SOUTH FORK WIND FARM

Navigation Safety Risk Assessment

South Fork Wind, LLC.

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List of abbreviations

Abbreviation	Meaning
ADLS	Aircraft Detection Light System
AIS	Automatic Identification System
ALARP	As low as reasonably practicable
ATON	Aids to Navigation
BOEM	U.S. Bureau of Ocean Energy Management
CFR	Code of Federal Regulations
COLREGs	International Regulations for Preventing Collisions at Sea
COP	Construction and Operations Plan
CTV	Crew Transfer Vessel
DNV GL	DNV GL Energy USA, Inc.
DWT	Dead Weight Tonnage
ECA	Emission Control Area
ECDIS	Electronic Chart Display and Information System
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 Offshore 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 Signal
MSL	Mean sea level
NAIS	Nationwide Automatic Identification System
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
OCS	Outer Continental Shelf
OREI	Offshore Renewable Energy Installation
OSP	Offshore Substation Platform(s)
PARS	Port Access Route Study
PATON	Private Aids to Navigation
PDE	Project Design Envelope
PPU	Portable Pilotage Unit
RODA	Responsible Offshore Development Alliance
SAR	Search and Rescue
SMC	Search and Rescue Mission Coordinator
SO_x	Sulfur oxides

Abbreviation	**Meaning**
SOLAS	The International Convention for the Safety Of Life At Sea
STCW	The International Convention on Standards of Training, Certification, and Watchkeeping for Fishing Vessel Personnel
TSS	Traffic Separation Scheme
U.S.	United States
UHF	Ultra-High Frequency
UK	United Kingdom
UKC	Under Keel Clearance
USACE	United States Army Corps of Engineers
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(s)

List of units

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

EXECUTIVE SUMMARY

This document presents the Navigation Safety Risk Assessment (NSRA) for the South Fork Wind Farm (the Project). The Project structures will be located within a Commercial Lease for Renewable Energy Development on the Outer Continental Shelf (OCS-A 0517) held by South Fork Wind, LLC (South Fork Wind) (BOEM, 2020).

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

This assessment covers the following elements:

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. Effects of tides, tidal streams, and currents
7. Weather
8. Configuration and collision avoidance
9. Visual navigation
10. Communications, radar, and positioning systems
11. Risk of collision, allision, or grounding
12. Emergency response considerations
13. Facility characteristics
14. Design requirements
15. Operational requirements
16. Operational procedures

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

Figure ES-1 shows the boundaries of the NSRA Project 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. 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.

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 some other risk controls that are widely regarded as beneficial such as PATON to be installed by the Project, safety vessels, safety zones, and similar measures.

Figure ES-1 Project Location

Marine risk modeling was used to estimate the increase in the number of collision, allision, and grounding 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 Project Area and is due to the potential for a vessel to strike a Project structure (allision risk). Generally, empirical data shows that 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 because drifting allisions involve lower energies and consequently less damage unless they occur extreme sea conditions and many powered allisions will be glancing rather than center-on impacts.

One year of Automatic Identification System (AIS) data were 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 (hereinafter “non-AIS”). Commercial fishing[1] is one such vessel type that is important in the Study Area. The number of non-AIS commercial fishing transits within 12 NM of the Project Area was estimated by scaling the number of AIS-carrying commercial fishing vessels per the ratio of registered commercial fishing vessels not required to carry AIS (shorter than 65 ft) to those that are required to carry AIS (65 ft in length or longer), a ratio of about 6:1.

The non-AIS commercial fishing vessels were assumed to take the same routes as the AIS-transmitting fishing vessels.

The modeling shows that the Project has no significant direct effect on collision risk or grounding risk. In this assessment, the modeled increase in accident frequency is an additional 0.04 accidents per year:

- 67% are allisions with Project structures.
- 31% are additional groundings near local ports. This is an indirect effect resulting from the assumption that the Project may attract new vessel traffic (100 new transits) for fishing or sightseeing in the Project Area.

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 Project Area. If the number of transits were half of the estimate, the risk would reduce by at least half.

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

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.

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[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 GL Energy USA, Inc. (DNV GL) conducted this independent Navigation Safety Risk Assessment (NSRA) of the proposed South Fork Wind Farm (the Project). The Project's offshore structures will be located within a Commercial Lease for Renewable Energy Development on the Outer Continental Shelf (OCS-A 0517) held by South Fork Wind, LLC (South Fork Wind).

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

1.1 Objective

The objective of the assessment is to address items in NVIC 01-19 as they relate 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 is based on maximum risk parameters for each part of the assessment, such that the NSRA will continue to be applicable as long as changes to the Project are within the parameters described below. The maximum risk parameters are within the Project Design Envelope (PDE).

1.2 Project components

Several alternatives are being considered for the number of and sizes of wind turbine generators (WTG) and offshore substation platform (OSP). This assessment evaluated the project maximum risk parameters shown in Table 1-1.

Table 1-1 Project parameters defining the NSRA maximum risk envelope (South Fork, 2020)

Project-related parameter	Values evaluated in this NSRA	Parts of NSRA that used this parameter
Maximum number of structure locations (WTGs and OSPs)	16	Considered in all parts of the NSRA
Number of evaluated WTG locations	15	Considered in all parts of the NSRA
Number of evaluated OSP locations	1	Considered in all parts of the NSRA
Maximum WTG monopile foundation diameter at mean sea level (MSL)	11 meters (m) 36 feet (ft)	Visual obstruction Allision model
Minimum WTG air gap from Mean Higher High Water (MHHW) based on monopile foundation	24.9 m 81.7 ft	Vessels under sail / air gap
Maximum WTG blade tip height from MSL	256 m 840 ft	Emergency response

Project-related parameter	Values evaluated in this NSRA	Parts of NSRA that used this parameter
Maximum OSP monopile foundation diameter at mean sea level (MSL)	11 m 36 ft	Visual obstruction Allision model
Minimum OSP air gap from MHHW	44.1 m 145 ft	Vessels under sail / air gap
Maximum OSP topsides footprint	40 x 40 m 131 x 131 ft	Vessels under sail / air gap Allision
Buried/covered cables at or below the seabed	Array cables connecting the WTGs to the OSP Export cables to convey power from the OSPs to shore	Hazards from offshore underwater structures

The evaluated locations of the structures and cables are presented in Section 1.3.

1.3 Site location and installation coordinates

The evaluated Project Area for the NSRA is shown in Figure 1-1. For the purpose of this NSRA, the Project Area is defined as the Bureau of Ocean Energy Management (BOEM) lease area OCS-A 0517.

