from passing vessels. Three primary means of reducing this risk are updates to mariners from the Project, safety zones around construction activity, and Project safety vessel(s) on scene.

The Project has committed to informing mariners about offshore activities related to the Sunrise Wind Farm. Fisheries liaisons and a team of fisheries representatives are based in regional ports, and updates will be provided to mariners online and via twice-daily updates on VHF channels.

Safety zones can also protect mariners from potential hazards during construction activities. It is anticipated that the Coast Guard will implement safety zones during construction of the Project, as they did for construction of the Block Island Wind Farm (18 FR 31862)[8].

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

The Elijah E. Cummings Coast Guard Authorization Act of 2020[9], which became law in January 2021 provides the USCG authority to establish and enforce safety zones on the OCS for activity related to wind energy development and operation. It is reasonable to assume that subsequent to Orsted's request, temporary safety zones will be established and enforced to protect mariners during construction and selected maintenance activities. Sunrise Wind will provide notice and status of safety zones in its frequent Mariners Information posted to the website https://us.orsted.com/mariners and through weekly Local Notice to Mariners submitted to the Coast Guard.

[8] FR stands for Federal Register
[9] H.R. 6395, Elijah E. Cummings Coast Guard Authorization Act of 2020, https://www.congress.gov/bill/116th-congress/house-bill/6395/text#H07669B44D8C54EC9887FF078B3A3165F

As with all marine navigation, it is required that all vessels, including construction and service vessels, follow COLREGs (IMO, 1972). Vessels 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 will assume that there is a risk of collision (IMO, 1972). This applies to vessels that should take special precautions when navigating within the vicinity of the WTGs, particularly in limited visibility. COLREGs also state that every vessel shall proceed at a safe speed so that proper and effective actions could be taken to avoid collision, and the vessel could be stopped within a distance appropriate for the prevailing circumstances and conditions. To determine a safe speed as defined in the COLREGs, the elements a vessel will consider include but are not limited to the following (IMO, 1972):

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

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

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

1. Completion of decommissioning planning, permitting, inspection, surveys, and disposal/recycling plans.
2. Immediately prior to dismantling the turbines, any movable equipment will be removed or secured, fluids or hazardous materials removed or made safe, the turbine rotor oriented and electrically isolated to the extent feasible, and the turbine is prepared to be dismantled (for example, easing bolts or cutting bolts that cannot be loosened).
3. A lift vessel will remove the blades, nacelle, then the tower. A detailed loading plan will specify how and where each of the components is secured on the transport vessel.
4. Immediately prior to removing the foundations, the array cable connections will be severed, the seabed material and/or scour protection around the foundation will be removed to allow access to the foundation, the cutting equipment will be fit, and the lifting equipment will be made fast.
5. A heavy lift vessel will take the load as the foundations are cut below the seabed.
6. If some cables are to be left in place, the cable ends will be buried. For the cables that are to be removed, the method of cable removal will depend on the soil type and is likely to be similar to the

method used to bury the cable. Once aboard, the cables will be cut with hydraulic shears to facilitate transportation.

7. A post-decommissioning survey will confirm the status of the seabed, removal of objects on the seabed, and confirm that the decommissioning has been carried out as agreed.
8. Activities per an agreed monitoring plan will be carried out per conditions and requirements established with authorities, typically at intervals of one, five, and ten years after decommissioning.

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

5.2 Operations phase navigation risks

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

The Project will lay on charted depths of 35.4 to 59.4 m (116 to 195 ft) (National Geophysical Data Center, 1999). Given these depths, vessels that choose to navigate through the Project will not be draft limited; therefore, grounding risk exists only outside the Project footprint.

To the north of the Project Assessment Area is the TSS of the Buzzards Bay Entrance. Large deep-draft vessels navigating in the vicinity of the Project will be within the TSS under normal circumstances. The potential hazards include collisions between vessels or allisions with Project structures.

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

It is also anticipated that deep draft vessels will not choose to transit through the wind farm. The PDE provides a minimum of 1 nm (1.9 km) of space between WTGs. This design is a navigation risk mitigation measure and, as concluded in the Coast Guard final MARI PARS report (2020a), provides sufficient room for anticipated vessels to transit through and safely maneuver within the Project.

The NVIC 01-19 Enclosure 3 provides Marine Planning Guidelines, which are intended to inform the NSRA and siting of offshore wind structures such as WTGs and Offshore Platforms, but not affect the boundaries of existing leases. There are no national or international requirements regarding minimum distances between offshore wind structures and shipping routes. Table 5-1 lists the marine planning guidelines concerning navigation distances referenced in the NVIC and compares them to Project characteristics.

Table 5-1 Relationships between Coast Guard Marine Planning Guidelines (2019a) and Project characteristics

Coast Guard Guideline	Project characteristics	Comments
TSS or port approaches planning guidelines		
2 nm from the parallel outer or seaward boundary of a traffic lane (based on risk for 300 to 400 m vessels)	WTGs in the evaluated layout are more than 2 nm from the Buzzards Bay TSS.	Congruent with the guideline.
5 nm from the entry/exit (terminations) of a TSS	WTGs in the evaluated layout are outside the Buzzards Bay 5-nm radius Precautionary Area.	Congruent with the guideline.
Coastal shipping route planning guidelines		
Identify a navigation safety corridor to ensure adequate sea area for vessels to transit safely	Sea room for fishing and pleasure vessels is available within the Assessment Area. Sea room for deep draft vessels is available to the west of the Assessment Area. New traffic routes were created for risk modeling, see Section 2.3 and Appendix E.	Congruent with the guideline.
Provide inshore corridors for coastal ships and tug/barge operations	The Assessment Area does not overlie significant coastwise traffic.	Congruent with the guideline.
Minimize displacement of routes further offshore	The Assessment Area does not overlie significant coastwise traffic.	Congruent with the guideline.
Avoid displacing vessels where it will result in mixing vessel types	The Project overlies fishing, passenger, and to a lesser extent, oil tanker and cargo/carrier vessel traffic. Deep draft vessels currently transit the western portion of the Assessment Area. Available sea room for deep draft vessels is available to the west of the Assessment Area. See new traffic routes created for modeling: Section 2.3 and Appendix E.	Congruent with the guideline. Fishing and pleasure traffic may choose to transit to or through the wind farm rather than around it, or may have the wind farm area as a destination. The number of pleasure vessel tracks crossing into the Assessment Area is on the order of 70 per year, so not many vessels would need to transit around if they chose to do so. Deep draft vessels could take an alternate route around the Assessment Area as a planned route deviation.

Coast Guard Guideline	Project characteristics	Comments
Identify and consider cumulative and cascading impacts of multiple Offshore Renewable Energy Installations (OREI), such as wind farms.	Offshore wind lease areas lie to the north and to the southeast of the Assessment Area. The presence of multiple OREI is included in the future case model, see Section 11.4.	Congruent with the guideline.
Offshore deep draft routes		
Offshore deep draft routes	The inbound Nantucket-to-Ambrose Safety Fairway lies 19 nm (35 km) to the south of the Assessment Area and is outside foreseeable influence of the Project.	Not applicable to the assessment.
Navigation safety corridors		
Cross track error	21 tugs or service vessel tracks entered the Assessment Area in one year based on the AIS data.	Accounted for in risk modeling.
Closest point of approach	The likelihood of encounters between vessels is included in risk modeling. See Section 11 and Appendix E.	Accounted for in risk modeling.
Density of traffic	The traffic density in the Assessment Area is described in Section 2.2.2 and Section 2.5.	Accounted for in risk modeling.
Other site-specific considerations		
Crossing or converging routes	The likelihood of encounters between vessels is part of the risk model. See Section 11 and Appendix E.	Accounted for in risk modeling.
Hazards on opposite sides of a route		None identified.
Severe weather/sea state	Accounted for in risk modeling.	Severe weather and sea states are accounted for in modeling. See Section 7, Section 11, and Appendix E .
Severe currents		Not applicable to the assessment.
Displacement of vessels into routes with other vessel types	See new traffic routes created for modeling: Section 2.3 and Appendix E.	Accounted for in risk modeling.
Complexity of vessel interactions	The Assessment Area is in an area of relatively lower complexity and has fewer vessel tracks than the nearby coastal waters.	Accounted for in risk modeling.

Coast Guard Guideline	Project characteristics	Comments
Transit distance affected by a new hazard	The transit distance is expected to increase for those vessels choosing to route around the Assessment Area. The types of vessels currently entering the Assessment Area are discussed in Section 2.1.3.	Accounted for in risk modeling.
Undersized routing measures		None identified.

5.3 Project impact on anchorage areas

NVIC 01-19 guides the applicant to consider the effect the Project will have on anchorage areas. Figure 5-1 shows the anchorage areas and cable routes. The closest anchorage is Anchorage G, located 12 nm (22 km) to the northwest. No anchorage areas lie to the south. The Project is not expected to affect vessel anchorage operations.

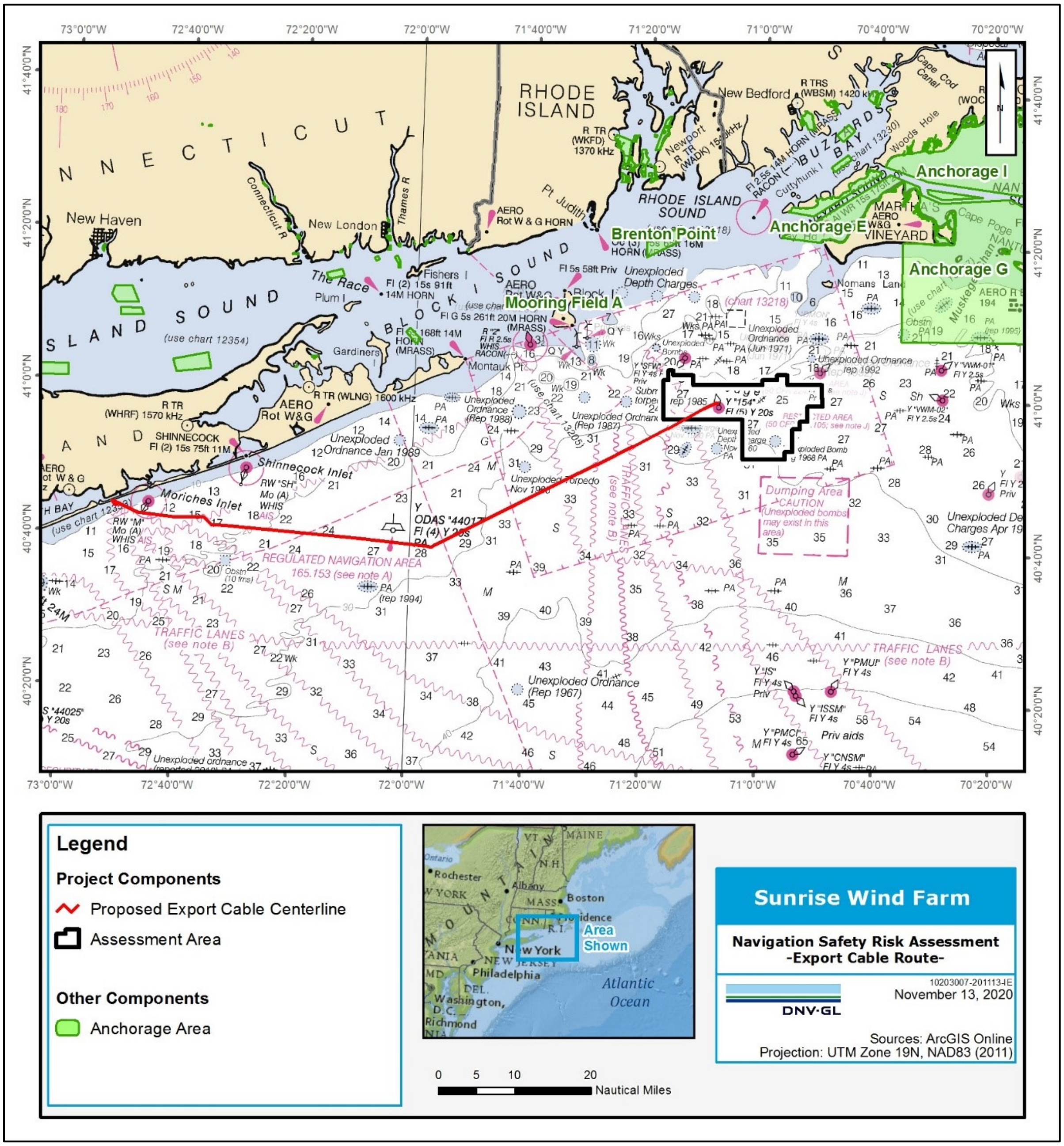


Figure 5-1 Designated anchorage areas in Marine Traffic Study Area (NOAA, 2017)

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

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

Based on the average DWT of vessels in the AIS dataset (see Section 2.1.3), only tankers carrying oil products have an average tonnage greater than 50,000 DWT, very few large vessels transit in the vicinity of the Project Assessment Area (see previous Figure 2-40), and all deep draft vessels are expected to transit at safe distances from WTGs. All other vessels in the AIS dataset are generally smaller and less likely to cause damage to the export cable even in an emergency anchorage situation. Fishing activities and cables present potential hazards to one another and are discussed in Section 3.1.

Based on historic analysis, construction vessels are the most likely to inadvertently damage a cable during normal operations if unaware of the location (BOEM, 2011). However, construction planning, safety meetings, and proper marking of the cable on applicable navigation charts will reduce this risk. The Project has also committed to publishing frequent Mariners Briefings on www.us.orsted.com/mariners to provide notice to all mariners of current and planned on-site Project activity. The Project will provide similar information to the First Coast Guard District for publication in its weekly Local Notice to Mariners. (Sunrise Wind LLC, 2020)

6 EFFECT OF TIDES, TIDAL STREAMS, AND CURRENTS

The Project WTGs and Offshore Platforms will be located offshore in waters where underkeel clearance, tides, and currents are not of general concern to mariners. Table 6-1 provides a summary of the waterways' characteristics and Figure 6-1 shows the Project on a nautical chart.

Table 6-1 Summary of waterways characteristics

Site characteristic	Summary	Source
Tidal range	Semi-diurnal tide with mean range of 1 m (2 ft)	Shonting and Cook (1970)
Tide height	3.0 ft (0.8 m) mean high water 3.2 ft (1.0 m) mean higher high water	Oregon State University Tidal Inversion Software (Egbert and Erofeev, 2010); National Oceanic and Atmospheric Administration (NOAA) coastal chart 13218 (2019a), Block Island station 8459681 (2019b); Montauk station 8510560 (2019c).
Tidal stream speed (surface)	0.6 kt (0.3 m/s) 1-year (tidal) 0.6 kt (0.3 m/s) 50-year (tidal)	DNV GL report on metocean design criteria (2018)
Tidal stream direction (set)	NW (flood), SE (ebb)	DNV GL report on metocean design criteria (2018)
Current speed (surface)	1.8 kt (0.9 m/s) 1-year (residual) 2.9 kt (1.5 m/s) 50-year (residual) 1.9 kt (1.0 m/s) 1-year (total) 2.9 kt (1.5 m/s) 50-year (total)	DNV GL report on metocean design criteria (2018)
Current direction	NW-SE (tidal) W-E (residual)	DNV GL report on metocean design criteria (2018)
Water depth	35.4 m – 59.4 m [MSL]	NOAA National Geophysical Data Center (NGDC) (1999)
Waves	Average monthly wave heights were 2.9 – 6.9 ft (0.9 – 2.1 m) in 2018, with waves greater than 9 ft occurring with 5 percent frequency	Coastal Data Information Program (2019) Coast Pilot 2 (NOAA, 2019a)

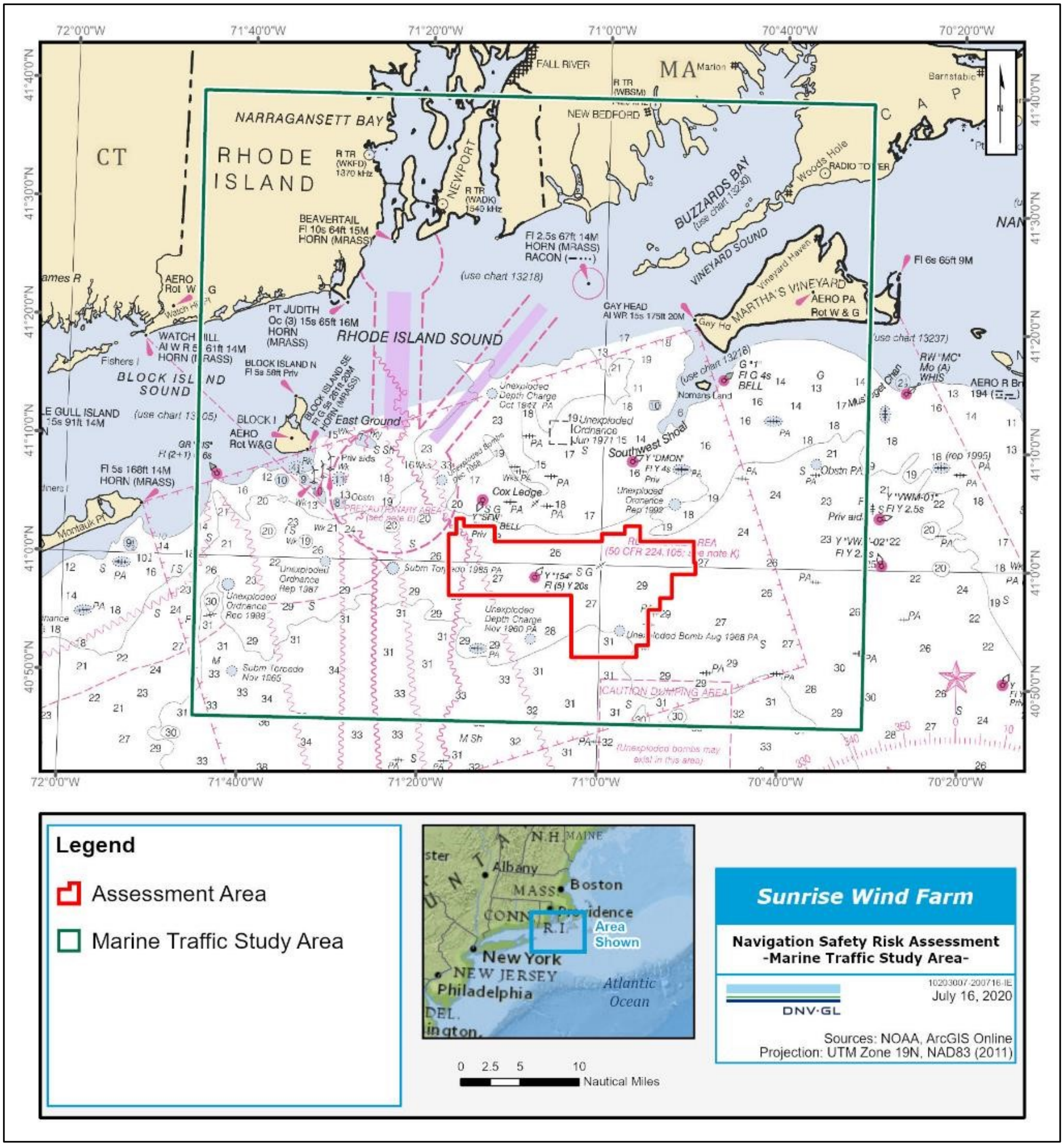


Figure 6-1 Location of Sunrise Wind Farm on a navigation chart

6.1 Tides

Tides and currents are not directly measured in the Project Assessment Area. Alternative means of estimating tides and currents were used to assure a complete year is represented in this assessment. A summary of the data and the estimated results are provided in the sections below; further discussion is provided in the DNV GL report on metocean design criteria for the nearby proposed South Fork Wind Farm (DNV GL, 2018).

For this assessment, tide heights were determined using two different methods:

- Analysis of tide height measurements from nearby NOAA stations
- Simulations using the Oregon State University Tidal Inversion Software (Egbert and Erofeev, 2010)

The closest NOAA stations to the Assessment Area that offer tidal data are Block Island, Rhode Island (NOAA station 8459681) and Montauk Point, New York (NOAA station 8510560), which are 15 nm (28 km) WNW and 30 nm (58 km) west of the Assessment Area, respectively.

Table 6-2 summarizes the available tidal data. The Block Island station was removed in July 2004, but usable data are available for the period 8 April 1998 to 31 October 2000 (NOAA, 2019a). The Montauk station data from 2010-2017 were analyzed (NOAA 2019b).

Table 6-2 Summary of tides at Block Island

	Mean Lower-Low Water	Mean Low Water	Mean High Water	Mean Higher-High Water
Block Island average	0.1 ft (0.0 m)	0.4 ft (0.1 m)	2.7 ft (0.8 m)	3.2 ft (1.0 m)
Block Island extreme	-2.1 ft (-0.6 m)	-1.5 ft (-0.5 m)	4.0 ft (1.2 m)	4.6 ft (1.4 m)
Montauk average	0.3 ft (0.1 m)	0.5 ft (0.2 m)	2.6 ft (0.8 m)	2.9 ft (0.9 m)
Montauk extreme	-0.2 ft (0.1 m)	-0.1 ft (0.0 m)	3.0 ft (0.9 m)	3.2 ft (1.0 m)

The East Coast of America 1/30° domain of the Oregon State University Tidal Inversion Software was used to estimate tide heights (Egbert and Erofeev, 2010) within 2 nm (2.3 km) of the Assessment Area. The data set has a spatial resolution of 1/30°, simulating 8 tidal constituents and it assimilated 531 cycles of Topex/Poseidon, 114 cycles of Topex/Tandem and 108 cycles of ERS/Envisat satellites. The model also assimilated tide gauges along the coast.

Table 6-3 Summary of modeled tide data for South Fork Wind Farm

Tide height relative to Mean Lower Low Water (MLLW)	SE corner	NW corner
Highest astronomical tide	4.7 ft (1.4 m)	4.8 ft (1.5 m)
Mean sea level	1.8 ft (0.5 m)	1.8 ft (0.6 m)
Lowest astronomical tide	-0.7 ft (-0.2 m)	-0.7 ft (-0.2 m)

The tidal summaries above are generally consistent with the tide information provided on NOAA coastal chart 13218 (NOAA, 2019a), which shows a Mean High Water (MHW) level at Old Harbor, Block Island, of 3.0 ft (0.9 m) and a MHHW of 3.2 ft (1.0 m) at Old Harbor, Block Island.

6.2 Tidal stream and current

Estimates of tidal stream and residual current speeds were obtained using a combination of the Admiralty TotalTide software (2001), the HYCOM model (HYbrid, 2018), the MIKE 21 simulation package (DHI, 2005a and 2005b), and the Oregon State University Tidal Inversion Software (Egbert and Erofeev, 2010).

Table 6-4 summarizes the tidal stream and residual current speeds based on analysis of the modeled results.

Table 6-4 Summary of tidal stream and residual current speeds within 2 nm of the Project Assessment Area

Omni-directional surface extremes	Tidal stream speed	Residual current speed	Total surface current
1-year	0.6 kt (0.3 m/s)	1.8 kt (0.9 m/s)	1.9 kt (1.0 m/s)
50-year	0.6 kt (0.3 m/s)	2.9 kt (1.5 m/s)	2.9 kt (1.5 m/s)

The DNV GL metocean report (2018) also estimated the directional frequency of the tidal stream, residual current, and total current. The annual average directional frequency distributions are shown in Figure 6-2 below and follow an overall northwest (flood) to southeast (ebb) pattern (NOAA, 2018).

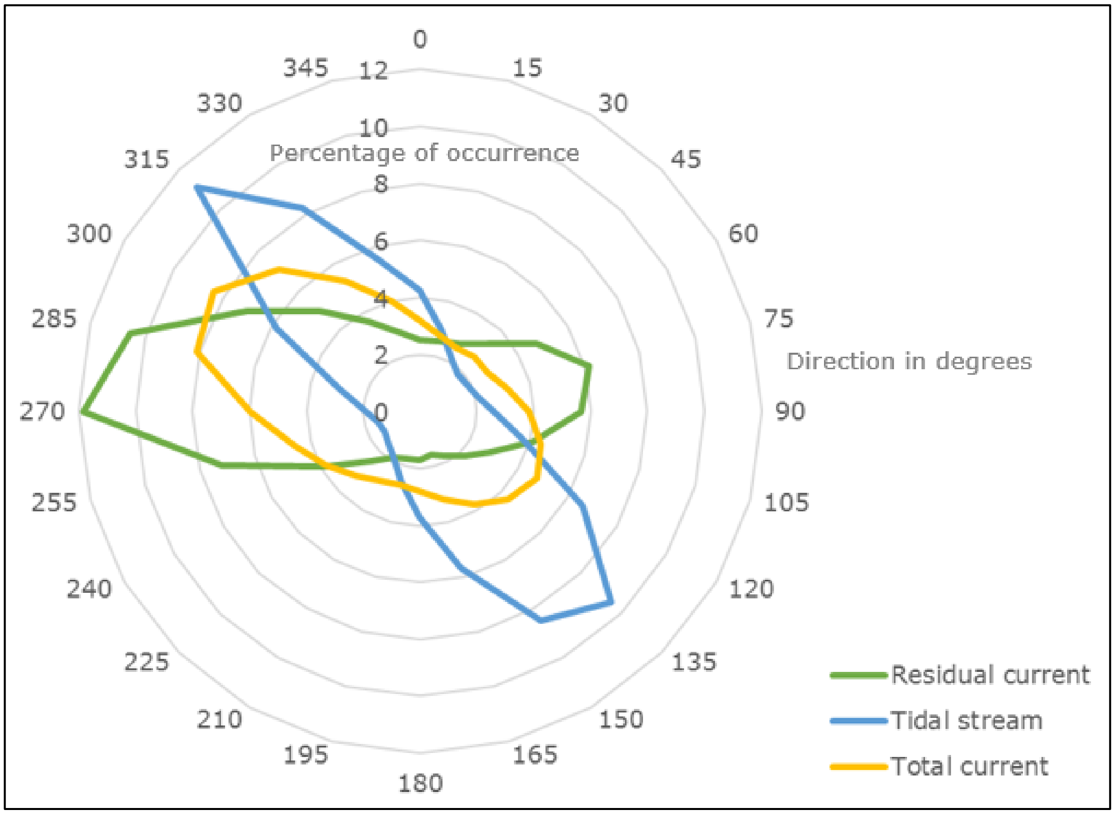


Figure 6-2 Tidal stream and current directional frequency (%) within 2 nm of the Project Assessment Area

The axis of the wind turbine layout is a north-south, east-west grid-like pattern. The effect of sea state and possible engine failure 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 tidal stream is low in the Assessment Area and is not expected to significantly affect navigation safety.

It is not anticipated that the WTGs and Offshore Platforms will affect the general set and rate of the tidal stream or current. Anticipated impacts, if any, to tides, currents, air column, water column, seabed, or sub-seabed are discussed in the appropriate section(s) of the Construction and Operations Plan.

6.3 Bathymetry

Data from the National Geophysical Data Center was used to determine water depths (1999). Water depths in the Project Assessment Area range from 35.4 to 59.4m (116 to 195 ft).

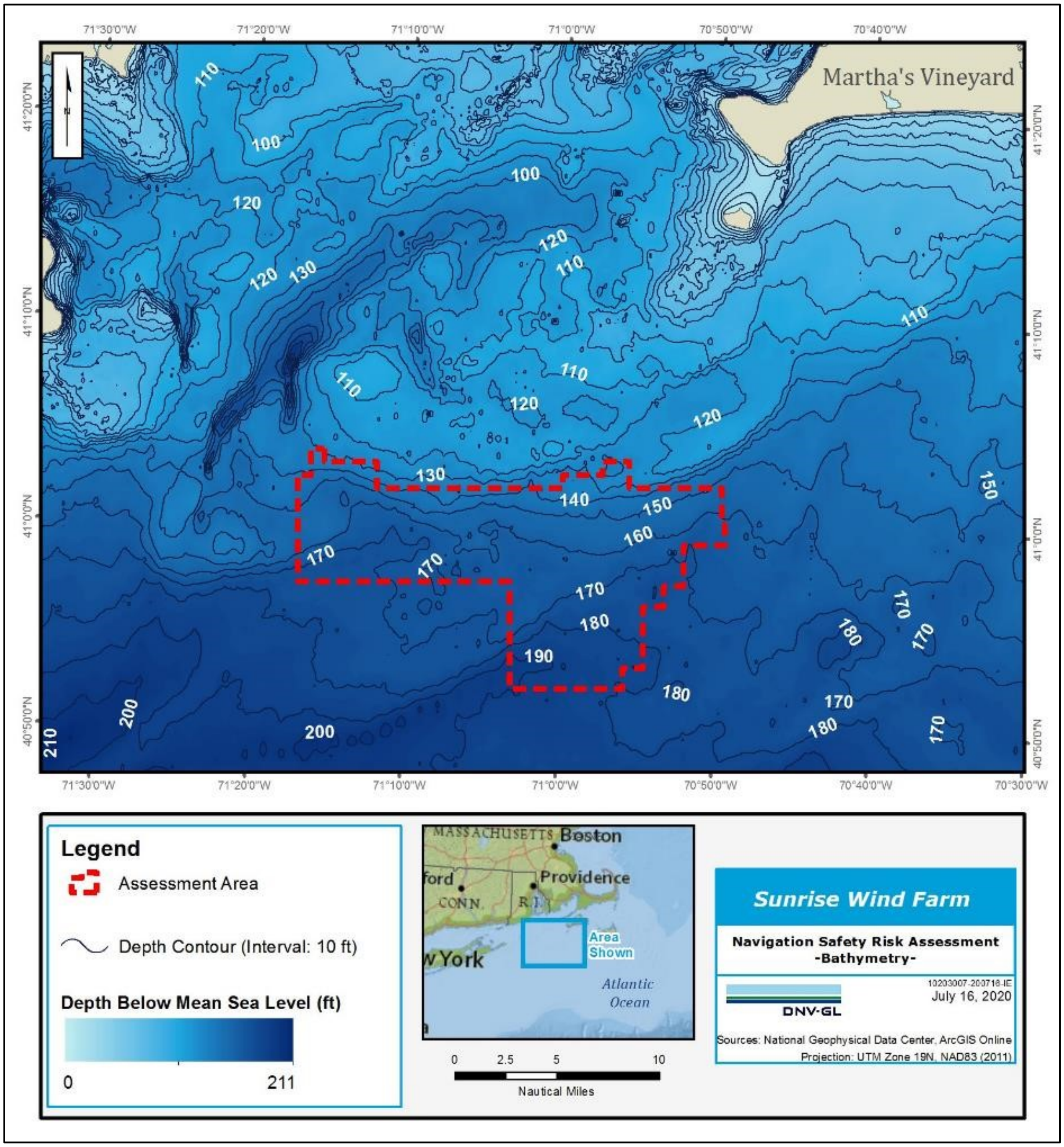


Figure 6-3 Bathymetry in and around the Assessment Area (depths in ft) (NOAA, 1999)

7 WEATHER

Weather, winds, and visibility are important factors for vessels to consider when considering transiting in the vicinity of the Project Assessment Area. Table 7-1 summarizes relevant weather characteristics in the Assessment Area. The effect of wind speed, wind direction, visibility, and possible engine failure are directly accounted for in the modeling described in Section 11 regarding the risk of collision, allision, and grounding.

Table 7-1 Summary of weather characteristics

Site characteristic	Summary	Source
Wind speed at 33 ft (10 m) height	14.1 kt (7.2 m/s) mean 55.1 kt (28.3 m/s) maximum hourly average 64.2 kt (33 m/s) 10-minute average (50-year return) 81.7 kt (42 m/s) 3-second gust (50-year return)	DNV GL Virtual Met Data (VMD)
Prevailing wind direction	west-southwest	DNV GL VMD
Visibility	91.4% > 8 nm (4.3 km) visibility	Block Island State Airport (NOAA, 2019a)
Ice	Floating ice is not present. Ice drop from light ice accretion may occur <9 days/month Nov.-Mar. Ice drop from moderate accretion is unlikely with <1 day/month Jan.-Feb. Ice throw is unlikely due to turbine control strategy and minimal moderate ice accretion.	Coast Pilot 2 (NOAA, 2018); Rhode Island (2010); Merrill (2010)

7.1 Winds

No long-term on-site wind speed measurements in the Assessment Area were available for this assessment. DNV GL's VMD system was used to generate a 17.5-year time series of hourly wind speed and wind direction at a horizontal resolution of 1.1 nm (2.0 km) for the nearby proposed South Fork Wind Farm, which is within 2 nm (2.3 km) of the Assessment Area. Summaries of the generated data at 33 ft (10 m) elevation are presented in this section.

Figure 7-1 and Figure 7-2 present the average and maximum hourly wind speeds expected for each month of the year over this period, respectively. It can be observed that the highest wind speeds occur between November and February, while the lowest wind speeds occur between June and August. DNV GL finds this to be consistent with other wind speed datasets reviewed in this region.

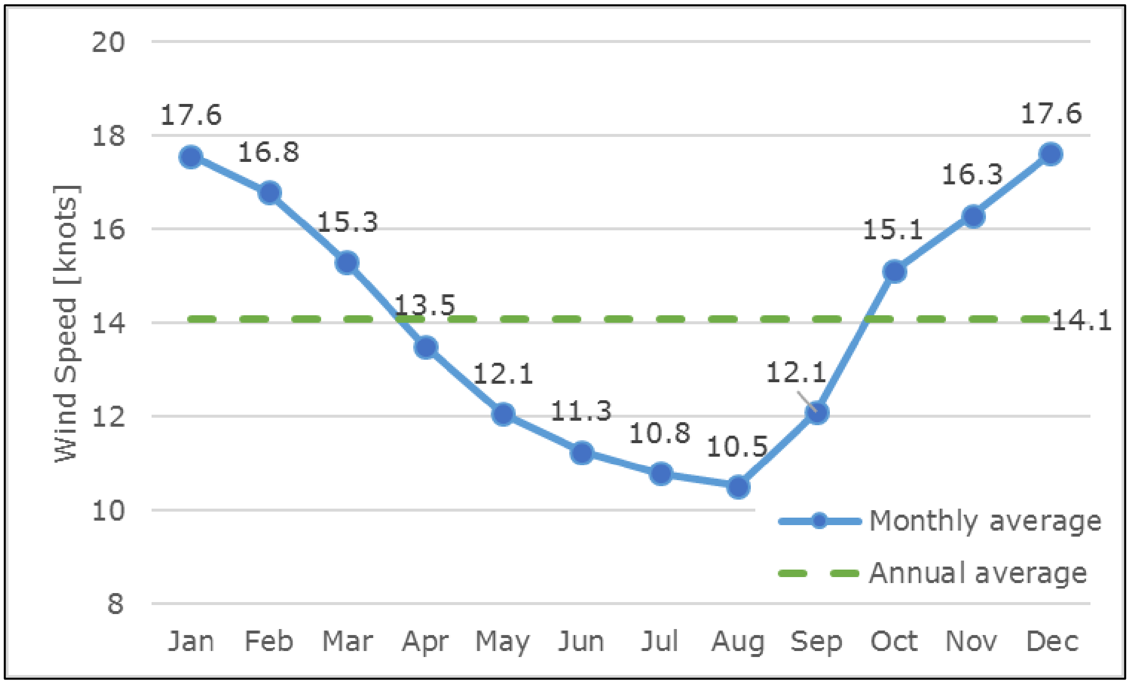


Figure 7-1 Average hourly wind speeds expected at 33 ft (10 m) height above MSL

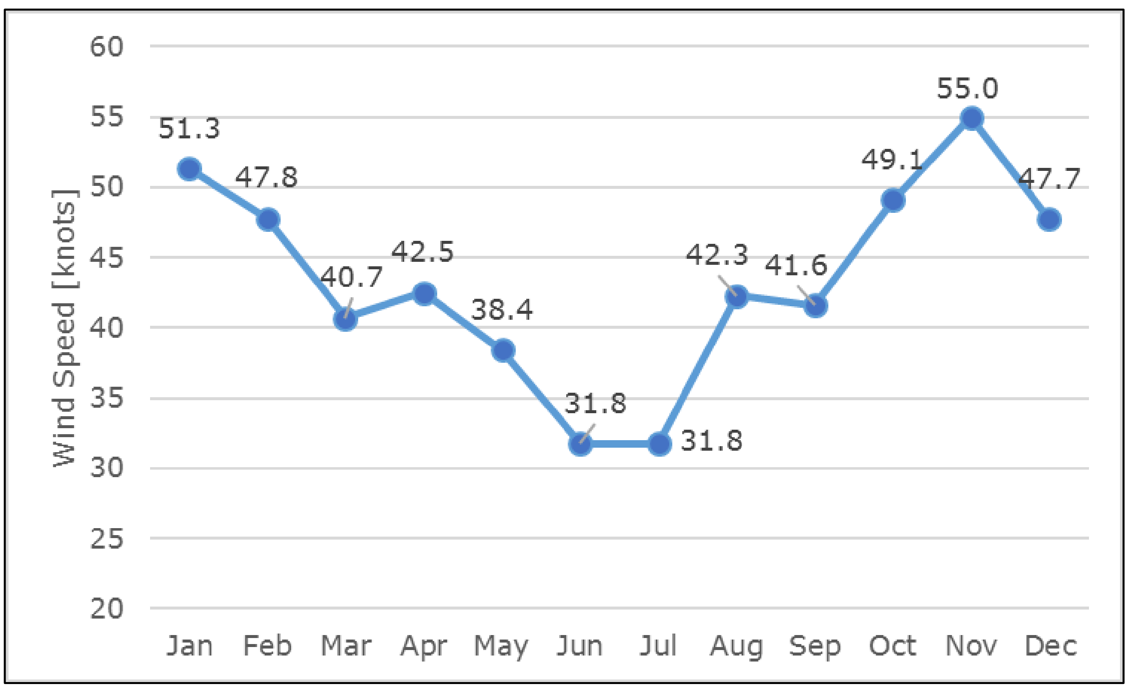


Figure 7-2 Maximum hourly winds speeds from 17.5-year VMD at 33 ft (10 m) height above MSL

The 17.5-year mean wind speed at 33 ft (10 m) elevation is 14.1 kt (7.2 m/s). The distribution of wind speeds over this period is shown in Figure 7-3.

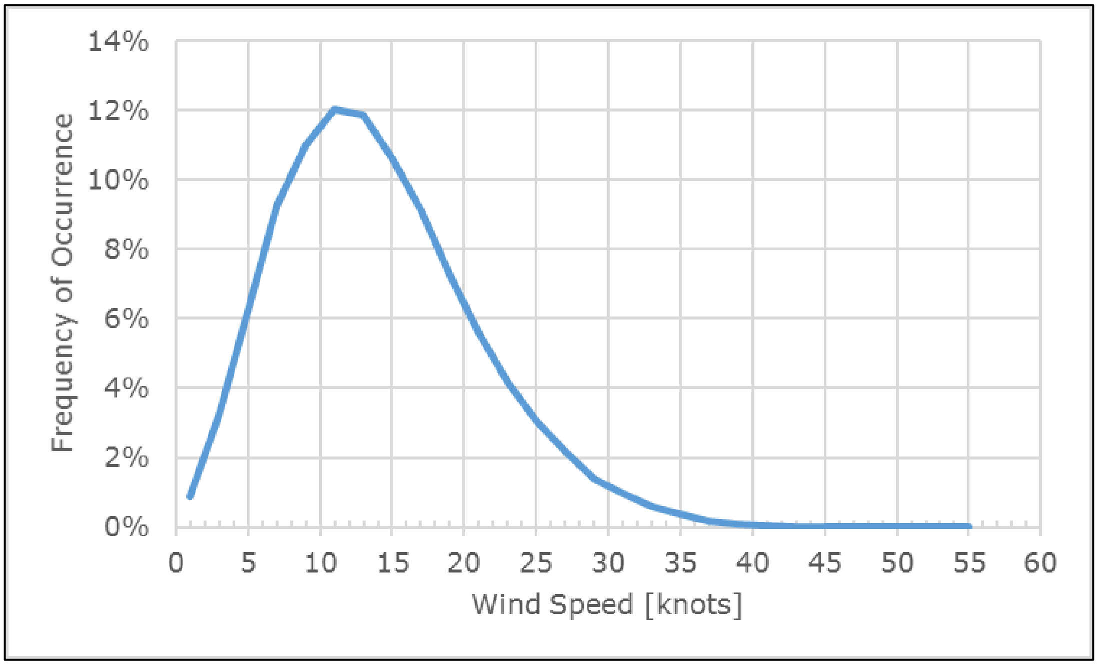


Figure 7-3 Distribution of wind speeds at 33 ft (10 m) height above MSL

The prevailing wind direction is from the west-southwest. Figure 7-4 presents the distribution of wind directions over this period. The distribution of wind directions (the wind rose) shows that winds come from almost all directions over the course of a year, although the wind comes from the southwest to west the majority of the time.

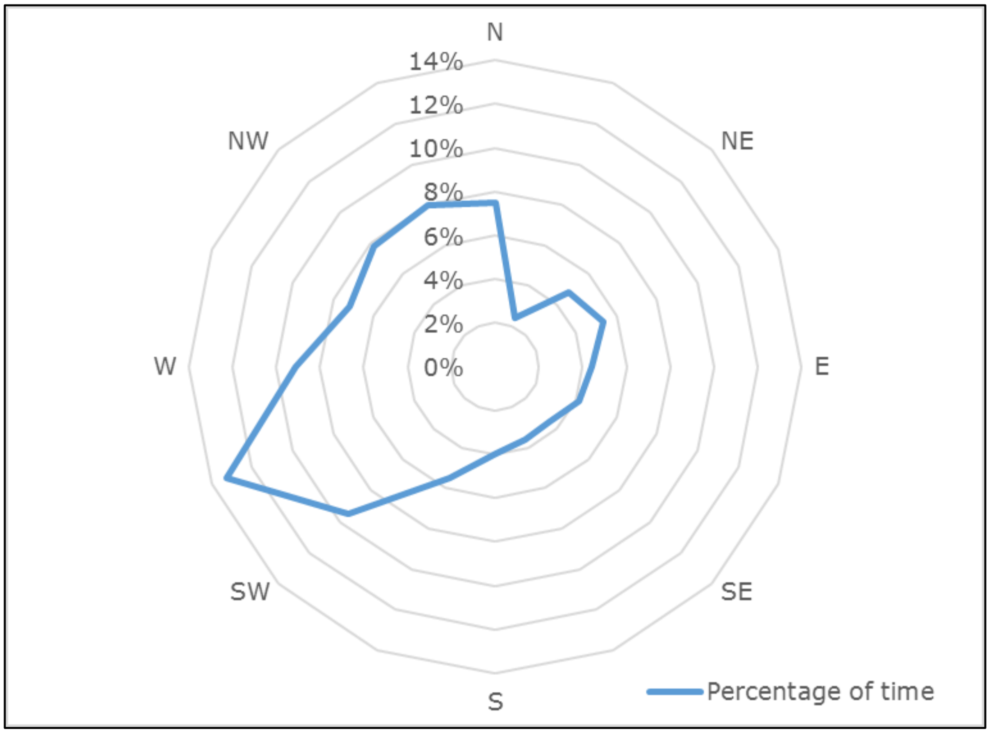


Figure 7-4 Wind direction distribution expected at 33 ft (10 m) height above MSL

There is a greater threat of tropical and extra tropical storms in the months of September and October (Knapp et al., 2010). The International Best Tracks for Climate Stewardship database track data was used to identify hurricanes that passed in the vicinity of the Assessment Area between 1969 and 2019 (NOAA, 2019e) (Table 7-2 and Figure 7-5). Of the 85 storms passing within 5 degrees of the Assessment Area, 85% were Category 1, or lesser, tropical events.

Table 7-2 Number of cyclones within 5 degrees of the Assessment Area (NOAA, 2019e)

Hurricane scale (Saffir Simpson)	Number of occurrences 1969-2019
Tropical Depression	11
Tropical Storm	39
Category 1	22
Category 2	10
Category 3	3
Total	**85**

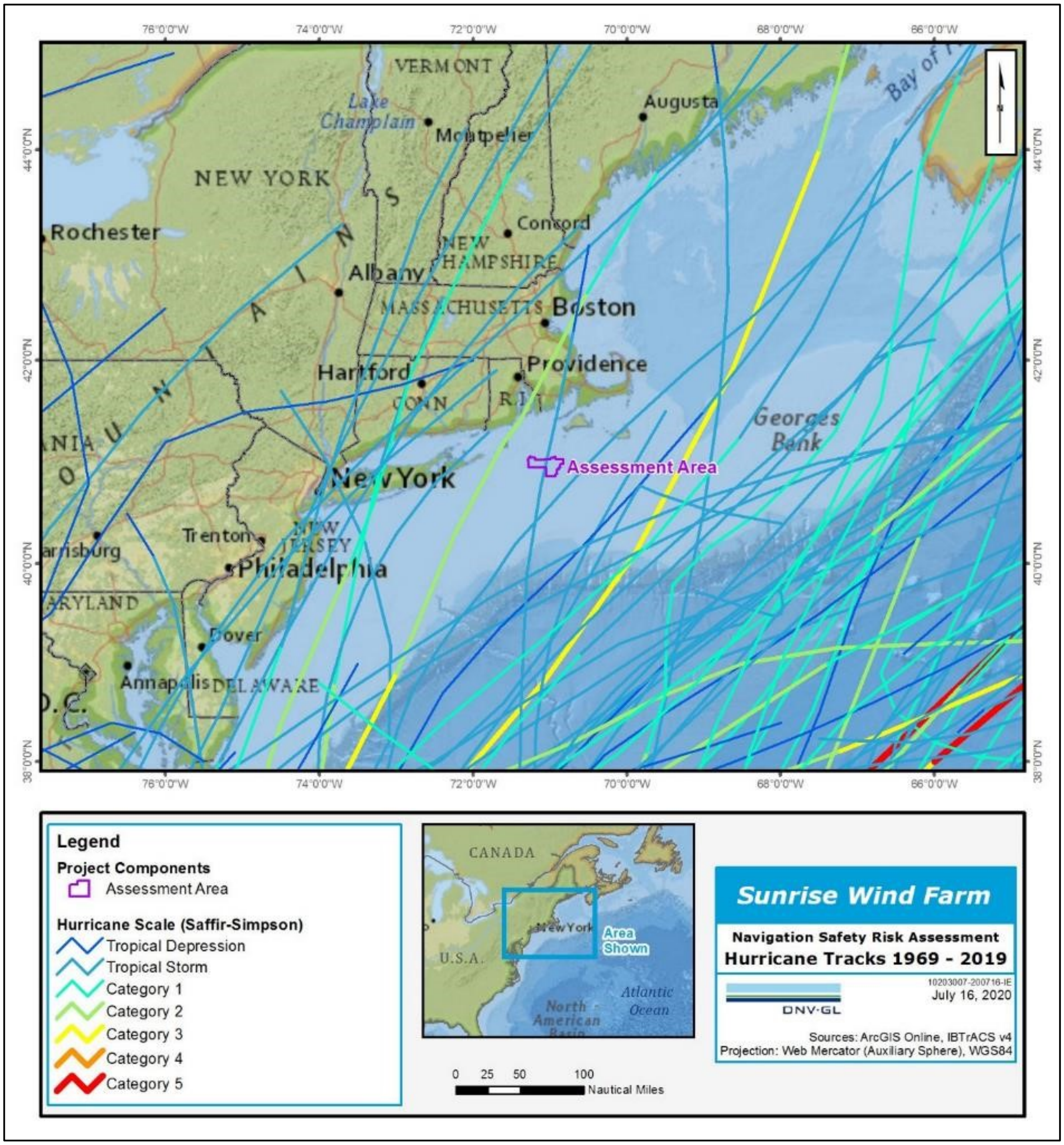


Figure 7-5 Tracks of cyclones within 5 degrees of the Project Assessment Area (1969-2019)(NOAA, 2019e)

7.2 Consideration of vessels under sail

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

7.3 Visibility

Visibility data were obtained from Climate Data Online for Block Island State Airport station 94793 (NOAA, 2019b). This is the closest station with available visibility data and is therefore taken to be the best available data for visibility conditions at the site.