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

Figure 1-1 NSRA Project Area

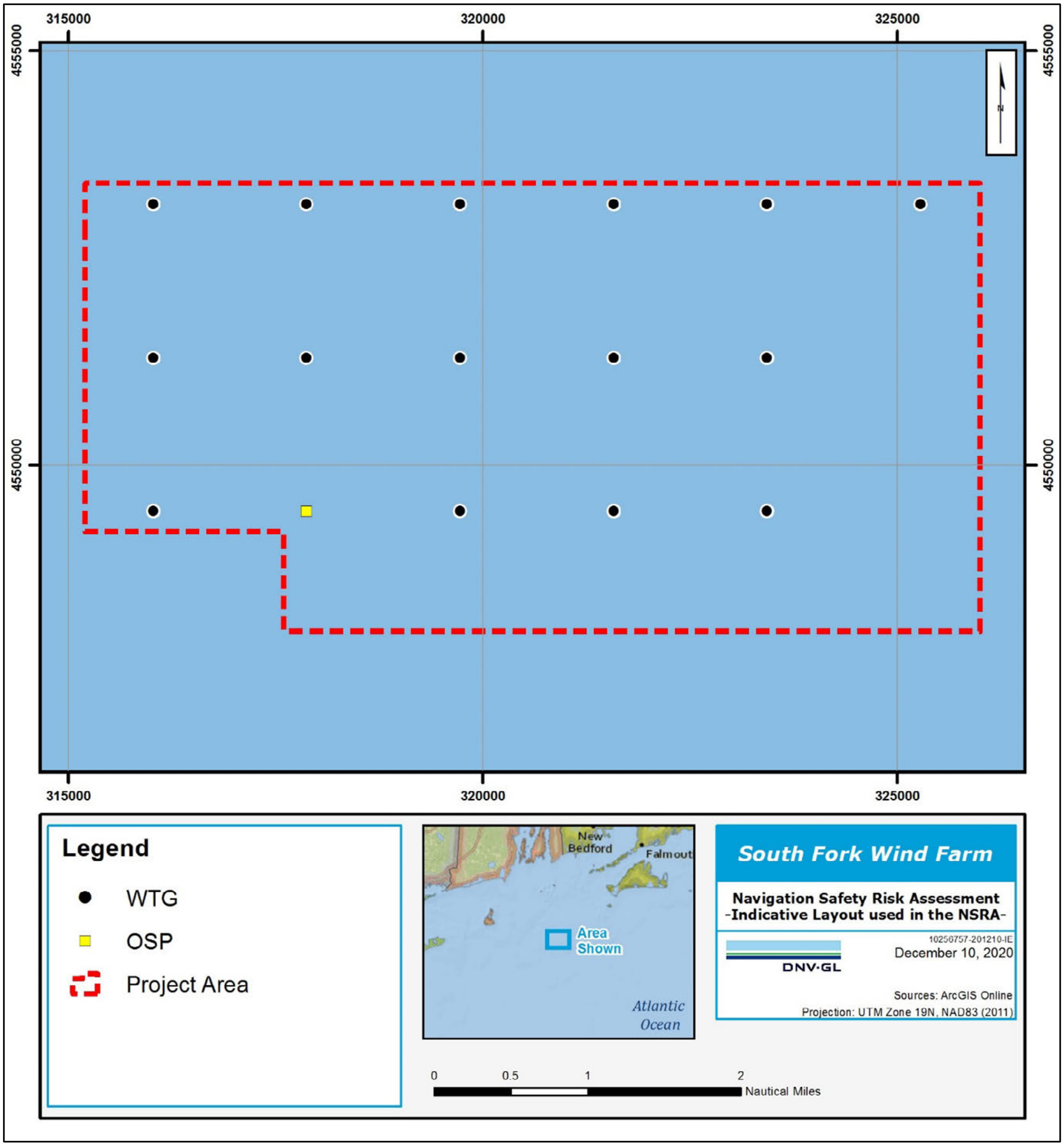

Figure 1-2 Indicative layout used in the NSRA

Figure 1-3 shows the evaluated export cable route.

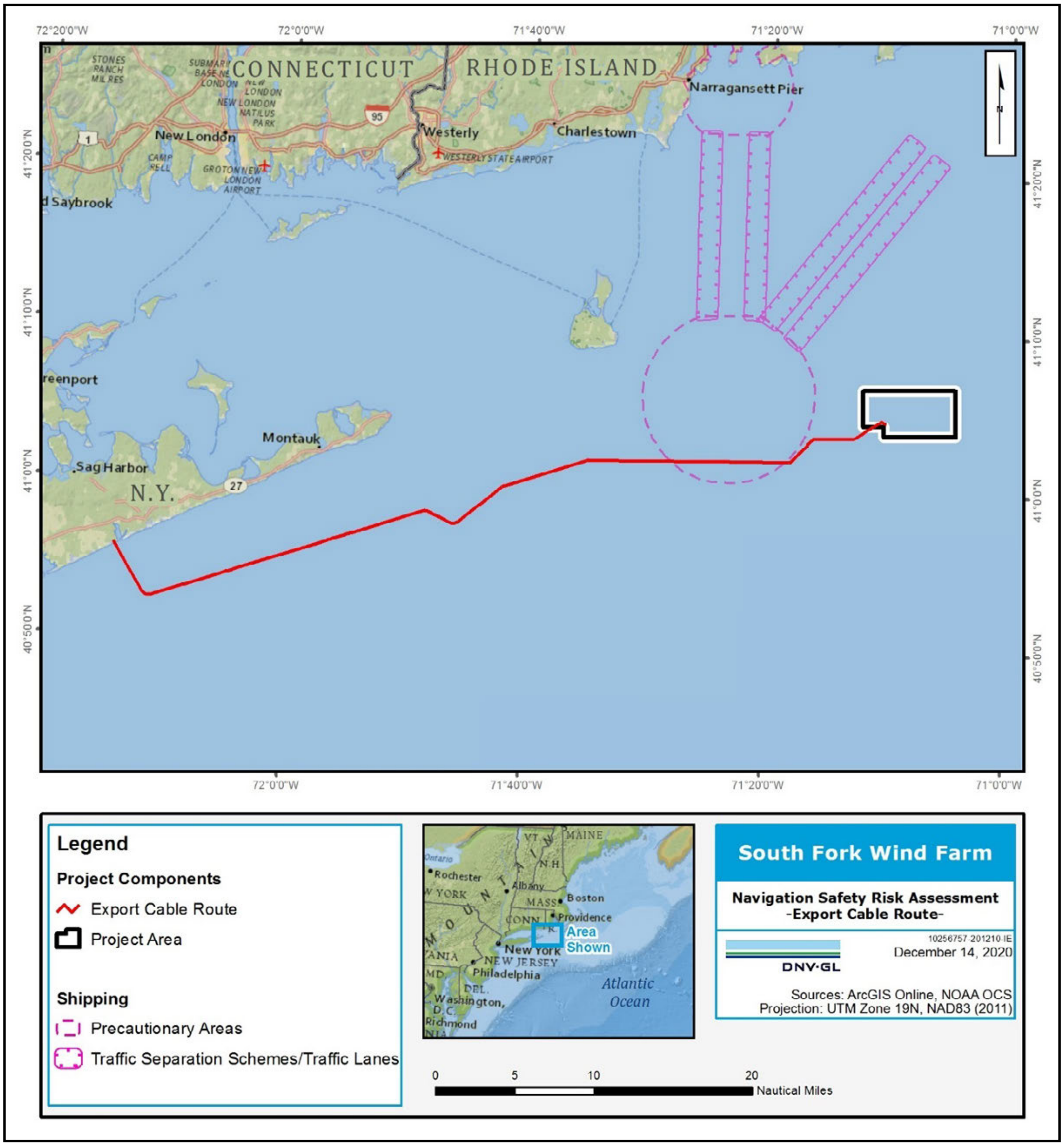

Figure 1-3 Export cable route

2 TRAFFIC SURVEY

This section describes marine traffic in the vicinity of the Project. 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 maps in Appendix B are based on this data set. The requirements for AIS carriage are discussed at the end of this section.
- 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 USCG. See Appendix C and Appendix D for additional detail.
- Relative commercial fishing density from Vessel Monitoring System (VMS) data from the National Marine Fisheries Service (NMFS). The most recent data set is available for the year 2016. VMS data are collected by National Oceanic and Atmospheric Administration (NOAA) NMFS via type-approved transmitters that automatically transmit a vessel’s position for relay to NMFS.
- Relative use of commercial fishing gear from combined permit / Vessel Trip Report (VTR) data. VTR data are collated from vessel reports provided to NOAA’s Northeast Fisheries Science Center by a subset of fishing vessels.
- The USCG Port Access Route Study for The Areas Offshore of Massachusetts and Rhode Island (MARI PARS), referred to as MARI PARS (USCG, 2020a).
- Interactions with recreational boating, fishing, and towing industry organizations (including the RODA), agencies, and other stakeholders. See Appendices C and D for details.
- Marine transportation / traffic Nationwide Automatic Identification System (NAIS) data from USCG viewed as counts of vessel tracks in a 100 m by 100 m grid (Northeast Ocean Data, 2020).

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 NSRA-defined Project Area and Study Area.

Figure 2-1 NSRA Study Area

The navigation features in the Project Area are shown in Figure 2-2. The Project Area overlies Cox Ledge and is located more than 3.5 NM (6.5 km) east of the Precautionary Area for Narragansett Bay and Buzzards Bay Traffic Separation Schemes (TSS). 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," (International Maritime Organization [IMO], 2019a). Vessel use of the TSS is voluntary (USCG, 2004).

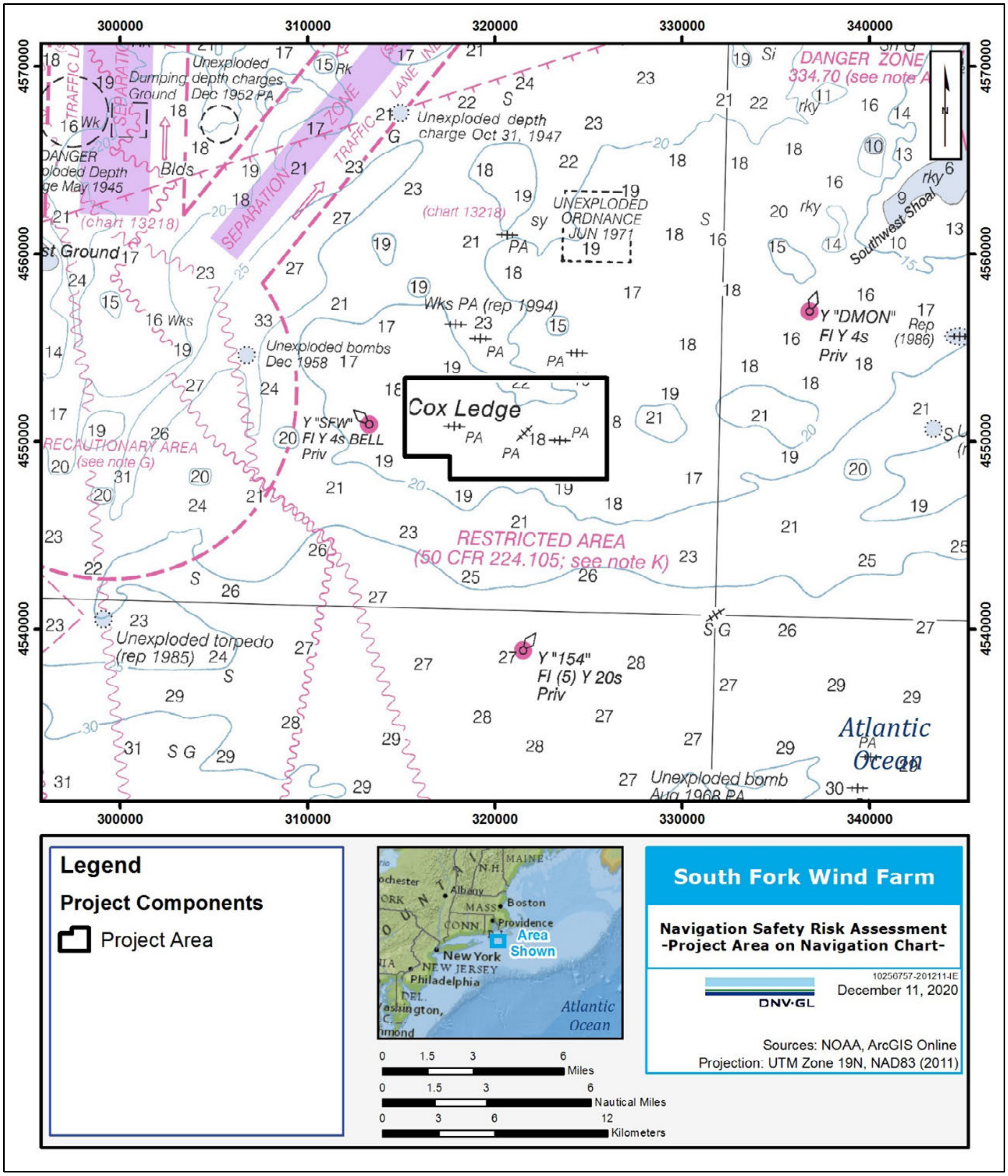

Figure 2-2 Navigation chart in the Project Area

AIS carriage requirements

Most of the traffic survey focuses on traffic as presented in the AIS data. All self-propelled vessels of more than 1,600 gross tons are required to carry AIS, with certain exceptions made for foreign vessels (USCG, 2019b). As a result, the data set provides a comprehensive view of the vessels and their routes for all of the vessel categories except fishing and pleasure/recreation. Many fishing and pleasure/recreation vessels 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 B.