Figure 7-6 summarizes 10 years of visibility data from the Block Island State Airport station. Visibility was less than 2 nm (2.3 km) about 8.6 percent of the time. April, May, and June are most likely to have hours of visibility less than 2 nm (2.3 km) due to any of several factors, including fog, haze, snow, rain, etc.

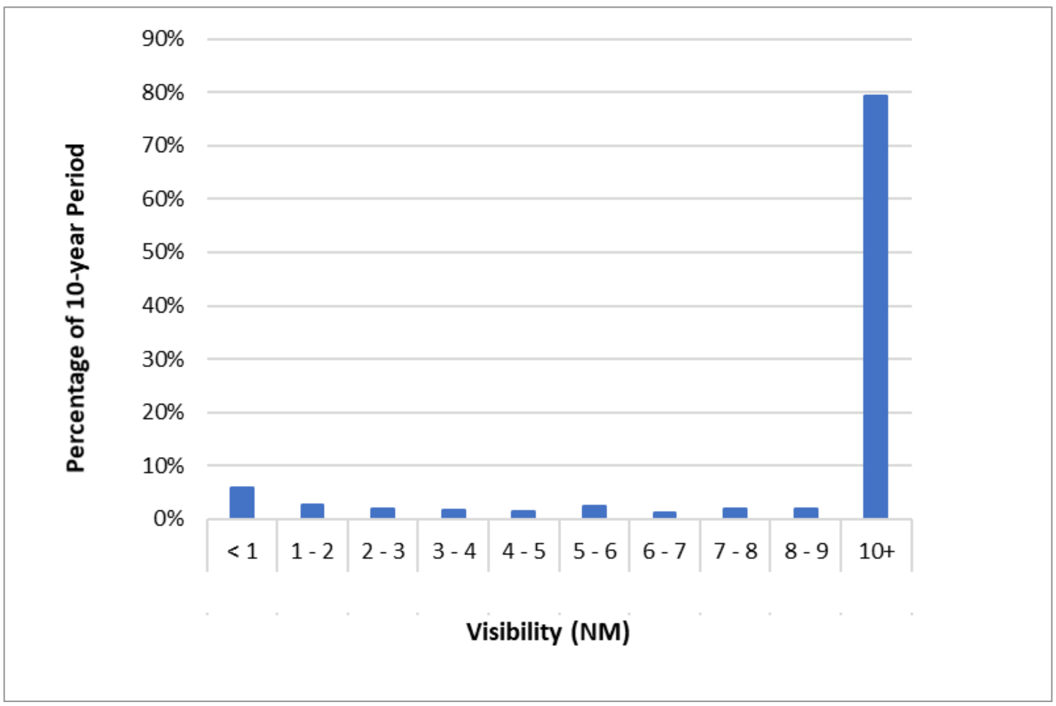


Figure 7-6 Summary of visibility measurements at Block Island State Airport (2009-2019) (NOAA, 2019b)

7.4 Ice

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

7.4.1 Floating ice

Coast Pilot 2 (NOAA, 2018) discusses ice within the waters of Narragansett Bay, Providence River, and Mount Hope Bay and other inland waterways. There is no discussion of ice accumulation in the vicinity of the Project site or in the traffic separation scheme in Coast Pilot 2. Admiralty Sailing Directions Volume 2 (UK Hydrographic Office, 2017) also describes floating ice as being extremely rare even during severe winter seasons. Pack ice usually lies well north of 40°N latitude and pack ice that does drift south is always well east of the Project Assessment Area. This assessment has found no other information to suggest that floating ice is present or poses a risk to navigation in the vicinity of the Project.

7.4.2 Falling ice

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

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

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

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

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

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

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

8 CONFIGURATION AND COLLISION AVOIDANCE

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

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

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

This assessment is provided to assist the Coast Guard with its own site-specific evaluation of the potential impacts (both positive and negative) to Search and Rescue (SAR) services in and around the Project.

The MARI PARS report provides the following conclusion about potential effects of structures on SAR in the WEA:

> "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." (Coast Guard, 2020a)

Project risk mitigations most relevant to collision avoidance include:

- The WTG layout will be in linear rows and columns oriented both north-south and east-west with 1 nm spacing between WTGs and OCS-DC. This will provide at least three lines of orientation and alternative routes for vessels or aircraft transiting the wind farm and provide multiple options in case of high winds or seas.
- Affiliates of Sunrise Wind have proposed development of additional wind farms in adjacent areas. The WTGs in adjacent/contiguous farms will have a congruent alignment.

9 VISUAL NAVIGATION

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

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

A geometric approach was used to determine potential visual obstruction caused by Project WTGs or OCS-DC, 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 in the PDE. A jacket foundation is a tubular structure with substantial open space between the supporting elements. Therefore, the largest considered monopile foundation is the basis for this assessment.

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

The potential length of visual obstruction for a Project structure is estimated based on the effective diameter plus a buffer. The largest monopile foundation in the PDE has a widest tube diameter, at the sea bottom, of 49 ft (15 m). An additional 1 m is added on either side to account for ancillary equipment, resulting in an effective diameter of 56 ft (17 m). A 56-ft vessel could be unseeable from an opposite position from the structure.

A safety buffer of 36 ft (10 m) was added to the effective diameter to account for the uncertainty in the distance between the unseen vessel and the structure that is impeding line of sight (LOS) to it. The resulting diameter is 89 ft (27 m), representing the maximum potential for visual obstruction.

For a vessel travelling at 5 kt, the visual obstruction would be 10.5 seconds. This is the period of time that a foundation could potentially limit a vessel's visibility of a second vessel, assuming the second vessel was centered directly opposite it and was not moving.

This is a conservative approach since the structures are spaced so far apart, both vessels would need to be transiting on specific routes to lose sight of each other for very long. Table 9-1 summarizes the potential time of limited visibility for vessels transiting at various speeds. The distance travelled without the other vessel in sight is approximately 0.014 nm (26 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	10.5
10	5.2
15	3.5

The Project layout evaluated in this assessment (Figure 9-1) has a minimum of 1.0 nm between Project structures. This represents more than 90 vessel lengths for a 65-ft fishing vessel.

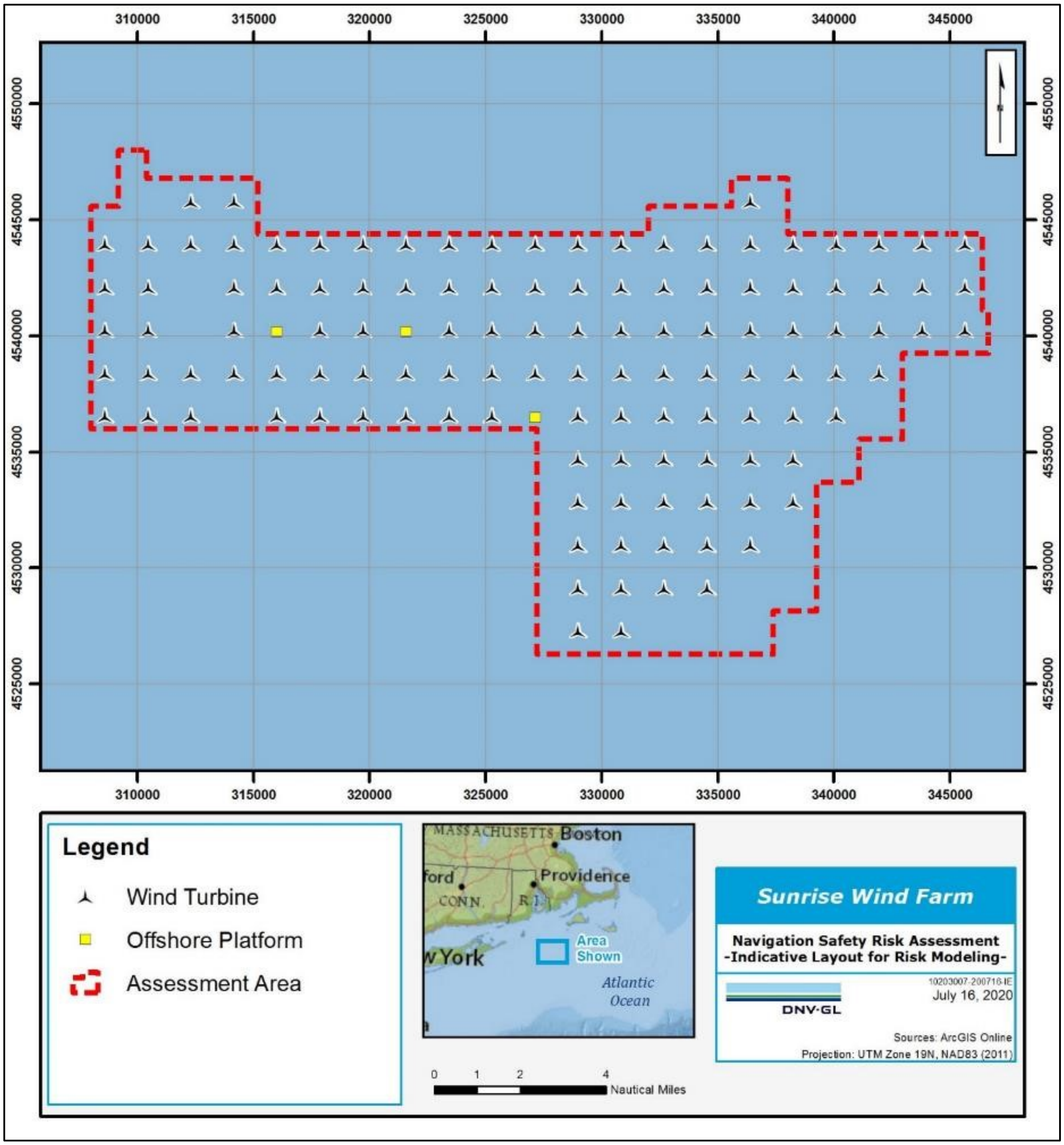


Figure 9-1 Project representative layout (structures larger than scale)

A more detailed discussion of navigation within the boundaries of the Project is included in Section 11.

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

During operation, each foundation will serve as an ATON for mariners as they are large structures that will be lighted and marked as required by applicable law and regulation and included in conditions the Coast Guard may impose in conjunction with its PATON permits. The prospective marking scheme for Project structures is described in Section13, pending revised formal guidance from the Coast Guard, which is being developed at the time of issuance of this NSRA.

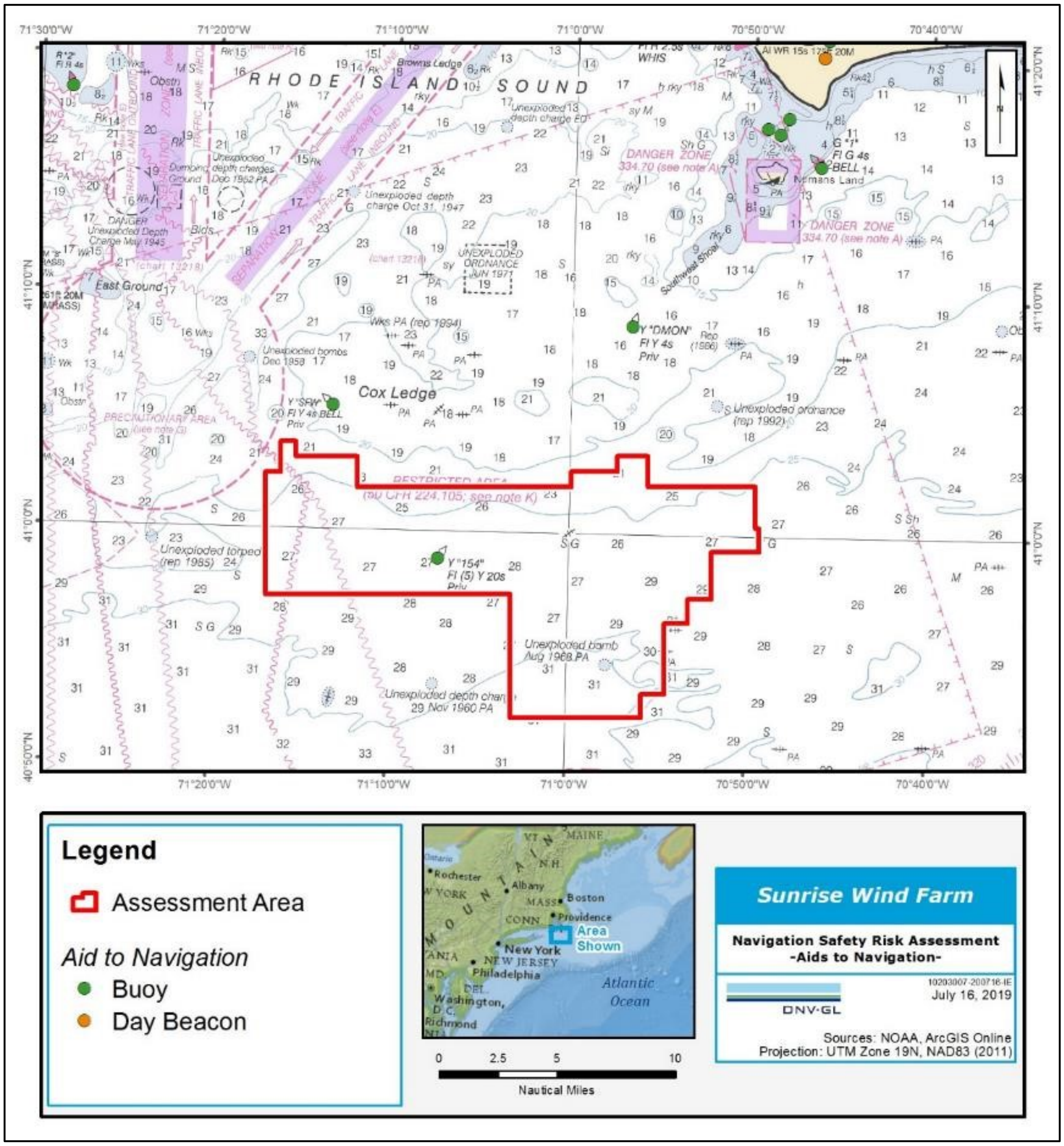


Figure 9-2 ATON in the Vicinity of the Project

10 COMMUNICATIONS, RADAR, AND POSITIONING SYSTEMS

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

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

No risks to the health of vessel crews are anticipated from the power and noise generated by Project structures.

10.1 Effect on communications

The scope of this section includes marine communications systems, including ship-to-ship and ship-to-shore communications systems. The research included evaluations of High Frequency (HF), Very High Frequency (VHF), and Ultra High Frequency (UHF) radio systems. In general, 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). The signal recovers within a few hundred yards.

Mariner Radio-Activated Sound Signals (MRASS) are also VHF-based and are expected to be deployed in the Sunrise Project, similar to the deployment at Block Island Wind Farm (Sunrise Wind LLC, 2020).

The Coast Guard's advanced command, control, and direction-finding system, "Rescue 21," is unlikely to experience any degradation from the Project. The Rescue 21 architecture and VHF propagation characteristics overcome interference associated with fixed structures such as wind turbines.

The Project has committed to expanding VHF and cellular phone coverage, which will improve communications in the vicinity of the Project.

The following sections summarize relevant studies.

U.S. Department of Energy

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

Horns Rev Wind Farm

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

North Hoyle Wind Farm

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

10.2 Effect on radar

The potential impacts on marine radar are variable, with the most likely effect being some signal degradation. Proximity to the WTGs is the primary factor that determines the degree of radar signal degradation. 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 wind farm. 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).

Below are summaries of project-specific radar studies of layouts for wind farms in the U.S. and UK.

10.2.1 Block Island Wind Farm

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

Pre- and post-construction radar impact studies have been conducted at the Block Island Wind Farm, and no permanent radar interference was detected (Sunrise Wind LLC, 2020).

10.2.2 Skipjack Wind Farm

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

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

Radar clutter assessment

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

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

Saturation assessment

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

Shadowing assessment

Shadowing estimates were made of the jacket foundation and tower. Significant shadowing zones were limited to narrow strips behind the turbines relative to the radar position. The likelihood of detection of vessels in the shadow zone can be reduced. The impact is likely to be largest for small targets at long range. In the scenarios considered, the width of shadow zones in the traffic separation scheme ranges from 400 ft (122 m) to 3,230 ft (1,000 m). The width of the zones in the vicinity of the turbines is much smaller. Shadowing impacts will not be persistent due to the motion of the radar vessel and other vessels. The impact of the monopile foundation has not been modeled but is likely to be greater than the jacket option.

10.2.3 Horns Rev 1 Wind Farm

The Horns Rev 1 Wind Farm is an 80-WTG wind farm located in the North Sea off the coast of Denmark (Vattenfall, 2017). Observations of radar interference were made during construction and during operations of the wind farm, which used monopile foundations. No shadowing was observed and vessels operating within the wind farm were able to detect all 80 WTG towers on radar (Elsam Engineering, 2004).

10.2.4 Kentish Flats Wind Farm

The Kentish Flats Wind Farm is situated between 4.6 and 7.0 nm (8.5 and 13 km) north of Herne Bay and Whitstable in Kent, UK (Vattenfall, 2017b). The wind farm consists of 30 WTGs on monopile foundations, with a combined capacity of 90 MW (MARICO Marine, 2017).

In 2006, independent research was conducted by MARICO Marine on behalf of the British Wind Energy Association to assess the effects of the wind farm on marine radar. The research was conducted in the actual wind farm environment using a wide range of vessel types, radar systems, and operators, including commercial ships, professional mariners and marine pilots, Vessel Traffic Service, and small recreational craft.

The MARICO findings concluded that trained mariners can identify the effects of wind farms on radar displays and can make necessary adjustments to mitigate their impacts. Many of the radar echoes were produced by ship structures and fittings. This is not uncommon for marine radar and mariners can adjust gain and sensitivity to account for the echoes. Echoes produced by WTGs are similar and, similarly, operators can adjust onboard radar systems to account for such interference.

In the study, mariners could track other large vessels within the wind farm as well as from behind the wind farm. Small craft in the vicinity of the wind farm were detectable by radar on ships passing nearby. But, radar signals from small craft within the wind farm were often lost within the stronger echoes from the WTGs when the small craft passed close to the WTGs. The effect was temporary until the small vessel moved away from the WTG. Small vessels operating within the wind farm were less detectable by all radar types evaluated, because of the WTGs. Adjustments to radar gain control could mitigate the effect but required some skill on the part of the radar operators.

The study evaluated the detection of floating ATON, specifically, a navigation buoy. Radar detection of the reference buoy was unobstructed from the opposite side of the wind farm.

Marine pilots were aware of the potential for radar interference caused by the wind farm. However, they were "relatively unconcerned" with the presence of the wind farm and its impact on shipboard radar. They did express that if wind farms were situated closer to shipping lanes, it could be cause of some concern and require further evaluation (MARICO Marine, 2017).

10.2.5 North Hoyle Wind Farm

The North Hoyle Wind Farm is located 3.7-4.3 nm (7-8 km) off the coast of North Wales. It consists of 30 WTGs on monopile foundations in an area of approximately 3 nm^2 (10 km^2) (Yelenic, 2016). QinetiQ partnered with the UK MCA to evaluate the impacts of the North Hoyle Wind Farm on shipboard radar systems. The study evaluated shipboard and shore-based radar systems (Howard and Brown, 2004).

The study found that the effects of radar shadowing prevented detection of small vessels behind the WTG towers when the subject vessel was stationary. At an observation angle of 4 degrees, at a range of 3 nm (5.5 km), vessels within the wind farm were detectable and not obscured by shadowing. Clutter caused by WTG towers was also observed but could be sufficiently reduced by the radar operator's reduction of the gain setting.

It should be noted that adjusting the amplification of a radar receiver (i.e., gain adjustments) also adjusts the return strength of vessel targets. It is possible to reduce the gain to a point that prohibits display of vessel targets. Sea state and precipitation can also impact radar performance and signal strength. Close attention to radar gain and sensitivity settings should be paid while transiting near an offshore wind farm.

10.3 Effect on positioning systems

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

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

10.4 Potential mitigation measures for radar effects

In general, mitigation measures can reduce the impacts of the wind farm on radar and communications. Potential measures 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 vicinity of the Project Assessment Area from operation of the Project that builds upon earlier work conducted by the Coast Guard (e.g., 2015 and 2020). The risk assessment consists of a "what if" consequence analysis and estimates of frequency or probability of each accident for each vessel type.

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

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

The results are presented by accident type 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 16 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.

The historical accident record for offshore wind farms is sparse. Offshore wind farms have been in operation in the European Union (EU) for 29 years (Wind Europe, 2019). This study identifies three documented allisions in wind farms involving vessels not associated with the 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. The supplementary traffic added to the AIS data is summarized in Table 11-1 and details are provided in Section 2.3 and Appendix E.

Table 11-1 Transits added to AIS data for modeling

Vessel type	Activity	Included in base case model (each way)	Included in future case model (each way)
Recreational Vessels without AIS (similar to "Pleasure" AIS vessel type) (see Section 2.1.1.4)	Fishing	386	386
	Other pleasure activities	374	374
Commercial Fishing Vessels without AIS (see Section 2.1.1.2)	Fishing in Assessment Area	13,324	13,324
	Transiting through Assessment Area	6,288	6,288
Passenger, shallow draft (see Section 2.3)	Sightseeing	-	100
LPG carrier, deep draft (see Section 2.3)	Traffic growth	-	8
Cruise ship, deep draft (see Section 2.3)	Traffic growth	-	50

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

- Vessel speed
- Vessel direction/route
- Distance traveled on the route
- Probability of steering and / or propulsion failure
- Probability of error in navigation
- Distribution of wind direction and effect on sea state
- Probability of visibility greater than 2 nm
- Whether another vessel or object is within 0.5 nm (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 to this NSRA. A detailed description of the Project-specific model for collision, grounding (drift and powered) and allision (drift and powered) is in Appendix E to this NSRA.

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

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

Table 11-2 provides a summary of the incremental risk results for Sunrise Wind Farm, reported as increases in the frequency of accidents in the Marine Traffic Study Area in Figure 11-3.

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

Vessel type	Increase in frequency of any accident (number per year)	Percentage of Total
Fishing	1.512	94%
Pleasure	0.035	2%
Other/Undefined	0.024	1%
Passenger	0.021	1%
Cargo/Carrier	0.010	1%
Tanker - Oil Product	0.003	<0.5%
Tanker	0.002	<0.5%
Tug/Service	0.002	<0.5%
Total	1.608	100%

The model shows that the frequency of marine accidents increases by 1.6 accidents per year. Marine accidents involving fishing vessels represent 94% of the increase (Figure 11-1). Note this accident frequency increase is for all accidents and will include accidents with small and zero consequence such as bumping into a foundation while drifting.

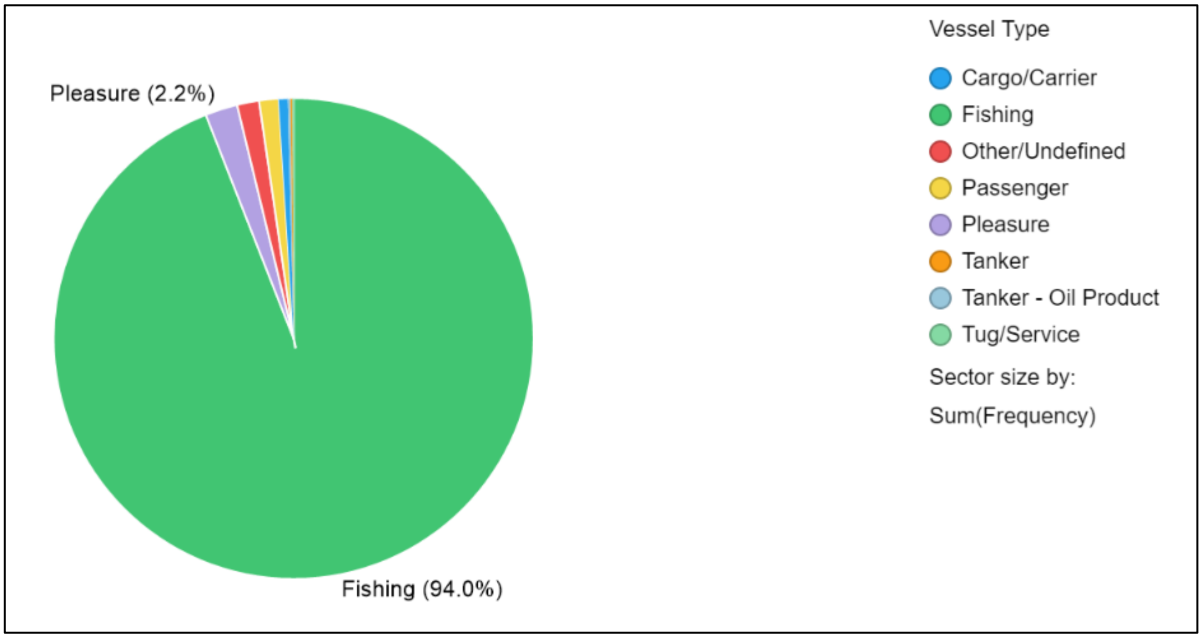


Figure 11-1 Risk contribution per vessel type

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

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

Accident type	Increase in frequency of any accident (number per year)	Percentage of Total
Powered allision	0.792	49%
Drift allision	0.776	48%
Powered grounding	0.019	1%
Drift grounding	0.015	1%
Collision	0.006	<0.5%
Total	1.608	100%

Allision accidents of any severity comprise 97 percent of the increase in risk and are predicted to occur 1.6 times annually (Figure 11-2).

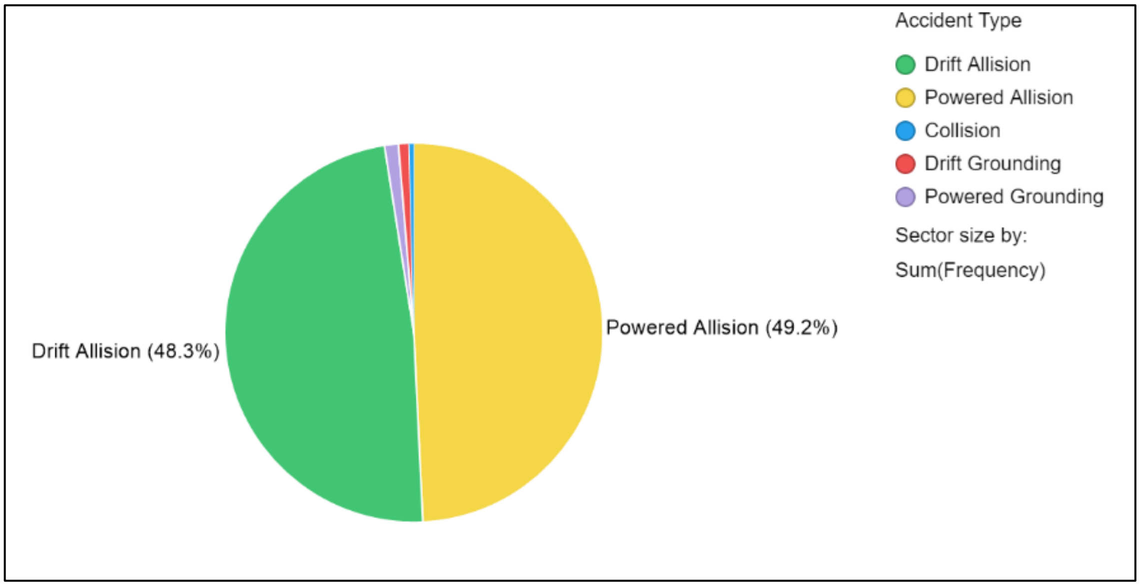


Figure 11-2 Risk contribution per accident type

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

- PATON to be installed by the Project. Insufficient data are available to support quantifying the effects of this measure in the model.
- Tug capability and availability to intervene and prevent a drift allision 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 vessels, if they have lost power, to prevent an allision by dropping anchor. 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 remainder of this section presents the risk for each sub-area shown in Figure 11-3. The sub-areas were selected to provide clarity on where risks change and where they do not. Based on the model, nearly all of the risk increase is in the Assessment Area. The other risk changes are related to re-routing of deep draft and tug vessels around the lease areas. The sub-areas adjacent to the Assessment Area were defined as simple polygons extending to 5 nm from the Assessment Area based on results of preliminary model runs. The remainder of the Marine Traffic Study Area is called sub-area "Other".

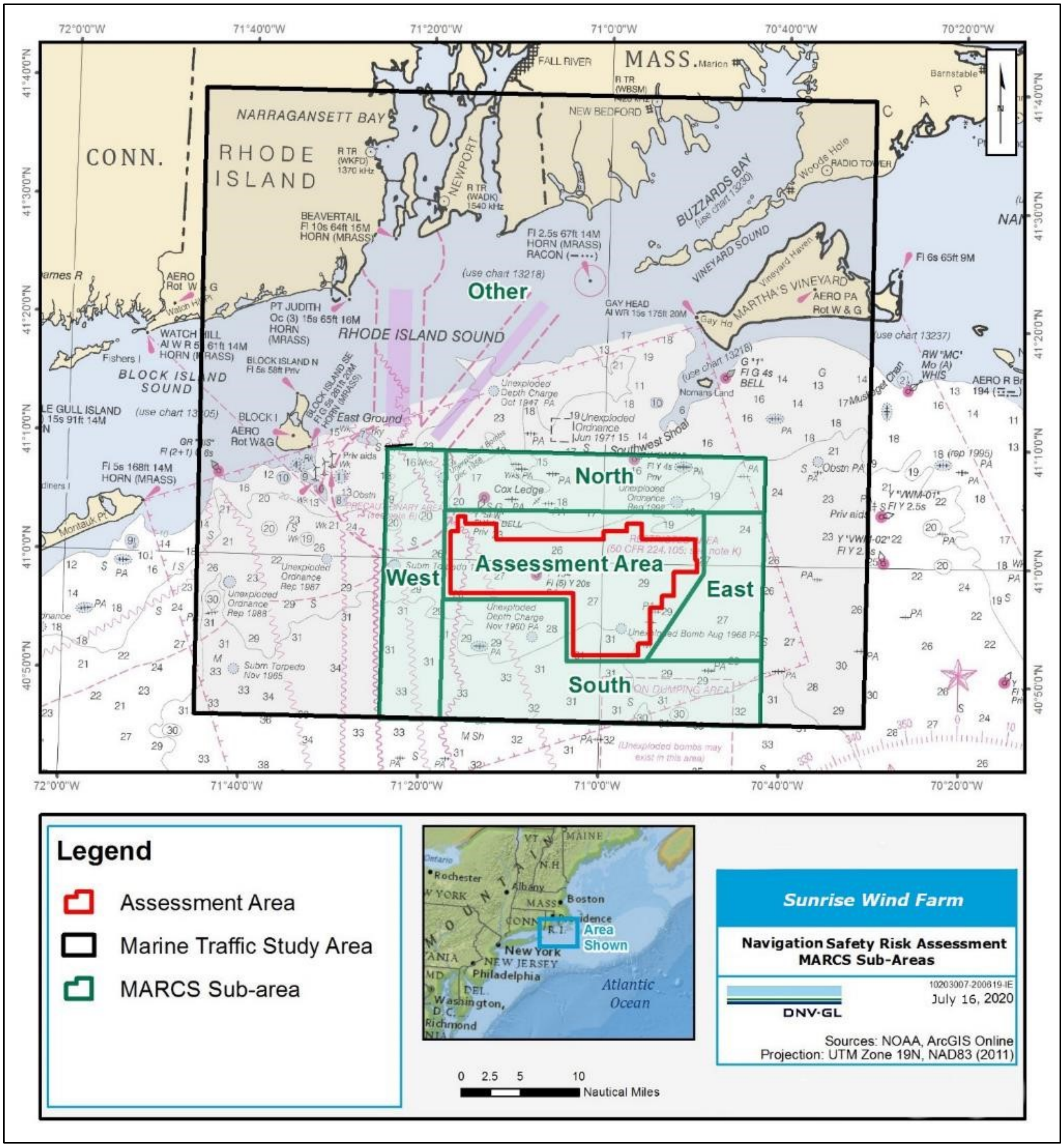


Figure 11-3 Definition of sub-areas within the Marine Traffic Study Area

11.1.1 Assessment Area

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

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

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

Vessel type	Drift allision	Powered allision	Collision	Drift grounding	Powered grounding	Total
Fishing	0.736	0.774	<0.0005	0	0	1.510
Other/Undefined	0.013	0.011	<0.0005	0	0	0.024
Pleasure	0.007	0.004	<0.0005	0	0	0.011
Passenger	0.007	0.002	<0.0005	0	0	0.010
Cargo/Carrier	0.006	<0.0005	<0.0005	0	0	0.006
Tug/Service	0.005	<0.0005	<0.0005	0	0	0.005
Tanker - Oil Product	0.002	<0.0005	<0.0005	0	0	0.002
Tanker	0.001	<0.0005	<0.0005	0	0	0.001
Total	0.776	0.969	<0.0005	0	0	1.568

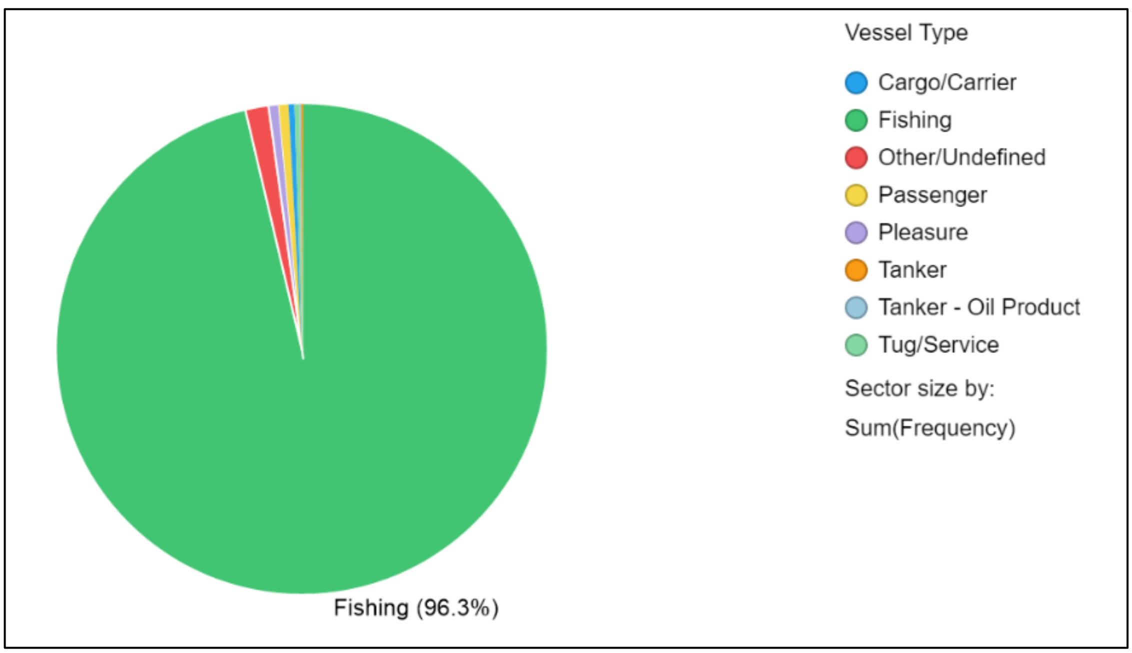


Figure 11-4 Risk contribution per vessel type in the Assessment Area

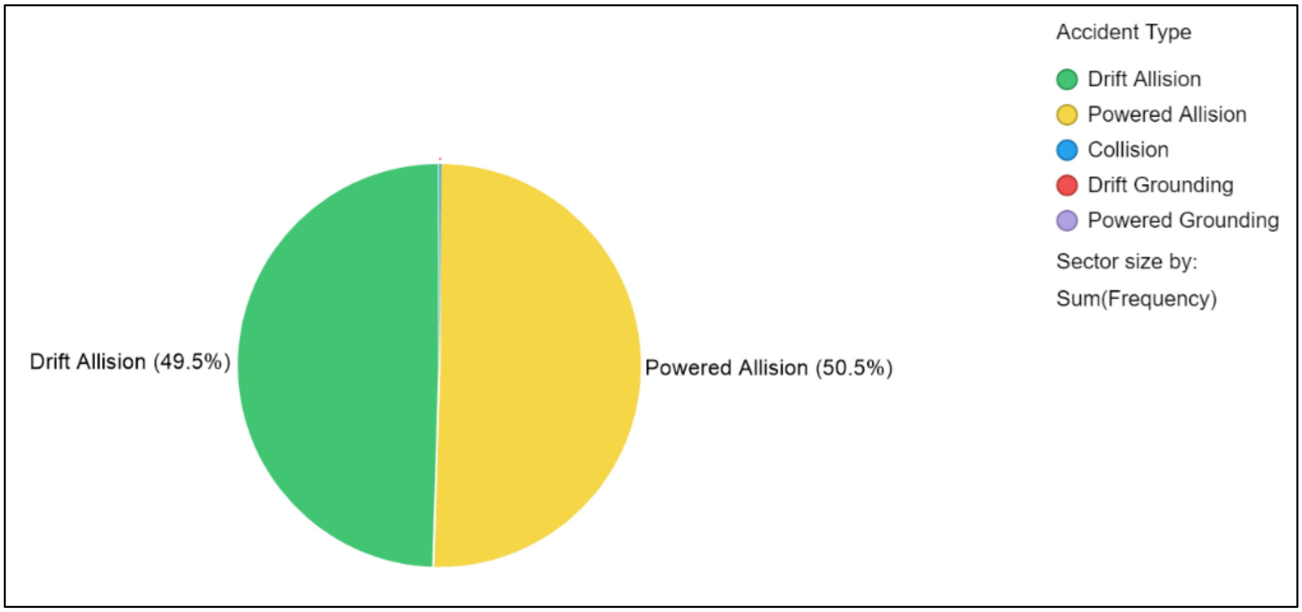


Figure 11-5 Risk contribution per accident type in the Assessment Area

11.1.2 Adjacent sub-areas

The four sub-areas adjacent to the Assessment Area were sized to capture risk in the vicinity of the Project. Note that none of the adjacent sub-areas contain grounding risk or allision risk.

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

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

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

* These values round up to 0.001; they are between 0.0005 and 0.001.

The modeled accident frequency related to the Project and adjacent lease areas increases by 1 collision in 1,000 years in the North sub-area. Compared to a baseline frequency of 0.131, the effect from the Project represents a 1 percent increase. Collisions involving pleasure vessels contribute 50% of this increase (Figure 11-6).

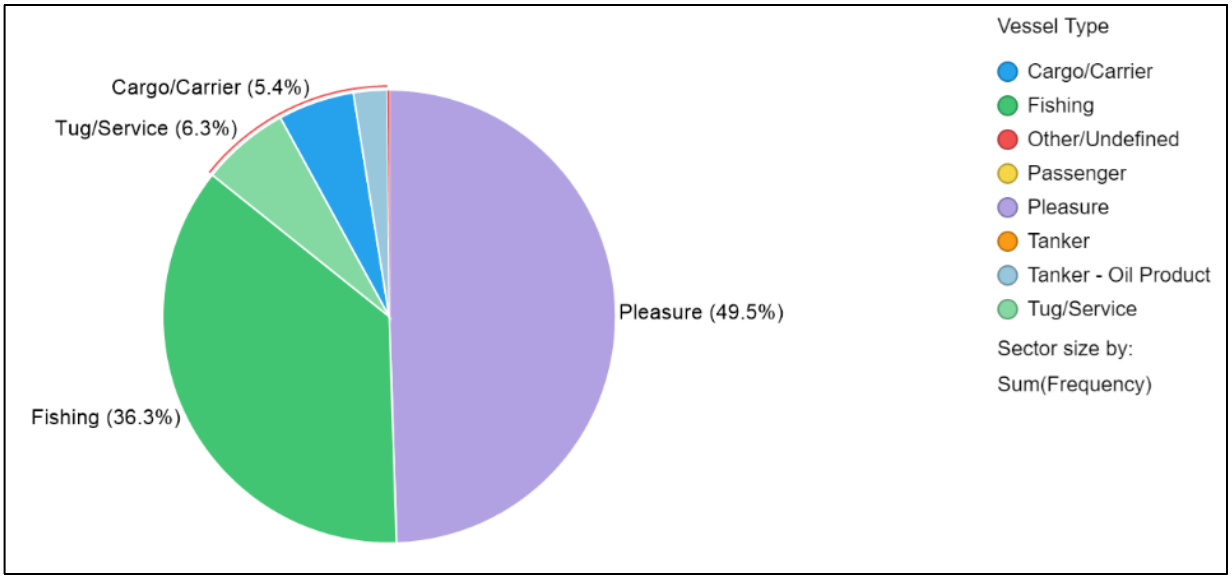


Figure 11-6 Risk contribution per vessel type in the North sub-area

The estimated risk increases for the East, South, and West sub-areas are less than 0.0005 per year each.

11.1.3 "Other" sub-area

Changes in risk from the Project in the "Other" sub-area are presented in Table 11-6. Negative values in the table indicate the risk is higher in the Base Case than is predicted for the Future Case. It is a result of routing tugs around the Rhode Island-Massachusetts lease areas.

Table 11-6 Risk increase in the "Other" sub-area (annual accident frequencies)

Vessel type	Drift allision	Powered allision	Collision	Drift grounding	Powered grounding	Total
Pleasure	-	-	0.002	0.008	0.014	0.023
Passenger	-	-	0.001	0.003	0.007	0.011
Cargo/Carrier	-	-	0.001	0.002	0.001	0.004
Fishing	-	-	0.002	<0.0005	<0.0005	0.002
Tanker - Oil Product	-	-	<0.0005	0.001	<0.0005	0.001
Tanker	-	-	<0.0005	0.001	0.001	0.001
Other/Undefined	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Tug/Service	-	-	<0.0005	<0.0005	-0.004	-0.004
Total	-	-	**0.006**	**0.015**	**0.019**	**0.039**

This is the largest sub-area, many times larger than the others. The risk increase related to the Project and adjacent lease areas is 0.04 accidents of any level of consequence, per operating year of the Project. On a baseline model risk of 12 accidents per year, this represents a 0.3% increase.

Re-routing deep draft and tug vessels around all of the Rhode Island-Massachusetts lease areas has the effect of transferring any collision risk that would have been estimated within the lease areas into the "Other" sub-area. The transferred risk is relatively minor: 0.005 collisions per year. The remainder of the risk increase (0.034 accidents per year) is the result of deep draft and tug vessels being assigned alternate routes around the lease areas.

In this sub-area, pleasure vessels comprise more than 50 percent of the risk increase (Figure 11-7). Concerning the type of accidents, powered groundings comprise nearly half of the risk increase.

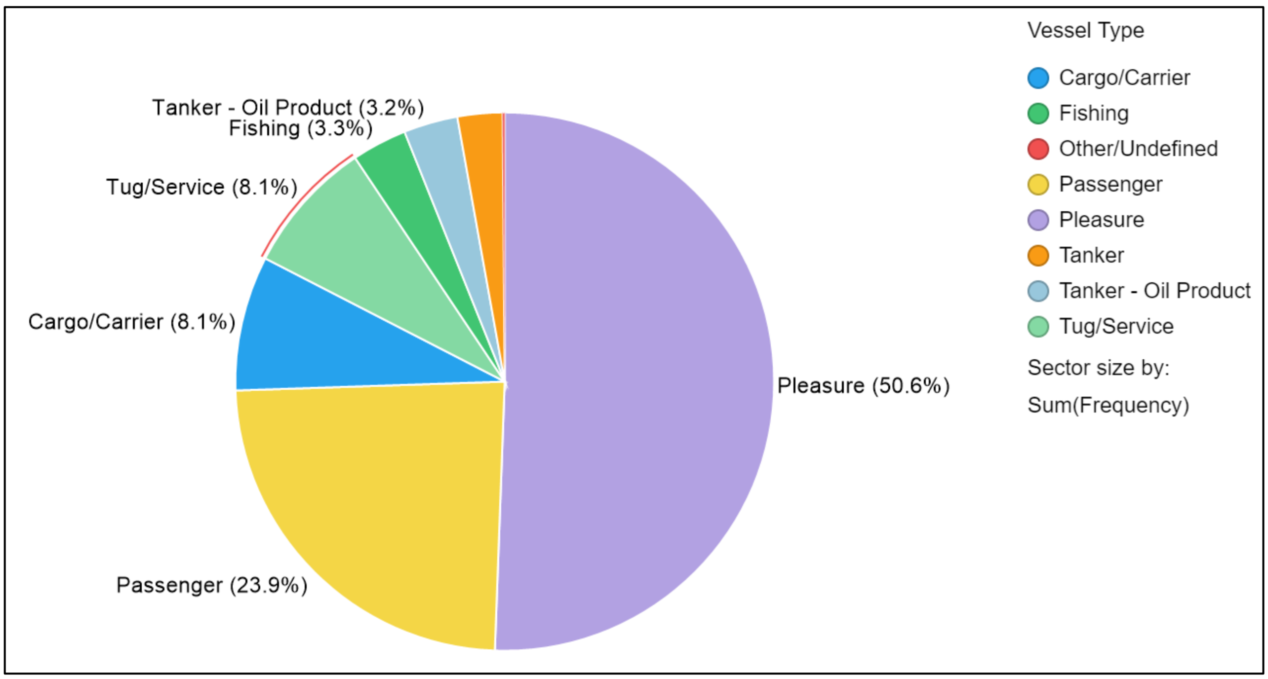


Figure 11-7 Risk contribution per vessel type in the "Other" sub-area

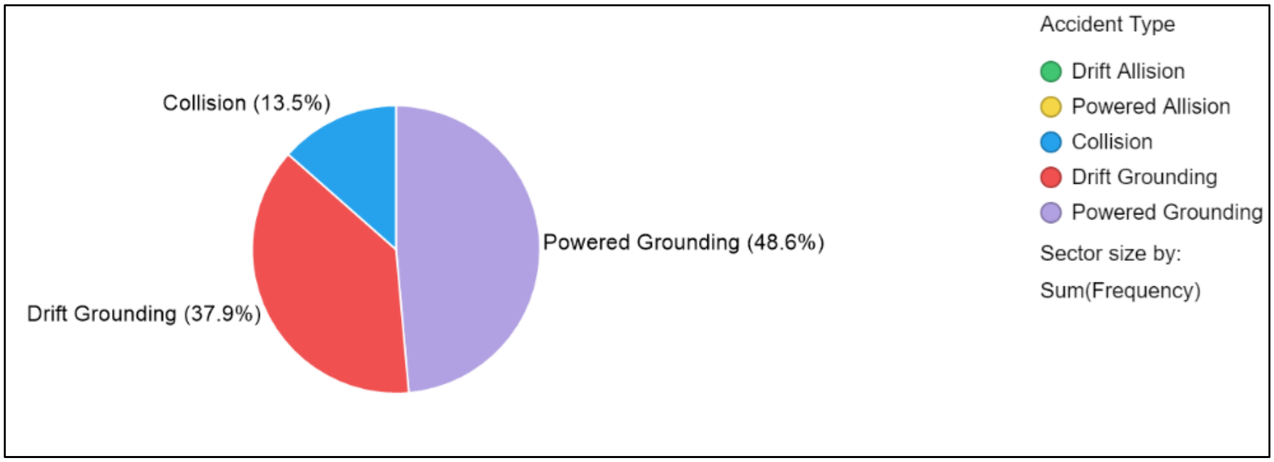


Figure 11-8 Risk contribution per accident type in the "Other" sub-area

11.2 Consequences of marine accidents

11.2.1 Consequences from a collision

In a collision, the consequence 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 water depths in the vicinity of the Project are not limiting for vessels transiting around the Project Assessment Area, so the Project effectively poses no increase to grounding risk.

Groundings are the most common marine event near the coast or inland waters; however, consequences from groundings are not discussed further because they are not relevant to the assessment.

11.2.3 Consequences from an allision

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

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 Offshore Platform. The severity of the damage is dependent on the design and the specific nature of the strike.