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 (IMO, 1974), which applies to all vessels in international trade, requires an AIS class A device on:

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

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

(i) A self-propelled vessel of 65 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 USCG type-approved AIS Class B device in lieu of an AIS Class A device is *permissible* on the following vessels if they are not subject to pilotage by other than the vessel Master or crew:

(i) Fishing industry vessels;

(ii) Vessels identified in paragraph (b)(1)(i) of this section that are certificated to carry less than 150 passengers and that: 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 USCG 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 Study Area except smaller fishing vessels and pleasure vessels (which include recreational craft) carry AIS class A or class B equipment:

- Deep draft vessels (cargo/carrier 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 26 ft or more in length and more than 600 hp
- Passenger vessels certificated to carry 150 or more passengers

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 Study Area.

AIS data contain detailed vessel type information; the data set for this NSRA includes 60 unique types. These were combined into eight general types for this assessment, listed in Table 2-1.

Table 2-1 Groupings of AIS vessel types for the NSRA (MarineTraffic, 2019)

NSRA vessel type	AIS vessel type	Number of AIS points	Number of unique vessels
Cargo/Carrier	Bulk Carrier	15,265	77
	Cargo	670	2
	Cargo/Containership	356	2
	General Cargo	7,863	36
	Reefer	1,401	8
	Ro-Ro Cargo	272	2
	Ro-Ro/Container Carrier	1,089	5
	Self Discharging Bulk Carrier	298	1
	Timber Carrier	160	1
	Vehicles Carrier	27,900	59
Fishing	Fish Carrier	109	1
	Fishery Patrol Vessel	4,198	1
	Fishing	269,334	386
	Fishing Vessel	152,695	156
	Trawler	26,681	39
Other/Undefined	Dive Vessel	19	1
	Drill Ship	1,401	1
	Exhibition Ship	100	1
	High Speed Craft	83,502	20
	Inland	8,575	8
	Local Vessel	3,668	4
	Multi Purpose Offshore Vessel	4,369	1
	NULL	8,332	101
	Offshore Supply Ship	729	4
	Other	39,816	36
	Platform	4,615	3
	Research/Survey Vessel	24,710	7
	Special Vessel	18,990	9
	Training Ship	355	3

NSRA vessel type	AIS vessel type	Number of AIS points	Number of unique vessels
	Unspecified	52,377	51
Passenger	Passenger	93,859	57
	Passengers Ship	83,751	37
	Ro-Ro/Passenger Ship	139,811	7
Pleasure	Pleasure Craft	497,973	1,557
	Sailing Vessel	511,158	1,451
	Yacht	87,403	116
Tanker	Asphalt/Bitumen Tanker	2,228	8
	Chemical Tanker	1,710	13
	Tanker	1,861	16
Tanker – Oil Cargo	Crude Oil Tanker	1,371	6
	Oil Products Tanker	1,854	12
	Oil/Chemical Tanker	15,528	67
Tug/Service	Articulated Pusher Tug	1,180	1
	Buoy-Laying Vessel	7,347	7
	Dredger	3,099	6
	Hopper Dredger	202	1
	Law Enforce	855	5
	Military Ops	28,690	17
	Offshore Construction Jack Up	2,496	1
	Pilot Vessel	24,737	9
	Port Tender	833	13
	Pusher Tug	9,250	6
	Reserved	425	7
	SAR	10,016	29
	Towing Vessel	1,266	4
	Tug	379,733	188
	Utility Vessel	2,539	1

Overview of Vessel Tracks

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

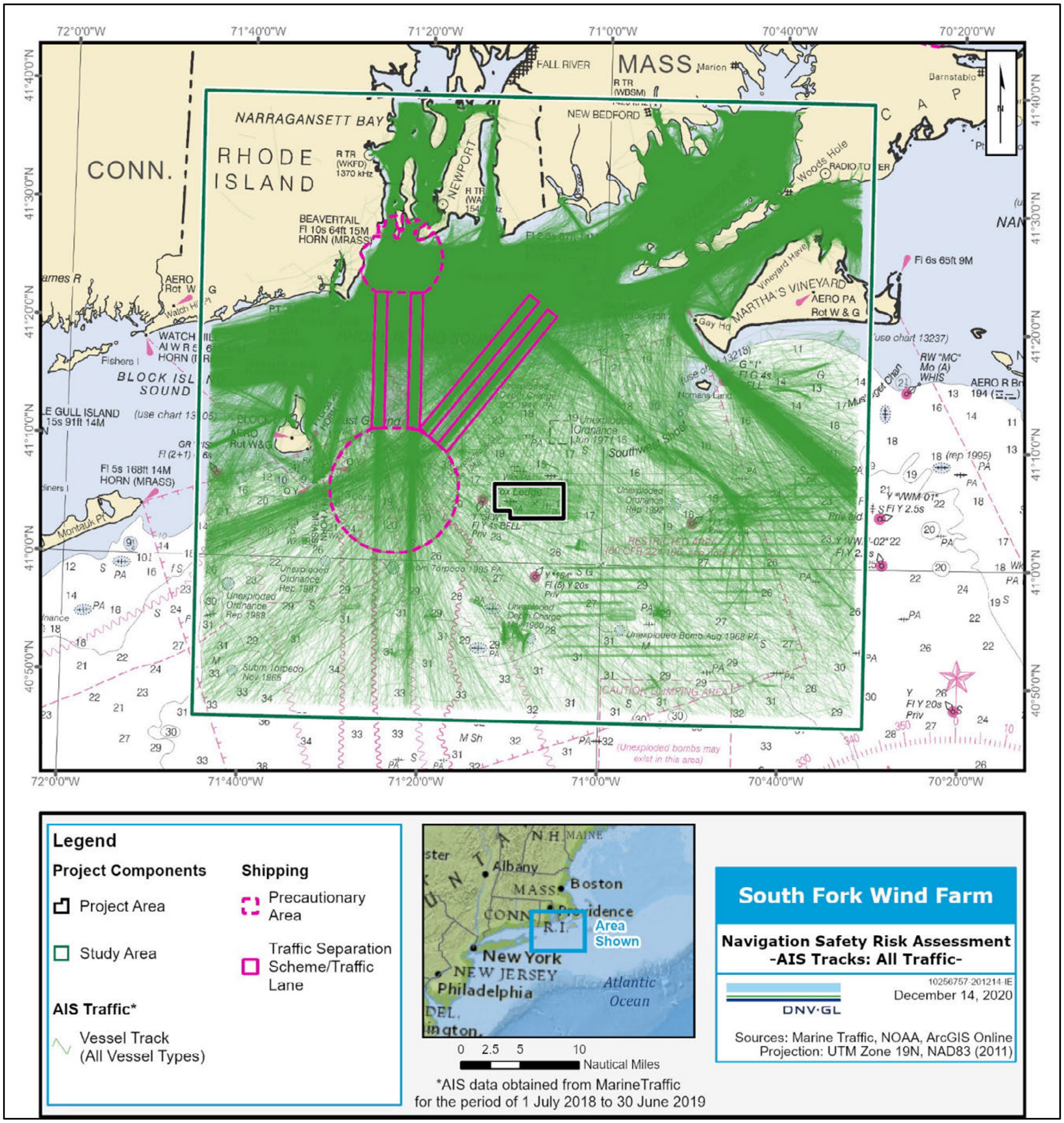

Figure 2-3 All AIS tracks in the Study Area[2]

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

Figure 2-4 shows the AIS traffic in the Project Area.

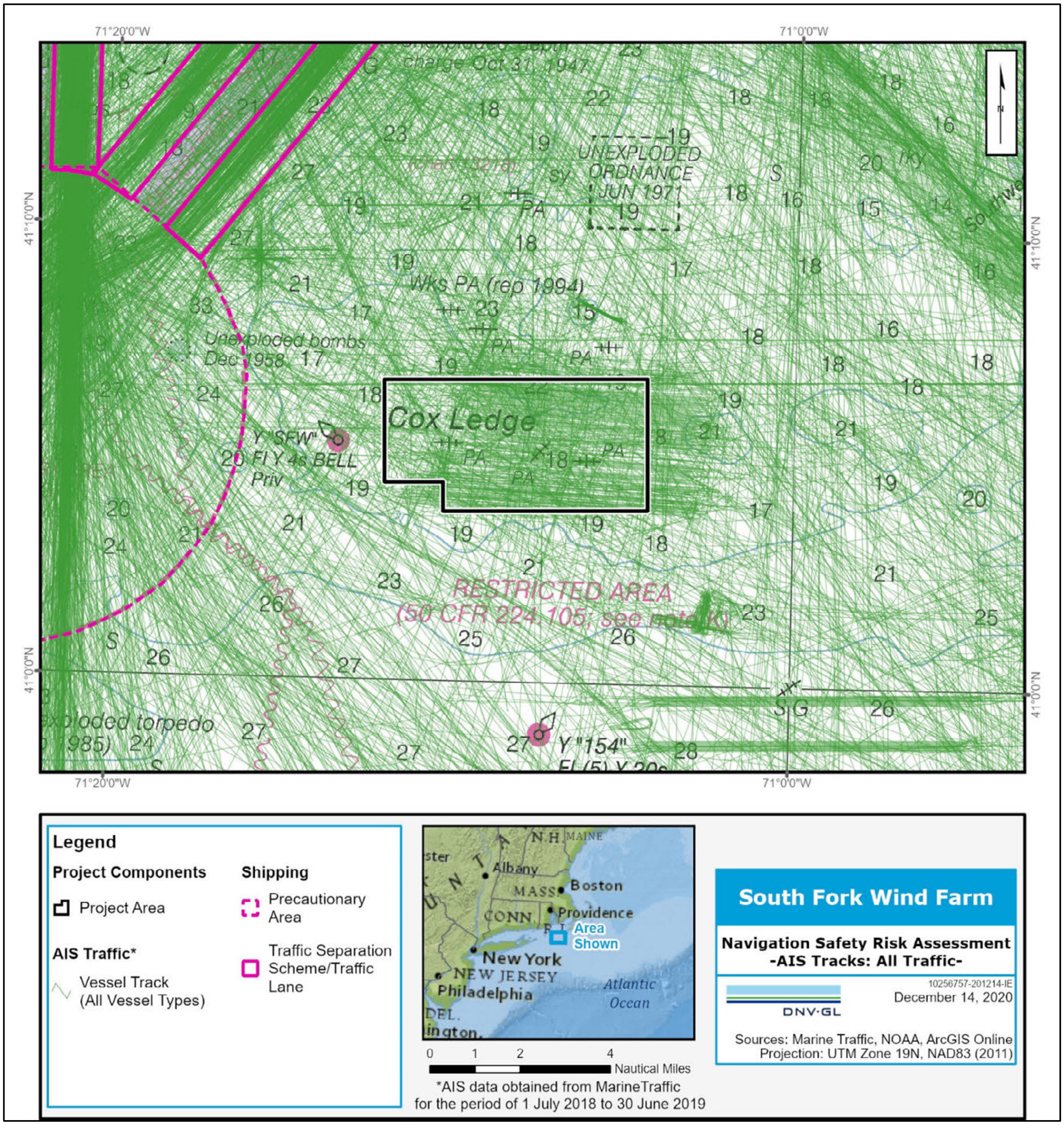


Figure 2-4 All AIS tracks in the Project Area[2]