Powered allision generally involves higher impact energies than drift allision; however, a drifting ship is likely to drift with its highest point away from the wind. As a result, a drifting oil tanker might contact a WTG on its stern quarter, which would increase the chance of a cargo or bunker fuel spill, as there are no cargo tanks in the bow of most ships.

11.3 Risk mitigation of marine accidents

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

Aspects that affect the risk level for Sunrise Wind include:

- Generally low traffic density
- Predominantly smaller vessels in the traffic
- 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

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

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

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

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

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

- SOLAS – The International Convention for the Safety of Life at Sea requires certain equipment and practices to increase the safety of people on board (various parts of 46 CFR)

- COLREGs -Convention on the International Regulations for Preventing Collisions at Sea. Requirements include vessel-to-vessel communication and safe transit speeds (primarily 33 CFR 80 et. seq.)
- STCW - International Convention on Standards of Training, Certification and Watchkeeping for Seafarers and International Convention on the Standards of Training, Certification and Watchkeeping for Fishing Vessel Personnel (46 CFR 11 et. seq.)

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

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

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

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

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

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

- Final Port Access Route Study: The Areas Offshore of Massachusetts and Rhode Island (MARI PARS), which was published on 27 May 2020 (Coast Guard, 2020a)
- Atlantic Coast Port Access Route Study (Coast Guard, 2015)
- Buzzards Bay Port Access Route Study (Coast Guard, 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.” (Coast Guard, 2019c)

The PDE conforms to the recommendations in the Coast Guard’s MARI PARS final report concerning WTG layout, including a standard and uniform grid pattern of structures located 1 nm x 1 nm 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.” (Coast Guard, 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, nautical charts and navigational information, and other data. Two NOAA offices, the National Ocean Service and the National Weather Service, offer data and services that directly support safe navigation.

The National Ocean Service provides real-time oceanographic data, mapping, charting, and water level information. The National Weather Service provides weather, water, and 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 a wind farm, a set of design and construction standards lay out minimum requirements. An independent Certified Verification Agent checks and confirms that the design and all aspects of construction conform to the agreed set of standards (30 CFR 585).

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

Good industry operational practices include:

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

Spacing of WTGs is generally guided by energy production targets, turbine size, available area, wind distributions, and other factors. Regularly spaced turbines can facilitate Coast Guard SAR. Management of risk due to adjacent location of several large wind farms is a nascent challenge in the industry, and many options are being evaluated (see Section 11.4). Adjacent leaseholders (Bay State Wind, Deepwater Wind, Vineyard Wind, Equinor, and Mayflower Wind) 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., all vessels that are not defined as deep draft) is a potential concern. Within a wind farm, this is particularly true in poor visibility or high sea states. Advance warnings to mariners and education initiatives could reduce the likelihood of a vessel in peril in the wind farm under such conditions.

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

In general, risk controls fall into three categories:

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

11.3.1 ALARP evaluation of risk mitigation measures

The general goals of risk assessment are to:

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

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

The challenges include:

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

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

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

11.3.2 Potential mitigation measures

This assessment provides risk information to enable the Coast Guard to evaluate whether Project risks are reduced to meet ALARP criteria. 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 various risk mitigation measures that are used in some jurisdictions. These are not necessarily standard or best practices, and are listed in no particular order:

- Additional ATON associated with the Project
- AIS transponders on Project structures
- Communications repeaters on Project structures
- Pilotage of deep draft vessels near the Project
- Emergency response planning and exercises
- Only specified designs/kinds of commercial fishing gear can be used in the wind farm

- Project structures along perimeter equipped with radar beacon to allow clear identification via radar
- Visible and consistent marking and lighting of each structure
- Tug on standby
- Vessel traffic services
- Vessel design and equipment maintenance requirements for all vessels in the vicinity of the Project
- Highly robust subsea cable protection
- Life safety equipment onboard all vessels
- Larger or additional precautionary areas
- Designation of areas to be avoided or limited access areas
- Designation of additional anchorages
- Ice hazard protocol
- Designation of additional routing measures
- Extension of cellular service further offshore
- A safety zone of 500 m around WTGs
- A safety zone of 500 m around offshore substations
- Real-time vessel monitoring in the wind farm
- Designation of routes for specific vessel types, such as fishing and tug-with-tow
- WTG platforms are accessible and can be used as a potential place of refuge
- Fishing / transits limited to daytime
- Transit or fishing only with a functioning and active VHF and AIS installation
- No seabed disturbing activities
- Limitation for ships exceeding a certain length
- Offshore cameras (to facilitate SAR)
- Alternate cable protection measures, such as armored ducting, rock placement, or concrete mattresses.

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

11.4 Cumulative effects

Cumulative effects from proposed wind farms on navigation were evaluated on a qualitative basis for the four affiliates of Sunrise Wind in the Marine Traffic Study Area (Figure 11-9):

- Sunrise Wind Farm
- Revolution Wind Farm
- South Fork Wind Farm
- Bay State Wind Farm

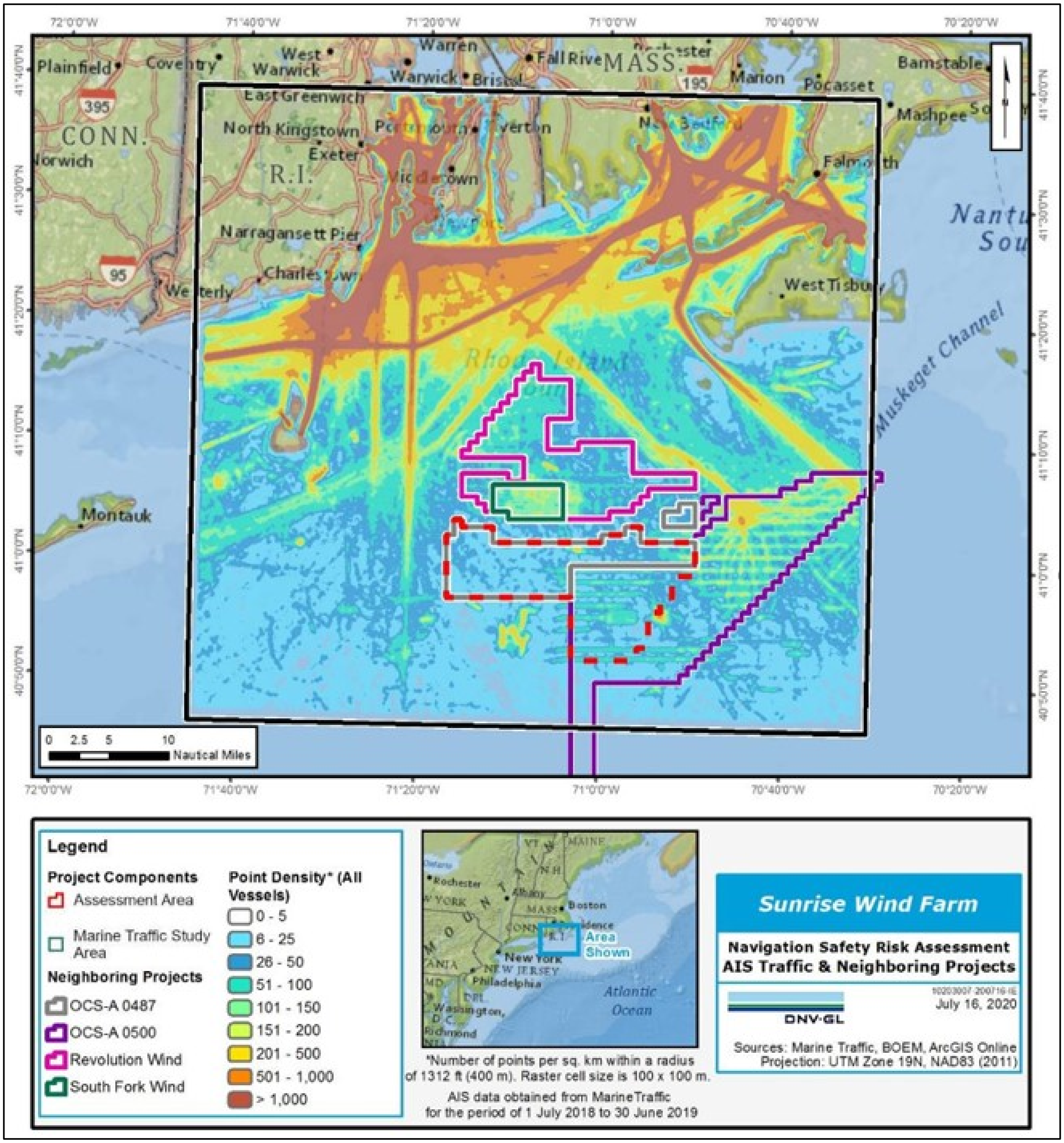


Figure 11-9 AIS traffic with Sunrise and adjacent Wind Farm Leases[4]

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

1. Commercial fishing traffic that currently transits through the lease areas may instead decide to take routes to the east or west around the lease areas.
   - These vessels generally avoid TSS, per Coast Pilot guidance (NOAA, 2018). Deep draft vessels generally follow only the TSS, so a result would be an increase in interaction among the various users, which may pose a potential safety 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 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 fishing vessel transits in the Buzzards Bay traffic lanes, and therefore increased interactions with tugs. This effect is likely very minor because the lane does not have very dense traffic considering temporal distance between vessels. As recorded in the year of AIS data (MarineTraffic, 2019), 1,083 vessels per year transited inbound or outbound lanes - an average of 3 vessels per day. These were primarily of fishing and tug vessels. The highest traffic level in the AIS data in the inbound Buzzards Bay traffic lane was in the summer months consisting of 376 transits, an average of 4.1 transits per day. Many additional fishing vessels could take this lane, a credible maximum of 760 annual additional fishing and pleasure transits per year were estimated based on data for the year 2012 (the most recent data available, see Section 2.3). The pleasure vessels are likely to sail in the summer, but the fishing vessels are likely more distributed throughout the year. Even if all 760 transits occurred in the summer in these two traffic lanes, the three-month total would be 763 transits, an average of 9 per day.
2. Changes to commercial and recreational fishing patterns, which are largely unpredictable at this time.
3. SAR efforts may be more challenging in bad visibility or in high seas over a fairly large, contiguous area. In its final MARI PARS report the Coast Guard confirmed that it would be able to execute its SAR mission if the entire Massachusetts/Rhode Island WEA array layout were in a 1x1 nm uniform pattern, as jointly proposed by leaseholders in the area.

12 EMERGENCY RESPONSE CONSIDERATIONS

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

The Coast Guard MARI PARS (2020a) report provides a summary of SAR incident data from 2005 through 2018. The number and types of cases within the Project Assessment Area are taken from that report.

Figure 12-1 and Figure 12-2 show the number of cases per year in the Coast Guard MARI PARS study area and the distribution of the types of cases occurring in the area from 2005 through 2018.

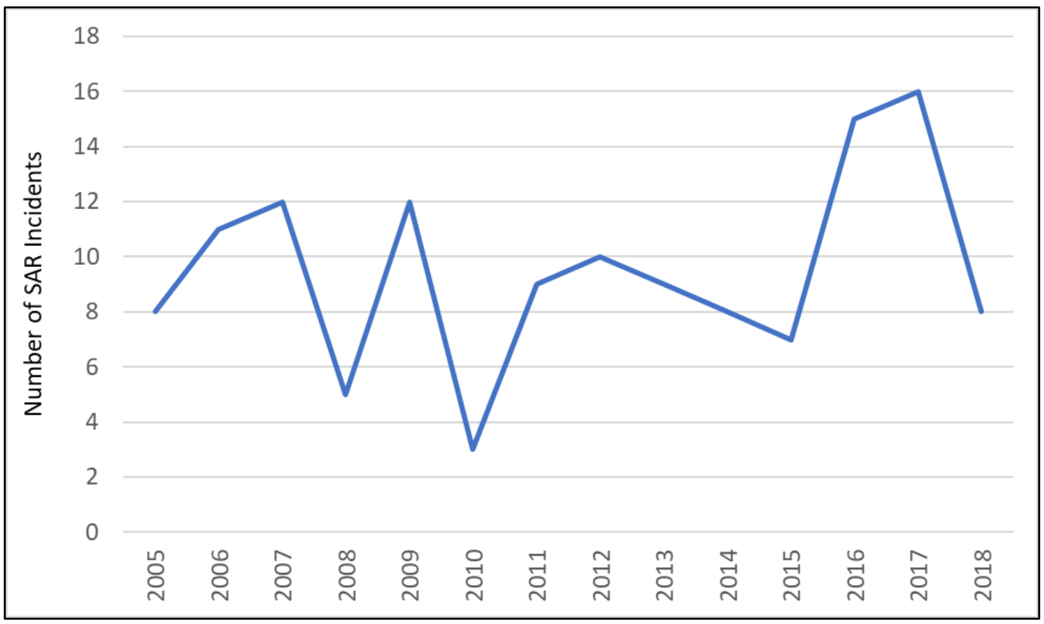


Figure 12-1 Number of SAR cases per calendar year in the Coast Guard MARI PARS study area (Coast Guard, 2020a)

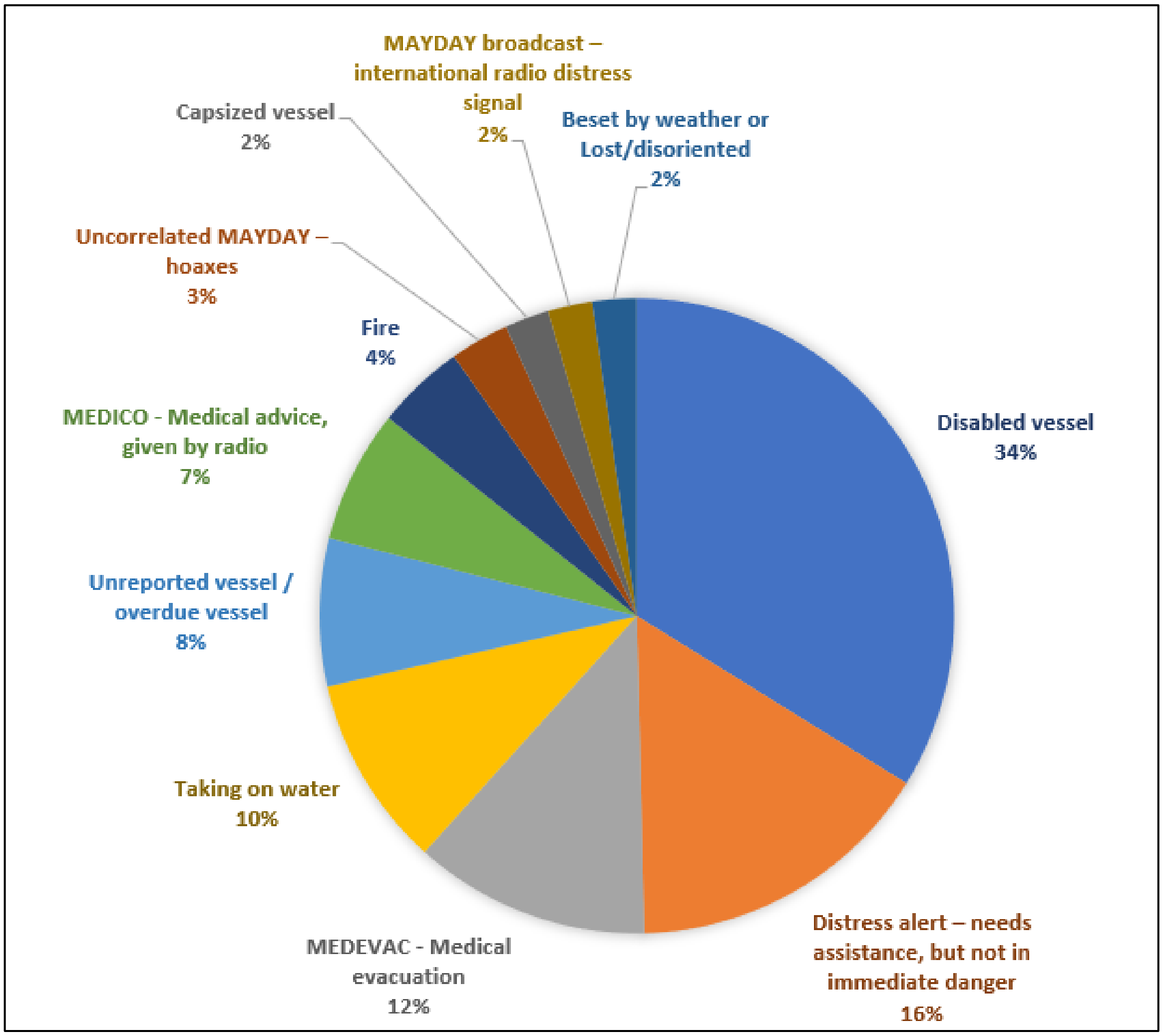


Figure 12-2 Percentage of SAR cases by type in the Coast Guard MARI PARS study area (2005 through 2018) (Coast Guard, 2020a)

The layout of the Project is a factor that will be considered when planning SAR activities in the Assessment Area. The MARI PARS 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 laid out in a predictable grid pattern, 1 nm apart. This conforms to the Coast Guard helicopter pilot recommendation for minimum spacing between structures along a search path (Coast Guard, 2020a) and visual flight rules in 14 CFR 91.155 specifying a minimum of ½-statute-mi visibility in daytime without clouds.

Table 12-1 lists the information requested in NVIC 01-19 to be considered when evaluating emergency response. Approximately 20 SAR cases were recorded in the Assessment Area over a 14-year period, an average of 1.4 per year (Coast Guard, 2020a). About 25 percent of which are reasonably expected to occur at night or in poor visibility, based on data provided by the Coast Guard for the South Fork Wind Farm NSRA. One of the benefits of having offshore structures distant from land is that their easily identifiable markings and lighting will be available to aid SAR. In addition, one or more Offshore Platforms within the Project or adjacent projects may provide helicopter refuge to facilitate SAR, discussed in the next section.

Table 12-1 Summary of SAR cases

Situation	Number of occurrences
SAR cases conducted by Coast Guard in or very close to the proposed Assessment Area	Approximately 20 cases over 14 years, 2005 through 2018 (Coast Guard, 2020a)
Cases involving helicopter hoists	Not specified in the available data
Cases at night or in poor visibility/low ceiling	Not specified in the available data; however, based on data provided for South Fork Wind Farm (Coast Guard, 2017b), less than 25% of the cases were conducted at night and/or with poor visibility
Cases involving aircraft (helicopter, fixed-wing) searches	Not specified in the available data
Number of times commercial salvors (for example, BOAT US, SEATOW, commercial tugs) responded to assist vessels in the proposed structure region over the last ten years	Not specified in the available data
Additional SAR cases estimated by modeling due to allision with the Project structures	1.6 allisions per year, with the vast majority not requiring Coast Guard assistance (conservative maximum estimate based on modeling presented in Section 11).

Concerning the safety of SAR missions, the Coast Guard final MARI PARS 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."

Concerning Marine environmental protection/response, the MARI PARS report is silent. However, the Coast Guard provided data for missions that occurred in the vicinity of the South Fork Lease Area during the ten-year period 2006-2016 (Figure 12-3).

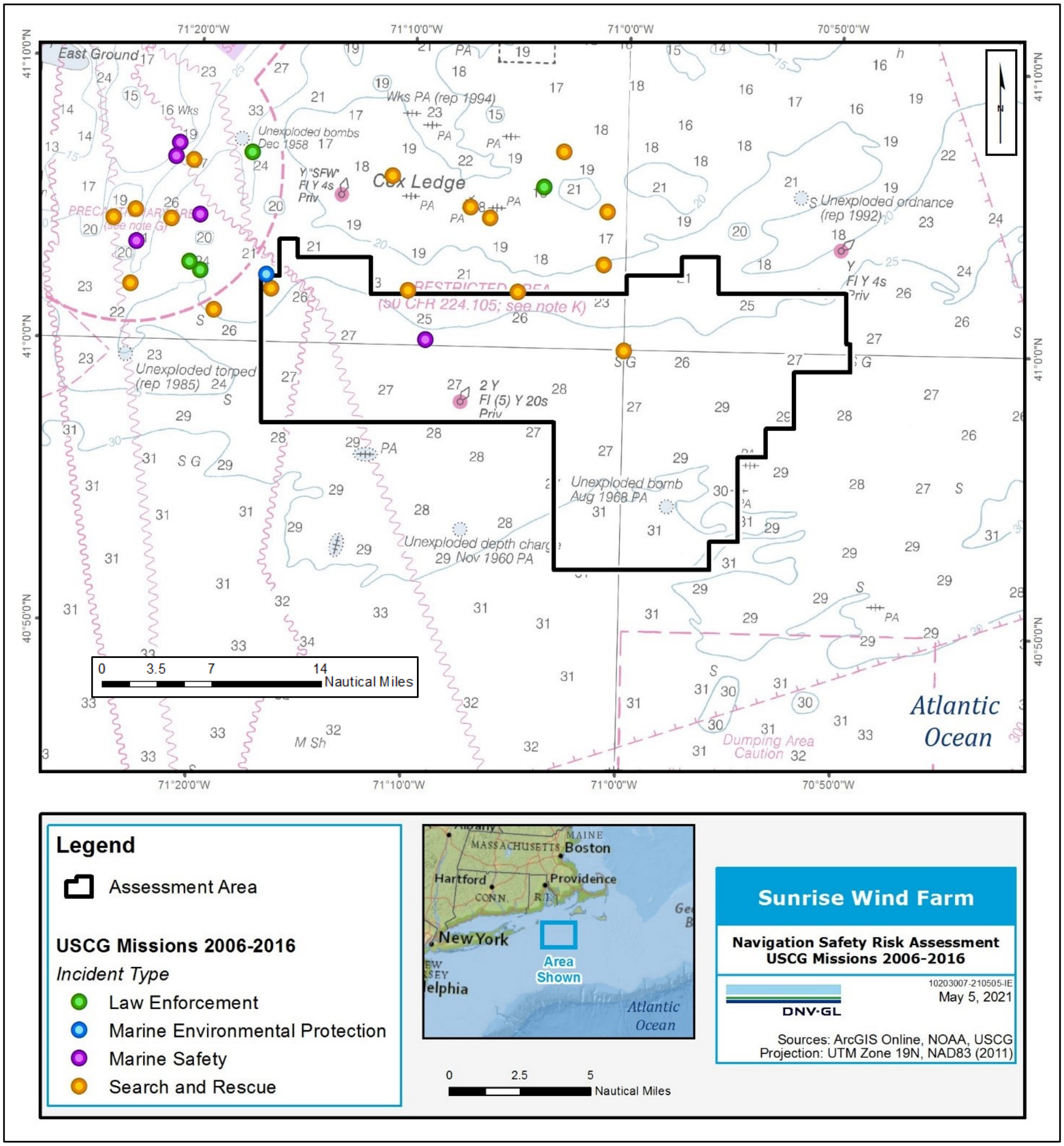


Figure 12-3 Coast Guard mission data (2006 to 2016)[10]

One marine environmental protection/response case was recorded just outside the Precautionary Area over the 10-year period. It is possible that additional cases may have occurred that are relevant to this Project.

[10] Data was provided for assessment of the South Fork Wind Farm.

Table 12-2 lists the information requested in NVIC 01-19 to be considered when evaluating effects on environmental response missions.

Based on the modeling conducted for allision risk (presented in Section 11), a conservative estimate is 0.16 oil spills per year from allisions with Project structures, equivalent to 1.6 every 10 years.

Table 12-2 Marine environmental protection/response

Situation	Number of occurrences 2006 - 2016
Marine environmental/pollution response cases conducted by Coast Guard in the vicinity of proposed structure region over the last ten years	1*
What type of pollution cases were they	Pollution - Oil
What type and how many assets responded	Unknown
Additional pollution cases estimated by modeling due to allision with the structures?	About 1.6 per 10 years [11]

* Based on an area adjacent to the Project Assessment Area.

[11] Multiplication of 1.6 allision frequency, 0.2 conditional probability of a severe impact, and 0.5 conditional probability that a severe impact results in a spill.

13 FACILITY CHARACTERISTICS

In general, marking of offshore wind farm structures is specified in international standards and U.S. Coast Guard guidance. The most relevant standards include:

- 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
- 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” (Coast Guard, 2020b)

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

- Identification marking
- Lighting
- Sound signals
- Automated Information System (AIS) transponder signals
- Other appropriate aids to navigation.

In 2019, BOEM published “Draft Proposed Guidelines for Providing Information on Lighting and Marking of Structures Supporting Renewable Energy Development” (2019). Should BOEM finalize these guidelines by the time of COP approval, the Project will comply (Sunrise Wind LLC, 2020).

No effects are anticipated to existing Federal ATON near the Project, shown in previous **Figure** 9**-**2. The luminous intensity of WTG lights are expected to be clearly distinguishable from lights ashore. No adverse effects on visual navigation are expected due to interactions of lights, backscatter, geographic versus visible horizon, or turbine spacing. Any PATON will be maintained to meet the Coast Guard’s availability standards. Procedures will be put into place to respond to and correct any deficiencies within required timeframes (Sunrise Wind LLC, 2020).

The Project is evaluating the implementation of methods to limit the visual impact of the aviation light, for example light dimming or the use of a radar-based Aircraft Detection Light System (ADLS) (or similar system) to assure they are lit when required and off when not needed (ICAO, 2013). As far as practicable, aviation lights will not be visible below the horizontal plane of the lights.

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

14 DESIGN REQUIREMENTS

All Project structures will be marked with clearly visible unique identification characters (for example, alpha-numeric labels). The identification characters will be illuminated by a low-intensity light or be coated with a phosphorescent material. They will be designed and installed to be clearly readable at a distance of at least 150 yards (Sunrise Wind LLC, 2020).

The Project will have a 24-hour operational monitoring center to verify safe operating conditions are being maintained. The monitoring center will have the ability to remotely operate and shut down WTGs and Offshore Platforms and fix/maintain the position of the turbine blades and hub in an emergency situation. Sunrise Wind will be able to shut down a WTG within two minutes of initiating a shutdown signal (Sunrise Wind LLC, 2020).

Emergency operating procedures for the monitoring center will be agreed in consultation with the Coast Guard and other emergency support services. Offshore enclosed spaces will be capable of being opened from the outside to allow emergency access (Sunrise Wind LLC, 2020). Access to the WTGs will be via a hoist system. Ladders will not be installed.

15 OPERATIONAL REQUIREMENTS

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

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

The Project operator will ensure that all applicable Coast Guard command centers (District and Sector) are advised of the contact telephone number of the operations center and that correct positions and identifiers of offshore Project structures have been provided to NOAA to include on navigation charts (Sunrise Wind LLC, 2020).

16 OPERATIONAL PROCEDURES

Sunrise Wind anticipates that the Coast Guard will recommend, and BOEM will include, a condition in its Sunrise Wind Farm permit (if issued) to require Sunrise Wind to submit to the Coast Guard an acceptable emergency shutdown procedure/plan similar to requirements in the Block Island Wind Farm permit issued by the U.S. Army Corps of Engineers. Additionally, Sunrise Wind will work in conjunction with the Coast Guard to develop an acceptable emergency shutdown procedure and emergency response plan that draw on the lessons learned from emergency shutdown exercises conducted with the Coast Guard at the Block Island Wind Farm. (Sunrise Wind LLC, 2020)

17 CONCLUSIONS AND PROJECT RISK MITIGATIONS

The primary conclusions of this study are as follows:

1. Site location and coordinates
   - 1 nm is the minimum spacing between Project structures evaluated in this assessment.[12]

2. Traffic survey
   - Vessel traffic near the coast can be relatively dense in the summer, particularly in areas close to the coastline, and primarily due to seasonal pleasure and recreational fishing vessel traffic.
   - Vessel traffic in the vicinity of the Project is much less dense than near the coast.
   - Among the vessel types, recreational/pleasure vessels represented the greatest proportion of the AIS-recorded vessel tracks in the Marine Traffic Study Area, 26.5%.
   - Fishing (commercial), tugs / service vessels, other / undefined vessels, and passenger vessels each comprised 15-19% of the AIS-recorded vessel tracks in the Marine Traffic Study Area.
   - Much of the passenger and other / undefined vessel traffic in the vicinity of the Project appears to be related to studies of potential offshore wind farms. These are not anticipated to continue as steady-state after the wind farms are either in operation or are cancelled. As a result, the risk estimates are likely to be higher than the reality in the future.
   - Deep draft vessels are not expected to enter the wind farm.

3. Offshore above water structures
   - Project structures could pose an allision and height hazard to vessels passing close by, and vessels could pose a hazard to the structures. Allision risk is specifically discussed in (11) below. Typical good practice is to mark any structure that constrains the air gap over a waterway; and in line with this practice, the air gap will be indicated on each Project structure.
   - Risk related to some types of fishing gear suggests that risk to vessels/crew and the Project can be controlled by assuring the cable is buried at sufficient depth and/or has sufficient cable protection for relevant gear types and/or using gear that has limited penetration depth when fishing in the wind farm.
   - The Coast Guard has determined that spacing between WTGs in the evaluated layout provides sufficient sea room for maneuvering for vessel types expected to transit and fish in the wind farm assuming that

[12] 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 (Orsted et. al, 2019).

		“mariners desiring to transit the area should use extra caution, ensure proper watch, and assess risk prior to entering an offshore wind farm.” (Coast Guard, 2020a) • Emergency rescue procedures will likely be adjusted to account for the Project structures once they are in place. • Noise from construction activities or operation of WTGs is not anticipated to have negative effects on safe navigation or on the health of crew/personnel of passing vessels. • In general, Project structures with monopile foundations could sustain significant damage from an allision by a deep draft vessel at speed; an accident leading to immediate collapse is extremely unlikely. A jacket foundation is a weaker structure relative to horizontal loads. If the final foundation design for the Offshore Platforms is a jacket, structural collapse from allision by a deep draft vessel at speed cannot be ruled out.
4.	Offshore under water structures	• The Project components will not affect underkeel clearance for vessels transiting in the Project Assessment Area. No Project structures will lie above the seabed except those that rise above sea level.
5.	Navigation within or close to a structure	• In general, any offshore structure poses a potential risk of allision. During construction, global good industry practice is to implement a safety zone around construction activity. • During operations, the safety of vessels and crews will rely on enhanced ATON and on good seamanship to control the risk. • Standard industry practice is that anchoring in a wind farm is a potentially hazardous activity and should be undertaken only by Project-related vessels or in emergency situations. To control this risk, Project cables will be buried and / or protected on the seabed and marked on charts.
6.	Effect of tides, tidal streams, and currents	• Tides, tidal streams and currents in the Assessment Area have a low level of influence on navigation risk related to the Project.
7.	Weather	• Weather, and in particular visibility, has a significant effect on navigation risk in a wind farm. Based on ten years of data at the Block Island Airport, visibility is less than 2 nm about 8.6% of a given year.

8.	Configuration and collision avoidance	Wind farm layout can have a significant influence on operational and navigation risks experienced during operations. An optimal configuration of offshore wind farm structures is sought through balancing many factors, including physical, environmental, technical, economic, and political aspects. Concerning configuration and collision / allision risk, the risk controls most relevant to risk avoidance include: • The WTG layout will be 1 nm by 1 nm in a uniform east-west/north-south grid. This will allow alternative routes by vessels or aircraft transiting the wind farm and provide options in case of high winds or seas. • The WTGs in adjacent/contiguous wind farms will align[12], including WTGs in the Sunrise Wind Farm.
9.	Visual navigation	• Project structures are not anticipated to significantly obscure view of other vessels, ATON, or the coastline. • Project structures will be available to serve as information navigation aids for mariners, particularly at night because they will be lit and marked on navigation charts.
10.	Communications, radar, and positioning systems	• The impacts on marine radar are variable, with the most likely effect being some signal degradation. Proximity to the WTGs is the primary factor that determines the degree of radar signal degradation. • The Coast Guard's advanced command, control and direction-finding system, "Rescue 21," is unlikely to experience degradation from the Project. • Due primarily to the quality of radars and the proficiency of professionally licensed crew, radar operations on commercial ships are not anticipated to be adversely affected by the Project. • Smaller vessels operating in the vicinity of the Project may experience radar clutter and shadowing. Risk controls relevant to this effect are: vessel operator awareness and competence regarding radar effects and corrections; placement of radar antenna at a favorable position on a vessel; regular communications regarding changes and activities in the wind farm; and, safety broadcasts from vessels operating in the vicinity of the wind farm.

11. Risk of collision, allision, or grounding	• In this assessment, the modeled increase in risk is 1.6 accidents per year, attributed almost entirely to the risk of allision. It is DNV GL's best estimate of the additional risk that results from the presence of the Project. The basis of the estimate assumes that all non-AIS commercial fishing vessels transit to or through the Assessment Area, which is a reasonable most conservative approach to the estimate. • The modeling shows that the Project has no significant effect on grounding risk or collision risk. The increase in estimated risk relates to allision. • The Project poses very little risk outside the Assessment Area: 98% of the estimated risk increase occurs within the Assessment Area. • A list of risk controls and risk mitigations which the Project is considering is provided below.
12. Emergency response considerations	• An estimated maximum of 1.6 SAR missions are anticipated per year in the Sunrise Wind Farm based on the model results for allisions. However, most allision events do not require emergency rescue operations.
13. Facility characteristics	• The Project will comply with Coast Guard requirements for lighting, sound signals, and marking of structures, as applicable and as determined in consultation with the Coast Guard (Sunrise Wind LLC, 2020). • No effects are anticipated to existing Federal ATON near the Project. • PATON will be maintained to meet conditions the Coast Guard may impose in conjunction with its PATON permits (Sunrise Wind LLC, 2020).
14. Design requirements	• Industry good practices will be utilized concerning visible markings, lighting, and safe emergency shutdown (fixing blade and hub positions), emergency access to structures, and emergency preparedness involving relevant agencies (Sunrise Wind LLC, 2020).
15. Operational requirements	• Project operations will be monitored 24 hours per day every day and Project emergency contact channels will be provided to the Coast Guard and other relevant agencies (Sunrise Wind LLC, 2020).
16. Operational procedures	• Emergency procedures will be developed and reviewed with relevant agencies, including the Coast Guard (Sunrise Wind LLC, 2020).

Potential Project mitigation measures

Table 17-1 summarizes the navigation risk mitigation measures that the Project may implement (Sunrise Wind LLC, 2020). The "Type" and "Threat or Hazard" columns are intended to provide context; however, nearly all of the mitigation measures would reduce risks from several threats. The complex interrelationships between risk mitigation benefits can be taken into account during the ALARP review.

Because the Project is still in planning / design phases, these measures will be modified to align with the final Construction and Operations Plan.

Table 17-1 Summary of potential Project mitigation measures (Sunrise Wind LLC, 2020)

Type *	Threat or hazard	Primary mitigation
D	Allision of a vessel with a WTG	Uniform minimum spacing between Project structures; N-S/E-W alignment of structures, and alignment with adjacent wind farm structures.
D	Vessel anchor or fishing gear snag on Project subsea cable	To reduce the risks associated with these hazards, the Project will typically target a burial depth of 3 to 7 ft (1 to 2 m), and the cables include various protective armoring and sheathing to protect the cable from external damage and keep it watertight. Cable protection measures will be employed where cable burial depth is not adequate. To ensure the risk is sufficiently mitigated, a separate cable burial risk assessment will be conducted for the Project, and the results of that study, as well as an assessment of seafloor conditions and seafloor mobility, will inform the depth of burial as well as cable protection measures for the Project.
E	Vessel less certain of its location; Coast Guard locating a vessel	Lighting and marking of Project structures according to U.S. requirements.
E	Vessel less certain of its course or location relative to the wind farm	Additional ATON associated with the Project.
E	Vessel less certain of its course or location relative to the wind farm	Project structures equipped with AIS technology. Expanded VHF and cellular phone coverage.
P	Vessel close to Project construction activity	Coast Guard established and enforced safety zones around Project construction activities. Sunrise Wind safety vessel(s) on scene to advise mariners of construction activity.
P	Vessel not aware of high level of activity in the Assessment Area	Notices to Mariners during construction, operation, and decommissioning activities. These may be published on and broadcasted though regular radio communications, online information for mariners, and Notices to Mariners from the Coast Guard.
P	Project construction activities in unsafe conditions	A Project construction guideline will define a window related to wind, sea state, and other constraints under which construction activities will start/continue or will stop/be discontinued. Conditions and forecasts will be monitored to enable proactive planning and early warning of future unsafe conditions.

Type *	Threat or hazard	Primary mitigation
P	Unsafe operation of the wind farm or continued operation of the wind farm during emergency conditions	A 24-hour operational monitoring center is planned to verify safe conditions are being maintained. The monitoring center will have the ability to remotely operate and shut down WTGs if required.
P	Vessel not aware of Project-related hazards	Locations and details of offshore Project components will be provided to NOAA so they can be included on nautical charts. The Project intends to work closely with Coast Guard and NOAA to chart all elements of the Project and have frequent communication with local mariners on location and status of Project activities, vessels, and components.
P	Fishing vessel not aware of Project-related hazards	Frequent updates on offshore activities to fishing operators will be provided via: • Project fisheries liaisons and local fisheries representatives based in regional ports • Online updates for mariners • Twice-daily updates on VHF channels.
O	Fishing gear snag on Project component	Project process for gear-loss/damage claims.
O	Ineffective emergency procedures	Coast Guard-approved emergency communication protocols and shut-down procedures will be exercised.
O	Delay in reaching injured worker in a WTG	Offshore enclosed spaces will be capable of being opened from the outside to allow emergency access.

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

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APPENDIX A AIS TRAFFIC MAPS

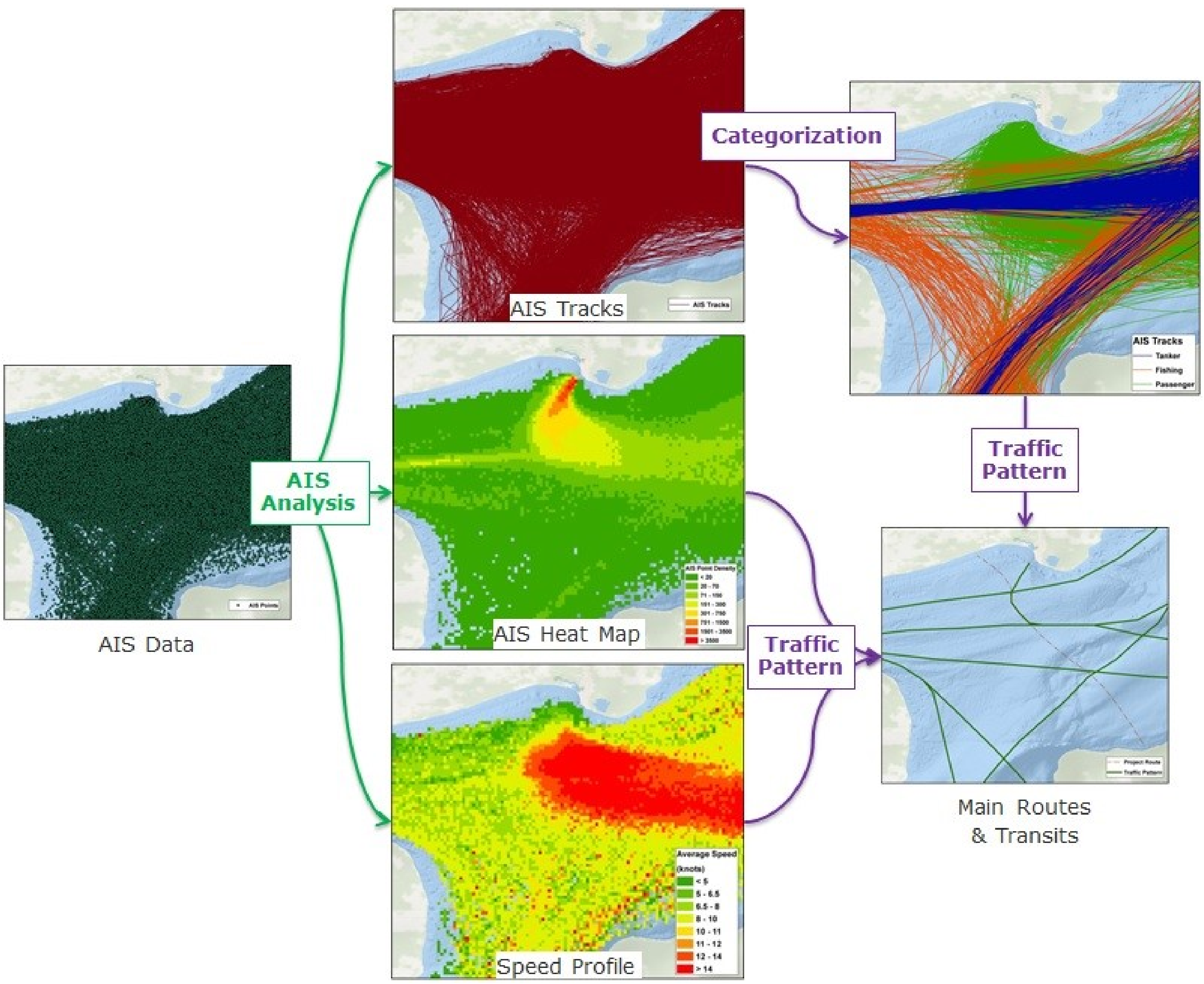
This appendix contains maps of marine traffic showing AIS tracks, AIS density, and vessel speed.

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 July 2018 to 30 June 2019 (MarineTraffic, 2019).