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

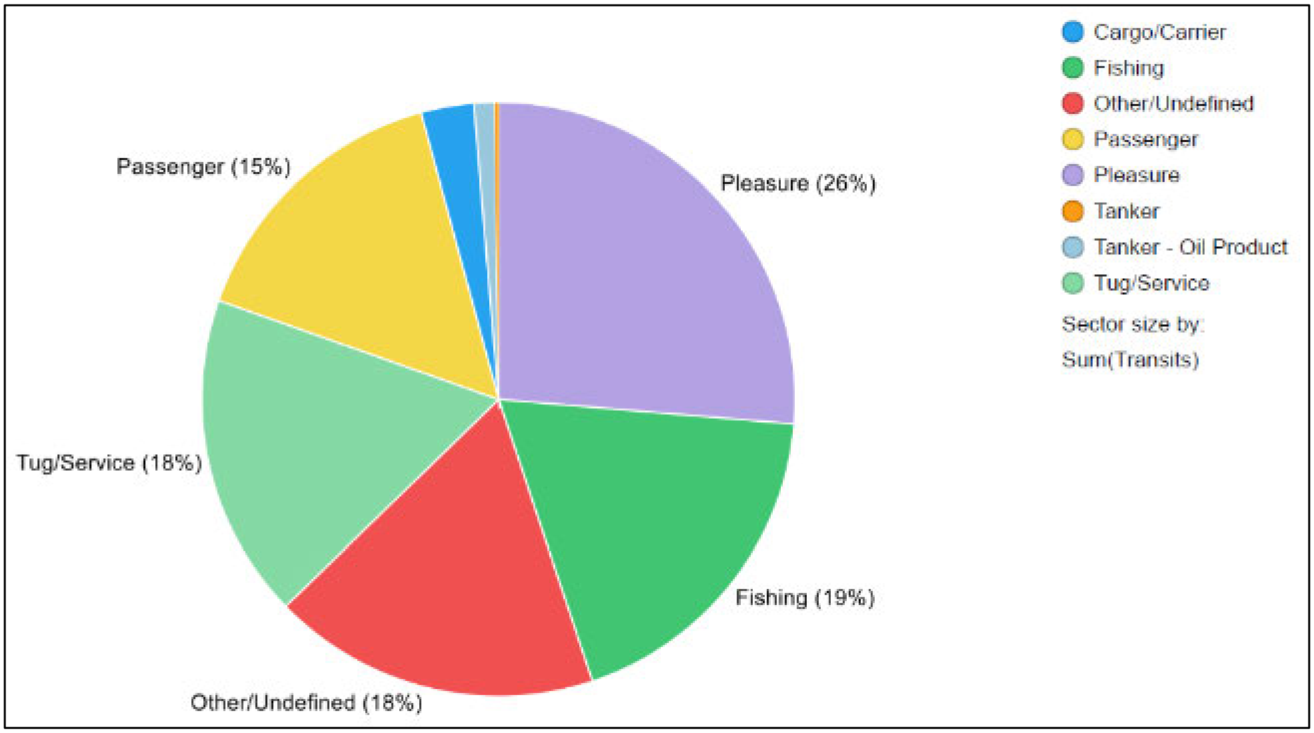


Figure 2-5 Distribution of vessel tracks in the Study Area[2]

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

2.1.1 Traffic patterns

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

- Cargo, carrier, and tanker 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 B.

2.1.1.1 Cargo, carrier, and tanker vessels

Cargo, carrier, and tanker vessels transport goods such as petroleum products, coal, commodities, and food to and from ports in the area. They transit the main shipping routes in the TSS. Cargo, carrier, and tanker vessels predominantly transit two main courses through the larger NSRA Study Area:

- West of the Project Area: southbound and northbound in the Narragansett Bay Traffic lanes.
- North and northwest of the Project Area: between Buzzards Bay and Block Island Sound.

On approach to and departure from the Precautionary Area, the tracks fan outward to the south over 110 degrees; the easternmost tracks cross the Project Area.

Figure 2-6 presents the tracks for cargo/carriers and tankers (those that carry hydrocarbon cargo and those that carry other cargoes). The figure shows that vessels enter and exit the TSS to and from the Precautionary Area, and do not cut the corner to enter/exit along the TSS.

A few cargo/carrier and tanker tracks cross the Project Area when transiting between the Precautionary Area and the NY Shipping Safety Fairway which lies outside of and south of the Study Area. Section 2.1.3.1 provides track counts and traffic statistics for each vessel type. The AIS data show that in the study year, 20 cargo/carrier tracks and 13 tanker tracks transited through the Project Area.

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

Traffic added to AIS for the purpose of risk modeling

The AIS vessel tracks for cargo/carrier and tanker vessels were used to define most of the transits in the model to estimate the risk of collision, allision, and grounding presented in Section 11. Table 2-2 summarizes the transits that were added to the model based on information from other sources.

No regulatory restrictions are anticipated that would prevent vessels of any type from transiting the Project. However, maritime pilots and captains in international and coastal trade have consistently indicated that they will route around the Project. Therefore, this NSRA assumes that after the Project is constructed, all deep draft traffic will take routes around the BOEM wind energy leases.

Table 2-2 Cargo/carrier and tanker vessel transits added to the AIS tracks for risk modeling

Vessel type and activity	Additional tracks	Routes	Model Case
Carrier – Liquified Petroleum Gas (LPG) cargo	8 transits each way USCG MARI PARS identified 6 to 8 LPG trips each way (USCG, 2020a)	Base Case –current inbound and outbound routes between the Narragansett Bay TSS from the NY Shipping Safety Fairway and vice-versa Future Case – strict north-south route between the Narragansett Bay TSS to and from the NY Shipping Safety Fairway (avoiding the BOEM wind energy leases)	Base Case and Future Case