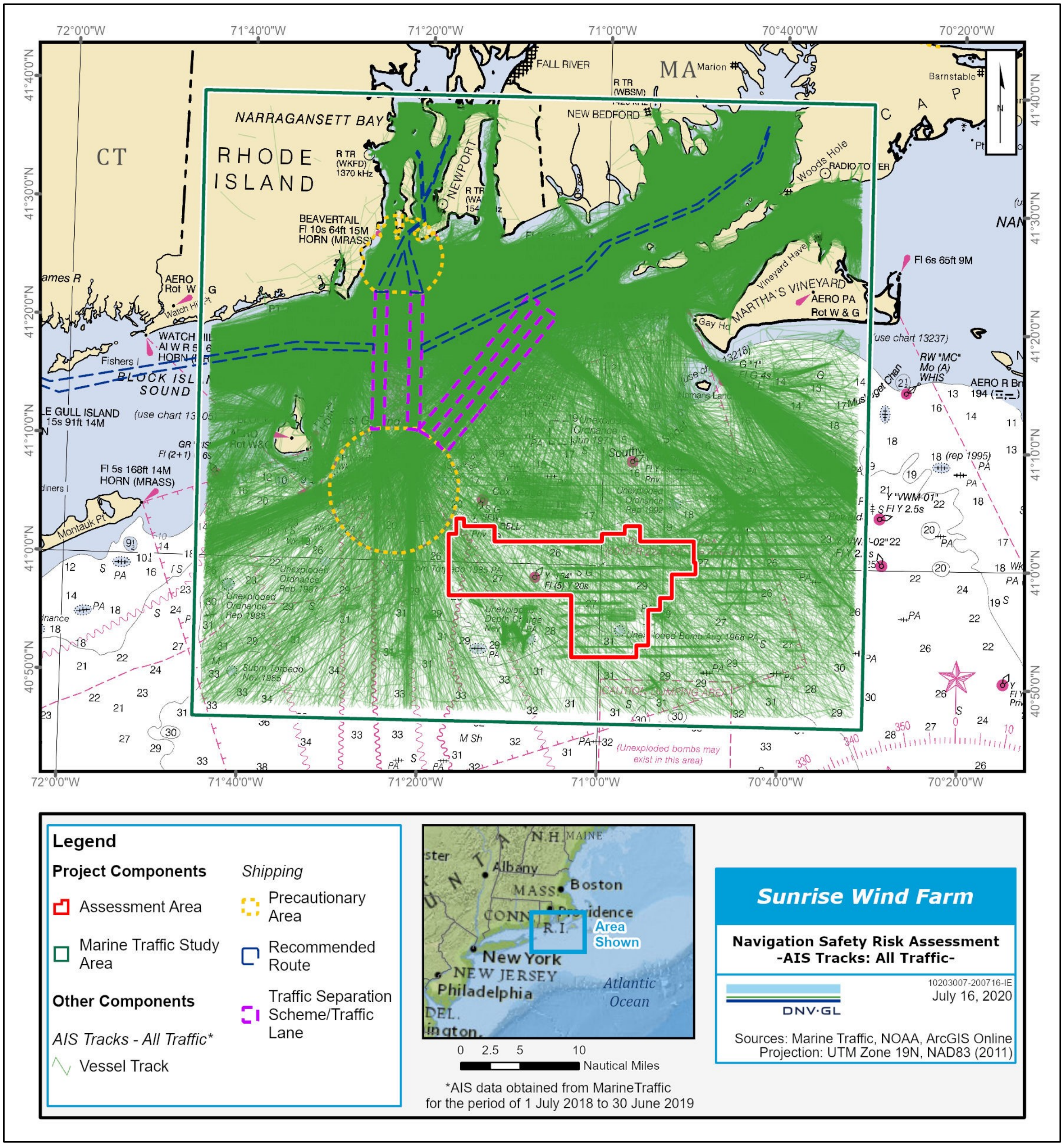
AIS data were converted into vessel tracks (Section A.1), vessel densities (Section A.2). Speed profiles were also developed from the data (Section A.3)

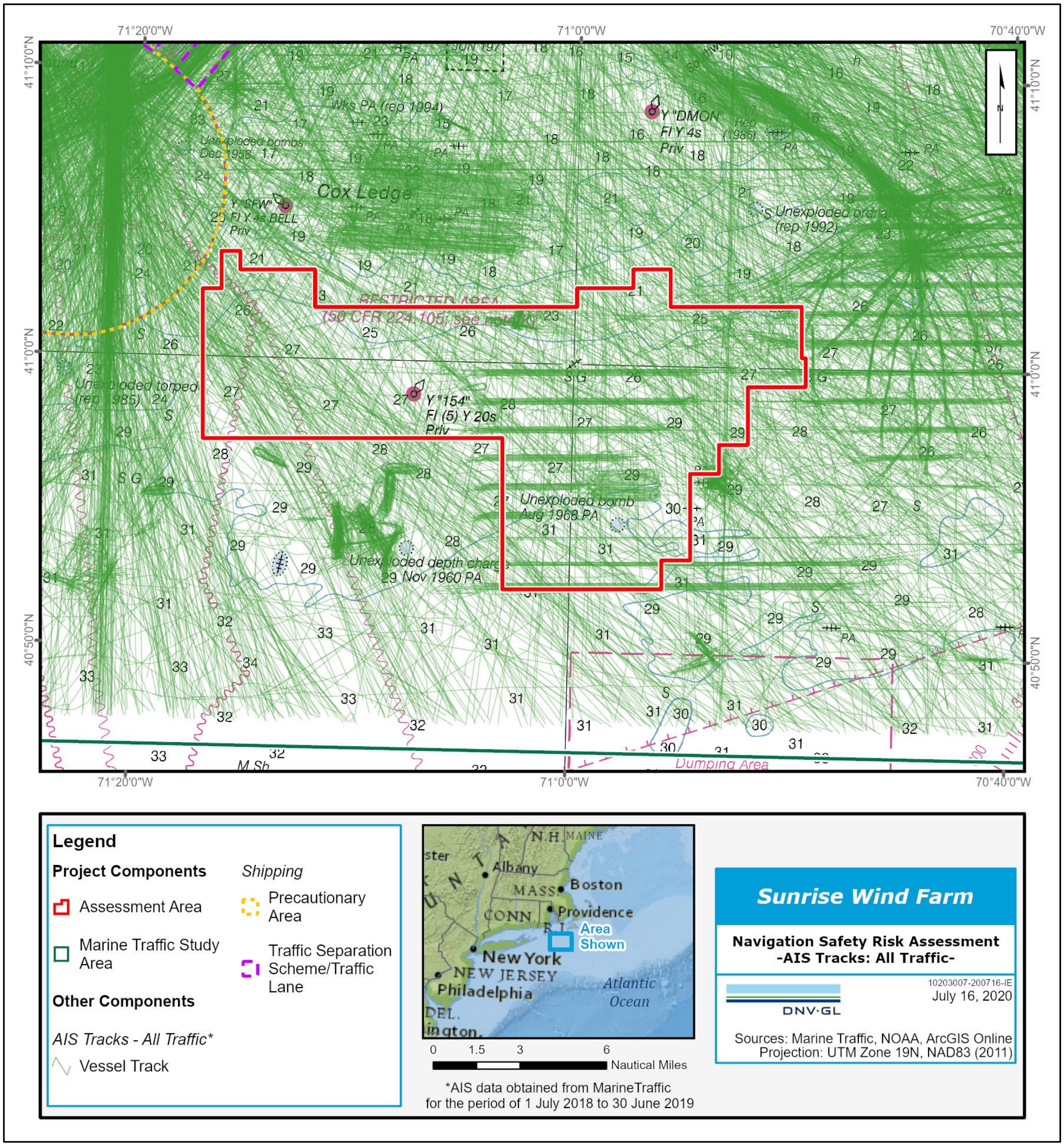
The AIS treatment methodology is schematically represented below:

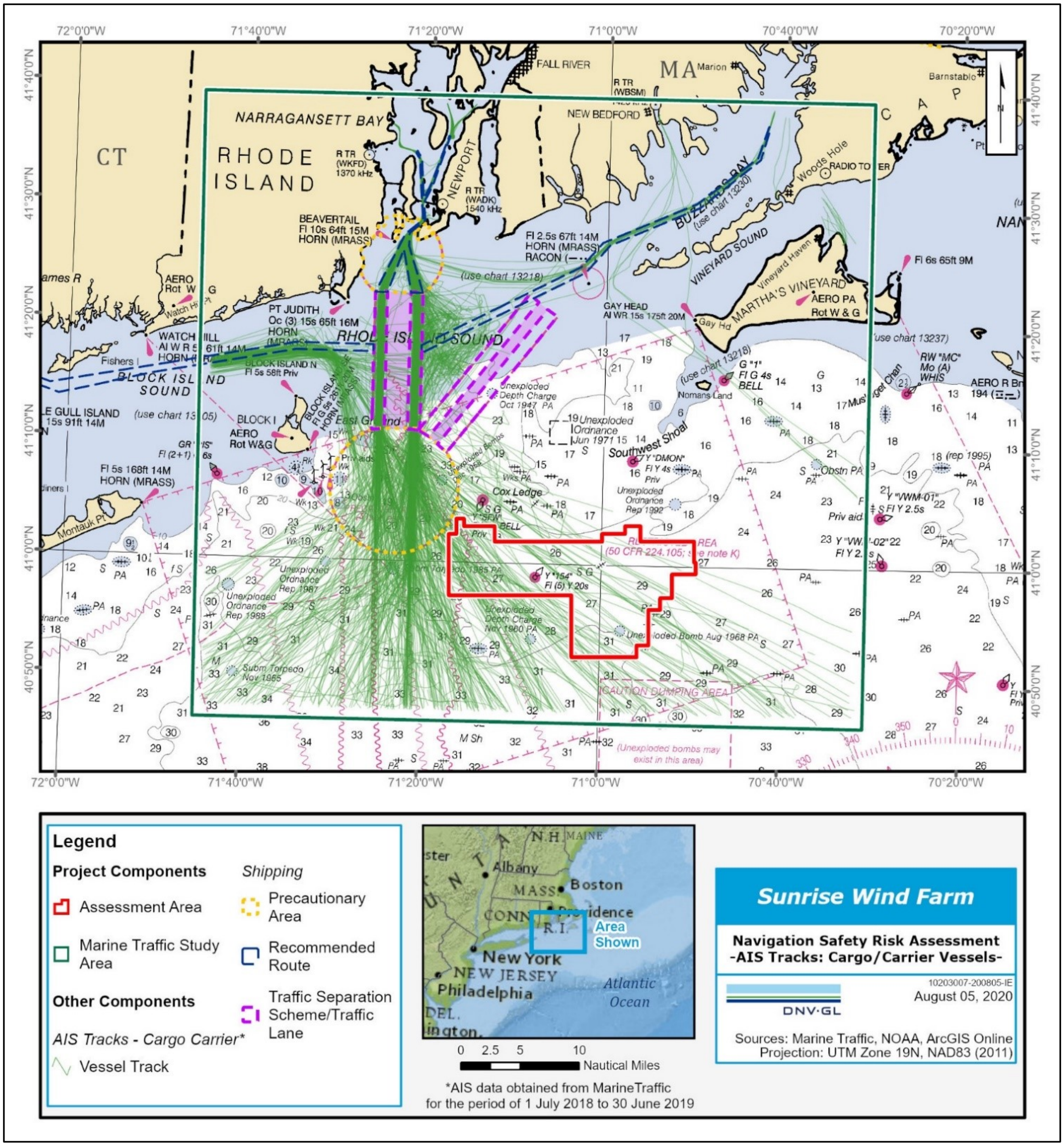


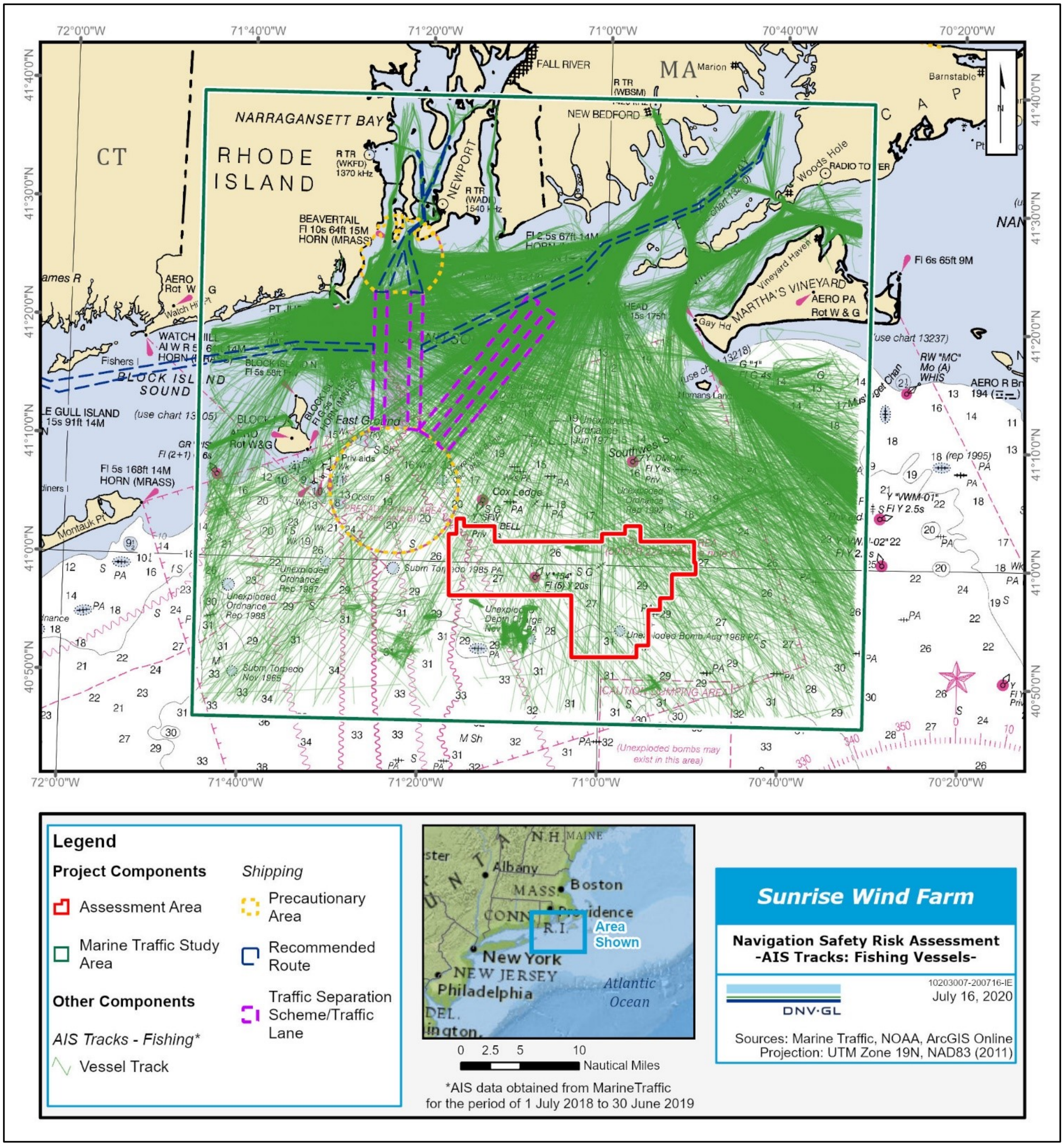
A.1 AIS track maps by vessel type

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

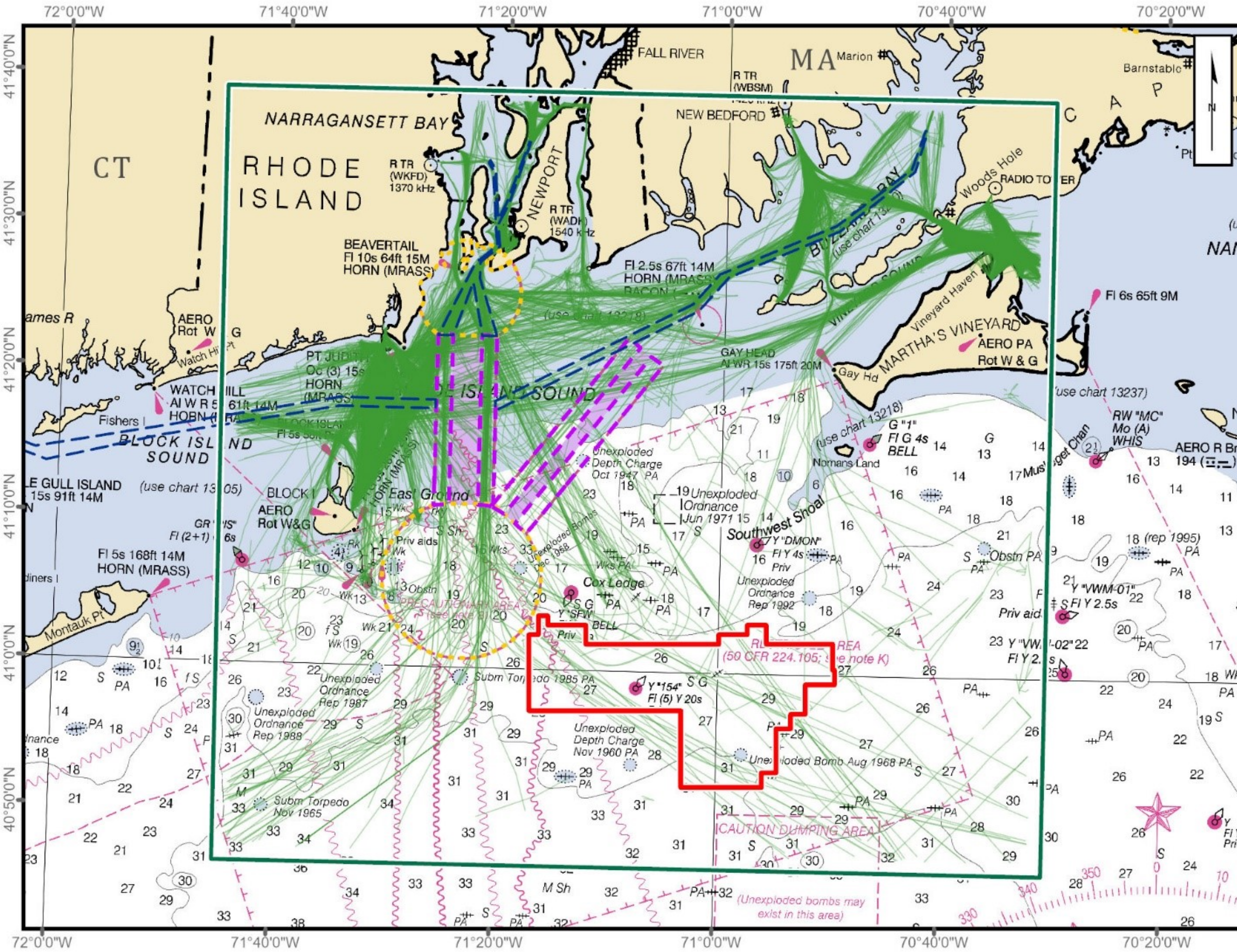



71°20'0"W
71°0'0"W
70°40'0"W
41°10'0"N
41°0'0"N
40°50'0"N
Cox Ledge
RESTRICTED AREA
(50 CFR 224.105; see note A)
Unexploded bombs Dec 1958
Unexploded depth charge 29 Nov 1960 PA
Unexploded bomb Aug 1968 PA
Unexploded ordnance (rep 1992)
Wks PA (rep 1994)
Y "SFW" Fl Y 4s BELL Priv
Y "DMON" Fl Y 4s Priv
Y "154" Fl (5) Y 20s Priv
Dumping Area
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
AIS Tracks - All Traffic*
Vessel Track
Shipping
Precautionary Area
Traffic Separation Scheme/Traffic Lane
Albany
Boston
Providence
New York
Philadelphia
Area Shown
Atlantic Ocean
0 1.5 3 6 Nautical Miles
*AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: All Traffic-
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)


RHODE ISLAND
CT
NARRAGANSETT BAY
BLOCK ISLAND SOUND
RHODE ISLAND SOUND
MARTHA'S VINEYARD
VINEYARD SOUND
BUZZARDS BAY
NEWPORT
NEW BEDFORD
FALL RIVER
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
AIS Tracks - Cargo Carrier*
Vessel Track
Shipping
Precautionary Area
Recommended Route
Traffic Separation Scheme/Traffic Lane
Boston
Providence
New York
Philadelphia
Atlantic Ocean
Area Shown
0 2.5 5 10 Nautical Miles
*AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: Cargo/Carrier Vessels-
10203007-200805-IE
August 05, 2020
DNV·GL
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)



Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
AIS Tracks - Fishing*
Vessel Track
Shipping
Precautionary Area
Recommended Route
Traffic Separation Scheme/Traffic Lane
Area Shown
0 2.5 5 10 Nautical Miles
*AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: Fishing Vessels-
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
NARRAGANSETT BAY
RHODE ISLAND
CT
MA
MARTHA'S VINEYARD
BLOCK ISLAND SOUND
72°0'0"W
71°40'0"W
71°20'0"W
71°0'0"W
70°40'0"W
70°20'0"W
41°40'0"N
41°30'0"N
41°20'0"N
41°10'0"N
41°0'0"N
40°50'0"N



Legend

Project Components

Assessment Area

Marine Traffic Study Area

Other Components

*AIS Tracks - Passenger**

Vessel Track

Shipping

Precautionary Area

Recommended Route

Traffic Separation Scheme/Traffic Lane

0 2.5 5 10 Nautical Miles

*AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

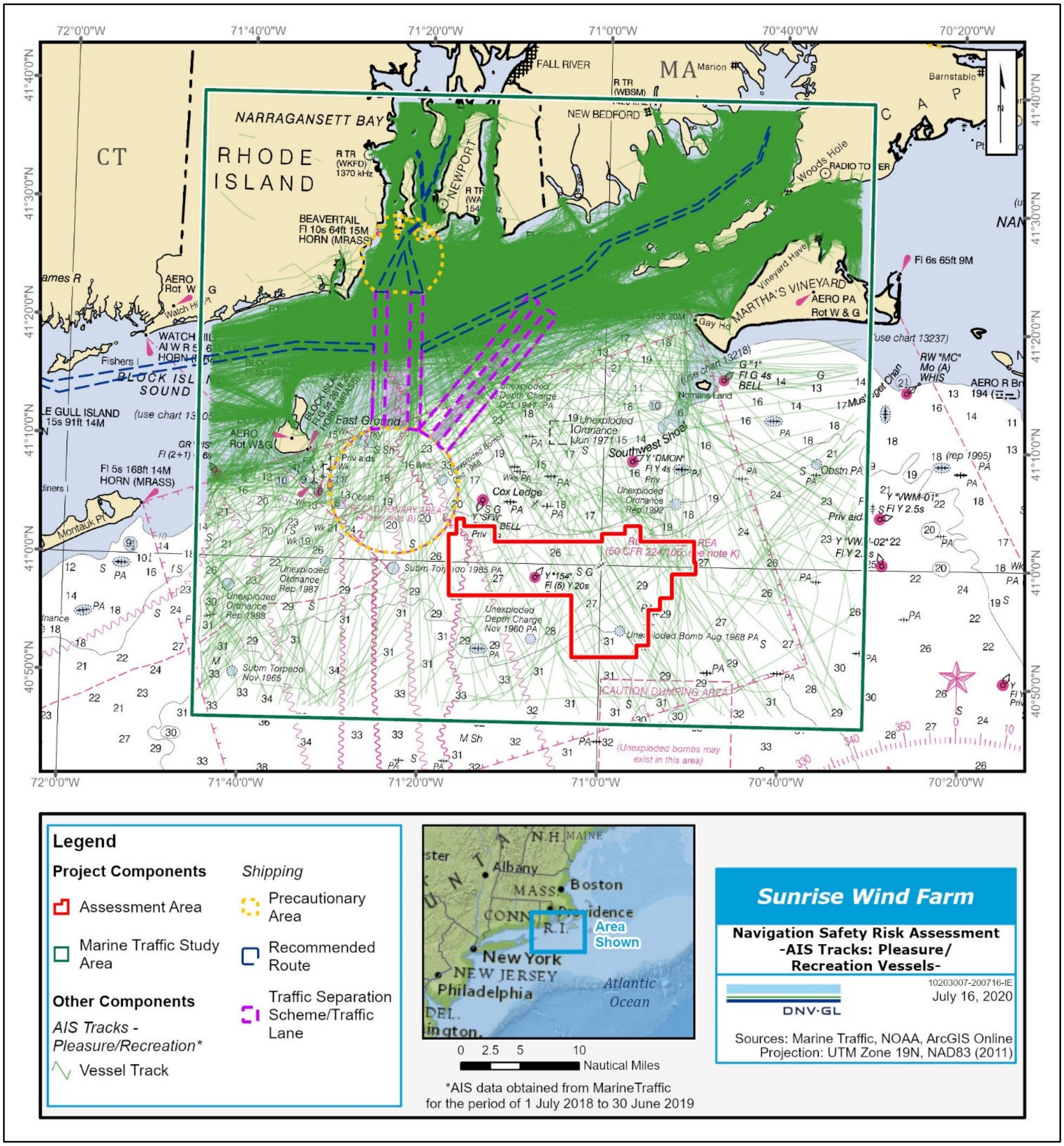
Sunrise Wind Farm

Navigation Safety Risk Assessment -AIS Tracks: Passenger Vessels-

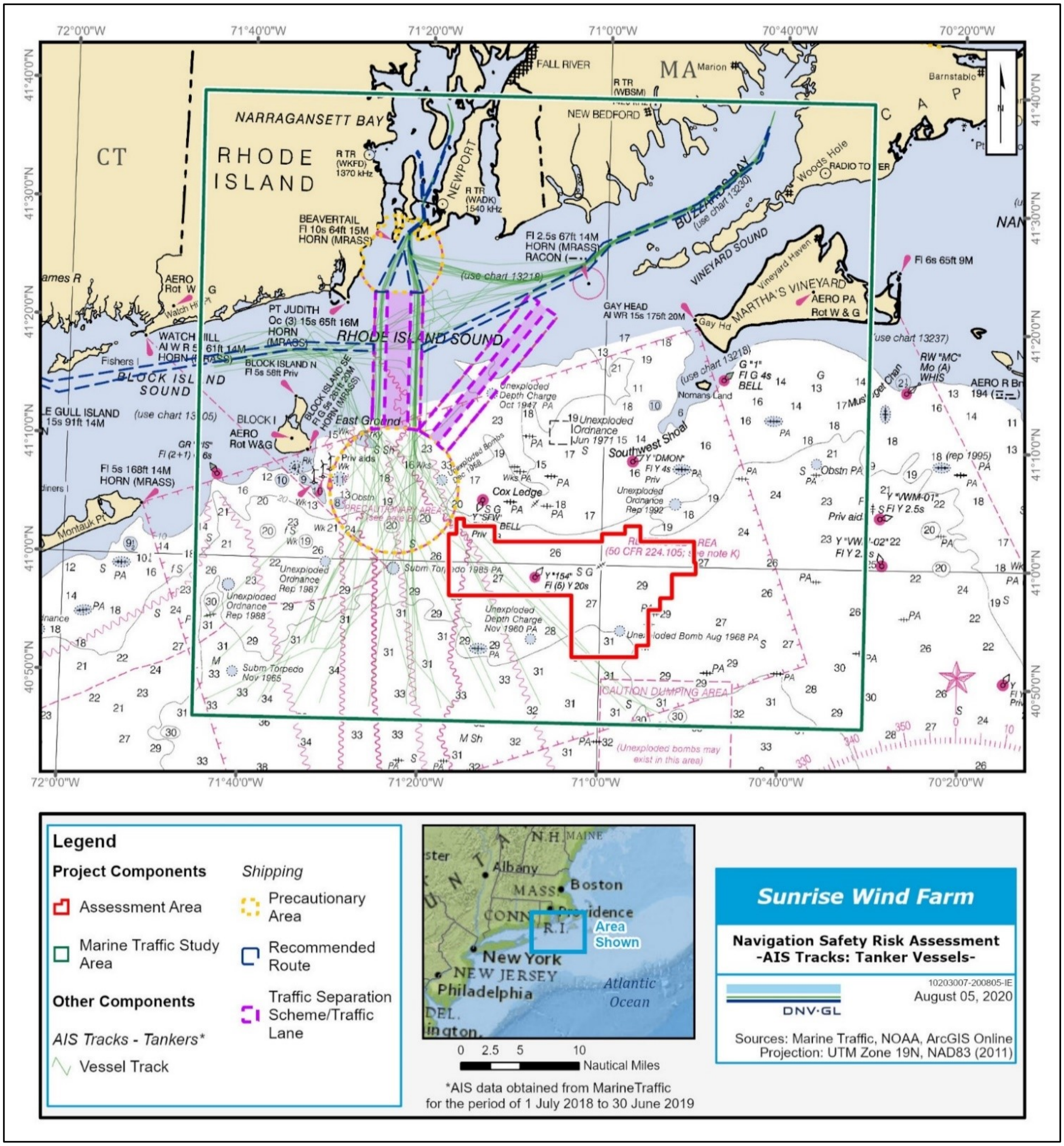
10203007-200716-IE
July 16, 2020

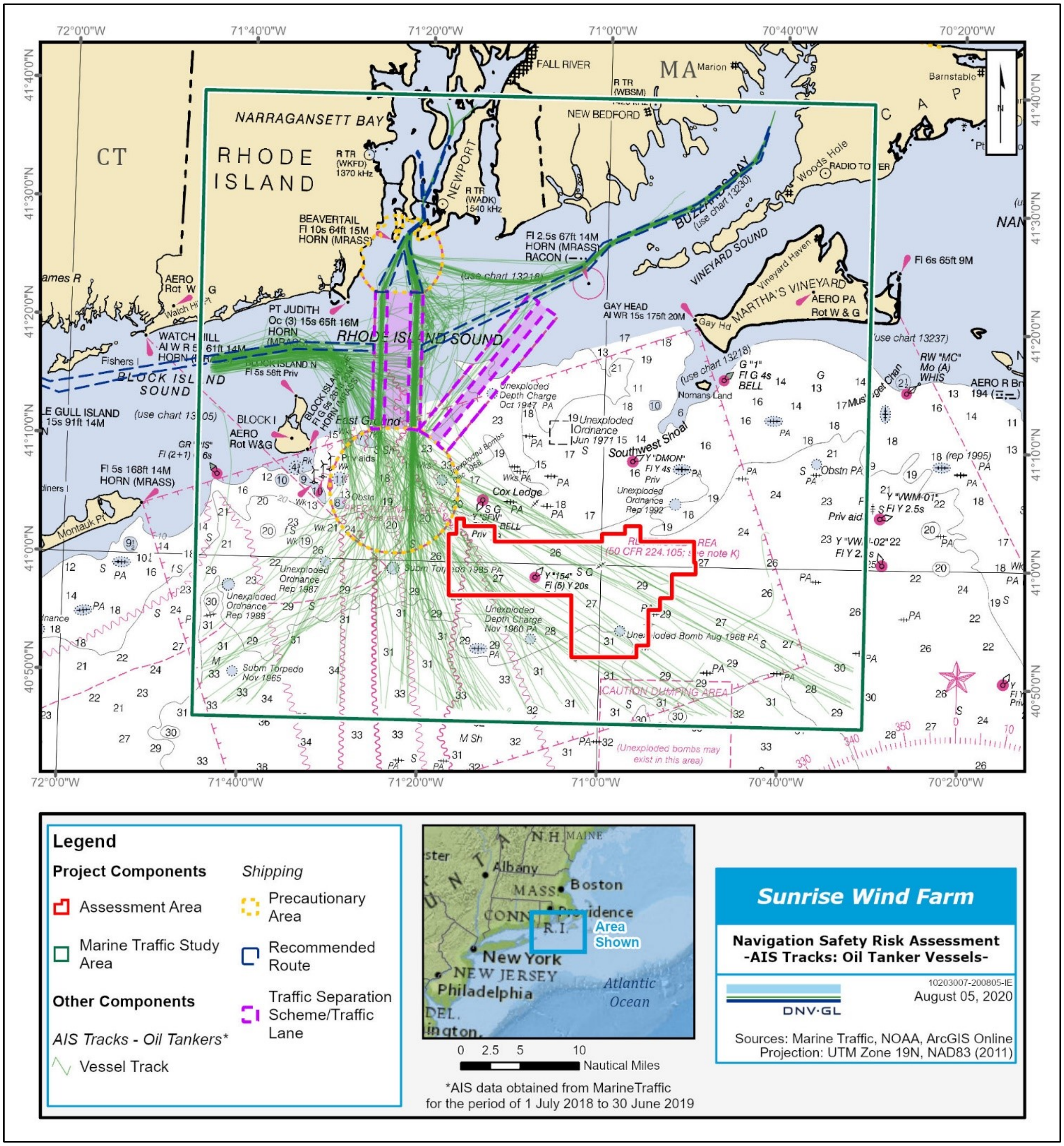
DNV·GL

Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)

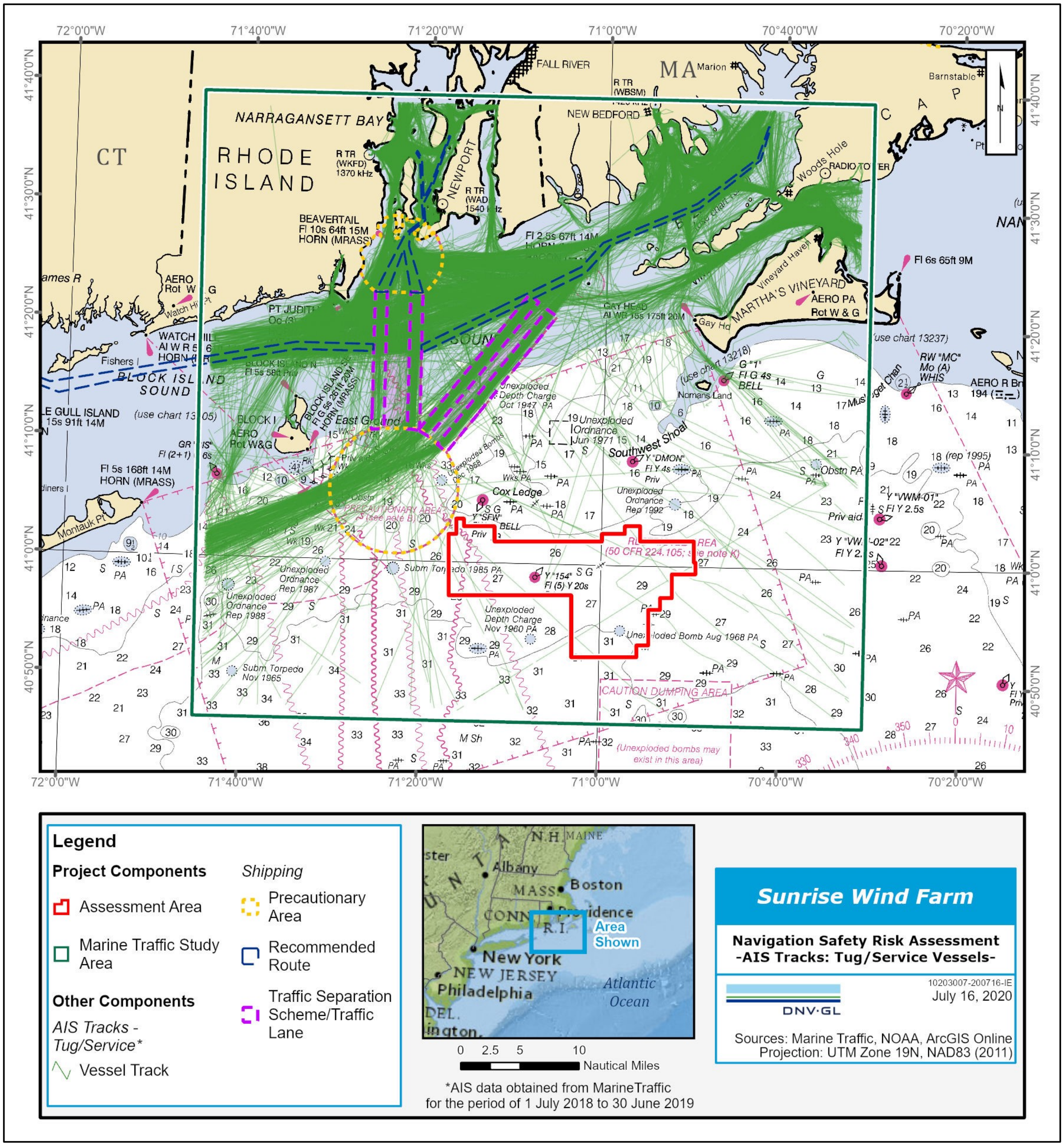


Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
AIS Tracks - Pleasure/Recreation*
Vessel Track
Shipping
Precautionary Area
Recommended Route
Traffic Separation Scheme/Traffic Lane
0 2.5 5 10
Nautical Miles
*AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: Pleasure/ Recreation Vessels-
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)

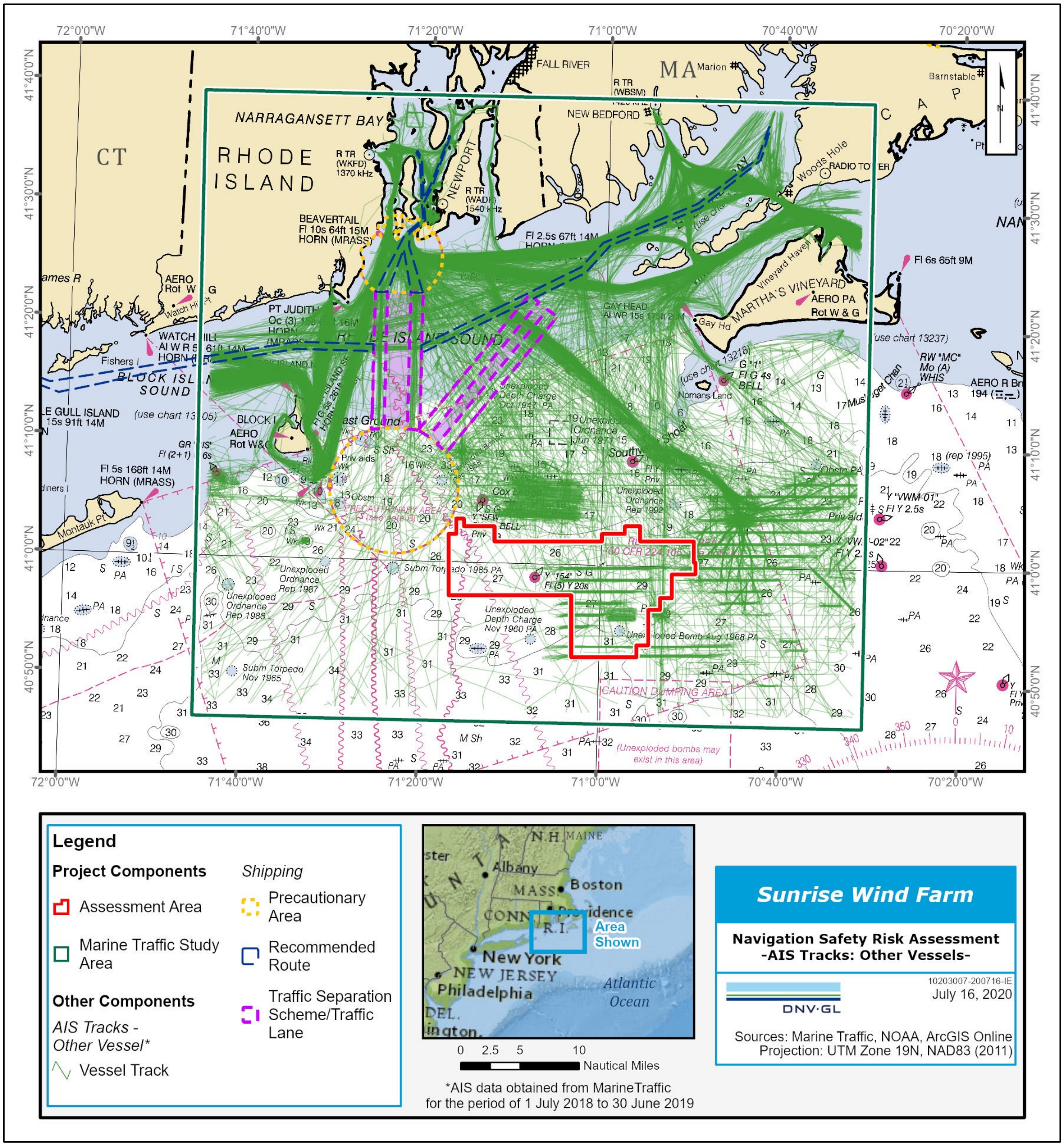

Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
AIS Tracks - Tankers*
Vessel Track
Shipping
Precautionary Area
Recommended Route
Traffic Separation Scheme/Traffic Lane
Area Shown
Atlantic Ocean
0 2.5 5 10 Nautical Miles
*AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: Tanker Vessels-
10203007-200805-IE
August 05, 2020
DNV·GL
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
RHODE ISLAND
NARRAGANSETT BAY
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
MARTHA'S VINEYARD
VINEYARD SOUND
BUZZARDS BAY
CT
MA



Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
AIS Tracks - Oil Tankers*
Vessel Track
Shipping
Precautionary Area
Recommended Route
Traffic Separation Scheme/Traffic Lane
Area Shown
0 2.5 5 10 Nautical Miles
*AIS obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: Oil Tanker Vessels-
10203007-200805-IE
August 05, 2020
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)

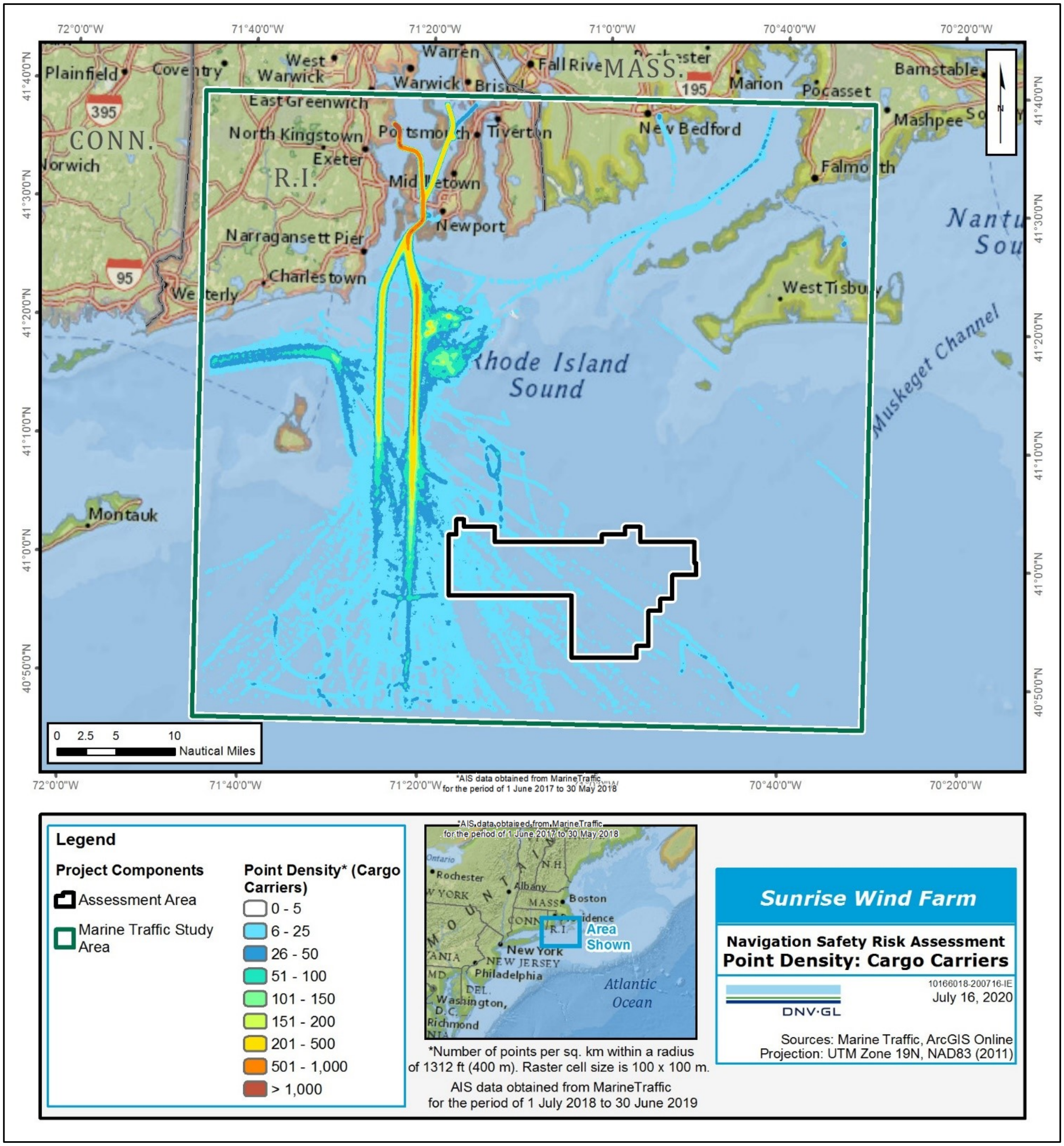


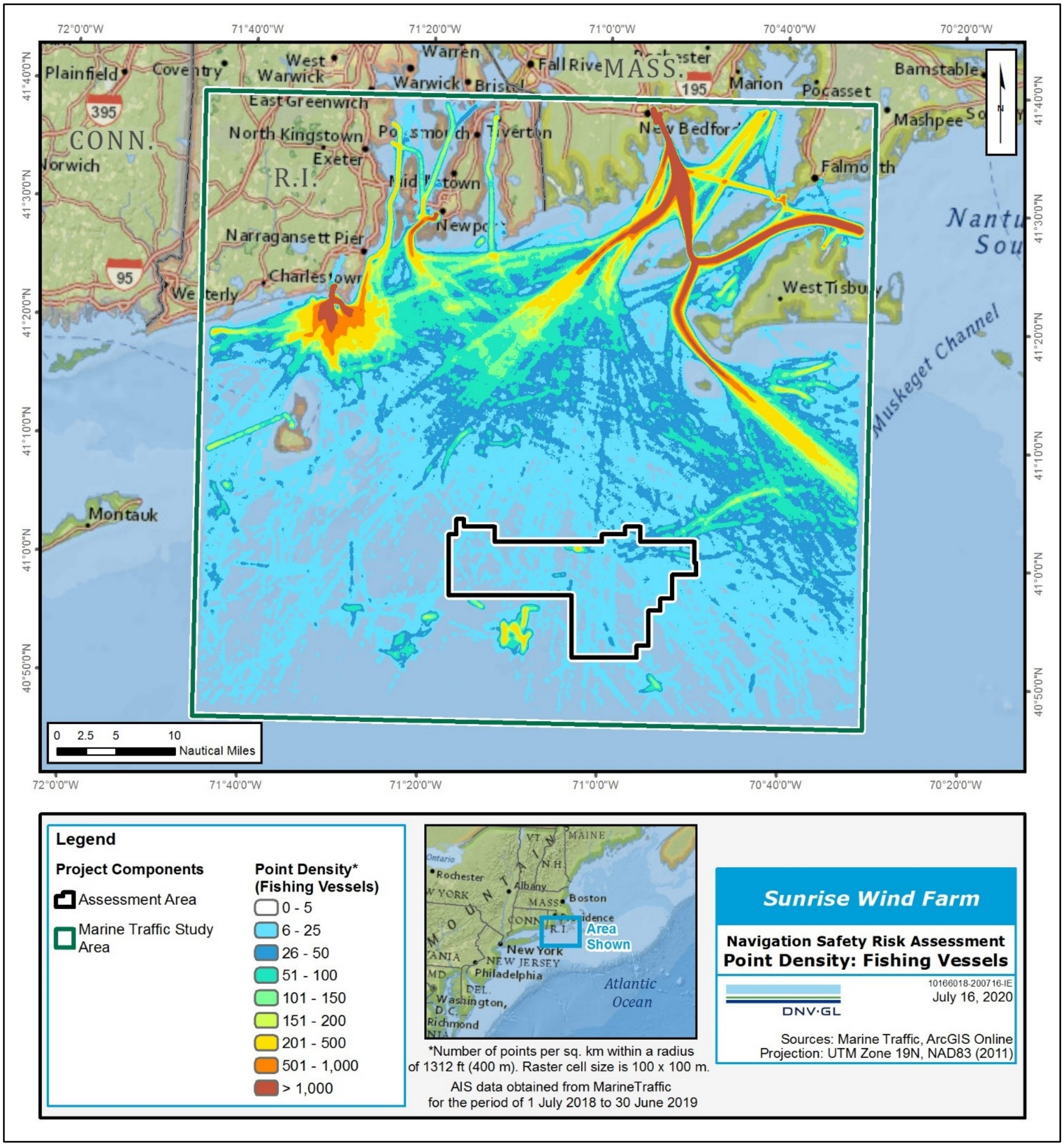
72°0'0"W
71°40'0"W
71°20'0"W
71°0'0"W
70°40'0"W
70°20'0"W
41°40'0"N
41°30'0"N
41°20'0"N
41°10'0"N
41°0'0"N
40°50'0"N
CT
RHODE ISLAND
MA
NARRAGANSETT BAY
FALL RIVER
NEW BEDFORD
NEWPORT
BLOCK ISLAND SOUND
MARTHA'S VINEYARD
Nomans Land
Southwest Shoal
Cox Ledge
East Ground
PRECAUTIONARY AREA
CAUTION DUMPING AREA
(Unexploded bombs may exist in this area)
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
AIS Tracks - Tug/Service*
Vessel Track
Shipping
Precautionary Area
Recommended Route
Traffic Separation Scheme/Traffic Lane
Albany
Boston
Providence
New York
NEW JERSEY
Philadelphia
Atlantic Ocean
Area Shown
0 2.5 5 10
Nautical Miles
*AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: Tug/Service Vessels-
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)

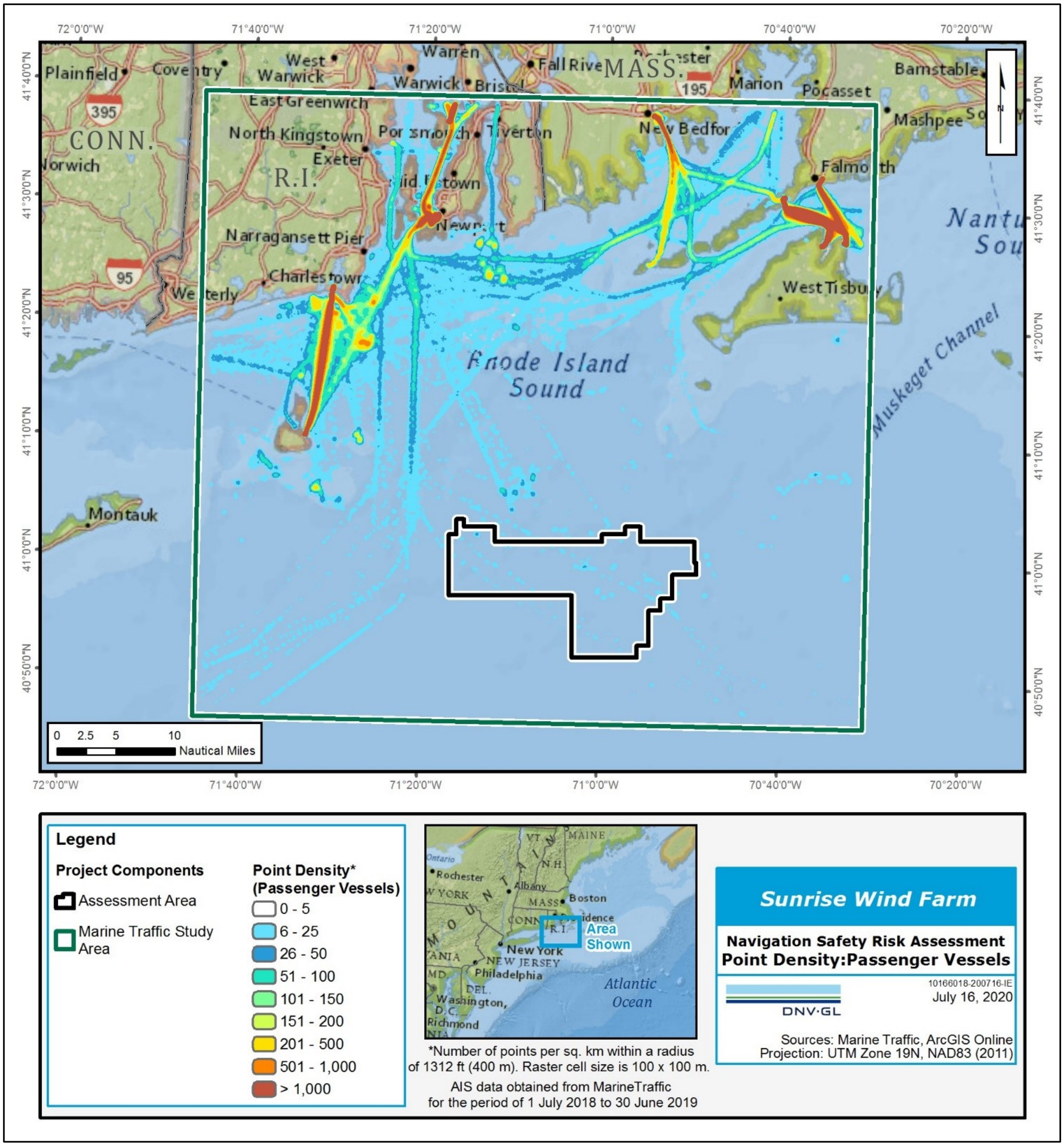

Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
AIS Tracks - Other Vessel*
Vessel Track
Shipping
Precautionary Area
Recommended Route
Traffic Separation Scheme/Traffic Lane
Boston
Providence
New York
Philadelphia
Atlantic Ocean
Area Shown
0 2.5 5 10 Nautical Miles
*AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: Other Vessels-
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)

A.2 AIS point density maps by vessel type

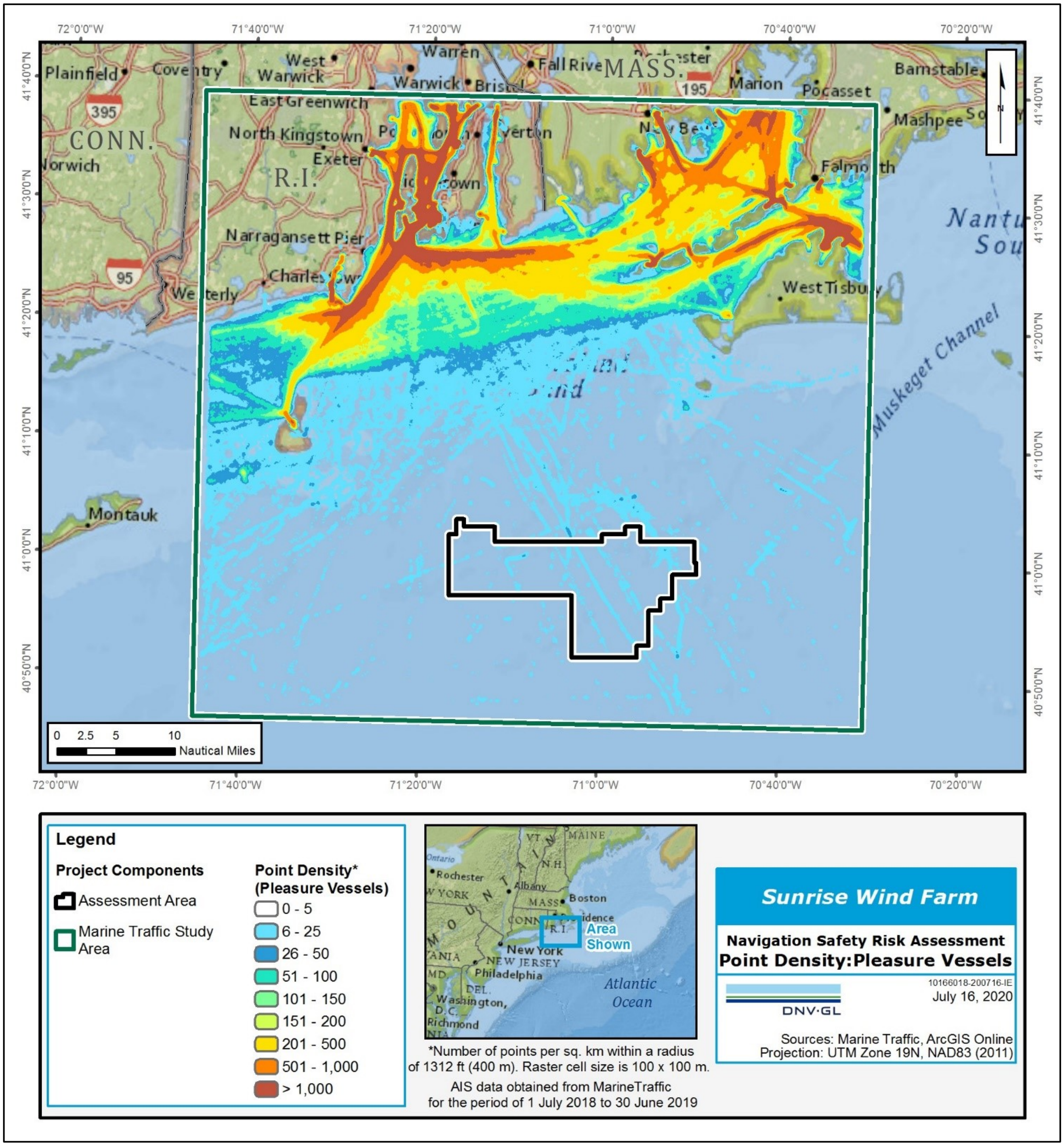
The figures in this section present density heat maps for all AIS points in the Study Area. The density is calculated by determining the number of AIS data points within a square kilometer grid cell.

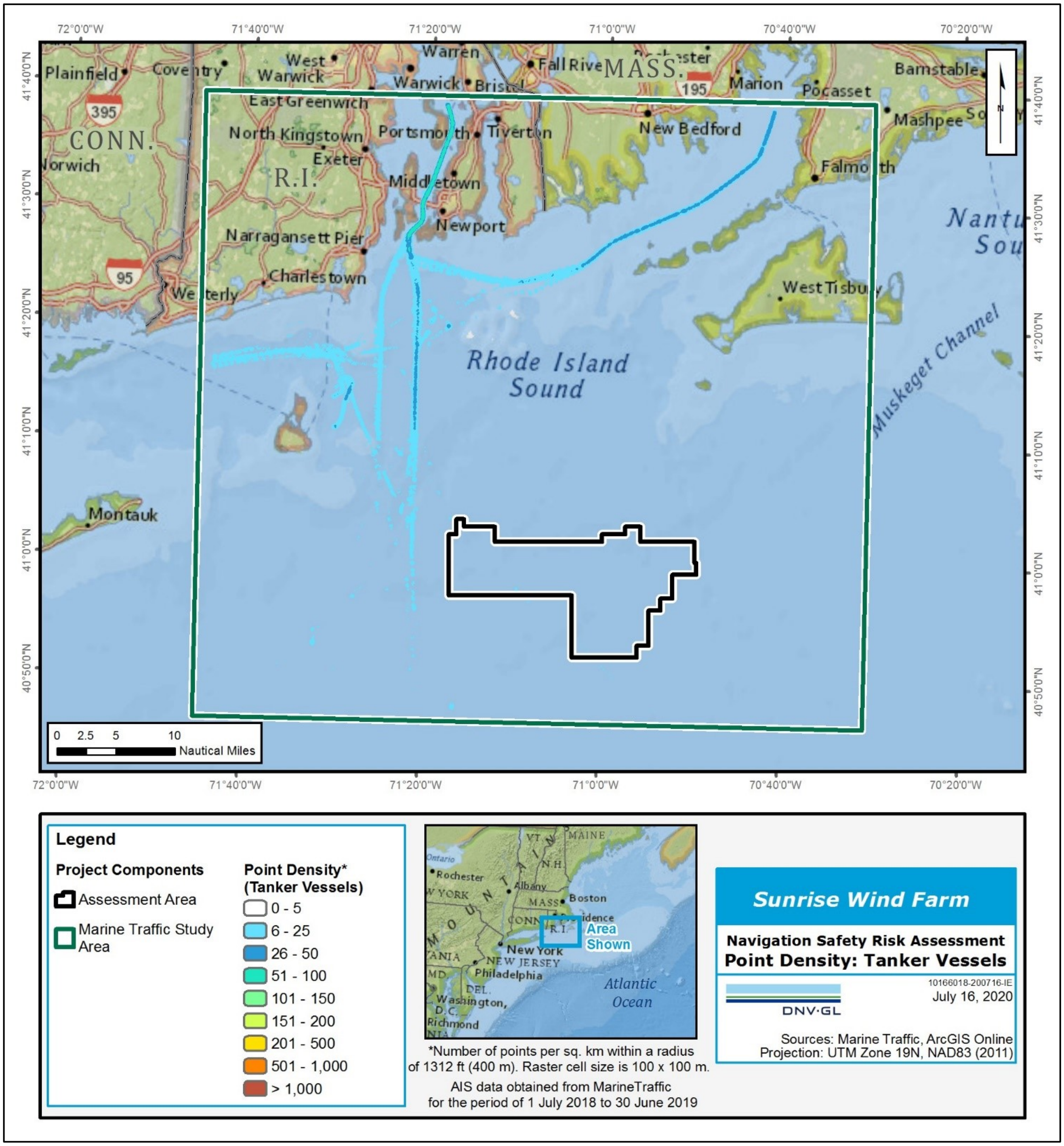


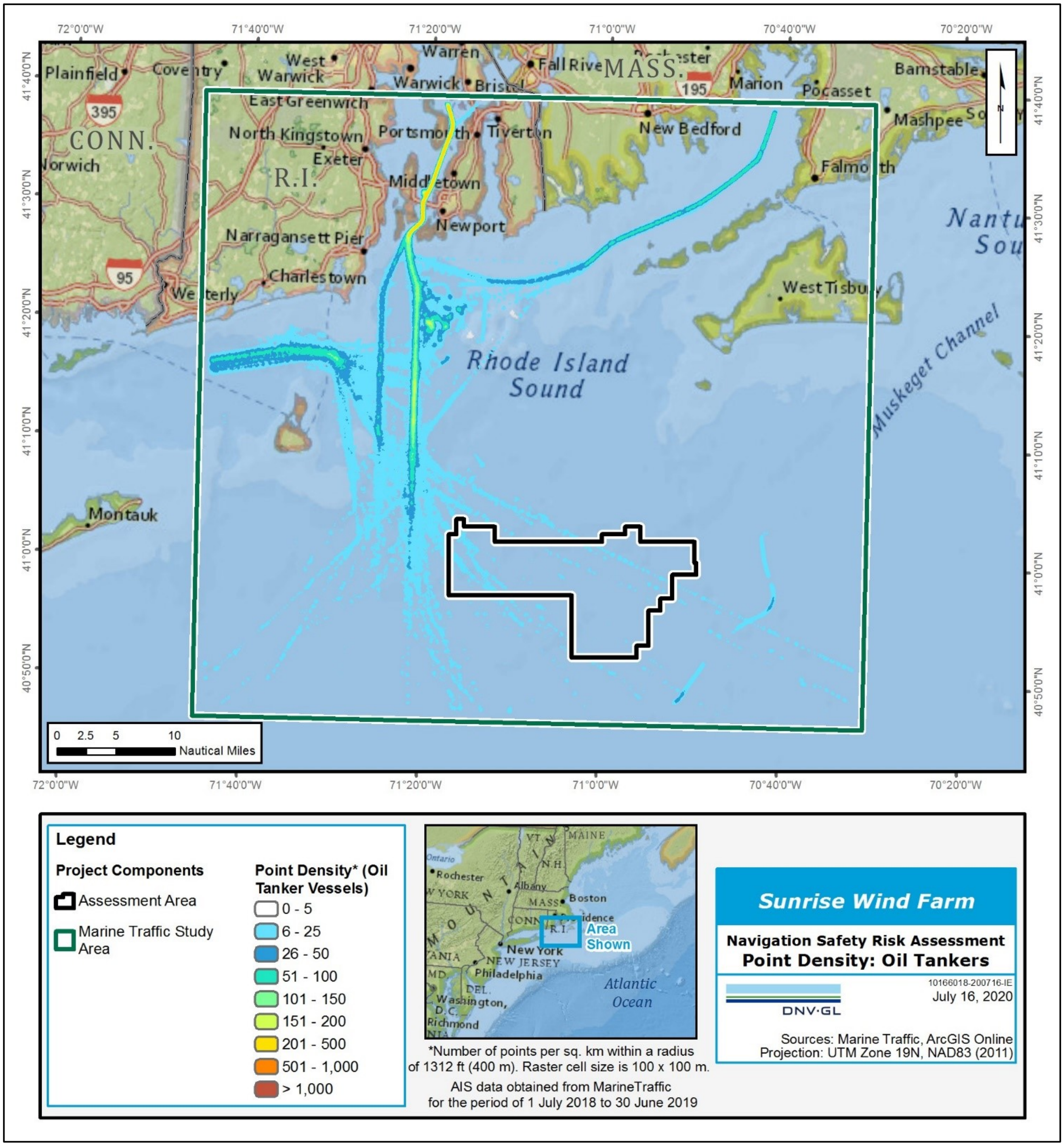

Legend
Project Components
Assessment Area
Marine Traffic Study Area
Point Density*
(Fishing Vessels)
0 - 5
6 - 25
26 - 50
51 - 100
101 - 150
151 - 200
201 - 500
501 - 1,000
> 1,000
Area Shown
Atlantic Ocean
*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Point Density: Fishing Vessels
10166018-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
0 2.5 5 10 Nautical Miles
72°0'0"W
71°40'0"W
71°20'0"W
71°0'0"W
70°40'0"W
70°20'0"W
41°40'0"N
41°30'0"N
41°20'0"N
41°10'0"N
41°0'0"N
40°50'0"N
CONN.
R.I.
MASS.
Muskeget Channel
Montauk



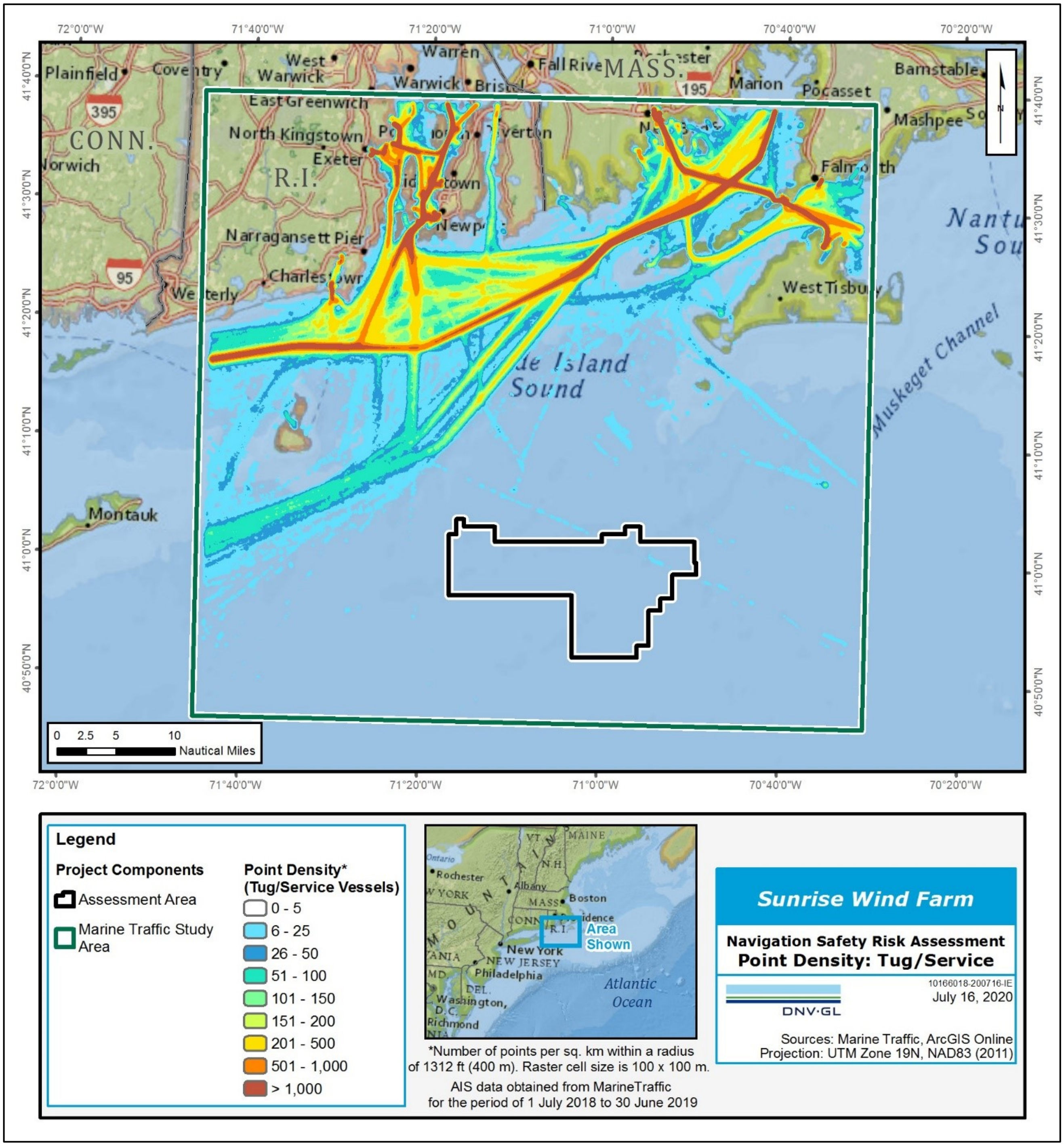
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Point Density* (Passenger Vessels)
0 - 5
6 - 25
26 - 50
51 - 100
101 - 150
151 - 200
201 - 500
501 - 1,000
> 1,000
Rhode Island Sound
Muskeget Channel
0 2.5 5 10 Nautical Miles
Area Shown
Atlantic Ocean
*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Point Density:Passenger Vessels
10166018-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)

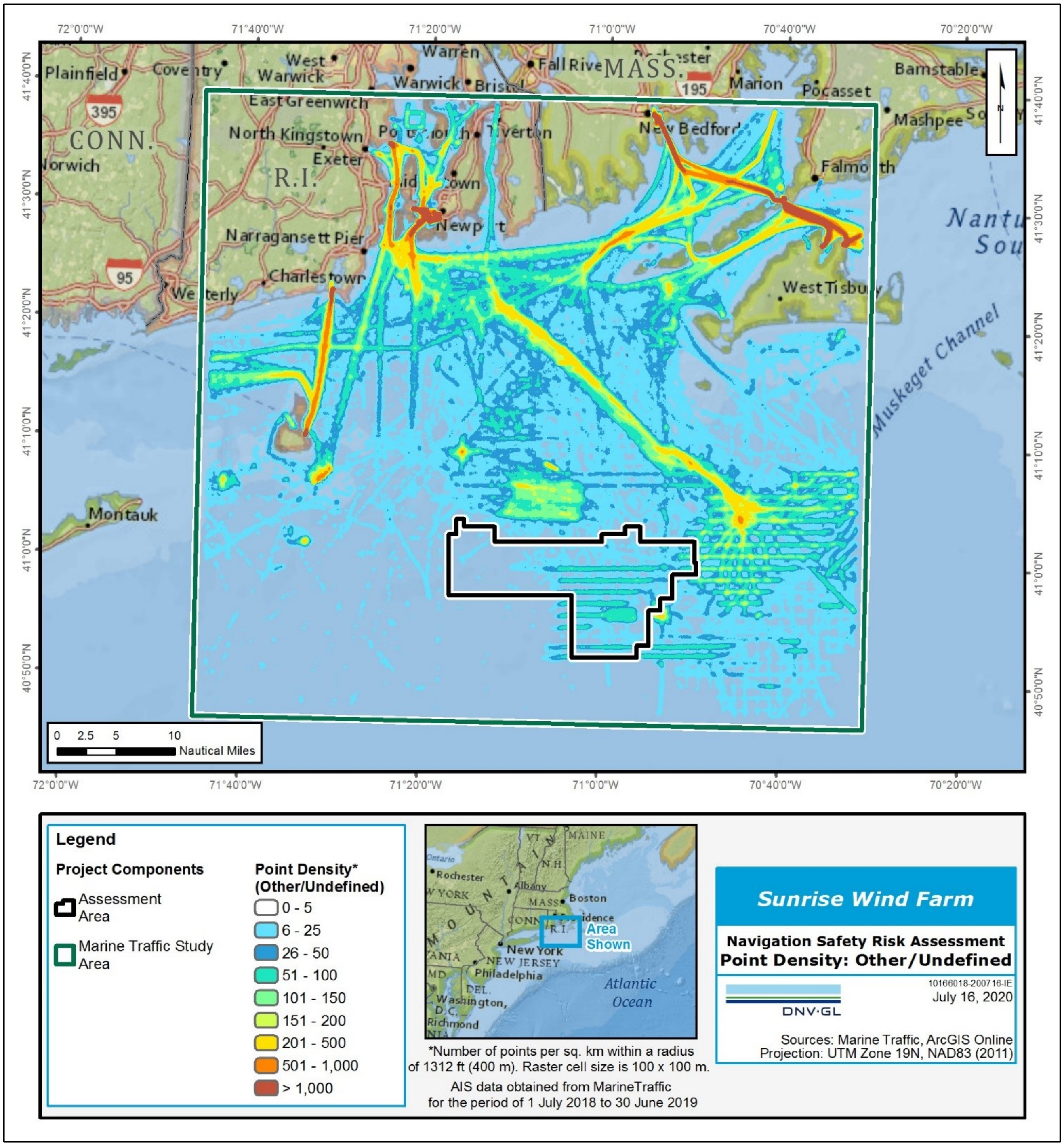

72°0'0"W
71°40'0"W
71°20'0"W
71°0'0"W
70°40'0"W
70°20'0"W
41°40'0"N
41°30'0"N
41°20'0"N
41°10'0"N
41°0'0"N
40°50'0"N
Plainfield
Coventry
West Warwick
Warren
Fall River
MASS.
Barnstable
CONN.
Norwich
East Greenwich
North Kingstown
Exeter
R.I.
Warwick
Marion
Pocasset
Mashpee
Falmouth
Narragansett Pier
Westerly
West Tisbury
Montauk
Muskeget Channel
395
95
195
0 2.5 5 10
Nautical Miles
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Point Density* (Pleasure Vessels)
0 - 5
6 - 25
26 - 50
51 - 100
101 - 150
151 - 200
201 - 500
501 - 1,000
> 1,000
Rochester
Albany
Boston
New York
Philadelphia
Washington, D.C.
Richmond
NEW JERSEY
Atlantic Ocean
Area Shown
*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Point Density:Pleasure Vessels
10166018-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)


72°0'0"W
71°40'0"W
71°20'0"W
71°0'0"W
70°40'0"W
70°20'0"W
41°40'0"N
41°30'0"N
41°20'0"N
41°10'0"N
41°0'0"N
40°50'0"N
Plainfield
Coventry
West Warwick
Warren
Fall River
MASS.
Warwick
Bristol
Marion
Pocasset
Barnstable
Mashpee
East Greenwich
North Kingstown
Portsmouth
Tiverton
New Bedford
CONN.
Norwich
Exeter
R.I.
Middletown
Falmouth
Newport
Narragansett Pier
Charlestown
Westerly
West Tisbury
Rhode Island Sound
Muskeget Channel
Montauk
395
95
195
0 2.5 5 10
Nautical Miles
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Point Density* (Tanker Vessels)
0 - 5
6 - 25
26 - 50
51 - 100
101 - 150
151 - 200
201 - 500
501 - 1,000
> 1,000
Area Shown
Atlantic Ocean
*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Point Density: Tanker Vessels
10166018-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)

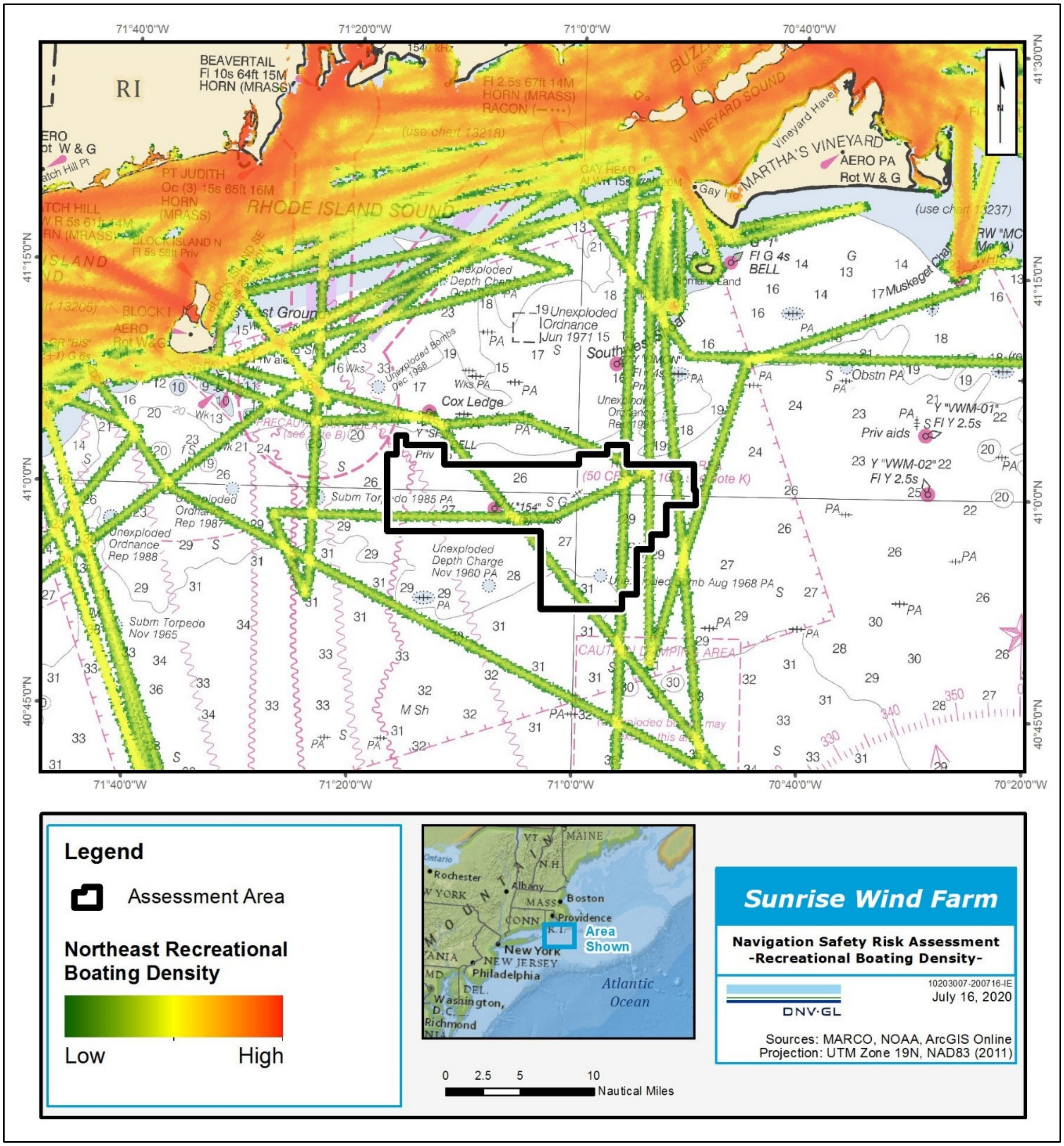


Legend
Project Components
Assessment Area
Marine Traffic Study Area
Point Density* (Oil Tanker Vessels)
0 - 5
6 - 25
26 - 50
51 - 100
101 - 150
151 - 200
201 - 500
501 - 1,000
> 1,000
*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Point Density: Oil Tankers
10166018-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
Rhode Island Sound
0 2.5 5 10 Nautical Miles


Legend
Project Components
Assessment Area
Marine Traffic Study Area
Point Density* (Tug/Service Vessels)
0 - 5
6 - 25
26 - 50
51 - 100
101 - 150
151 - 200
201 - 500
501 - 1,000
> 1,000
*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Point Density: Tug/Service
10166018-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
Area Shown
Atlantic Ocean
0 2.5 5 10
Nautical Miles
72°0'0"W
71°40'0"W
71°20'0"W
71°0'0"W
70°40'0"W
70°20'0"W
41°40'0"N
41°30'0"N
41°20'0"N
41°10'0"N
41°0'0"N
40°50'0"N
CONN.
R.I.
MASS.
Montauk
Westerly
Charlestown
Narragansett Pier
North Kingstown
East Greenwich
West Warwick
Warwick
Warren
Fall River
Marion
Pocasset
Barnstable
Mashpee
West Tisbury
Muskeget Channel
Sound

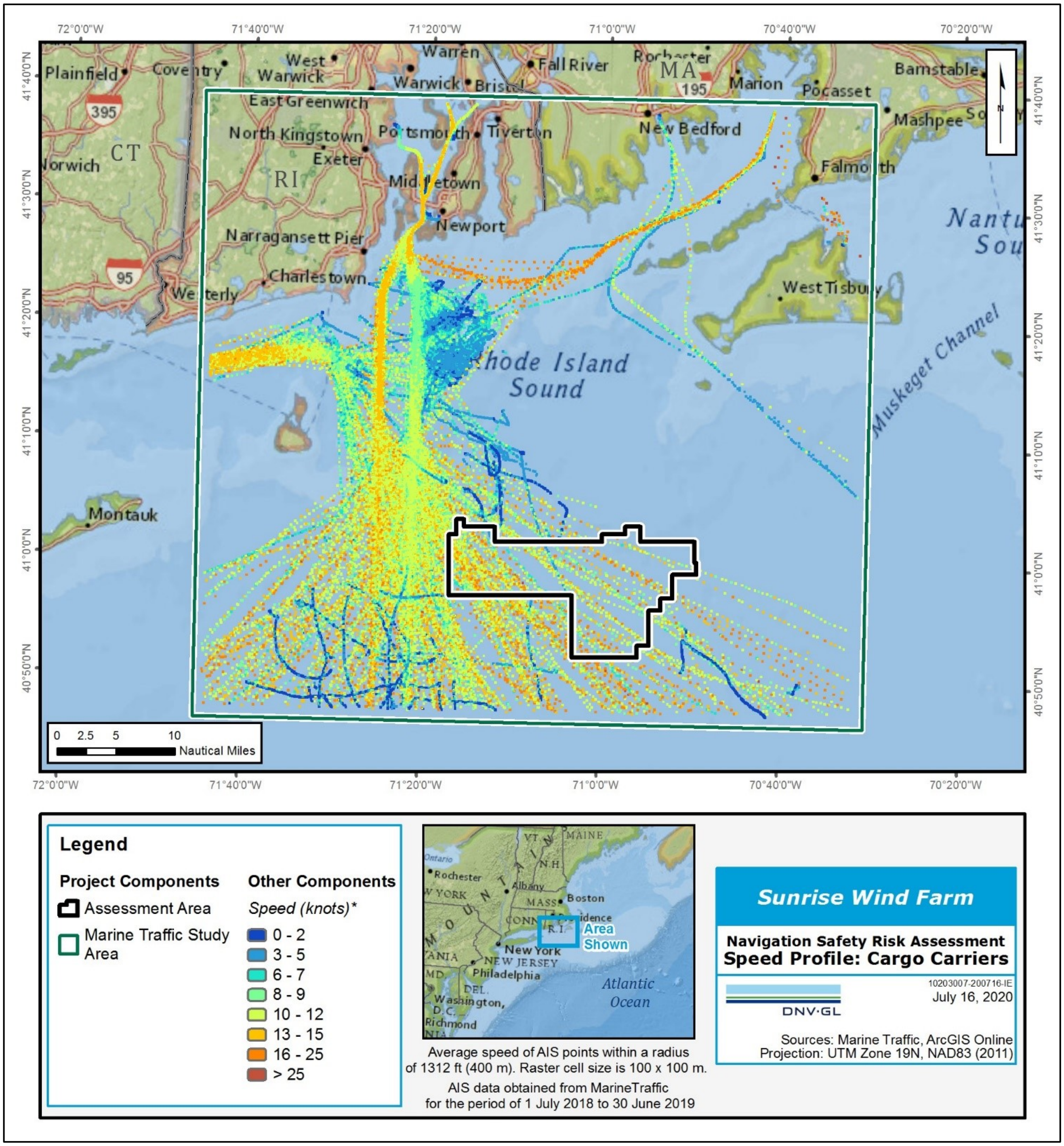


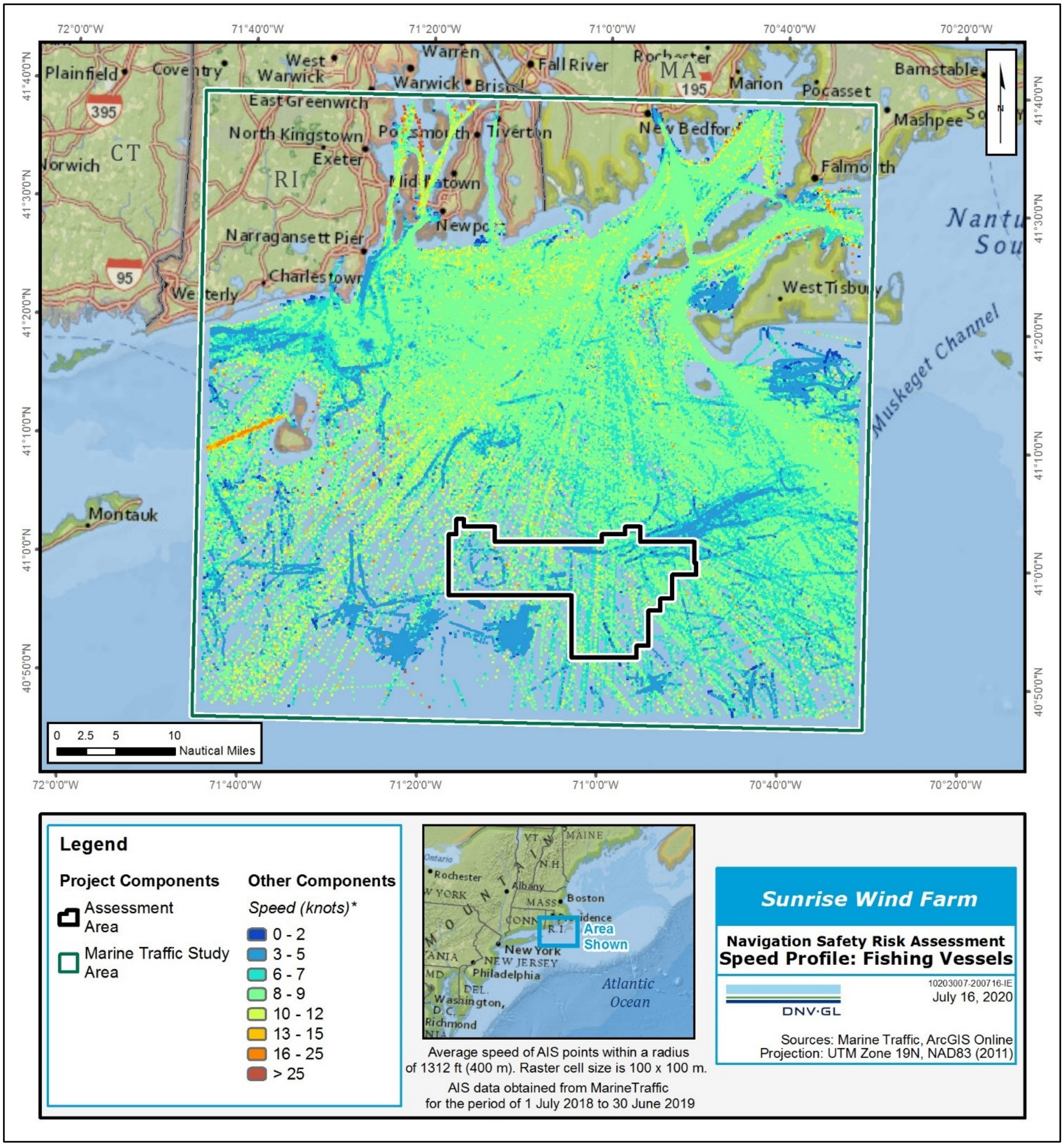
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Point Density* (Other/Undefined)
0 - 5
6 - 25
26 - 50
51 - 100
101 - 150
151 - 200
201 - 500
501 - 1,000
> 1,000
*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Point Density: Other/Undefined
10166018-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
0 2.5 5 10 Nautical Miles



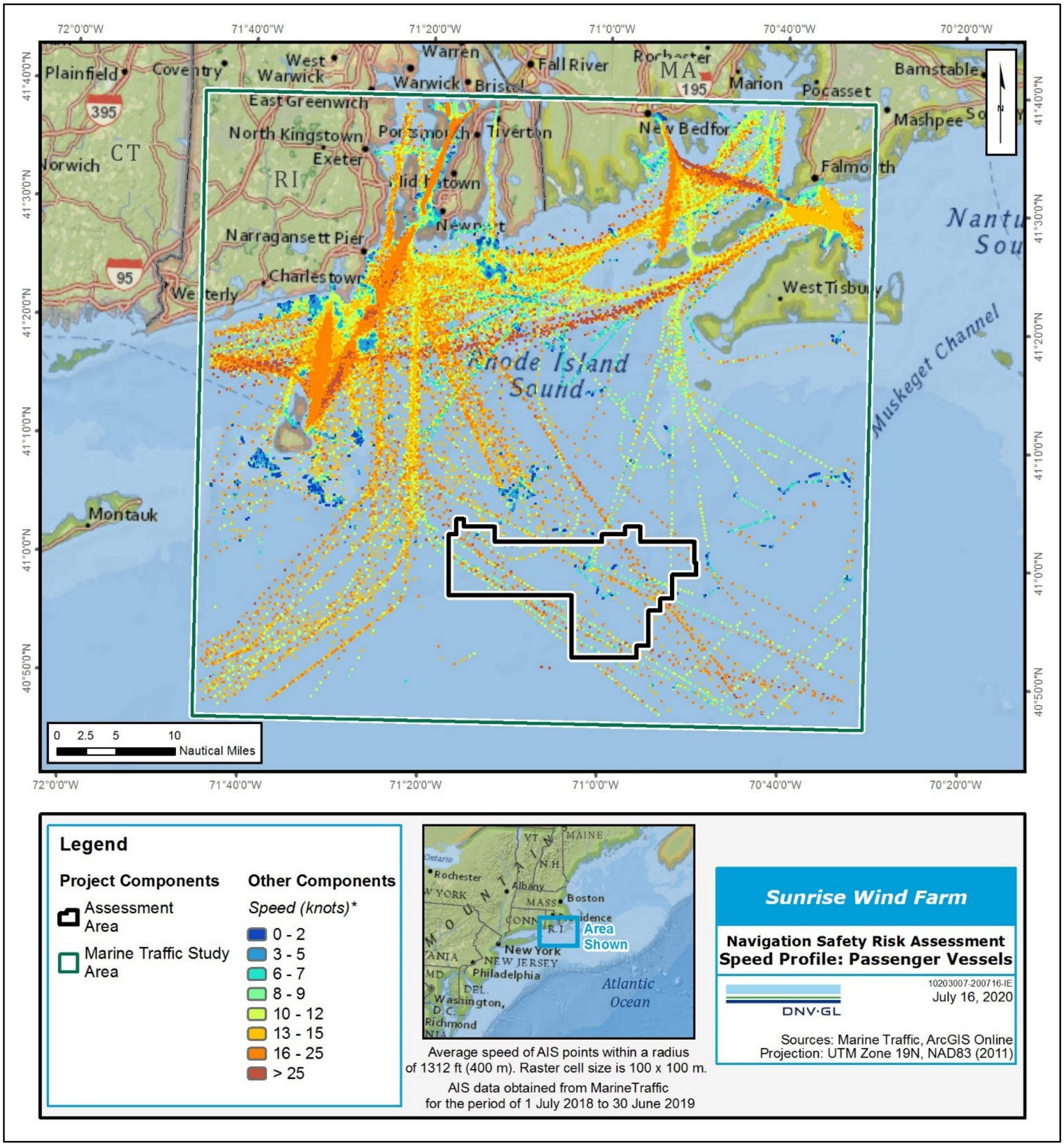
Legend
Assessment Area
Northeast Recreational Boating Density
Low
High
Sunrise Wind Farm
Navigation Safety Risk Assessment
-Recreational Boating Density-
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: MARCO, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
0 2.5 5 10
Nautical Miles
Area Shown
Atlantic Ocean
Boston
Providence
New York
Philadelphia
Washington, D.C.
Richmond
Albany
Rochester
RI
RHODE ISLAND SOUND
VINEYARD SOUND
MARTHA'S VINEYARD
Cox Ledge
71°40'0"W
71°20'0"W
71°0'0"W
70°40'0"W
70°20'0"W
41°30'0"N
41°15'0"N
41°0'0"N
40°45'0"N

A.3 AIS speed profile by vessel type

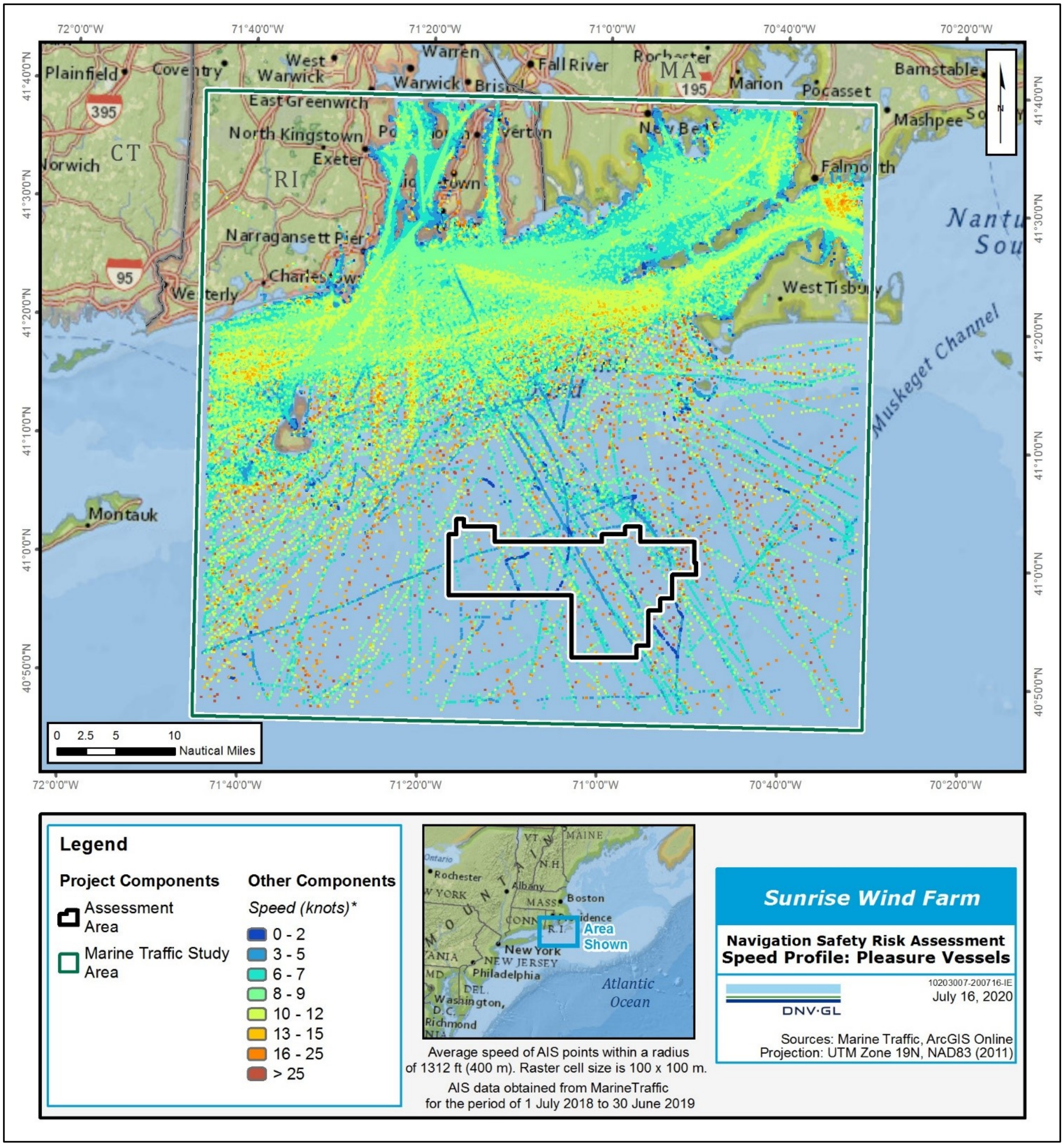




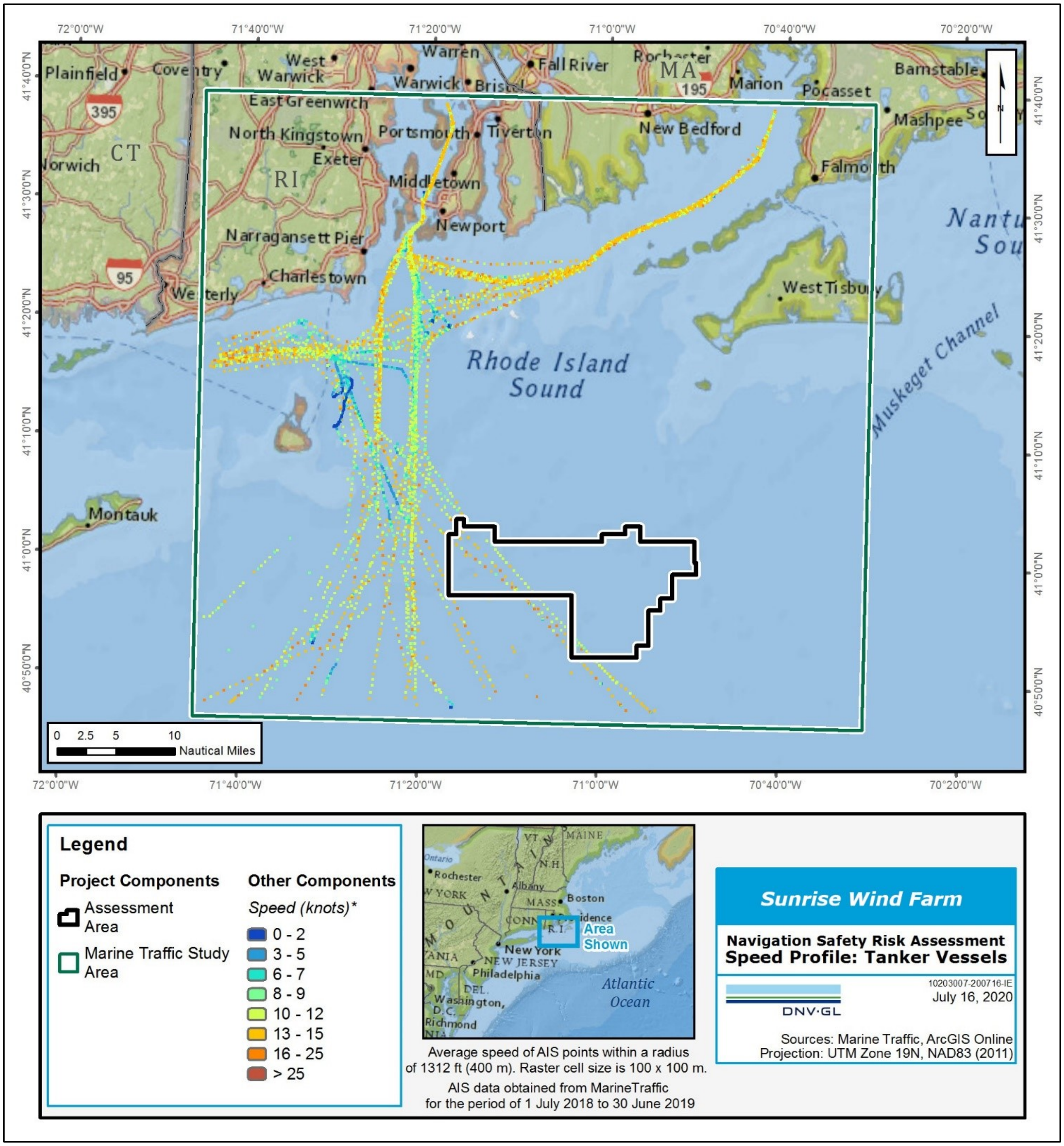
Average speed of AIS points within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019