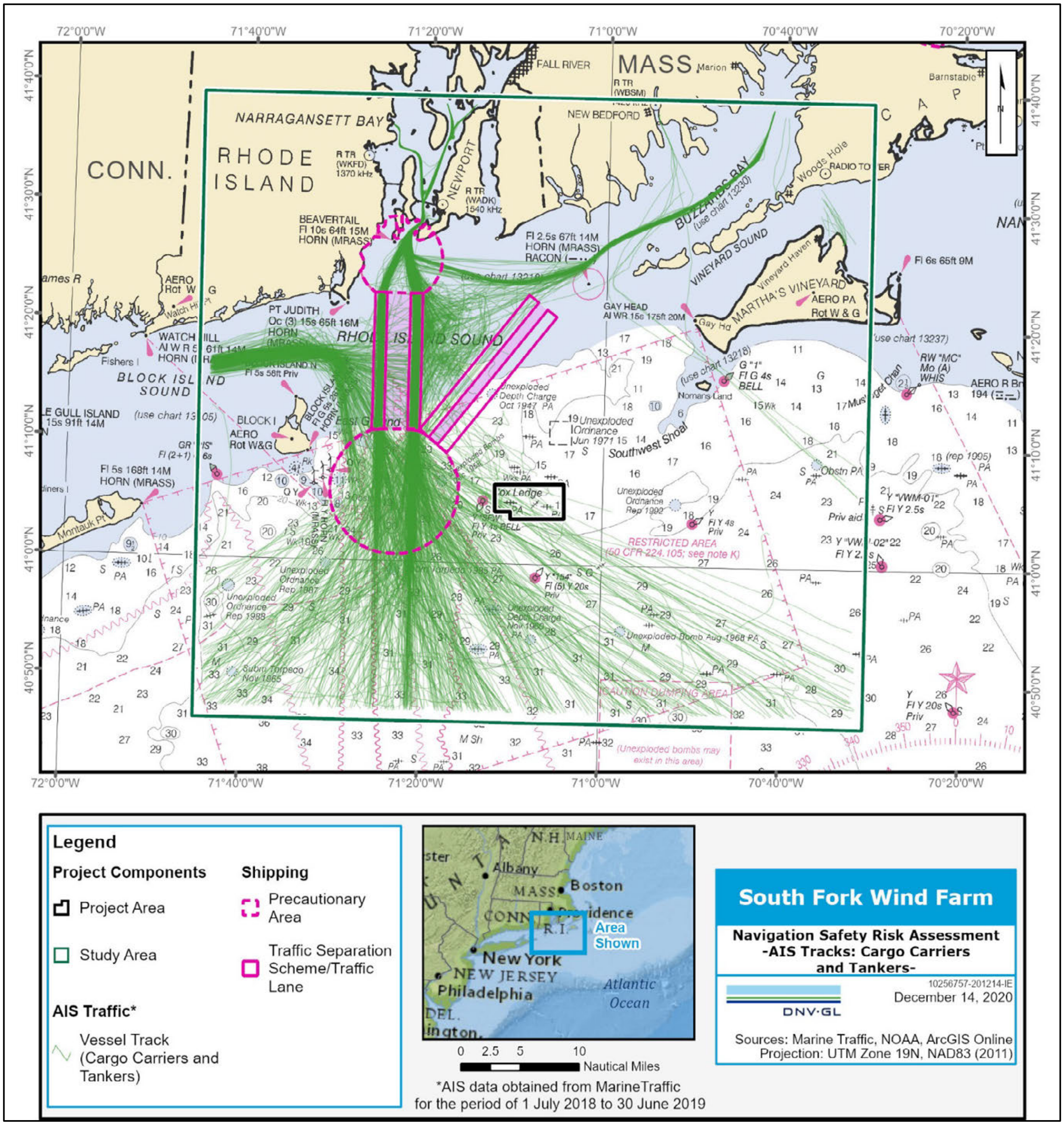


Figure 2-6 AIS tracks for cargo, carrier, and tanker vessels[2]

2.1.1.2 Commercial fishing vessel traffic

In contrast with cargo/carrier traffic, commercial fishing vessels do not follow a set of common routes, although there are a few apparent routes in the AIS data.

A large proportion of the fishing vessels in regional ports are not required to carry and transmit AIS because they are less than 65 ft in length. Of those that do carry AIS, a study of AIS-based fishing activity by the Food and Agriculture Organization of the United Nations (Taconet et al., 2019) concluded that in the Atlantic waters off the U.S., "…three quarters of the fishing vessels broadcasting AIS use the lower-quality Class B devices, whose reception is poor in most of the area." As a result, the model built to estimate risk includes more fishing vessel traffic than is represented in the AIS data.

The sections below summarize the available information on where fishing vessels have transited in the past, including fishing activity by catch and by gear type, the recently-completed USCG MARI PARS report (USCG, 2020a), and AIS data.

Commercial fishing activity

The fishing locations chosen by commercial fishing boats, 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 will vary over time as well. Fishing activity was evaluated in two ways:

- VMS data that indicate which types of fish were caught in the Study Area.
- VTR data that indicate where specific fishing gear was used in the Study Area.

The raw data are subject to strict confidentiality restrictions, which do not allow for individual vessel tracks or positions to be identified or for the underlying data to be downloaded for uses such as this assessment.

Fishing activity by catch (VMS data)

This section summarizes fishing activity based on VMS data for:

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

Figure 2-7 provides views of commercial fishing activity in the vicinity of the Project Area based on VMS data provided by NMFS for a 12-month period in 2015 through 2016, the most recent year of available data (NROC, 2016). The data are subject to confidentiality restrictions, which do not allow for individual vessel tracks or positions to be identified or for the underlying data to be downloaded for uses such as in this assessment.

The color scale in the figure is based on relative values rather than absolute values. The categories are "Low," "Med-Low," "Med-Hi," "High," and "Very High." An area defined as "High" indicates higher than average fishing activity compared within the Mid-Atlantic region (approximately Virginia to Maine). Fishing activity for monkfish indicates a preponderance of Med-Hi and Med-Low activity throughout the Project Area. Fishing activity for herring, pelagics, squid, and scallops was indicated in some parts of the Project Area. The data show no activity for multispecies groundfish and surfclam in the Project Area.