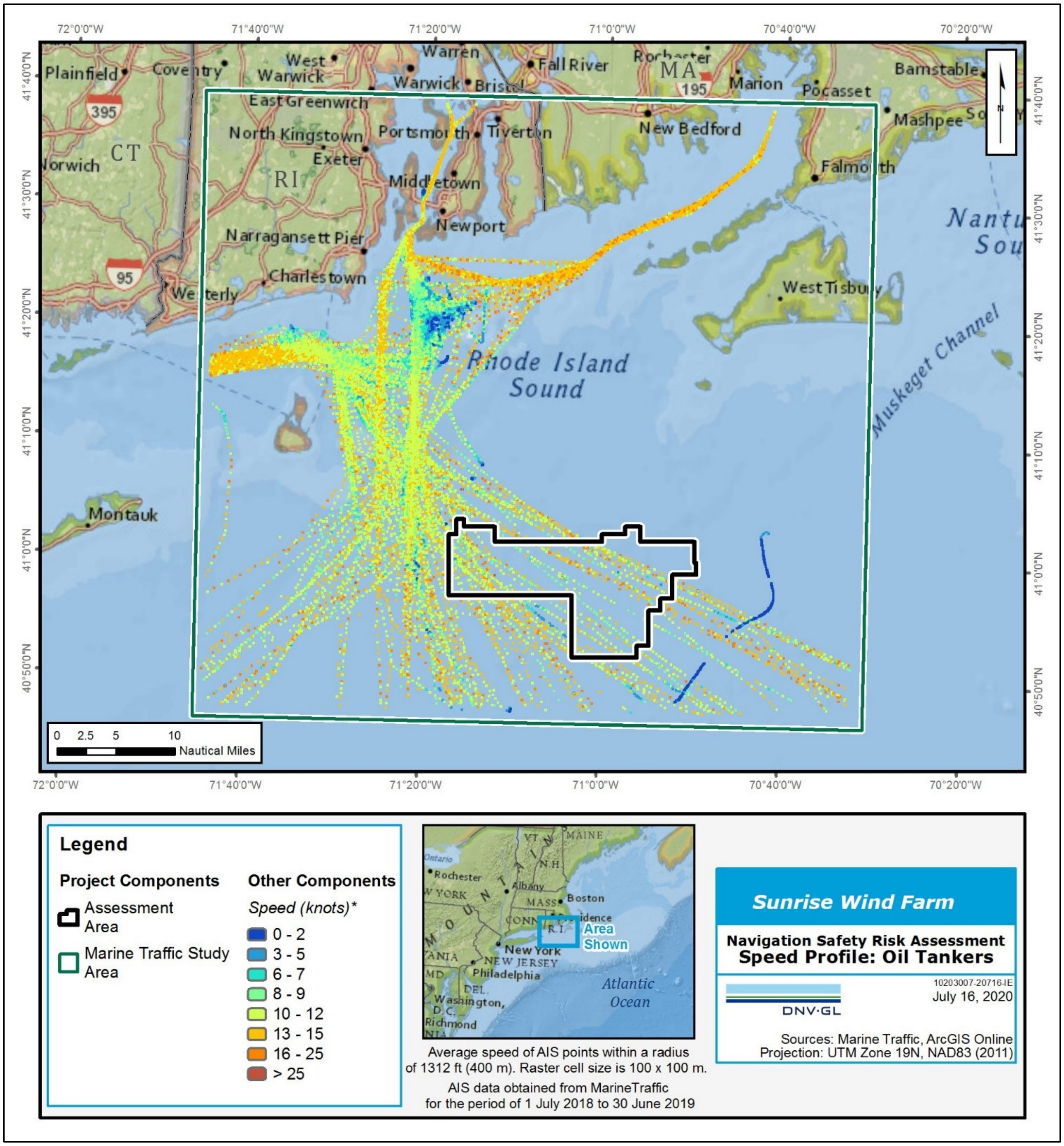
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
Speed (knots)*
0 - 2
3 - 5
6 - 7
8 - 9
10 - 12
13 - 15
16 - 25
> 25
Average speed of AIS points within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Area Shown
Sunrise Wind Farm
Navigation Safety Risk Assessment
Speed Profile: Passenger Vessels
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
Rhode Island Sound
Muskeget Channel
0 2.5 5 10 Nautical Miles



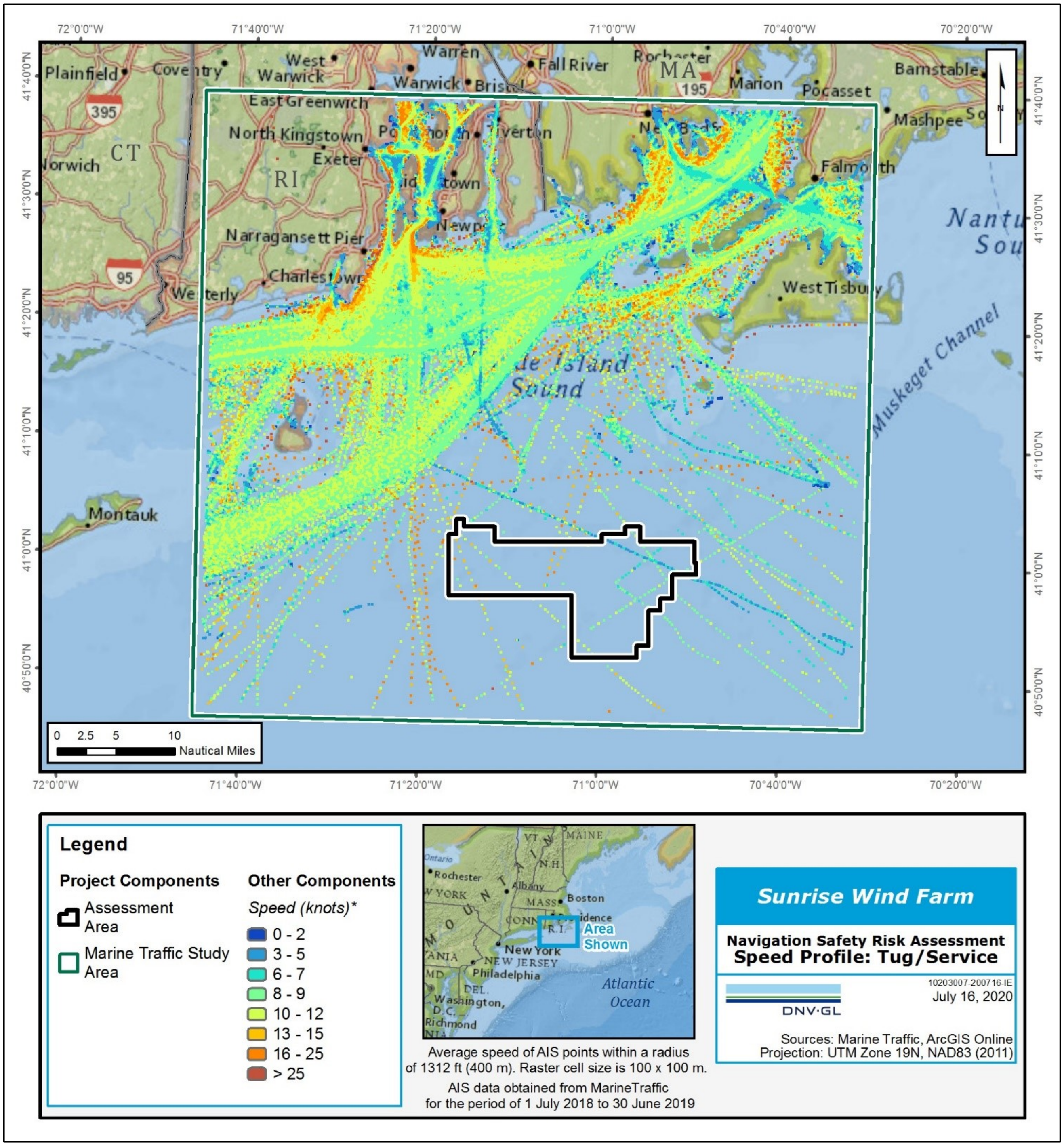
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
Speed (knots)*
0 - 2
3 - 5
6 - 7
8 - 9
10 - 12
13 - 15
16 - 25
> 25
Average speed of AIS points within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Speed Profile: Pleasure Vessels
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
0 2.5 5 10 Nautical Miles



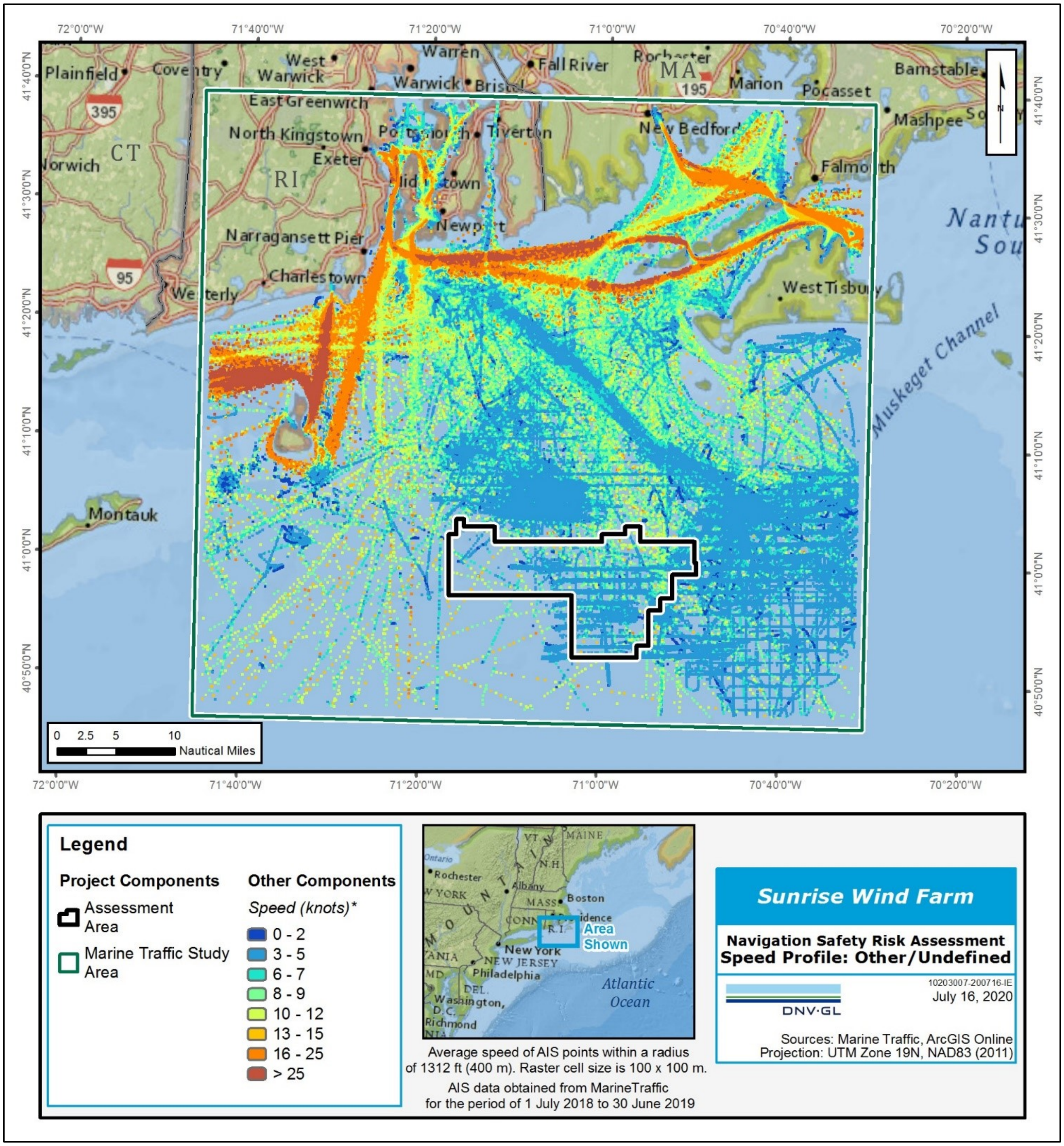
Rhode Island Sound
Muskeget Channel
Newport
Narragansett Pier
Charlestown
Westerly
Montauk
New Bedford
Falmouth
West Tisbury
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
Speed (knots)*
0 - 2
3 - 5
6 - 7
8 - 9
10 - 12
13 - 15
16 - 25
> 25
Average speed of AIS points within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Speed Profile: Tanker Vessels
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)



Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
Speed (knots)*
0 - 2
3 - 5
6 - 7
8 - 9
10 - 12
13 - 15
16 - 25
> 25
Average speed of AIS points within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Speed Profile: Oil Tankers
10203007-20716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)
Rhode Island Sound
Muskeget Channel
0 2.5 5 10 Nautical Miles



72°0'0"W
71°40'0"W
71°20'0"W
71°0'0"W
70°40'0"W
70°20'0"W
41°40'0"N
41°30'0"N
41°20'0"N
41°10'0"N
41°0'0"N
40°50'0"N
Plainfield
Coventry
West Warwick
Warren
Fall River
Rochester
MA
Barnstable
Warwick
Bristol
Marion
Pocasset
East Greenwich
Mashpee
North Kingstown
Tiverton
New Bedford
Norwich
CT
RI
Exeter
Falmouth
Middletown
Newport
Narragansett Pier
Charlestown
West Tisbury
Westerly
Muskeget Channel
Rhode Island Sound
Montauk
395
95
195
N
0 2.5 5 10
Nautical Miles
Legend
Project Components
Assessment Area
Marine Traffic Study Area
Other Components
Speed (knots)*
0 - 2
3 - 5
6 - 7
8 - 9
10 - 12
13 - 15
16 - 25
> 25
MAINE
VT
N.H.
Rochester
Albany
MASS
Boston
CONN
R.I.
Area Shown
New York
NEW JERSEY
Philadelphia
DEL.
MD
Washington, D.C.
Richmond
Atlantic Ocean
Average speed of AIS points within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
Sunrise Wind Farm
Navigation Safety Risk Assessment
Speed Profile: Tug/Service
10203007-200716-IE
July 16, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)



Average speed of AIS points within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

Sunrise Wind Farm

Navigation Safety Risk Assessment
Speed Profile: Other/Undefined

10203007-200716-IE
July 16, 2020

DNV·GL

Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)

A.4 References

1. MarineTraffic (2019), Automatic Identification System data acquired from MarineTraffic, Historical AIS-T data (vessel positions) for TIMESTAMP between '2018-07-01 00:00' and '2019-06-30 23:59' UTC, LAT between 40.79041 and 41.64521 and LON between -71.73783 and -70.52470.

APPENDIX B LIST OF PARTIES CONTACTED

Stakeholder engagement is an important aspect of assuring maritime safety. Sunrise Wind has contacted the below entities regarding marine use / safety (Sunrise Wind LLC, 2020):

1. Atlantic Clam Farm
2. Atlantic Offshore Lobstermen's Association
3. Atlantic State Marine Fisheries Commission
4. Cape Cod Fishermen's Alliance
5. Commercial Fisheries Center of Rhode Island
6. Commercial Fisheries Research Foundation
7. Connecticut Fisheries Advisory Council
8. Connecticut Lobsterman's Association
9. Eastern New England Scallop Association
10. Fisheries Survival Fund
11. Long Island Commercial Fishing Association
12. Martha's Vineyard Shellfish Group
13. Massachusetts Division of Marine Fisheries
14. Massachusetts Fishermen's Partnership
15. Massachusetts Lobstermen's Association
16. Narragansett Bay Propeller Club
17. National Marine Fisheries Services
18. New Bedford Port Authority
19. New Bedford Seafood Consulting
20. New England Fisheries Management Council
21. New York State Fisheries Technical Working Group
22. Northeast Marine Pilots
23. Responsible Offshore Development Alliance (RODA)
24. Rhode Island Coastal Resources Management Council
25. Rhode Island Department of Environmental Management
26. Rhode Island Fisheries Advisory Board
27. Rhode Island Fishermen's Alliance

28. Rhode Island Lobstermen’s Association

29. Sea Freeze Limited

30. The Town Dock

31. U.S. Coast Guard

APPENDIX C MARINERS' PERSPECTIVES OF PROJECT IMPACT

The Project has engaged and continues to engage numerous stakeholders regarding the potential impacts—both positive and negative—that the proposed Sunrise Wind project may have on their particular waterway uses (Sunrise Wind LLC, 2020).

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

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

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

Recreational boating: Recreational boaters are expected to visit the Project to view the novelty of an offshore wind farm. After an initial uptick of recreational vessel traffic to the Project, it is expected that little recreational traffic would regularly operate in the vicinity.

Recreational fishing: Recreational fishing is expected to increase as fish congregate around the artificial reef associated with each foundation.

Commercial fishing: Commercial fishing stakeholders expressed concerns about lines of orientation (rows and columns) and spacing between turbines. Based on feedback received from this constituency, the Project plans an array with three lines of orientation, east/west, north/south, and diagonals in intercardinal directions, and a minimum of one nm separation between towers.

Commercial vessel operators/pilots: Commercial vessels will make slight adjustments to their intended courses to avoid the vicinity of the Project completely.

Port Authorities: Port authorities are supportive of the Project and welcome the port activity and economic benefit the Project may have on port operations.

APPENDIX D DESCRIPTION OF MARCS MODEL

D.1 Introduction

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

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

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

D.2 Overview of MARCS

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

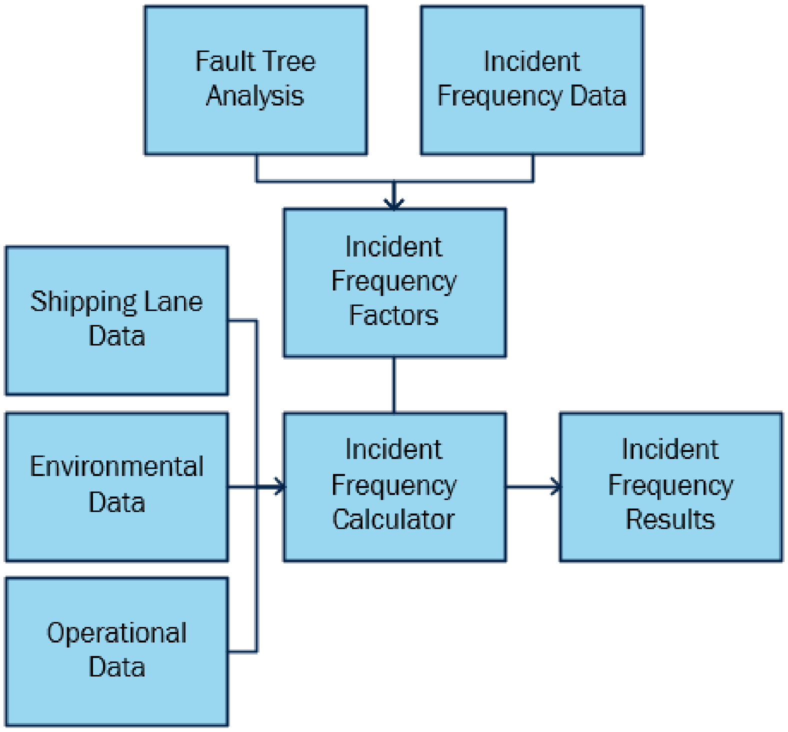


Figure D-1 Block diagram of MARCS incident frequency model

The MARCS model classifies data into three 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.

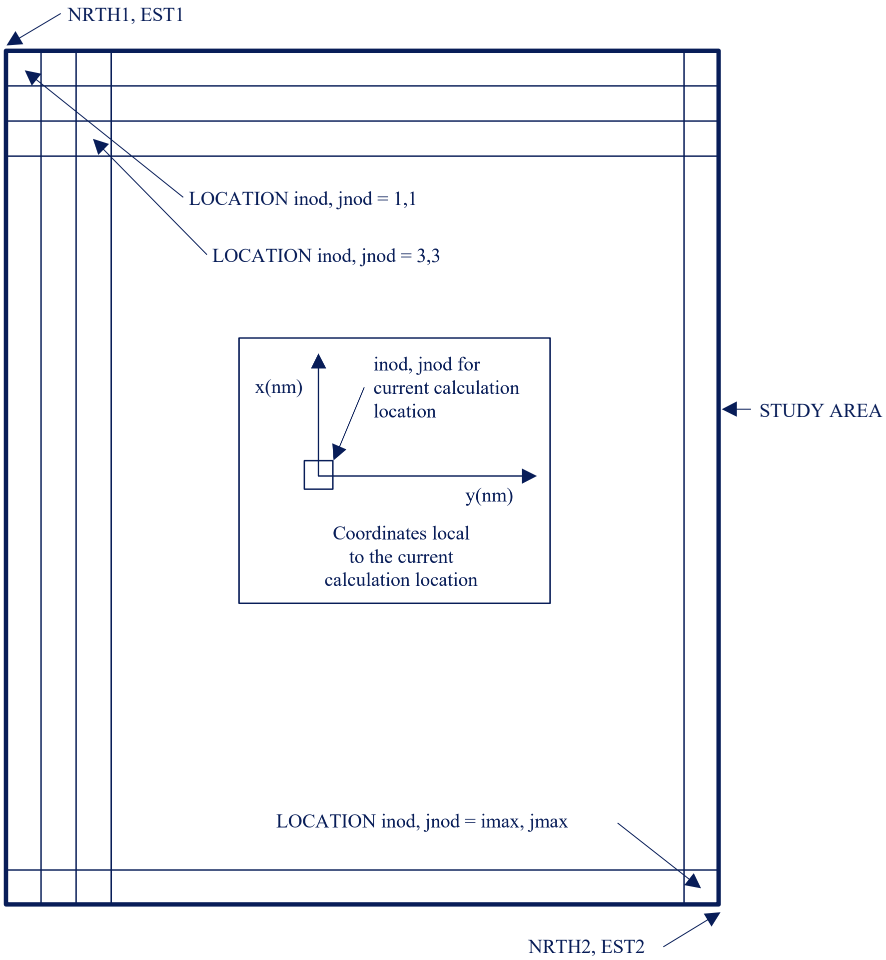


Figure D-2 Basic definitions and coordinate sets

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 square nm, but dependent on the chosen calculation resolution). The definition of a critical situation varies with the incident type).

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

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

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

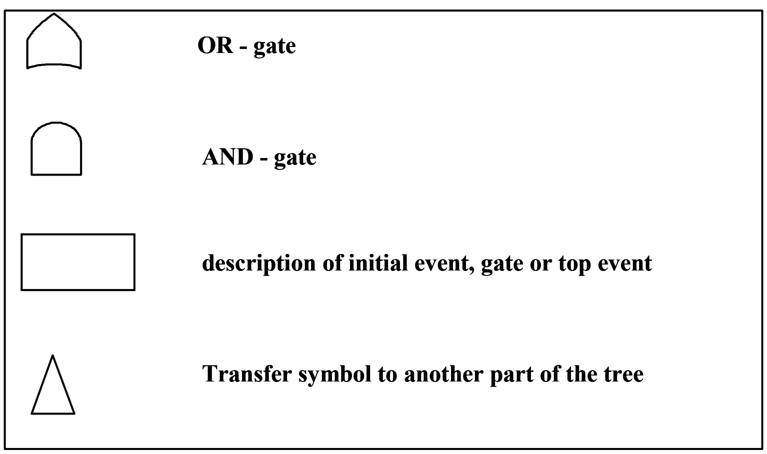


Figure D-3 Fault tree symbols

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

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

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

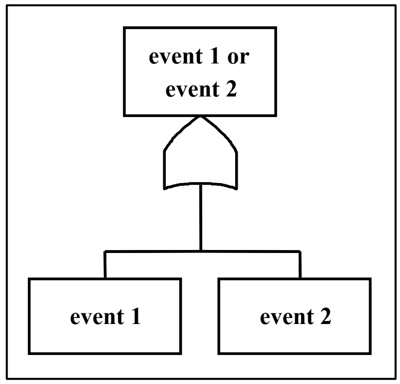


Figure D-4 OR gate

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

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

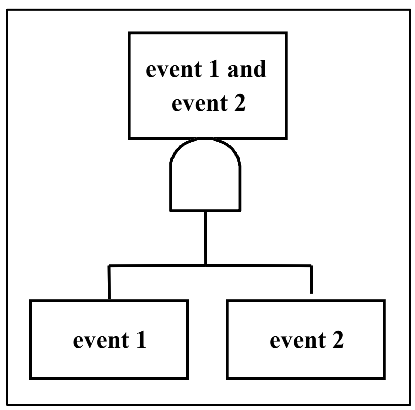


Figure D-5 AND gate

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

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

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.

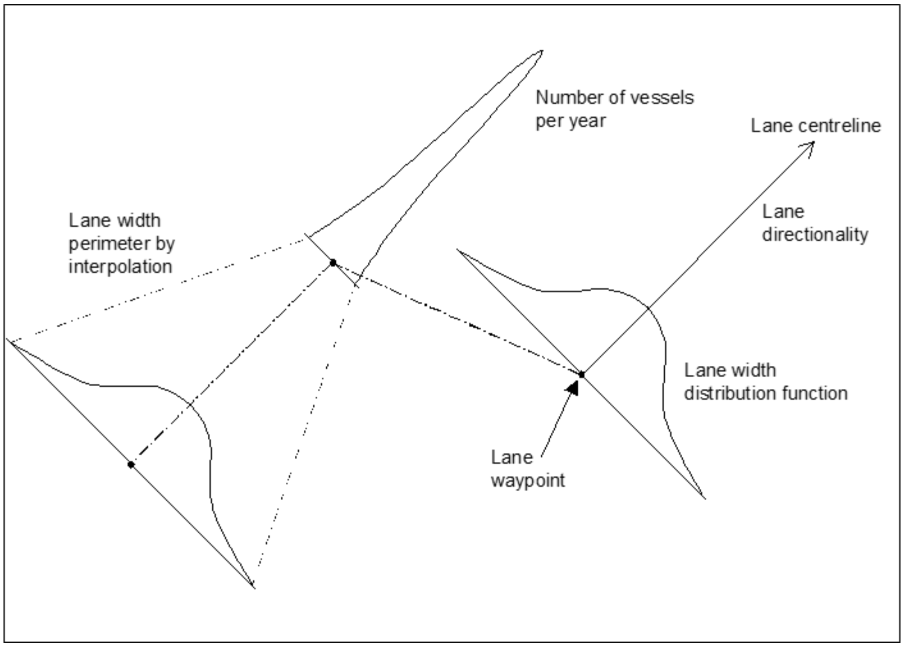


Figure D-6 Shipping lane representation used in MARCS

Detailed surveys of marine traffic in UK waters in the mid-1980s (HMSO, 1985) 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.

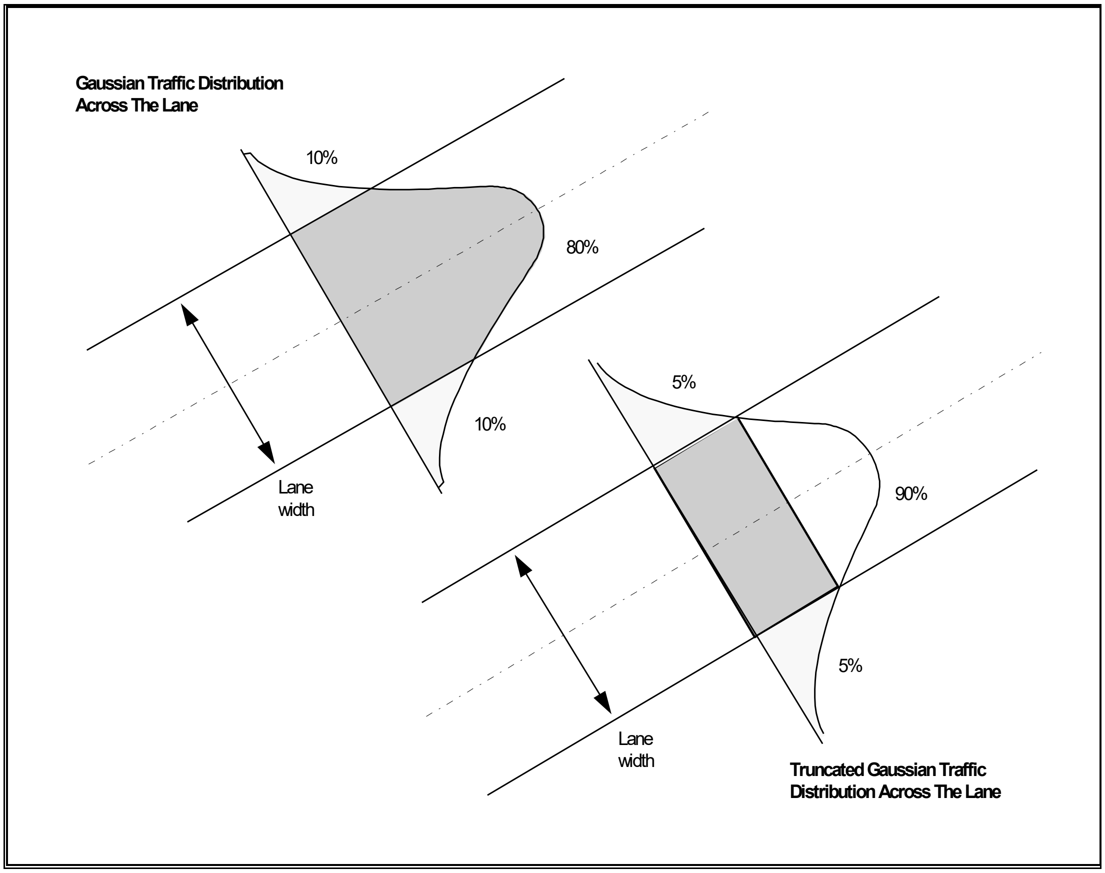


Figure D-7 Shipping lane width distribution functions used in MARCS

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 (Cockcroft and Lameijar, 1982). Such vessels are assumed to represent an enhanced collision hazard. These four parameters can be specified as a function of location within the study area for each traffic type.

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

D.3.2 Operational data

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

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

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

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

D.3.3 Environmental data

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

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

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

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

- Clear water location. Here ships can always pass through. Groundings or allisions 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 with 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 allide with 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 allision (or grounding) accident frequency is set to zero. If one of more of these locations is a “clear water locations plus a man-made object” location, then the accident frequency is multiplied by the proportion of clear water in the location (size of the location – size of the man-made object)/size of the location. In this way, the accident frequency for turbines at the edge of a large array is higher than that for turbines in the center of the array. This mechanism is sometimes called the “shadow effect”.

D.4 Description of incident frequency models

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

D.4.1 The collision model

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

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

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

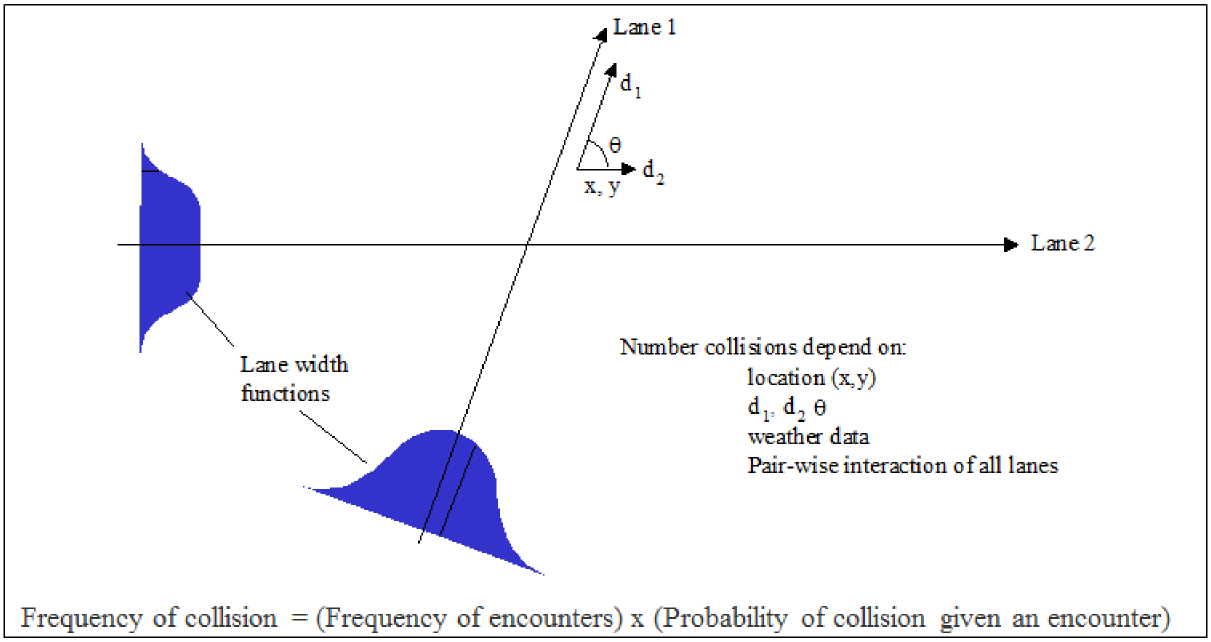


Figure D-8 Graphical representation of the collision model

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

It should be noted that the MARCS collision accident frequency does not depend on the sizes (lengths and breadths) of the encountering ships. This is because MARCS uses a probability of avoiding collision given an encounter which assumes that the navigators on one or both 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.

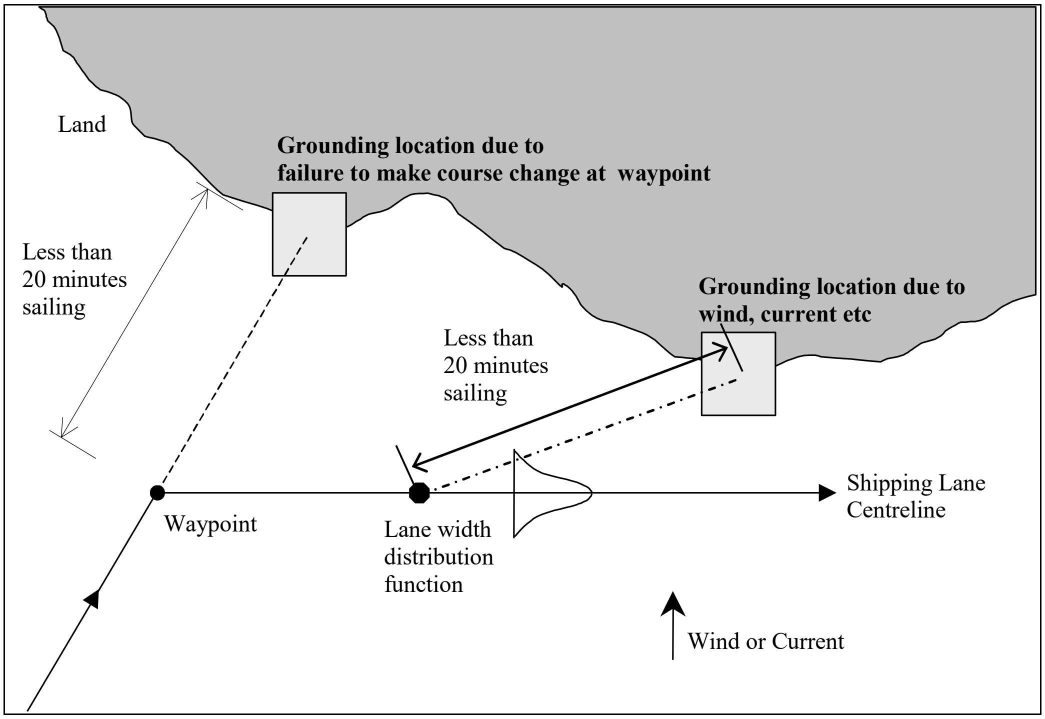


Figure D-9 Graphical representation of the powered grounding model

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, the recovery of control of drifting ships can be regained by one of three mechanisms:

- Repair
- Emergency tow vessel assistance
- Anchoring

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

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

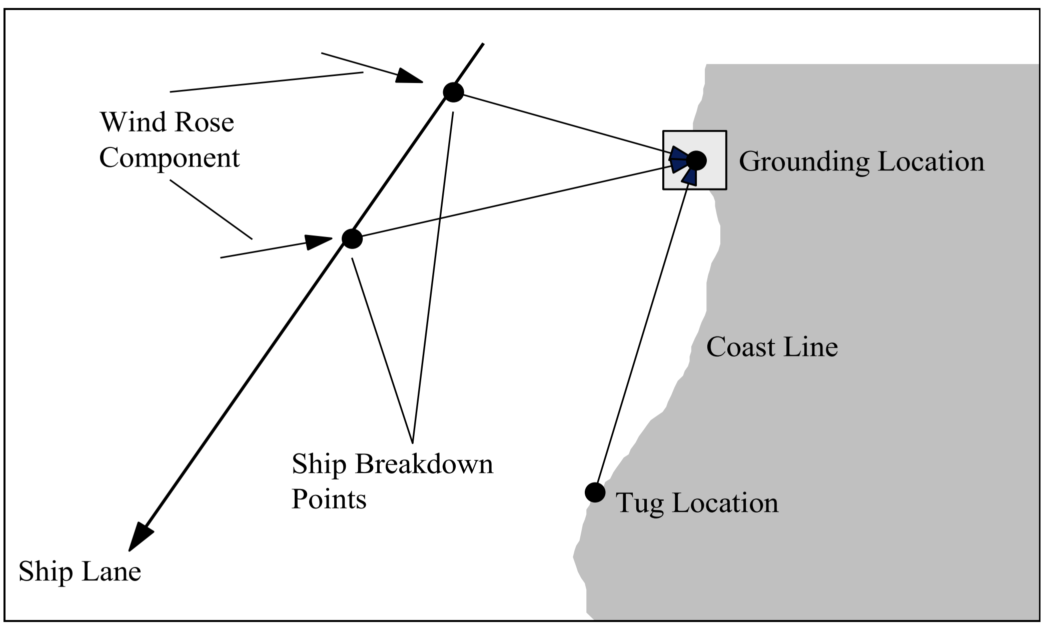


Figure D-10 Graphical representation of the drift grounding model

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

The MARCS drift grounding accident frequency does not depend on the size (length and breadth) of the drifting ship.

D.4.3.1 The repair recovery model

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

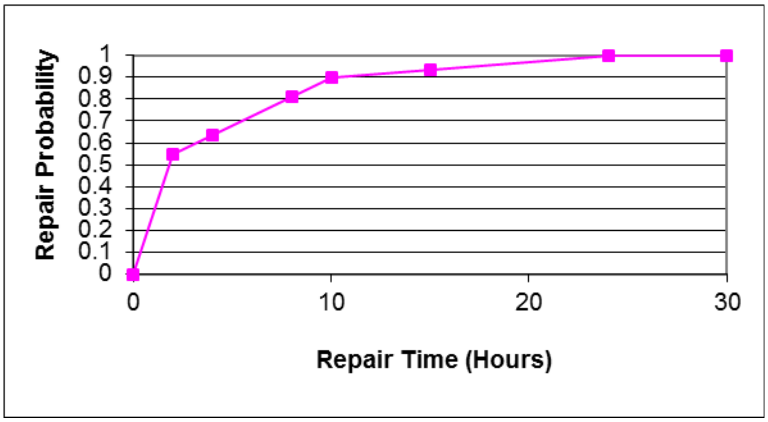


Figure D-11 Graphical representation of the self-repair save mechanism

D.4.3.2 Recovery of control by anchoring

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

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

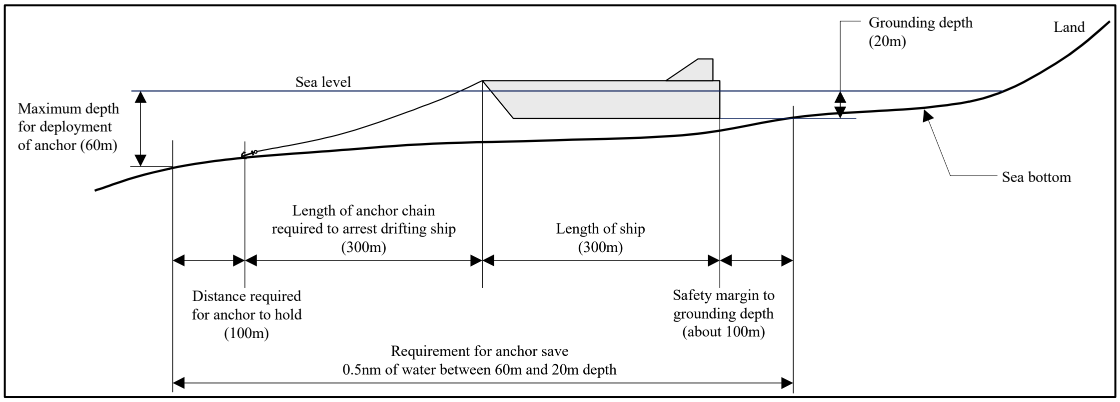


Figure D-12 Graphical representation of the anchor save mechanism

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

D.4.4 The powered allision model

The powered allision frequency model calculates the frequency of serious powered allision accidents in two stages. The model first calculates the frequency of critical situations (sometimes called "dangerous courses" for powered allision 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 an allision 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 allision object is within the lane width distribution. In each case the overlap integral of the lane width distribution aligned with the size of the allision object is calculated.

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

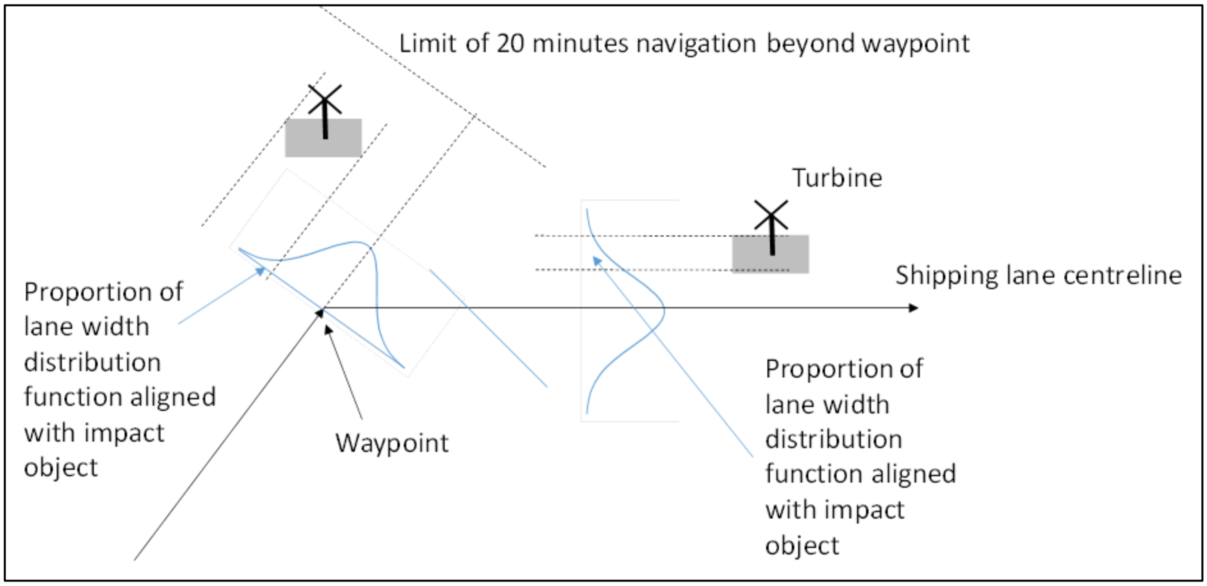


Figure D-13 Graphical representation of powered allision model

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

The drift allision 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 allision 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 (no allision occurs) is determined from the vessel recovery models. The drift allision frequency model is illustrated in Figure D-14.

In order to avoid over prediction of grounding or allision frequencies MARCS needs to know if a LOS[13] exists between the location of a ship and the grounding or allision location. This is achieved by assigning every calculation location one of three types:

- Clear water location. Here ships can always pass through. Groundings or allisions cannot occur in clear water locations.

[13] "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 allide with 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 allide with 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 allision (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."

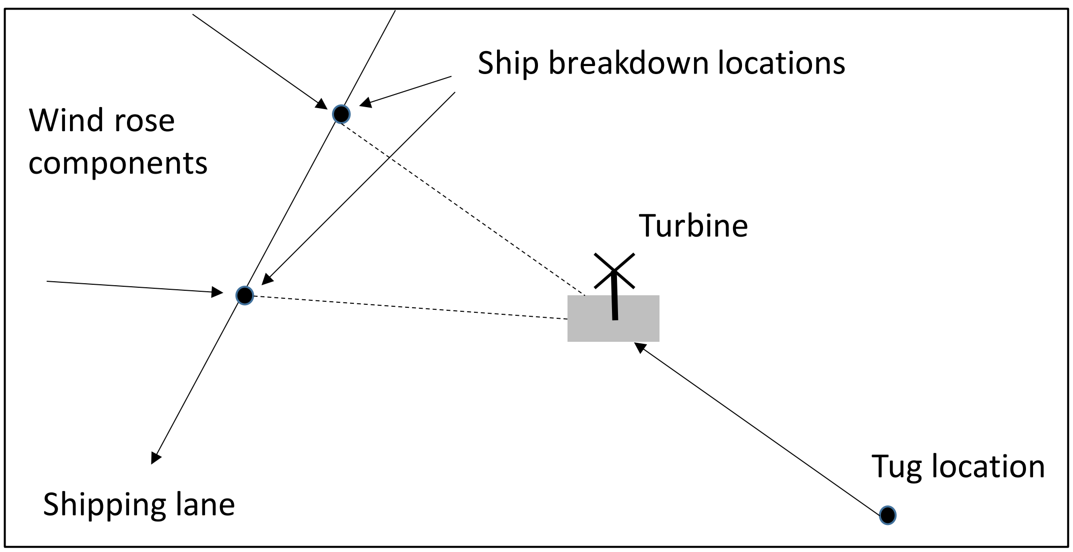


Figure D-14 Graphical representation of the drift allision model

Implicit in Figure D-14 is the importance of the time taken for the ship to drift to the allision 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 alliding (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 Allision 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 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 on model results.

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; and DNV, 1998)

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

D.5.2 Pilotage

The use of pilots has two main benefits:

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

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

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

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

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

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

D.5.3 Aids to navigation

D.5.3.1 Electronic chart display and information system

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

D.5.3.2 Conventional aids to navigation

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

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

Table D-1 Relative risk factors for aids to navigation

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

D.6 Additional background on MARCS

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

D.6.1 Selected wind farm projects

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

2018	Skipjack
2017	South Fork
2015	Baltic Eagle in the Baltic Sea
2013	Iberdrola in the Baltic Sea
2013	Kriegers Flak in the Baltic Sea
2012	Baltic Eagle in the Baltic Sea
2011	Iberdrola in the Baltic Sea
2010	Iberdrola in the Baltic Sea
2010	Arcadis in the Baltic Sea
2009	Arcadis In the Baltic Sea
2009	Aldlergrund in the Baltic Sea
2008	Frederic Haven in the Baltic Sea
2008	Stignaes in the Baltic Sea
2007	Aldlergrund in the Baltic Sea
2006	Arcadis in the Baltic Sea
2006	Roedsand in the Baltic Sea
2005	Horns Rev in the Baltic Sea
2003	Adlergrund and Pommersche Bucht in the Baltic Sea
2003	Arkona in the Baltic Sea

D.6.2 Selected navigation risk projects

North East Shipping Risk Assessment, PP042653, 2012-2013

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

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

Aleutian Islands Marine Risk Assessment, EP007543, 2009-2011

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

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

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

The traffic study was combined with DNV's marine risk model MARCS (Marine Accident Risk Calculation System) to calculate cargo and bunker fuel oil spill risks. ERM's spill trajectory model was then used to assess detailed accident consequences for a small group of agreed spill scenarios. Risk Reduction Options (RROs) were identified and subjected to an assessment of their risk reduction effectiveness, practicality and cost effectiveness by an expert judgement process at a DNV-led 4-day workshop in Anchorage. The outputs from the study were published in a 60-page summary report in August 2011.

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

Prince William Sound Risk Assessment, 1995-1997

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

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

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

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

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

D.6.3 Selected model development projects

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

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

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

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

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

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

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

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

D.6.4 Additional documents in the public domain

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

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

APPENDIX E SUNRISE WIND FARM MARINE ACCIDENT MODELING

E.1 Introduction

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

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

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

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

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

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

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

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 the wind farm, in the absence of any modification to the traffic pattern.
3. The Future Case (or Case 2). This is similar to Case 1 but includes additional traffic caused by the presence of the wind farm and includes modified traffic routes assuming some ship types will navigate around the wind farm once it is installed.

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

E.2 Model inputs

E.2.1 Study area

This is a quantitative assessment of collision, allision, and grounding in the modeled Study Area during operation of the Project. The Study Area utilized in the MARCS modeling of Sunrise Wind Farm (the Project) is shown in Figure E-1. For the purposes of this NSRA, the Marine Traffic Study Area defining the AIS boundaries is identical to the MARCS Study Area defining the area studied in the risk model.

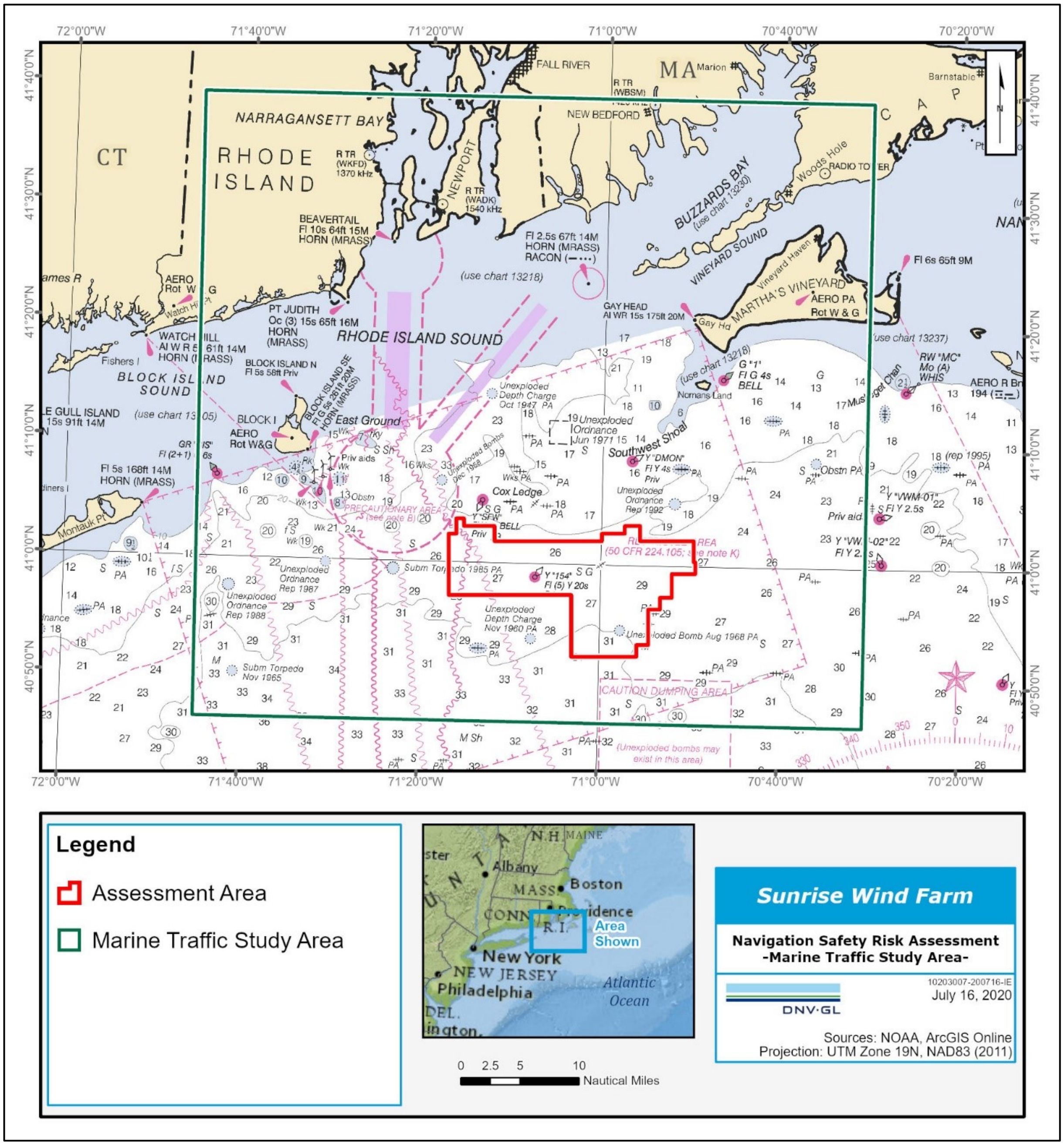


Figure E-1 Risk Study Area Quantified in MARCS

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

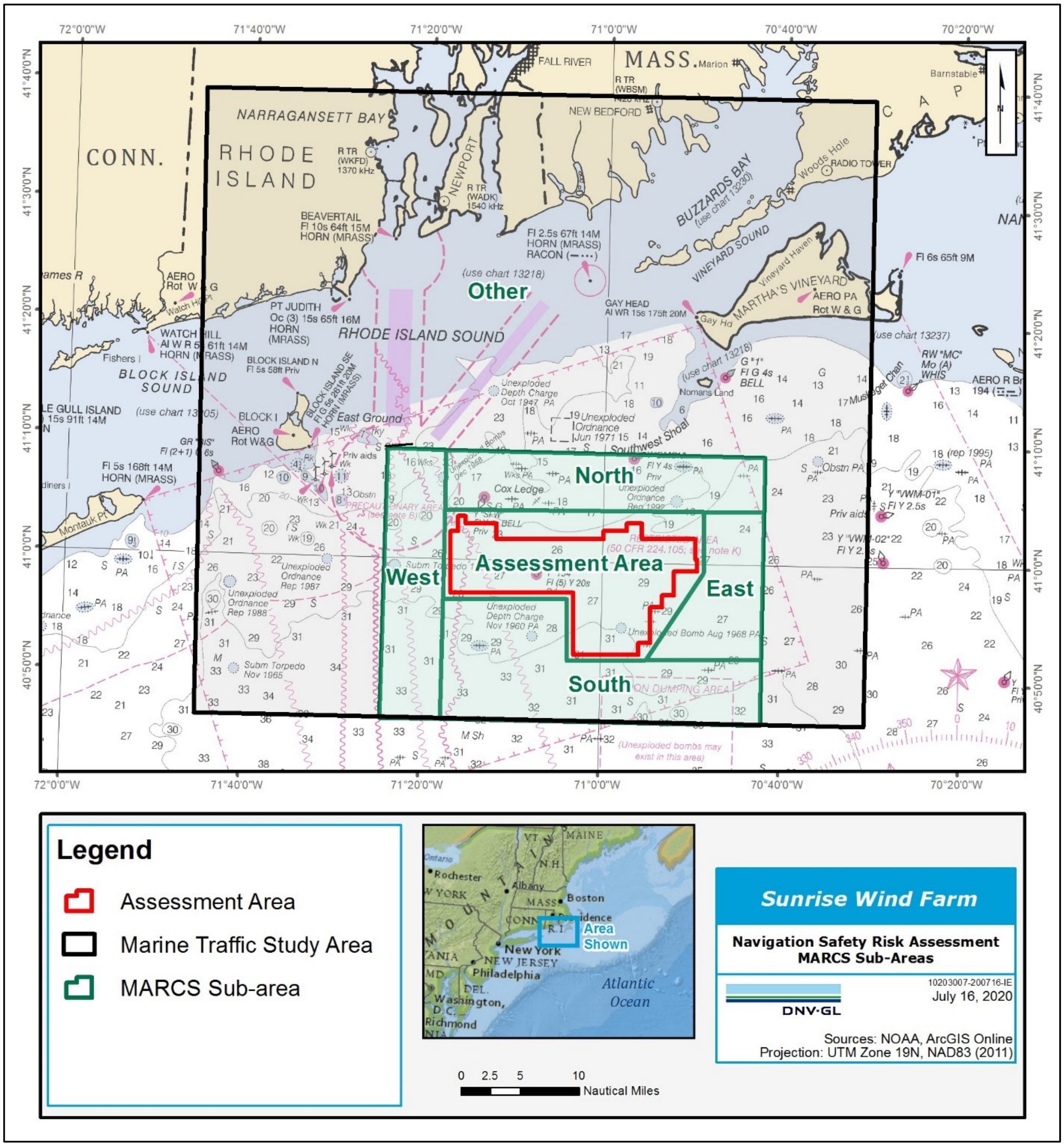


Figure E-2 Definition of Sub Areas within the Marine Traffic Study Area

E.2.2 Wind Farm

The Project is modeled as 123 Project structures, consisting of 120 potential WTG positions, and three potential platform positions (Figure E-1). In practice, Sunrise when built will consist of fewer than 123 structures so this risk assessment model will over-estimate the risks due to Sunrise. The Project structures are separated by a minimum distance of 1.0 nm. The WTGs are modeled as having an effective diameter of 36 m at and near sea level and the platforms as having an effective diameter of 95 m (i.e., the collision cross sections are the footprints of 25 x 25 m and 67 x 67 m circumscribed).

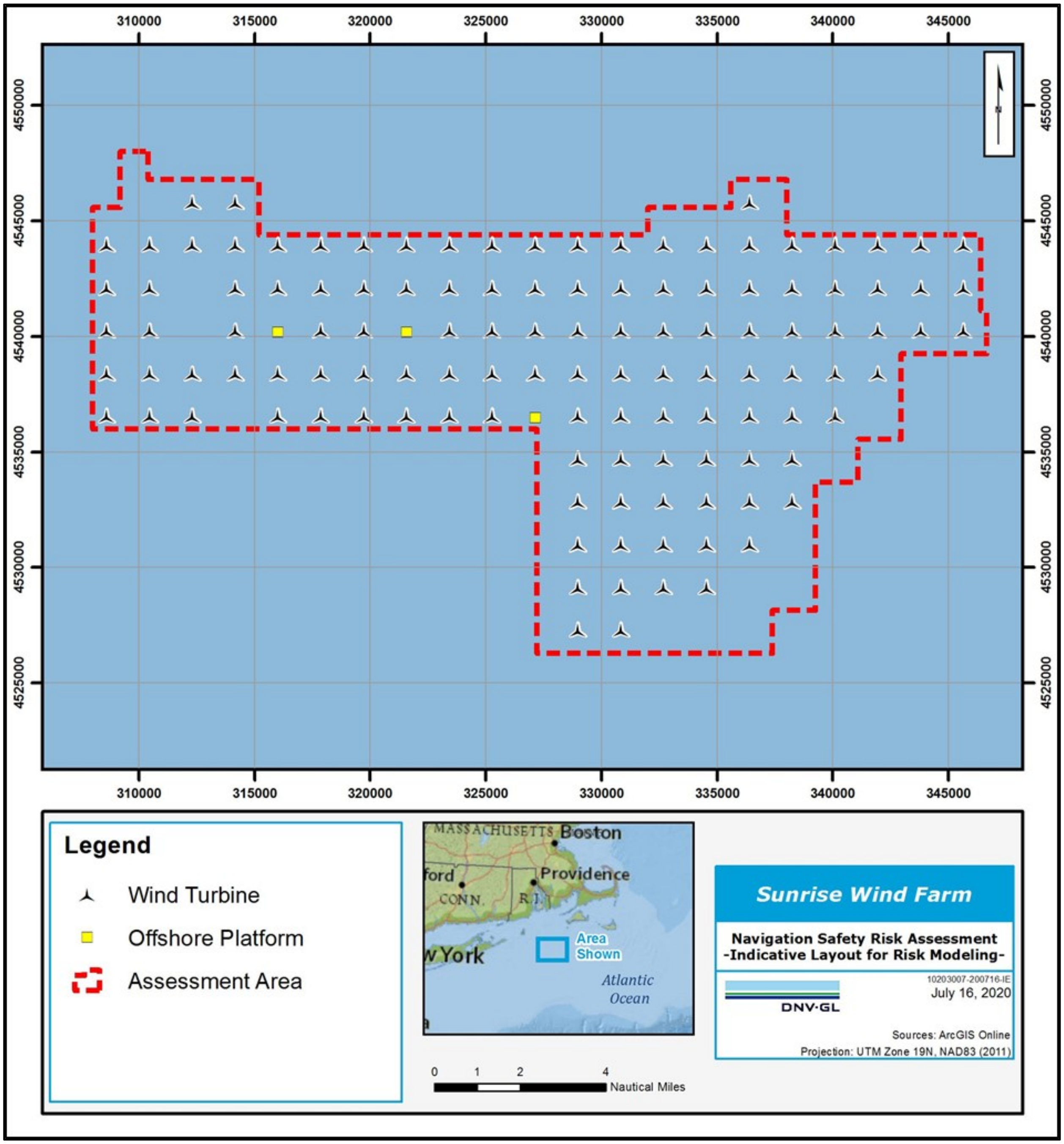


Figure E-3 Indicative Layout used for Risk Modeling

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 Annual wind direction and wind speed probabilities 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 a virtual model of 17.5 years of hourly wind speed and direction data.

Table E-1 Annual wind direction and wind speed probabilities

Wind Speed in kt	N	NE	E	SE	S	SW	W	NW	Total
< 20 (Calm)	0.0742	0.0758	0.0692	0.0635	0.1039	0.2136	0.1164	0.0976	0.8141
20 – 30 (Fresh)	0.0169	0.0193	0.0116	0.0079	0.0107	0.0237	0.0278	0.0455	0.1632
30 – 45 (Gale)	0.0034	0.0045	0.0015	0.0009	0.0005	0.0008	0.0049	0.0059	0.0224
> 45 (Storm)	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
Total	0.0945	0.0997	0.0823	0.0722	0.1151	0.2381	0.1492	0.1490	1.0000

Visibility

The Journal of Navigation's information regarding marine traffic studies (Lewison, 1980) 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 Visibility presents the visibility data used in the MARCS model.

Table E-2 Visibility (NOAA, 2019d)

Visibility in nm	Frequency	Modeled visibility
< 1	5.9%	Bad visibility = 8.6% of an average year
1 – 2*	2.7%	
2 – 3	1.8%	Good visibility = 91.4% of an average year
3 – 4	1.8%	
4 – 5	1.4%	
5 - 6	2.4%	
6 - 7	1.1%	
7 - 8	1.8%	
8-9	1.9%	
9-10	79.2%	
10+	5.9%	
Total	**100.0%**	

* Visibility was not measured at 2.2 nm

Sea state

A designation of "open water" in MARCS allows a higher power transfer from the wind to the waves than "semi-sheltered" or "sheltered" waters leading to higher wave heights (also called higher sea state). This allows for the wind speed in the area to have a greater effect on sea state, with higher winds resulting in rougher seas. The entire Marine Traffic Study Area was modeled as an "open water" area because the Assessment Area is located more than 10 nm from the nearest shoreline at Martha's Vineyard and is directly open to the North Atlantic.

Shoreline

Figure E-4 Shoreline utilized in MARCS illustrates the shoreline used in MARCS. The defined shoreline identifies possible grounding locations for the model.

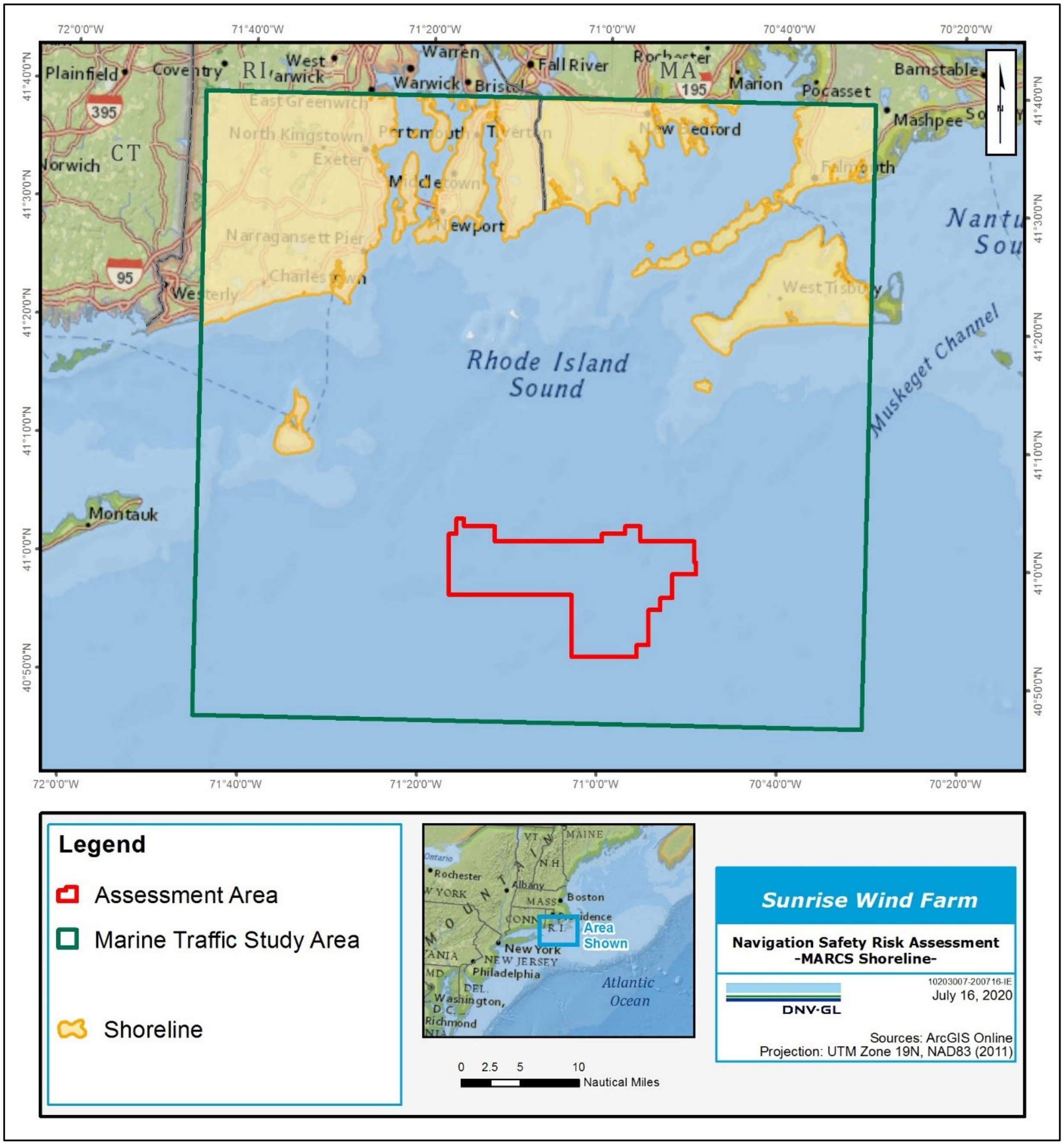


Figure E-4 Shoreline utilized in MARCS

E.2.4 Traffic data

Traffic data was derived by analysis of 3.6 million lines of Automatic Identification System (AIS) data collected between 1 July 2018 and 30 June 2019 within the Study Area. MARCS uses a statistical representation of aggregated ship tracks (Appendix D) and up to 8 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.

Table E-3 Traffic types used for MARCS analysis

Id	Traffic type name	Draft	Speed (kt)
1	Cargo/Carrier	Deep draft	9.5
2	Fishing	Not deep draft	7.5
3	Other/Undefined	Not deep draft	11.3
4	Passenger	Not deep draft	11.7
5	Pleasure	Not deep draft	7.5
6	Tanker	Deep draft	11.0
7	Tanker - Oil Product	Deep draft	10.8
8	Tug/Service	Not deep draft	8.5

The AIS dataset was analyzed in the following stages:

- Dirty or missing data were corrected or removed.
- Each AIS ship type was mapped to the most appropriate ship type category in Table E-3.
- Each AIS ship size was mapped to a MARCS ship size category for that ship type. Where no ship size data were available in the AIS data, the average ship size for that ship type category was assigned.
- Ship position reports were used to derive shipping density plots for each ship type and for all ships.
- A ship route structure was derived from the shipping density plots.
- Ship tracks were derived by linking successive ship position reports separated by a short time interval and a small distance for a specified ship.
- The ship tracks were allocated to the ship routes to derive the annual frequency of movement of each ship type and ship size along each route.

E.2.5 Traffic data adjustments

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

1. The addition of traffic that is not correctly captured in the AIS data.
2. The addition of traffic that is projected to be generated by the presence of the wind farm.
3. The modification of traffic routes for some ship types due to the construction of the wind farm and other windfarm developments in the Rhode Island and Massachusetts lease areas, shown in Figure E-5.

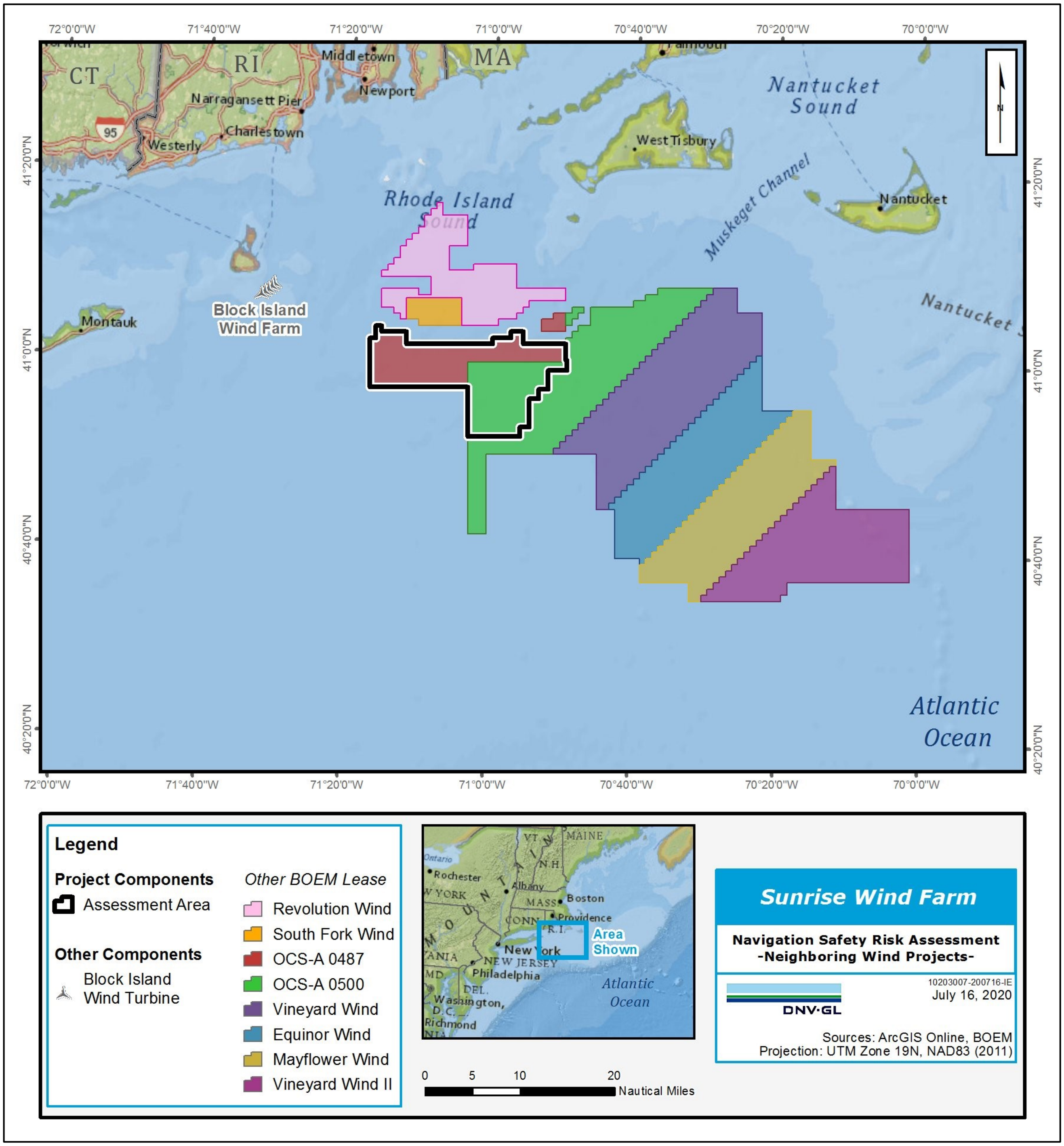


Figure E-5 Operational and proposed neighboring wind energy projects

Each is described below.

Additional Traffic Added to all the cases (Base Case, Base Case Plus and Future Case)

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

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

First, for recreational boating, data were obtained from the Northeast Recreation Boater Activities from the Northeast Ocean Data portal. The activities are from participants in the 2012 Northeast Recreational Boater survey, conducted by SeaPlan (2013), the Northeast Regional Ocean Council (NROC), states' coastal agencies, marine trade association of industry representatives, and the First Coast Guard District. The data are from a randomly selected survey of registered boaters in the 2012 boating season.

The data contain 760 registered activities in the defined Study Area: 386 for fishing activity and 374 for other pleasure activities (such as diving and swimming). Each record was implemented in the model as an outbound and a return transit. This analysis was originally performed for Revolution Wind Farm. Sunrise Wind Farm is located south of Revolution, further away from the safety of the coastline and ports. It was concluded that this recreational and pleasure traffic is unlikely to transit as far South as Sunrise, therefore the routes for Revolution were used for Sunrise without adjustment.

Figure E-6 shows the fishing routes that had additional recreational fishing transits added to them and Figure E-7 shows the route that had additional recreational pleasure boating transits added to it.

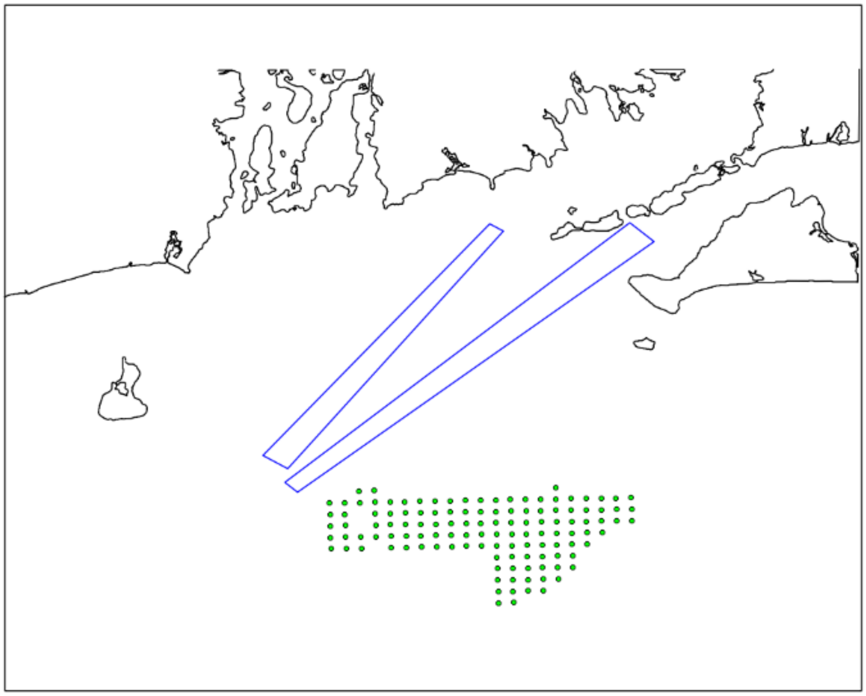


Figure E-6 Recreational boater routes that had additional transits added to them

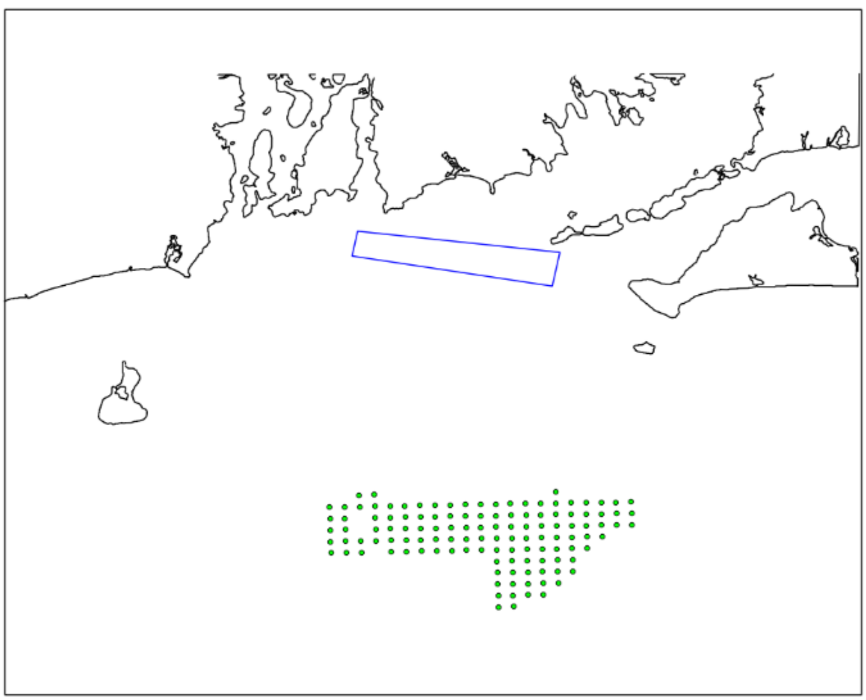


Figure E-7 Pleasure vessels' route that had additional transits added to it

Second, for commercial fishing, an analysis of fishing ship lengths for commercial fishing vessels registered in Rhode Island and Connecticut was performed. This showed that 17.5% of the registered commercial fishing vessels have lengths greater than 65 ft and hence are required to use AIS.

Key assumptions are:

- All of the commercial fishing vessels with lengths of at least 65 ft are represented in the AIS dataset on departure from or approach to port, and fishing vessels under 65 ft are assumed to not be represented in the data at all. According to vessel registration records (NOAA, 2020), 17.5% of all registered vessels are at least 65 ft in length and must use AIS. This study assumes that AIS data represent only 17.5% of the commercial vessel traffic at port entries/exits. The number of transits is scaled up appropriately.
- Regardless of vessel size, the number of transits per vessel is assumed to be the same. The number of transits per year taken by an average fishing vessel longer than 65 ft is the same as the number of transits per year taken by an average fishing vessel shorter than 65 ft.
- Regardless of vessel size, the routes taken are assumed to be the same. The port of departure and fishing grounds of an average fishing vessel longer than 65 ft is the same as the port of departure and fishing grounds of an average fishing vessel shorter than 65 ft.

The number of additional commercial fishing vessel trips for vessels shorter than 65 ft was estimated as:

$$\textit{Number of trips} = N / 0.175$$

where:

N is 3,432, the number of trips for fishing vessels longer than 65 ft obtained from the AIS data

The resulting 19,611 additional commercial fishing vessel trips (19611 inbound and 19611 outbound per year) were allocated to new routes.

As for the recreational fishing and pleasure ships, this analysis was originally performed for Revolution Wind Farm and non-AIS commercial fishing vessel transits were assumed to transit to or through Revolution. However, commercial fishing vessels are more likely to transit south of Revolution. Thus, for this NSRA, it is assumed that all non-AIS commercial fishing vessels transit to or through the Project as shown in Figure E-8. This is a conservative assumption that tends to over-estimate the calculated risks.

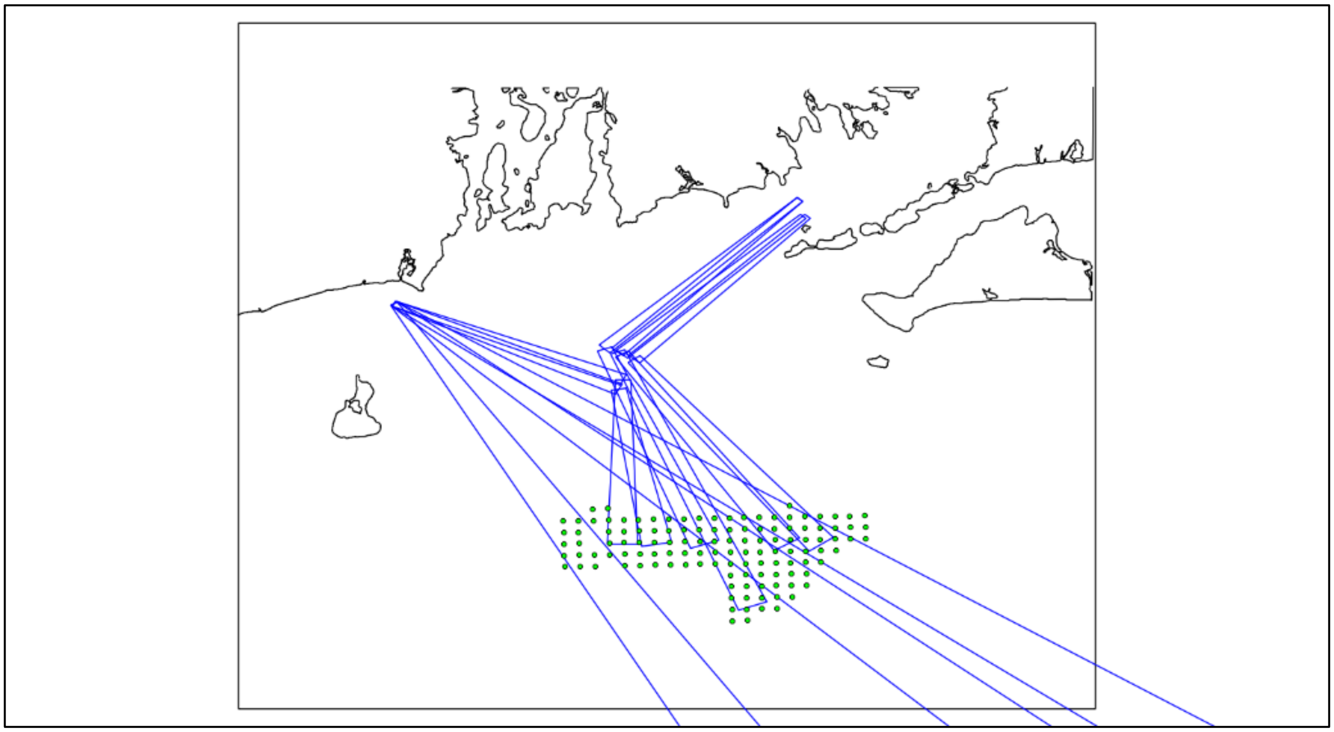


Figure E-8 New fishing vessel route centerlines that had transits added to them

<u>Additional Traffic Added to the Future Case</u>

The adjustments described in this section are to the Future Case (Case 2) MARCS model, with the Project.

It is anticipated that there will be public interest in the Project that could potentially lead to pleasure tours of the wind farm and a potential increase of recreational traffic (including recreational fishing). It is difficult to estimate a precise number of vessels per year that will be added to local traffic patterns. To incorporate the potential tours, excursion and recreational (including recreational fishing) traffic surrounding the Project, it is assumed that there will be 100 transits per year inbound and outbound. This is a conservatively high estimate for the first operational year of the Project. It is anticipated that as time passes, there will be less traffic due to wind farm tours and the increase in vessels may diminish. This study aims to present the conservative case with the most possible traffic, as opposed to an average traffic scheme over a longer period.

As above, this analysis was originally performed for Revolution windfarm. For Sunrise it is assumed that this additional traffic in the Future Case is included in the Pleasure vessel category and is allocated a new route from Narragansett to the wind farm, as shown in Figure E-9.

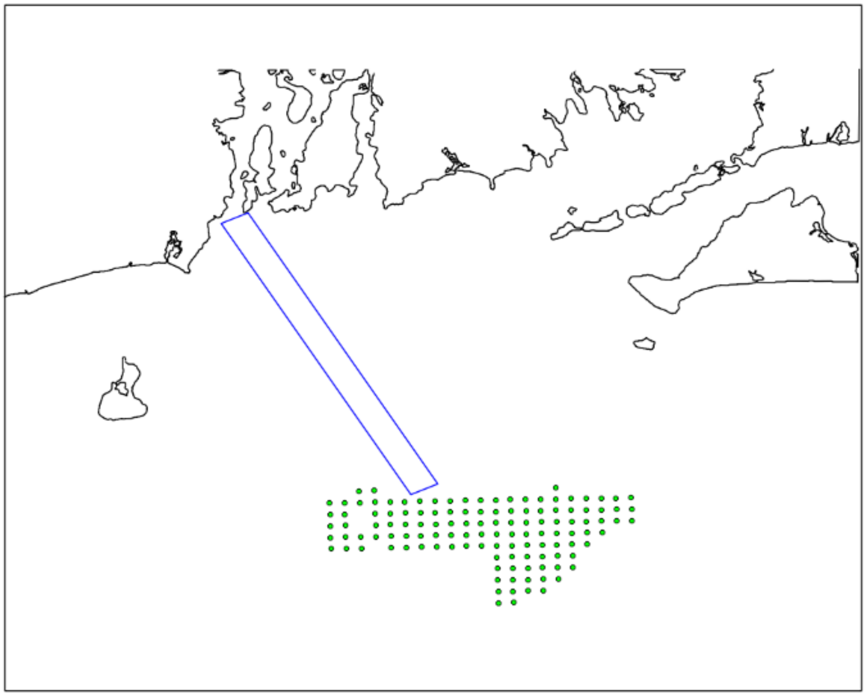


Figure E-9 New Pleasure vessel transit route added to the Future Case

Two additional increases in traffic not related to the Project were identified. The draft MARI PARS report (Coast Guard, 2020a) reviewed the characteristics of potential future traffic 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 MARI PARS report comprised:

- Six to eight new LPG transits to and from Providence. This study assumes that and additional eight LPG vessels per year enter the AIS Marine Traffic Study Area from the Nantucket-to-Ambrose Safety Fairway, take the Narragansett TSS to the Port of Providence and the reverse route on departure from the port.
- An additional 50 cruise ship visits to Newport, approximately doubling its current cruise traffic. The cruise ships in the AIS data enter the Marine Traffic Study Area from both the southwest and the southeast and take the Narragansett TSS on approach to Newport. This study assumes the southeastern route will be modified to a more north-south direction after construction of the Project, as deep draft vessels will modify their routes to navigate safely around the wind farms. The additional 100 transits are assumed to be divided equally between the two approach routes. This study assumes a reverse route is taken on departure from the port.

Modification of Traffic Routes in the Future Case

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

Figure E-10 shows an example of how this modification was performed for 1 of the 5 routes that needed modification.

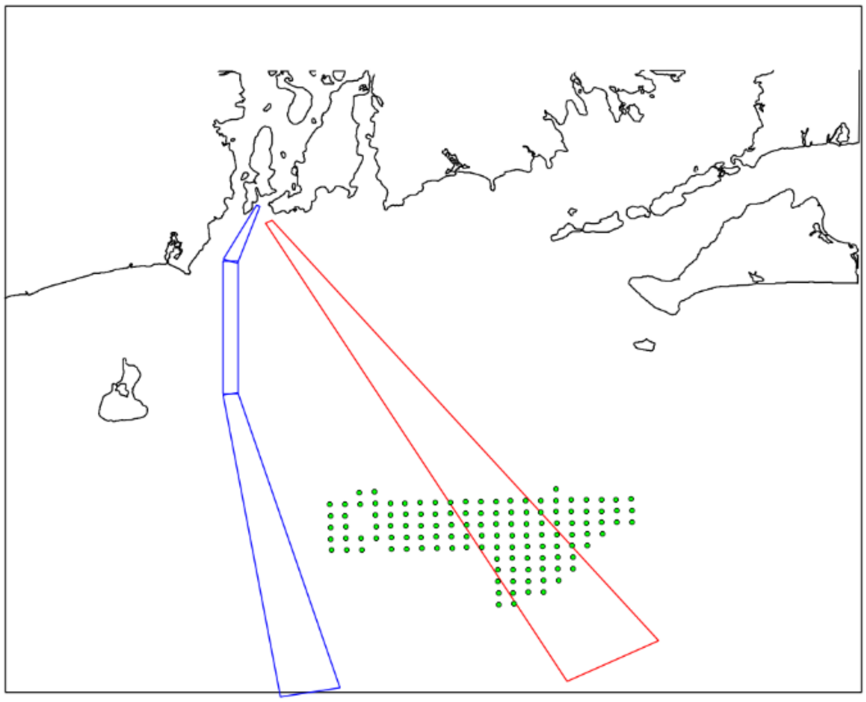


Figure E-10 Example of how one route was modified (red route was deleted, blue route was added)

Deep draft ships (Cargo, Tanker and Tanker Oil Products) as well as Tug/Service vessels that were on routes through the wind farm were re-allocated to these modified routes outside of the wind farm for the Future Case. Other traffic types (Fishing, Other, Passenger and Pleasure) continue to navigate through the wind farm in the Future Case.

E.2.6 Operational inputs

The MARCS model can apply different risk reduction options to specifics type of traffic and/or to specified areas, see Figure E-11. The risk controls applied to vessels transiting are described in Table E-4. This table show which risk controls are applied based on vessel types and areas.

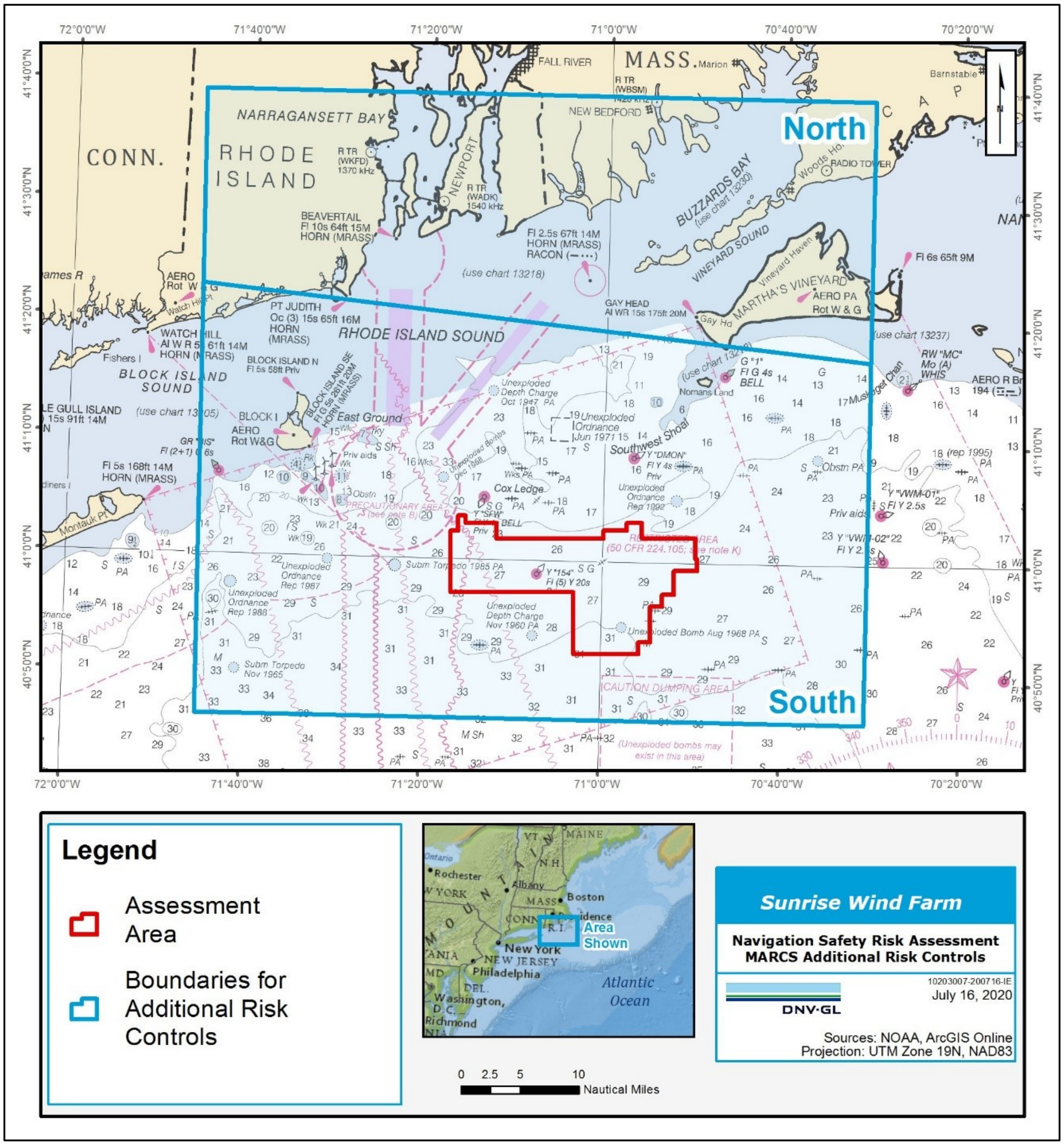


Figure E-11 Boundaries for model-specific risk controls

Table E-4 Risk controls applied in MARCS modeling

Risk control	Vessel type		
	Deep draft vessels		All other vessels
	Study Area North	Study Area South	Study Area North and South
Vessel traffic services	Yes	No	No (Note: some tugs yes dep. on cargo in Zone A)
Pilotage	Yes	No	No (Note: depends on vessel, some tugs yes)
Portable pilotage unit	Yes	No	No (Note: depends on vessel, some tugs yes)
Differential global positioning systems	Yes	Yes	Yes
Conventional aids to navigation	Yes	Yes	Yes
Electronic chart display and information system	Yes	Yes	Yes
Underkeel clearance management	N/A (only applied in Providence River)	N/A	N/A

When a risk control is not applied to all ships of a specified type in an area then it is applied to none of the ships of that ship type in that area. This is a conservative assumption that tends to over-estimate the calculated risks.

In addition, Port State Control is applied to all deep draft ships as defined in Table E-3 Traffic types used for MARCS analysis and the National Oceanic and Atmospheric Administration PORTS® (Physical Oceanographic Real-Time System) System is applied to deep draft ships in Study Area North. The NOAA PORTS system provides real-time data to enhance safe navigation to and from the major ports in the Study Area. It provides many of the same capabilities as a Portable Pilotage Unit; however, its risks and benefits have not been quantified. As a result, PORTS is not included as a quantified risk reduction measure in the risk modeling conducted for the Project. This is a conservative assumption that tends to over-estimate the calculated risks.

Pilotage requirements are defined in Rhode Island Code § 46-9-2 and § 46-9.1-5. DNV GL applied pilotage requirements to vessels in the method most appropriate for modeling purposes: to deep draft and passenger vessels in Rhode Island Sound and Block Island Sound.

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 Marine Traffic Study Area. The results from the Base Case consist of collision, powered grounding and drift grounding accident frequencies alone since this case is an estimate of the risk levels today prior to the construction of the wind farm.
- A Base Case Plus (Case 1) was modeled for the current conditions in the Study Area plus the proposed wind farm. This provides a hypothetical estimate of the risk after construction of the wind

farm but without any modifications to the traffic pattern. The Base Case Plus estimates the frequency of a collision, grounding, and allision with Project structures.

- A Future Case with the Project (Case 2). This estimates the anticipated future conditions of the Study Area. The Future Case incorporates the Project structures, traffic redistribution due to the Project, and any anticipated increases in traffic due to the Project. The Future Case estimates the frequency of a collision, grounding, and allision with Project structures.

Table E-5 summarizes these cases.

Table E-5 Summary of modeled cases

Case	Considerations
Base Case (Case 0)	- AIS data - Traffic adjustments to fishing and pleasure vessels not in the AIS data
Base Case Plus (Case 1)	- AIS data - Traffic adjustments to fishing and pleasure vessels not in the AIS data - Implementation of the Project structures
Future Case with the Project (Case 2)	- AIS data - Traffic adjustments to fishing and pleasure vessels not in the AIS data - Traffic adjustments to tour passenger vessel traffic - Re-distribution of traffic lanes for ship types Cargo, Tankers, Tanker - Oil Product, and Tugs - Implementation of Project structures

Cases 0, 1, and 2 are modeled in MARCS. The MARCS model is detailed further in Appendix D to this NSRA.

All results are reported for the Assessment Area, the adjacent sub-areas, and the sum across them. The residual area comprises the remainder of the Marine Traffic Study Area. The results for the residual area:

- Grounding risk exists only in the residual area, but the frequency of groundings is not significantly affected by the Project
- Collision risk in the residual area is not significantly affected by the Project (a frequency increase <0.001 per year)

E.3.1 Base Case (Case 0)

The Base Case results define the baseline average annual frequencies of marine accidents. The Base Case utilized AIS data from 1 July 2018 through 30 June 2019 plus additional transits for recreational boating and commercial fishing vessels described 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 Study Area. Cells in grey denote frequencies less than 1 in 10,000 per year. Note these frequencies represent all accidents irrespective of whether the accident has significant consequences.

Table E-6 Accident frequencies (per year) for Base Case (Case 0) in the Study Area without the Wind Farm[14]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.0050	0.0723	0.0274	0	0	0.1047
Fishing	1.1380	1.7070	2.2610	0	0	5.1060
Other/Undefined	0.0451	0.9382	0.3146	0	0	1.2979
Passenger	0.0609	0.8868	0.2837	0	0	1.2314
Pleasure	0.0876	1.696	0.9664	0	0	2.7500
Tanker	0.0004	0.0052	0.0042	0	0	0.0098
Tanker - Oil Product	0.0019	0.0206	0.0137	0	0	0.0362
Tug/Service	0.0797	0.8358	0.7485	0	0	1.6640
Total	1.4186	6.1619	4.6195	0	0	12.2000

The modeled Base Case accident frequency today without the wind farm is estimated to be 12.20 per year, primarily involving commercial fishing vessels. There is zero frequency of allision with Project structures in the Study Area because there are no Project structures in the Base Case.

Table E-7 shows the accident return periods in years for each ship type modeled.

Table E-7 Accident return periods (in years) in the Study Area (on average, 1 accident expected every return period)

Base Case	Base Case Marine Accident Return Period
Cargo/Carrier	9.6
Fishing	0.2
Other/Undefined	0.8
Passenger	0.8
Pleasure	0.4
Tanker	102.0
Tanker - Oil Product	27.6
Tug/Service	0.6

[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-8 through Table E-13 show the accident frequencies for Case 0 in the Assessment Area and each of the sub-areas around the Project (Figure E-2).

Table E-8 Accident frequencies (per year) for Case 0 in Sub-Area "Assessment Area"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0002	0	0	0	0	0.0002
Fishing	0.0953	0	0	0	0	0.0953
Other/Undefined	0.0006	0	0	0	0	0.0006
Passenger	0	0	0	0	0	0
Pleasure	0.0002	0	0	0	0	0.0002
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0.0001	0	0	0	0	0.0001
Tug/Service	0.0001	0	0	0	0	0.0001
Total	0.0965	0	0	0	0	0.0965

Note these frequencies are for all accidents irrespective of whether the accident has significant consequences.

Table E-9 Accident frequencies (per year) for Case 0 in Sub-Area "South"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0001	0	0	0	0	0.0001
Fishing	0.0067	0	0	0	0	0.0067
Other/Undefined	0	0	0	0	0	0
Passenger	0	0	0	0	0	0
Pleasure	0	0	0	0	0	0
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0	0	0	0	0	0
Tug/Service	0	0	0	0	0	0
Total	0.0068	0	0	0	0	0.0068

Table E-10 Accident frequencies (per year) for Case 0 for Sub-Area "West"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0004	0	0	0	0	0.0004
Fishing	0.0067	0	0	0	0	0.0067
Other/Undefined	0.0001	0	0	0	0	0.0001
Passenger	0	0	0	0	0	0
Pleasure	0.0001	0	0	0	0	0.0001
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0.0001	0	0	0	0	0.0001
Tug/Service	0.0003	0	0	0	0	0.0003
Total	0.0077	0	0	0	0	0.0077

Table E-11 Accident frequencies (per year) for Case 0 for Sub-Area "East"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0.0045	0	0	0	0	0.0045
Other/Undefined	0.0001	0	0	0	0	0.0001
Passenger	0	0	0	0	0	0
Pleasure	0	0	0	0	0	0
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0	0	0	0	0	0
Tug/Service	0	0	0	0	0	0
Total	0.0046	0	0	0	0	0.0046

Table E-12 Accident frequencies (per year) for Case 0 for Sub-Area "North"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0001	0	0	0	0	0.0001
Fishing	0.1300	0	0	0	0	0.1300
Other/Undefined	0.0004	0	0	0	0	0.0004
Passenger	0	0	0	0	0	0
Pleasure	0.0004	0	0	0	0	0.0004
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0	0	0	0	0	0
Tug/Service	0.0001	0	0	0	0	0.0001
Total	0.1310	0	0	0	0	0.1310

Table E-13 Accident frequencies (per year) for Case 0 for Sub-Area "Other"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0042	0.0723	0.0274	0	0	0.1039
Fishing	0.8948	1.7070	2.2610	0	0	4.8628
Other/Undefined	0.0439	0.9382	0.3146	0	0	1.2967
Passenger	0.0609	0.8868	0.2837	0	0	1.2314
Pleasure	0.0869	1.696	0.9664	0	0	2.7493
Tanker	0.0004	0.0052	0.0042	0	0	0.0098
Tanker - Oil Product	0.0017	0.0206	0.0137	0	0	0.0360
Tug/Service	0.0792	0.8358	0.7485	0	0	1.6635
Total	1.172	6.1619	4.6195	0	0	11.9534

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

The Case 1 results show the average annual frequencies of marine accidents using unmodified Base Case traffic data plus including the Project structures. This case is used to verify the modeling. Table E-14 shows the model results for the Study Area.

Table E-14 Accident frequencies (per year) for Case 1

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.0050	0.0723	0.0274	0.0060	0.0148	0.1255
Fishing	1.1380	1.7070	2.2610	0.7740	0.7360	6.6160
Other/Undefined	0.0451	0.9382	0.3146	0.0111	0.0128	1.3218
Passenger	0.0609	0.8868	0.2837	0.0024	0.0041	1.2379
Pleasure	0.0876	1.6960	0.9664	0.0030	0.0056	2.7586
Tanker	0.0004	0.0052	0.0042	0.0002	0.0005	0.0105
Tanker - Oil Product	0.0019	0.0206	0.0137	0.0029	0.0054	0.0445
Tug/Service	0.0797	0.8358	0.7485	0.0016	0.0066	1.6722
Total	1.4186	6.1619	4.6195	0.8012	0.7858	13.7870

Table E-14 to Table E-19 show the model 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-15 Accident frequencies (per year) for Case 1 in Sub-Area "Assessment Area"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0002	0	0	0.0060	0.0148	0.0210
Fishing	0.0953	0	0	0.7741	0.7359	1.6053
Other/Undefined	0.0006	0	0	0.0111	0.0128	0.0245
Passenger	0	0	0	0.0024	0.0041	0.0065
Pleasure	0.0002	0	0	0.0030	0.0056	0.0088
Tanker	0	0	0	0.0002	0.0005	0.0007
Tanker - Oil Product	0.0001	0	0	0.0029	0.0054	0.0084
Tug/Service	0.0001	0	0	0.0016	0.0066	0.0083
Total	0.0965	0	0	0.8013	0.7857	1.6835

Table E-16 Accident frequencies (per year) for Case 1 in Sub-Area "South"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0001	0	0	0	0	0.0001
Fishing	0.0067	0	0	0	0	0.0067
Other/Undefined	0	0	0	0	0	0
Passenger	0	0	0	0	0	0
Pleasure	0	0	0	0	0	0
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0	0	0	0	0	0
Tug/Service	0	0	0	0	0	0
Total	0.0068	0	0	0	0	0.0068

Table E-17 Accident frequencies (per year) for Case 1 for Sub-Area "West"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0004	0	0	0	0	0.0004
Fishing	0.0067	0	0	0	0	0.0067
Other/Undefined	0.0001	0	0	0	0	0.0001
Passenger	0	0	0	0	0	0
Pleasure	0.0001	0	0	0	0	0.0001
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0.0001	0	0	0	0	0.0001
Tug/Service	0.0003	0	0	0	0	0.0003
Total	0.0077	0	0	0	0	0.0077

Table E-18 Accident frequencies (per year) for Case 1 for Sub-Area "East"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0.0045	0	0	0	0	0.0045
Other/Undefined	0.0001	0	0	0	0	0.0001
Passenger	0	0	0	0	0	0
Pleasure	0	0	0	0	0	0
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0	0	0	0	0	0
Tug/Service	0	0	0	0	0	0
Total	0.0046	0	0	0	0	0.0046

Table E-19 Accident frequencies (per year) for Case 1 for Sub-Area "North"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0001	0	0	0	0	0.0001
Fishing	0.1300	0	0	0	0	0.1300
Other/Undefined	0.0004	0	0	0	0	0.0004
Passenger	0	0	0	0	0	0
Pleasure	0.0004	0	0	0	0	0.0004
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0	0	0	0	0	0
Tug/Service	0.0001	0	0	0	0	0.0001
Total	0.1310	0	0	0	0	0.1310

Table E-20 Accident frequencies (per year) for Case 1 for Sub-Area "Other"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0042	0.0723	0.0274	0	0	0.1039
Fishing	0.8948	1.7070	2.2610	0	0	4.8628
Other/Undefined	0.0439	0.9382	0.3146	0	0	1.2967
Passenger	0.0609	0.8868	0.2837	0	0	1.2314
Pleasure	0.0869	1.6960	0.9664	0	0	2.7493
Tanker	0.0004	0.0052	0.0042	0	0	0.0098
Tanker - Oil Product	0.0017	0.0206	0.0137	0	0	0.0360
Tug/Service	0.0792	0.8358	0.7485	0	0	1.6635
Total	1.1720	6.1619	4.6195	0	0	11.9534

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

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

Table E-21 presents the Future Case accident frequencies for each ship type and for each accident type in the Study Area.

Table E-21 Accident frequencies (per year) for Future Case (Case 2) with the Wind Farm[15]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.0052	0.0733	0.0296	0.0003	0.0060	0.1144
Fishing	1.1400	1.7070	2.2610	0.7740	0.7360	6.6180
Other/Undefined	0.0451	0.9382	0.3146	0.0111	0.0128	1.3218
Passenger	0.0617	0.8938	0.2871	0.0025	0.0073	1.2524
Pleasure	0.0903	1.7100	0.9742	0.0037	0.0067	2.7849
Tanker	0.0005	0.0058	0.0048	0	0.0006	0.0117
Tanker - Oil Product	0.0020	0.0209	0.0146	0.0001	0.0015	0.0391
Tug/Service	0.0799	0.8319	0.7484	0.0001	0.0053	1.6656
Total	1.4247	6.1809	4.6343	0.7918	0.7762	13.8079

The modeled Future Case accident frequency today with the wind farm is estimated to be 13.8 per year. Accidents involving commercial fishing vessels are the dominant accident frequency contributor.

Table E-22 to Table E-24 show the model results for each sub-area.

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

Table E-22 Accident frequencies (per year) for Case 2 in Sub-Area "Assessment Area"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0.0003	0.0060	0.0063
Fishing	0.0951	0	0	0.7741	0.7359	1.6051
Other/Undefined	0.0006	0	0	0.0111	0.0128	0.0245
Passenger	0	0	0	0.0025	0.0073	0.0098
Pleasure	0.0004	0	0	0.0037	0.0067	0.0108
Tanker	0	0	0	0	0.0006	0.0006
Tanker - Oil Product	0	0	0	0.0001	0.0015	0.0016
Tug/Service	0	0	0	0.0001	0.0053	0.0054
Total	0.0961	0	0	0.7919	0.7761	1.6641

[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-23 Accident frequencies (per year) for Case 2 in Sub-Area "South"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0.0066	0	0	0	0	0.0066
Other/Undefined	0	0	0	0	0	0
Passenger	0	0	0	0	0	0
Pleasure	0	0	0	0	0	0
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0	0	0	0	0	0
Tug/Service	0	0	0	0	0	0
Total	0.0066	0	0	0	0	0.0066

Table E-24 Accident frequencies (per year) for Case 2 in Sub-Area "West"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0003	0	0	0	0	0.0003
Fishing	0.0067	0	0	0	0	0.0067
Other/Undefined	0.0001	0	0	0	0	0.0001
Passenger	0.0001	0	0	0	0	0.0001
Pleasure	0.0001	0	0	0	0	0.0001
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0.0001	0	0	0	0	0.0001
Tug/Service	0.0003	0	0	0	0	0.0003
Total	0.0077	0	0	0	0	0.0077

Table E-25 Accident frequencies (per year) for Case 2 in Sub-Area "East"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0.0045	0	0	0	0	0.0045
Other/Undefined	0.0001	0	0	0	0	0.0001
Passenger	0	0	0	0	0	0
Pleasure	0	0	0	0	0	0
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0	0	0	0	0	0
Tug/Service	0	0	0	0	0	0
Total	0.0046	0	0	0	0	0.0046

Table E-26 Accident frequencies (per year) for Case 2 in Sub-Area "North"

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0.1306	0	0	0	0	0.1306
Other/Undefined	0.0004	0	0	0	0	0.0004
Passenger	0	0	0	0	0	0
Pleasure	0.0012	0	0	0	0	0.0012
Tanker	0	0	0	0	0	0
Tanker - Oil Product	0	0	0	0	0	0
Tug/Service	0	0	0	0	0	0
Total	0.1322	0	0	0	0	0.1322

Table E-27 Accident frequencies (per year) for Case 2 in Sub-Area "Other"

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.0049	0.0733	0.0296	0	0	0.1078
Fishing	0.8965	1.7069	2.2609	0	0	4.8645
Other/Undefined	0.0439	0.9382	0.3146	0	0	1.2967
Passenger	0.0616	0.8938	0.2871	0	0	1.2425
Pleasure	0.0886	1.7100	0.9742	0	0	2.7728
Tanker	0.0005	0.0058	0.0048	0	0	0.0111
Tanker - Oil Product	0.0019	0.0209	0.0146	0	0	0.0374
Tug/Service	0.0796	0.8319	0.7484	0	0	1.6599
Total	1.1775	6.1809	4.6343	0	0	11.9927

E.4 Model verification

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

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

The difference between Case 2 and Case 1 provides an estimate of how risk is mitigated when some traffic types are re-routed around the wind farm footprint.

E.4.1 Comparing Case 1 to Case 0

The Base Case (Case 0) is without the Project structures and without modification of the traffic data. The Base Case Plus (Case 1) is the same as the Base Case but includes the Project structures. Comparing the two cases shows that the total accident frequency increases by 1.6 accidents per year when the Project structures are present and without modification of the traffic data to account for anticipated changes in traffic patterns. It also shows that the collision, powered grounding and drift grounding accident frequencies are 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 0.801 and 0.786 for powered and drift allision respectively. The sum of the allision frequencies represent the difference in the total accident frequency between Case 1 and Case 0. Approximately 51% of the total allision frequency is due to powered allision.

Other comparisons that were made to assure model quality were miles travelled per vessel type and ratio of accident frequencies per vessel type and per accident type.

E.4.2 Comparing Case 2 to Case 1

The Future Case (Case 2) includes the Project structures and the modified traffic data (additional traffic and modified routes). The Base Case Plus (Case 1) is the same as the Future Case but without the modifications to the traffic data.

The accident frequencies are mostly either identical or very similar for the Future Case (Case 2) compared to the Base Case Plus (Case 1). The main differences expected for the Future Case (Case 2) are:

- Powered allision is reduced for Cargo, Tanker – Oil and Tugs. This is because these ship types are re-routed around the wind farm in the Future Case. (Tankers are also re-routed around the wind farm but there is no significant Tanker traffic through the wind farm area in the Base Case (and Base Case Plus)).
- Powered allision for Pleasure ships is increased. This is because of the additional pleasure tour ships included in the Future Case (Case 2).

E.5 Results and discussion

E.5.1 Project risk difference: comparing Case 2 to Case 0

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

Table E-28 shows the predicted effect of the Project on accident frequency, that is, the difference between Case 2 and Case 0 for the Study Area. Differences in frequency less than 0.001 per year are highlighted in grey.

The difference between the two cases for the Assessment Area and adjacent sub-areas shows that the total accident frequency increases 1.61 accidents per year. This is because Case 2 includes the Project WTGs and introduces extra wind farm pleasure tour transits which are not included in Case 0.

Non-allision accident frequencies in the Future Case (Case 2) after the installation of the Project structures are very similar to those in the Base Case (Case 0).

Differences less than 0.001/year are highlighted in grey.

Table E-28 Risk Difference: Future Case (Case 2) minus Base Case (Case 0) (annual accident frequency)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0002	0.0010	0.0022	0.0003	0.0060	0.0097
Fishing	0.0020	0.0000	0.0000	0.7740	0.7360	1.5120
Other & Undefined	0.0000	0.0000	0.0000	0.0111	0.0128	0.0239
Passenger	0.0008	0.0070	0.0034	0.0025	0.0073	0.0210
Pleasure	0.0027	0.0140	0.0078	0.0037	0.0067	0.0349
Tanker	0.0001	0.0006	0.0006	0.0000	0.0006	0.0019
Tanker – Oil	0.0001	0.0003	0.0009	0.0001	0.0015	0.0029
Tug & Service	0.0002	-0.0039	-0.0001	0.0001	0.0053	0.0016
Total	0.0061	0.0190	0.0148	0.7918	0.7762	1.6079

E.5.2 Discussion of the sub-area results

The sub-area accident frequency differences between Case 0 and Case 2 are discussed below. These are conservative estimates of the risk increase from the Project.

In general, the accident frequencies observed reflect the amount of shipping traffic of each ship type in each sub-area.

Table E-29 shows the modeled difference in risk from the Project in the sub-area "Assessment Area". The Assessment Area contains all the Project structures and hence it contains all the powered allision and all the drift allision accidents. There is zero frequency of powered grounding and drift grounding in this and all sub-areas because the sub-areas contain no land.

Differences less than 0.001/year are highlighted in grey.

Table E-29 Risk difference: Assessment Area (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	-0.0002	0.0000	0.0000	0.0003	0.0060	0.0061
Fishing	-0.0002	0.0000	0.0000	0.7741	0.7359	1.5098
Other & Undefined	0.0000	0.0000	0.0000	0.0111	0.0128	0.0239
Passenger	0.0000	0.0000	0.0000	0.0025	0.0073	0.0098
Pleasure	0.0002	0.0000	0.0000	0.0037	0.0067	0.0106
Tanker	0.0000	0.0000	0.0000	0.0000	0.0006	0.0006
Tanker – Oil	-0.0001	0.0000	0.0000	0.0001	0.0015	0.0015
Tug & Service	-0.0001	0.0000	0.0000	0.0001	0.0053	0.0053
Total	-0.0004	0.0000	0.0000	0.7919	0.7761	1.5676

Table E-30 shows the modeled difference in accident frequency from the Project in the South sub-area. There is zero frequency of grounding or allision with Project structures in this sub-area because it contains no land and there are no Project structures.

Differences less than 0.001/year are highlighted in grey.

Table E-30 Risk difference: South (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	-0.0001	0.0000	0.0000	0.0000	0.0000	-0.0001
Fishing	-0.0001	0.0000	0.0000	0.0000	0.0000	-0.0001
Other & Undefined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tanker	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tanker – Oil	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug & Service	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	-0.0002	0.0000	0.0000	0.0000	0.0000	-0.0002

Table E-31 shows the modeled difference in accident frequency from the Project in the West sub-area. There is zero frequency of grounding or allision with Project structures in this sub-area because it contains no land and there are no Project structures.

Table E-31 Risk difference: West (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	-0.0001	0.0000	0.0000	0.0000	0.0000	-0.0001
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other & Undefined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tanker	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tanker – Oil	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug & Service	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table E-32 shows the modeled difference in accident frequency from the Project East sub-area. There is zero frequency of grounding or allision with Project structures in this sub-area because it contains no land and there are no Project structures.

Table E-32 Risk difference: East (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fishing	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Other & Undefined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tanker	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tanker – Oil	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug & Service	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table E-33 shows the modeled difference in accident frequency from the Project in the North sub-area. There is zero frequency of grounding or allision with Project structures in this sub-area because it contains no land and there are no Project structures.

Table E-33 Risk difference: North (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	-0.0001	0.0000	0.0000	0.0000	0.0000	-0.0001
Fishing	0.0006	0.0000	0.0000	0.0000	0.0000	0.0006
Other & Undefined	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Passenger	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pleasure	0.0008	0.0000	0.0000	0.0000	0.0000	0.0008
Tanker	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tanker – Oil	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tug & Service	-0.0001	0.0000	0.0000	0.0000	0.0000	-0.0001
Total	0.0012	0.0000	0.0000	0.0000	0.0000	0.0012

Table E-34 Risk difference: Other (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0007	0.0010	0.0022	0	0	0.0039
Fishing	0.0017	-0.0001	-0.0001	0	0	0.0017
Other & Undefined	0	0	0	0	0	0
Passenger	0.0007	0.0070	0.0034	0	0	0.0111
Pleasure	0.0017	0.0140	0.0078	0	0	0.0235
Tanker	0.0001	0.0006	0.0006	0	0	0.0013
Tanker – Oil	0.0002	0.0003	0.0009	0	0	0.0014
Tug & Service	0.0004	-0.0039	-0.0001	0	0	-0.0036
Total	0.0055	0.0190	0.0148	0	0	0.0393

E.6 Summary

The MARCS model calculates accident frequencies for the Base Case (Case 0), for Base Case Plus (addition of the Project to the Base Case) (Case 1), and the Future Case with the addition of the Project (and additional vessel traffic caused by the presence of the wind farm and assumes modified traffic routes) (Case 2).

Per NVIC 01-19 recommendations, the 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 risk between Case 2 and Case 0, 1.61 accidents per year, is our best estimate of the extra risk that results from the presence of the Project assuming all non-AIS commercial fishing vessel transit to or through the Assessment Area. The Project poses very little risk outside the Assessment Area: over 97% of the estimated risk increase occurs in the Assessment Area (within the sub-area "Assessment Area").

The quantified risk assessment of the navigation risk for the Project concludes there is a small risk increase due to the Project. The actual observed accident rate of fishing vessel allisions with Project structures will depend directly on how many transits fishing vessels take to / through the Project. This modeling included a maximum estimate of the number of commercial fishing vessels that will transit to and through the Project, as the current number of transits is not available in the public domain.

APPENDIX F CHECKLIST FOR NSRA DEVELOPMENT AND REVIEW

Enclosure (6) to NVIC 01-19 contains the below checklist for review and development of an NSRA. This appendix provides the checklist that was completed during development of this NSRA.

ISSUE	Covered in the NSRA?	COMMENTS
1. SITE AND INSTALLATION COORDINATES		
Has the developer ensured that coordinates and subsequent variations of site perimeters and individual structures are made available, upon request, to interested parties at all, relevant project stages?	Yes, for current project stage	See Section 1.3 and Appendix G.
Has the coordinate data been supplied as authoritative Geographical Information System (GIS) data, preferably in Environmental Systems Research Institute (ESRI) format? Metadata should facilitate the identification of the data creator, its date and purpose, and the geodetic datum used. For mariners' use, appropriate data should also be provided with latitude and longitude coordinates in World Geodetic System 1984 (WGS84) datum.	Yes	See Appendix G.
2. TRAFFIC SURVEY		
Was the traffic survey conducted within 12 months of the NSRA?	Yes	See Section 2
Does the survey include all vessel types?	Yes	See Section 2 See details per vessel type in Section 2.1
Is the time period of the survey at least 28 days duration?	Yes	See Section 2
Does the survey include consultation with recreational vessel organizations?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include consultation with fishing vessel organizations?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include consultation with pilot organizations?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include consultation with commercial vessel organizations?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include consultation with port authorities?	Yes	See Section 2, Appendix B, and Appendix C
Does the survey include proposed structure location relative to areas used by any type of vessel?	Yes	See Section 2.2.2.
Does the survey include numbers, types, sizes and other characteristics of vessels presently using such areas?	Yes	See Section 2.1.3

ISSUE	Covered in the NSRA?	COMMENTS
Does the survey include types of cargo carried by vessels presently using such areas?	Yes	See Section 2.1.4
Does the survey identify non-transit uses of the areas (for example, fishing, day cruising of leisure craft, racing, marine regattas and parades, aggregate mining)?	Yes	See Section 2.2.1
Does the survey include whether these areas contain transit routes used by coastal or deep-draft vessels, ferry routes, and fishing vessel routes?	Yes	See Section 2.2.2.1 and Section 2.2.2.2 (refers to Section 2.1.1.2)
Does the survey include alignment and proximity of the site relative to adjacent shipping routes	Yes	See Section 2.2.2.3
Does the survey include whether the nearby area contains prescribed or recommended routing measures or precautionary areas?	Yes	See Section 2.2.2.4
Does the survey include whether the site lies on or near a prescribed or conventionally accepted separation zone between two opposing routes or traffic separation scheme?	Yes	See Section 2.2.2.4
Does the survey include the proximity of the site to anchorage grounds or areas, safe haven, port approaches, and pilot boarding or landing areas?	Yes	See Section 2.2.2.5
Does the survey include the feasibility of allowing vessels to anchor within the vicinity of the structure field?	Yes	See Section 2.2.2.5
Does the survey include the proximity of the site to existing fishing grounds, or to routes used by fishing vessels to such grounds?	Yes	See Section 2.2.3 (refers to Section 2.1.1.2)
Does the survey include whether the site lies within the limits of jurisdiction of a port and/or navigation authority?	Yes	See Section 2.2.3
Does the survey include the proximity of the site to offshore firing/bombing ranges and areas used for any marine or airborne military purposes?	Yes	See Section 2.2.3
Does the survey include the proximity of the site to existing or proposed offshore OREI/gas platform or marine aggregate mining?	Yes	See Section 2.2.3
Does the survey include the proximity of the site to existing or proposed structure developments?	Yes	See Section 2.2.3
Does the survey include the proximity of the site relative to any designated areas for the disposal of dredging material or ocean disposal site?	Yes	See Section 2.2.3
Does the survey include the proximity of the site to aids to navigation and/or Vessel Traffic Services (VTS) in or adjacent to the area and any impact thereon?	Yes	See Section 2.2.3

ISSUE	Covered in the NSRA?	COMMENTS
Does the survey include a researched opinion using computer simulation techniques with respect to the displacement of traffic, mixing of vessel types that were previously segregated; changes in traffic density and resultant change in vessels encounters; and, in particular, the creation of 'choke points' in areas of high traffic density?	Yes	See Section 2.3 and Appendix E
Does the survey include whether the site lies in or near areas that will be affected by variations in traffic patterns as a result of changes to vessel emission requirements?	Yes	See Section 2.4
Does the survey include seasonal variations in traffic?	Yes	See Section 2.5
3. OFFSHORE ABOVE WATER STRUCTURES		
Does the NSRA denote whether any features of the offshore above water structure, including auxiliary platforms outside the main generator site and cabling to the shore, could pose any type of difficulty or danger to vessels underway, performing normal operations, or anchoring? Such dangers would include clearances of wind turbine blades above the sea surface, the burial depth of cabling, and lateral movement of floating wind turbines.	Yes	See Section 3 and Section 4
Does the NSRA denote whether minimum safe (air) clearances between sea level conditions at Mean Higher High Water (MHHW) and wind turbine rotors are suitable for the vessels types identified in the traffic survey? Depths, clearances, and similar features of other structure types which might affect navigation safety and other Coast Guard missions should be determined on a case by case basis.	Yes	See Section 3.2
Does the NSRA denote whether any feature of the installation could impede emergency rescue services, including the use of lifeboats, helicopters and emergency towing vessels (ETVs)?	Yes	See Section 3.3
Does the NSRA denote how rotor blade rotation and power transmission, etc., will be controlled by the designated services when this is required in an emergency?	Yes	See Section 3.3
Does the NSRA denote whether any noise or vibrations generated by a structure above and below the water column would impact navigation safety or affect other Coast Guard missions?	Yes	See Section 3.4
Does the NSRA denote the ability of a structure to withstand collision damage by vessels without toppling for a range of vessel types, speeds, and sizes?	Yes	See Section 3.5

ISSUE	Covered in the NSRA?	COMMENTS
4. OFFSHORE UNDER WATER STRUCTURES		
Does the NSRA denote whether minimum safe clearance over underwater devices has been determined for the deepest draft of vessels that could transit the area?	Yes	See Section 4
Has the developer demonstrated an evidence-based, case- by-case approach which will include dynamic draft modeling in relation to charted water depth to ascertain the safe clearance over a device?	NA	Not applicable. See Section 4
To establish a minimum clearance depth over devices, has the developer identified from the traffic survey the deepest draft of observed traffic? This will then require modeling to assess impacts of all external dynamic influences giving a calculated figure for dynamic draft. A 30% factor of safety for under keel clearance (UKC) should then be applied to the dynamic draft, giving an overall calculated safe clearance depth to be used in calculations.	NA	Not applicable. See Section 4
5. ASSESSMENT OF ACCESS TO AND NAVIGATION WITHIN, OR CLOSE TO, A STRUCTURE. Has the developer determined the extent to which navigation would be feasible within the structure site itself by assessing whether:		
Navigation within the site would be safe? • By all vessels or • By specified vessel types, operations and/or sizes? • In all directions or areas; or • In specified directions or areas? • In specified tidal, weather or other conditions; and • At any time, day or night?	Yes	See Section 5 for information to support Coast Guard's evaluation.
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	See Section 5 for information to support Coast Guard's evaluation
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	See Section 5 and supporting information in Section 2.3, Section 3.1, and Section 11

ISSUE	Covered in the NSRA?	COMMENTS
6. THE EFFECT OF TIDES, TIDAL STREAMS, AND CURRENTS. Does the NSRA contain enough information for the Coast Guard to determine whether or not:		
Current maritime traffic flows and operations in the general area are affected by the depth of water in which the proposed structure is situated at various states of the tide, that is, whether the installation could pose problems at high water which do not exist at low water conditions, and vice versa?	Yes	See Section 6
Current maritime traffic flows and operations in the general area are affected by existing currents in the area in which the proposed structure is situated?	Yes	See Section 6 introductory material and Section 6.2
The set and rate of the tidal stream, at any state of the tide, would have a significant effect on vessels in the area of the structure site?	Yes	See Section 6 introduction and Section 6.2
Current directions/velocities might aggravate or mitigate the likelihood of allision with the structure?	Yes	See Section 6.2
The maximum rate tidal stream runs parallel to the major axis of the proposed site layout, and, if so, its effect?	Yes	See Section 6.2
The set is across the major axis of the layout at any time, and, if so, at what rate?	Yes	See Section 6.2
In general, whether engine failure or other circumstance could cause vessels to be set into danger by the tidal stream or currents?	Yes	See Section 6.2 and Section 11 for risk results
Structures themselves could cause changes in the set and rate of the tidal stream or direction and rate of the currents?	Yes	See Section 6.2
Structures in the tidal stream could produce siltation, deposition of sediment or scouring, any other suction or discharge aspects, which could affect navigable water depths in the structure area or adjacent to the area?	Yes	See Section 6.2 and relevant sections of the COP
Structures would cause danger and/or severely affect the air column, water column, seabed and sub-seabed in the general vicinity of the structure?	Yes	See Section 6.2 and relevant sections of the COP
7. WEATHER. Does the NSRA contain a sufficient analysis of expected weather conditions, water depths and sea states that might aggravate or mitigate the likelihood of allision with the structure, so that Coast Guard can properly assess the applicant's determinations of whether:		
The site, in all weather conditions, could present difficulties or dangers to vessels, which might pass in close proximity to the structure?	Yes	See Section 7 and Section 11 risk results
The structures could create problems in the area for vessels under sail, such as wind masking, turbulence, or sheer?	Y	See Section 7.2

ISSUE	Covered in the NSRA?	COMMENTS
In general, taking into account the prevailing winds for the area, whether engine failure or other circumstances could cause vessels to drift into danger, particularly if in conjunction with a tidal set such as referred above?	Y	See Section 7 and Section 11 risk results
Depending on the location of the structure and the presence of cold weather, sea ice and/or icing of the structure may cause problems? A thorough analysis of how the presence of the structure would mitigate or exacerbate icing?	Yes	See Section 7.4
An analysis of the ability for structures to withstand anticipated ice flows should be conducted by the applicant?	Yes	See Section 7.4
An analysis of the likelihood that ice may form on the structure, especially those types that have rotating blades such as a Wind Turbine Generator (WTG), should be conducted by the applicant, and should include an analysis of the ability of the structure to withstand anticipated ice accumulation on the structures, and potential for ice to be thrown from the blades, and the likely consequences of that happening and possible actions to mitigate that occurrence?	Yes	See Section 7.4
8. CONFIGURATION AND COLLISION AVOIDANCE		
The Coast Guard will provide Search and Rescue (SAR) services in and around OREIs in US waters. Layout designs should allow for safe transit by SAR helicopters operating at low altitude in bad weather, and those vessels (including rescue craft) that decide to transit through them. Has the developer conducted additional site specific assessments, if necessary, to build on any previous assessments to assess the proposed locations of individual turbine devices, substations, platforms and any other structure within OREI such as a wind farm or tidal/wave array? Any assessment should include the potential impacts the site may have on navigation and SAR activities. Liaison with the USCG is encouraged as early as possible following this assessment which should aim to show that risks to vessels and/or SAR helicopters are minimized and include proposed mitigation measures.	Yes	See Section 8 and Section 10
Each OREI layout design will be assessed on a case-by-case basis.	Yes	See Section 8

ISSUE	Covered in the NSRA?	COMMENTS
Risk assessments should build on any earlier work conducted as part of the NSRA and the mitigations identified as part of that process. Where possible, an original assessment should be referenced to confirm where information or the assessment remains the same or can be further refined due to the later stages of project development. Risk assessments should present information to enable the USCG to adequately understand how the risks associated with the proposed layout have been reduced to As Low As Reasonably Practicable (ALARP).	Yes	See Section 8 and Section 11
In order to minimize risks to surface vessels and/or SAR helicopters transiting through an OREI, structures (turbines, substations) should be aligned and in straight rows or columns. Multiple lines of orientation may provide alternative options for passage planning and for vessels and aircraft to counter the environmental effects on handling i.e. sea state, tides, currents, weather, visibility. Developers should plan for at least two lines of orientation unless they can demonstrate that fewer are acceptable.	Yes	See Section 1.3
Packed boundaries will be considered on a case-by-case basis as part of the risk assessment process. For opposite boundaries of adjacent sites due consideration should be given to the requirement for lines of orientation which allow a continuous passage of vessels and/or SAR helicopters through both sites. Where there are packed boundaries this will affect layout decisions for any possible future adjacent sites. The definition of 'adjacent' will be assessed on a case-by-case basis.	NA	Not applicable to the considered layouts
9. VISUAL NAVIGATION. Does the NSRA contain an assessment of the extent to which:		
Structures could block or hinder the view of other vessels underway on any route?	Yes	See Section 9
Structures could block or hinder the view of the coastline or of any other navigational feature such as aids to navigation, landmarks, promontories?	Yes	See Section 9
Structures and locations could limit the ability of vessels to maneuver in order to avoid collisions?	Yes	See Section 9 and Section 11
10. COMMUNICATIONS, RADAR AND POSITIONING SYSTEMS. Does the NSRA provide researched opinion of a generic and, where appropriate, site specific nature concerning whether or not:		
Structures could produce interference such as shadowing, reflections or phase changes, with marine positioning, navigation, or communications, including Automatic Identification Systems (AIS), whether ship borne, ashore, or fitted to any of the proposed structures?	Yes	See Section 10

<table>
<tr><th>ISSUE</th><th>Covered in the NSRA?</th><th>COMMENTS</th></tr>
<tr><td>Structures could produce radar reflections, blind spots, shadow areas or other adverse effects in the following interrelationships:
Vessel to vessel;
Vessel to shore;
Vessel Traffic Service radar to vessel;
Radio Beacons (RACONS) to/from vessel; and
Aircraft and Air Traffic Control?</td><td>Yes</td><td>See Section 10</td></tr>
<tr><td>Structures, in general, would comply with current recommendations concerning electromagnetic interference?</td><td>Yes</td><td>See Section 10</td></tr>
<tr><td>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?</td><td>Yes</td><td>See Section 10.1 and Section 3.4</td></tr>
<tr><td>Structures, generators, and the seabed cabling within the site and onshore might produce electro-magnetic fields affecting compasses and other navigation systems?</td><td>Yes</td><td>See Section 10</td></tr>
<tr><td>The power and noise generated by structures above or below the water would create physical risks that would affect the health of vessel crews?</td><td>Yes</td><td>See Section 10</td></tr>
<tr><td colspan="3">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:</td></tr>
<tr><td>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?</td><td>Yes</td><td>See Section 11</td></tr>
</table>

ISSUE	Covered in the NSRA?	COMMENTS
12. EMERGENCY RESPONSE CONSIDERATIONS. In order to determine the impact on Coast Guard and other emergency responder missions, has the developer conducted assessments on the Search and Rescue and the Marine Environmental Protection emergency response missions?		
Search and Rescue (SAR): • The Coast Guard will assist in gathering and providing the following information: The number of search and rescue cases the USCG has conducted in the proposed structure region over the last ten years. • The number of cases involving helicopter hoists. • The number of cases performed at night or in poor visibility/low ceiling • The number of cases involving aircraft (helicopter, fixed-wing) searches. • The number of cases performed by commercial salvors (for example, BOAT US, SEATOW, commercial tugs) responding to assist vessels in the proposed structure region over the last ten years. • Has the developer provided an estimate of the number of additional SAR cases projected due to allisions with the structures? • Will the structure enhance SAR such as by providing a place of refuge or easily identifiable markings to direct SAR units?	Yes	See Section 12 summarizing the available data and relevant model results
Marine Environmental Protection/Response: • How many marine environmental/pollution response cases has the USCG conducted in the • proposed structure region over the last ten years? • What type of pollution cases were they? • What type and how many assets responded? • How many additional pollution cases are projected due to allisions with the structures?	Yes	See Section 12 summarizing the available data and relevant model results
13. FACILITY CHARACTERISTICS. In addition to addressing the risk factors detailed above, does the developer's NSRA include a description of the following characteristics related to the proposed structure:		
Marine Navigational Marking?	Yes	See Section 13
How the overall site would be marked by day and by night, taking into account that there may be an ongoing requirement for marking on completion of decommissioning, depending on individual circumstances?	Yes	See Section 13
How individual structures on the perimeter of and within the site, both above and below the sea surface, would be marked by day and by night?	Yes	See Section 13

ISSUE	Covered in the NSRA?	COMMENTS
If the site would be marked by one or more Radar Beacons (RACONS) or, an Automatic Identification System (AIS) transceiver, or both and if so, the AIS data it would transmit?	Yes	Addressed to the extent practical at this project stage, see Section 13
If the site would be fitted with a sound signal, the characteristics of the sound signal, and where the signal or signals would be sited?	Yes	Addressed to the extent practical at this project stage, see Section 13
If the structure(s) are to be fitted with aviation marks, how would they be screened from mariners or potential confusion with other navigational marks and lights be resolved?	Yes	Addressed to the extent practical at this project stage, see Section 13
Whether the proposed site and/or its individual generators would comply in general with markings for such structures, as required by the Coast Guard?	Yes	See Section 13
Whether its plans to maintain its aids to navigation are such that the Coast Guard's availability standards are met at all times. Separate detailed guidance to meet any unique characteristics of a particular structure proposal should be addressed by the respective District Waterways Management Branch?	Yes	See Section 13
The procedures that need to be put in place to respond to and correct discrepancies to the aids to navigation, within the timeframes specified by the Coast Guard?	Yes	See Section 13
How the marking of the structure will impact existing Federal aids to navigation in the vicinity of the structure?	Yes	See Section 13
14. DESIGN REQUIREMENTS. Is the structure designed and constructed to satisfy the following recommended design requirements for emergency shut-down in the event of a SAR, pollution response, or salvage operation in or around a structure?		
All above surface structure individual structures should be marked with clearly visible unique identification characters (for example, alpha-numeric labels such as "Al," "B2."). The identification characters should each be illuminated by a low-intensity light visible from a vessel, or be coated with a phosphorescent material, thus enabling the structure to be detected at a suitable distance to avoid a collision with it. The size of the identification characters in combination with the lighting or phosphorescence should be such that, under normal conditions of visibility and all known tidal conditions, they are clearly readable by an observer, and at a distance of at least 150 yards from the structure. It is recommended that, if lighted, the lighting for this purpose be hooded or baffled so as to avoid unnecessary light pollution or confusion with navigation aids. (Precise dimensions to be determined by the height of lights and necessary range of visibility of the identification numbers).	Yes	See Section 14
All generators and transmission systems should be equipped with control mechanisms that can be operated from an operations center of the installation.	Yes	See Section 14

ISSUE	Covered in the NSRA?	COMMENTS
Throughout the design process, appropriate assessments and methods for safe shutdown should be established and agreed to through consultation with the Coast Guard and other emergency support services.	Yes	See Section 14
The control mechanisms should allow the operations center personnel to fix and maintain the position of the WTG blades, nacelles and other appropriate moving parts as determined by the applicable Coast Guard command center. Enclosed spaces such as nacelle hatches in which personnel are working should be capable of being opened from the outside. This would allow rescuers (for example, helicopter winch-man) to gain access if occupants are unable to assist or when sea-borne approach is not possible.	Yes	See Section 14
Access ladders, although designed for entry by trained personnel using specialized equipment and procedures for maintenance in calm weather, could conceivably be used in an emergency situation to provide refuge on the structure for distressed mariners. This scenario should therefore be considered when identifying the optimum position of such ladders and take into account the prevailing wind, wave, and tidal conditions.	Yes	See Section 14
15. OPERATIONAL REQUIREMENTS. Will the operations be continuously monitored by the facility's owners or operators, ostensibly in an operations center? Does the NSRA identify recommended minimum requirements for an operations center such as:		
The operations center should be manned 24 hours a day?	Yes	See Section 15
The operations center personnel should have a chart indicating the Global Positioning System (GPS) position and unique identification numbers of each of the structure?	Yes	See Sections 15 and 16
All applicable Coast Guard command centers (District and Sector) will be advised of the contact telephone number of the operations center?	Yes	See Section 15
All applicable Coast Guard command centers will have a chart indicating the position and unique identification number of each of the structures?	Yes	See Sections 15 and 16
16. OPERATIONAL PROCEDURES. Does the NSRA provide for the following operational procedures?		
Upon receiving a distress call or other emergency alert from a vessel that is concerned about a possible allision with a structure or is already close to or within the installation, the Coast Guard Search and Rescue Mission Coordinator (SMC) will establish the position of the vessel and the identification numbers of any structures visible to the vessel. The position of the vessel and identification numbers of the structures will be passed immediately to the operations center by the SMC.	NA	See Section 16

ISSUE	Covered in the NSRA?	COMMENTS
The operations center should immediately initiate the shut-down procedure for those structures as requested by the SMC, and maintain the structure in the appropriate shut-down position, again as requested by the SMC, until receiving notification from the SMC that it is safe to restart the structure.	Yes	See Sections 14, 15, and 16
Communication and shutdown procedures should be tested satisfactorily at least twice each year.	Yes	See Section 16
After an allision, the applicant should submit documentation that verifies the structural integrity of the structure.	Yes	See Section 16

APPENDIX G PROJECT OFFSHORE STUCTURE COORDINATES

Table H-1 lists the locations of the offshore Project structures evaluated in this NSRA. Universal Transverse Mercator (UTM) coordinates provided by Sunrise Wind LLC (2020) and WGS84 latitude and longitude are shown.

Table G-1 Structure Coordinates

ID[16]	NAD83 (2011) UTM Zone 19 (m)		WGS84 (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
63	336394	4545740	41.046468	-70.946655
64	314170	4545740	41.0417	-71.210909
65	312318	4545740	41.041275	-71.232927
77	345654	4543888	41.031602	-70.836067
78	343802	4543888	41.031249	-70.858088
79	341950	4543888	41.030891	-70.880107
80	340098	4543888	41.03053	-70.902126
81	338246	4543888	41.030164	-70.924145
82	336394	4543888	41.029795	-70.946164
83	334542	4543888	41.029421	-70.968182
84	332690	4543888	41.029042	-70.990199
85	330838	4543888	41.02866	-71.012216
86	328986	4543888	41.028273	-71.034233
87	327134	4543888	41.027882	-71.056249
88	325282	4543888	41.027487	-71.078265
89	323430	4543888	41.027088	-71.100281
90	321578	4543888	41.026685	-71.122296
91	319726	4543888	41.026277	-71.14431
92	317874	4543888	41.025865	-71.166324
93	316022	4543888	41.025449	-71.188338
94	314170	4543888	41.025029	-71.210351
95	312318	4543888	41.024604	-71.232364
96	310466	4543888	41.024176	-71.254376
97	308614	4543888	41.023743	-71.276387
107	345654	4542036	41.014927	-70.835604
108	343802	4542036	41.014574	-70.857619
109	341950	4542036	41.014217	-70.879633
110	340098	4542036	41.013856	-70.901646
111	338246	4542036	41.013491	-70.92366
112	336394	4542036	41.013121	-70.945673

[16] These are reference identifiers and do not reflect a sequential numbering system.

ID[16]	NAD83 (2011) UTM Zone 19 (m)		WGS84 (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
113	334542	4542036	41.012747	-70.967685
114	332690	4542036	41.012369	-70.989697
115	330838	4542036	41.011987	-71.011709
116	328986	4542036	41.011601	-71.03372
117	327134	4542036	41.01121	-71.055731
118	325282	4542036	41.010815	-71.077741
119	323430	4542036	41.010416	-71.099751
120	321578	4542036	41.010013	-71.12176
121	319726	4542036	41.009605	-71.143769
122	317874	4542036	41.009194	-71.165778
123	316022	4542036	41.008778	-71.187786
124	314170	4542036	41.008358	-71.209793
126	310466	4542036	41.007505	-71.253807
127	308614	4542036	41.007073	-71.275813
136	345654	4540184	40.998252	-70.835141
137	343802	4540184	40.9979	-70.85715
138	341950	4540184	40.997543	-70.879159
139	340098	4540184	40.997182	-70.901167
140	338246	4540184	40.996817	-70.923175
141	336394	4540184	40.996447	-70.945182
142	334542	4540184	40.996074	-70.967189
143	332690	4540184	40.995696	-70.989195
144	330838	4540184	40.995314	-71.011202
145	328986	4540184	40.994928	-71.033207
146	327134	4540184	40.994537	-71.055212
147	325282	4540184	40.994143	-71.077217
148	323430	4540184	40.993744	-71.099221
149	321578	4540184	40.993341	-71.121225
150	319726	4540184	40.992934	-71.143229
151	317874	4540184	40.992523	-71.165232
152	316022	4540184	40.992107	-71.187234
153	314170	4540184	40.991687	-71.209236
155	310466	4540184	40.990835	-71.253239
156	308614	4540184	40.990403	-71.27524
165	341950	4538332	40.980869	-70.878685
166	340098	4538332	40.980508	-70.900688
167	338246	4538332	40.980143	-70.92269
168	336394	4538332	40.979774	-70.944692
169	334542	4538332	40.9794	-70.966693
170	332690	4538332	40.979023	-70.988694

ID[16]	NAD83 (2011) UTM Zone 19 (m)		WGS84 (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
171	330838	4538332	40.978641	-71.010695
172	328986	4538332	40.978255	-71.032695
173	327134	4538332	40.977865	-71.054695
174	325282	4538332	40.977471	-71.076694
175	323430	4538332	40.977072	-71.098693
176	321578	4538332	40.976669	-71.120691
177	319726	4538332	40.976262	-71.142689
178	317874	4538332	40.975851	-71.164686
179	316022	4538332	40.975436	-71.186683
180	314170	4538332	40.975016	-71.20868
181	312318	4538332	40.974593	-71.230676
182	310466	4538332	40.974165	-71.252672
183	308614	4538332	40.973733	-71.274667
193	340098	4536480	40.963834	-70.900209
194	338246	4536480	40.963469	-70.922206
195	336394	4536480	40.9631	-70.944202
196	334542	4536480	40.962727	-70.966198
197	332690	4536480	40.962349	-70.988194
198	330838	4536480	40.961968	-71.010189
199	328986	4536480	40.961582	-71.032183
200	327134	4536480	40.961192	-71.054177
201	325282	4536480	40.960798	-71.076171
202	323430	4536480	40.9604	-71.098164
203	321578	4536480	40.959997	-71.120157
204	319726	4536480	40.959591	-71.142149
205	317874	4536480	40.95918	-71.164141
206	316022	4536480	40.958765	-71.186133
208	312318	4536480	40.957922	-71.230114
209	310466	4536480	40.957494	-71.252104
210	308614	4536480	40.957062	-71.274094
219	338246	4534628	40.946795	-70.921722
220	336394	4534628	40.946426	-70.943713
221	334542	4534628	40.946053	-70.965703
222	332690	4534628	40.945676	-70.987693
223	330838	4534628	40.945295	-71.009683
224	328986	4534628	40.944909	-71.031672
233	338246	4532776	40.930121	-70.921238
234	336394	4532776	40.929752	-70.943224
235	334542	4532776	40.92938	-70.965209
236	332690	4532776	40.929003	-70.987193

ID[16]	NAD83 (2011) UTM Zone 19 (m)		WGS84 (Decimal Degrees)	
	Easting	Northing	Latitude	Longitude
237	330838	4532776	40.928622	-71.009177
238	328986	4532776	40.928236	-71.031161
246	336394	4530924	40.913079	-70.942736
247	334542	4530924	40.912706	-70.964715
248	332690	4530924	40.912329	-70.986694
249	330838	4530924	40.911948	-71.008672
250	328986	4530924	40.911563	-71.03065
259	334542	4529072	40.896032	-70.964221
260	332690	4529072	40.895656	-70.986195
261	330838	4529072	40.895275	-71.008168
262	328986	4529072	40.89489	-71.03014
272	330838	4527220	40.878602	-71.007663
273	328986	4527220	40.878217	-71.02963

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