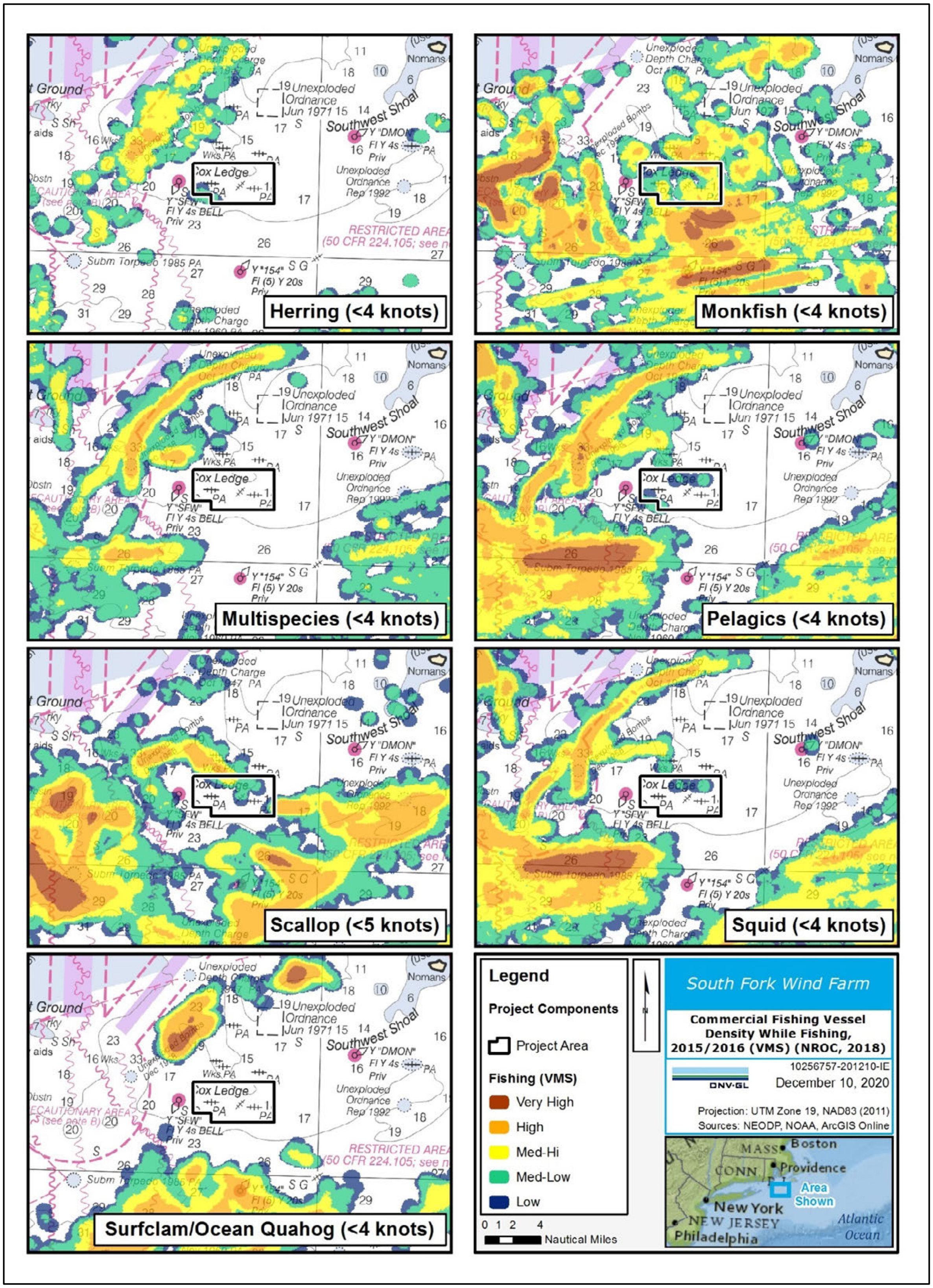


Figure 2-7 Commercial fishing vessel density while fishing, 2015/2016 (VMS) (NROC, 2016)

Fishing activity by permitted gear (VTR data)

The most recent publicly available data were obtained for fishing gear use in the Study Area. The data cover the period 2011 through 2015 and were obtained from Communities at Sea (NOAA, 2016). Figure 2-8 shows activity level by fishing gear type, in order of relative activity in the Project Area.

The data show low levels of commercial gear use in the Project Area. Pots and traps and gillnet use were the highest among the reported gear. Some trawling and dredging were indicated, and no longline activity was reported in the Project Area during the evaluated five-year period.

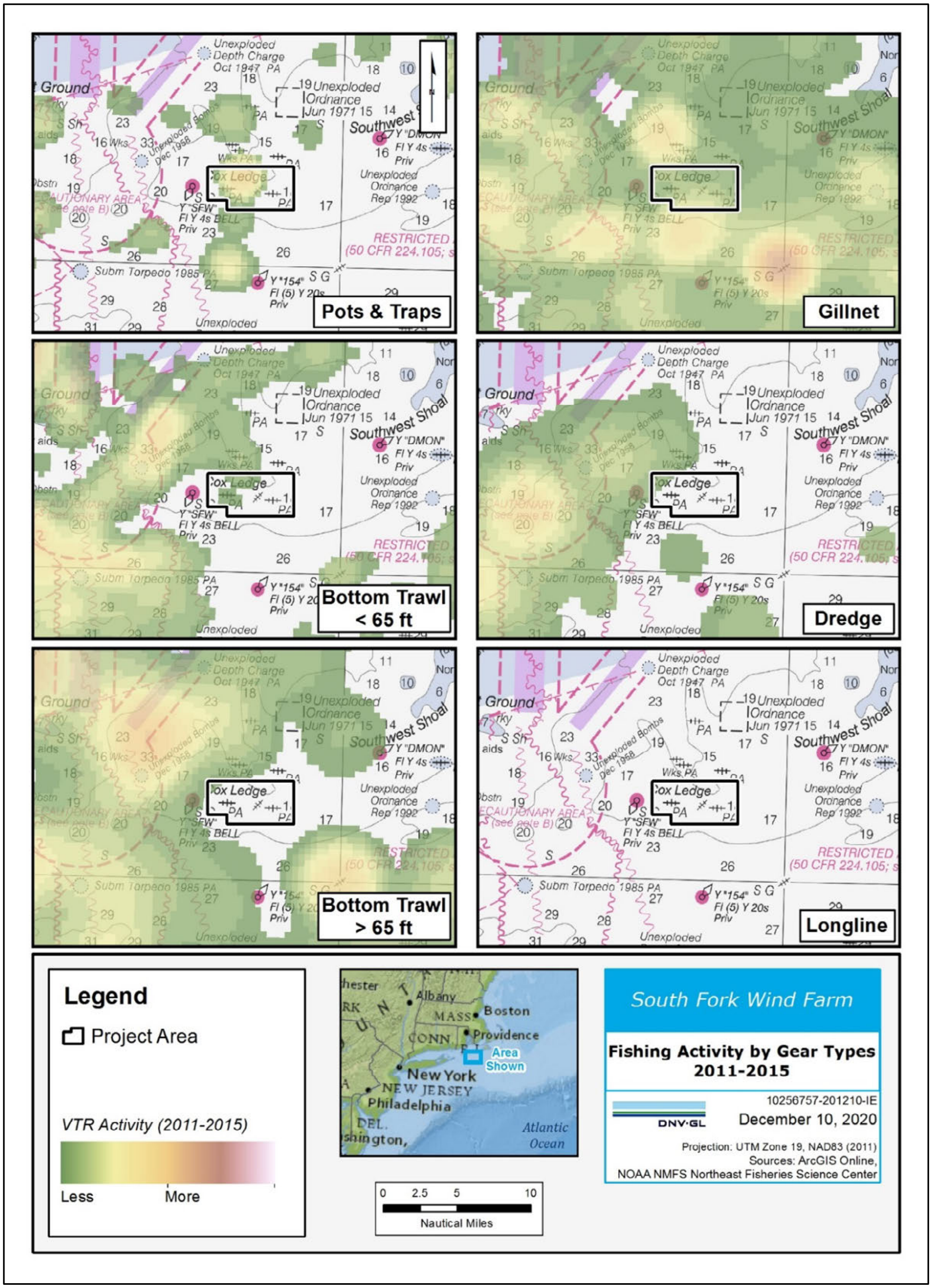


Figure 2-8 Fishing activity by gear types, 2011/2015 (NOAA, 2016)

USCG MARI PARS - additional fishing activity

The USCG MARI PARS report (USCG, 2020a) identified additional commercial fishing activity not included in the AIS data: fishing for squid, mackerel, butterfish, and lobster. This activity is low in the Project Area; it occurs primarily south and east of the Project.

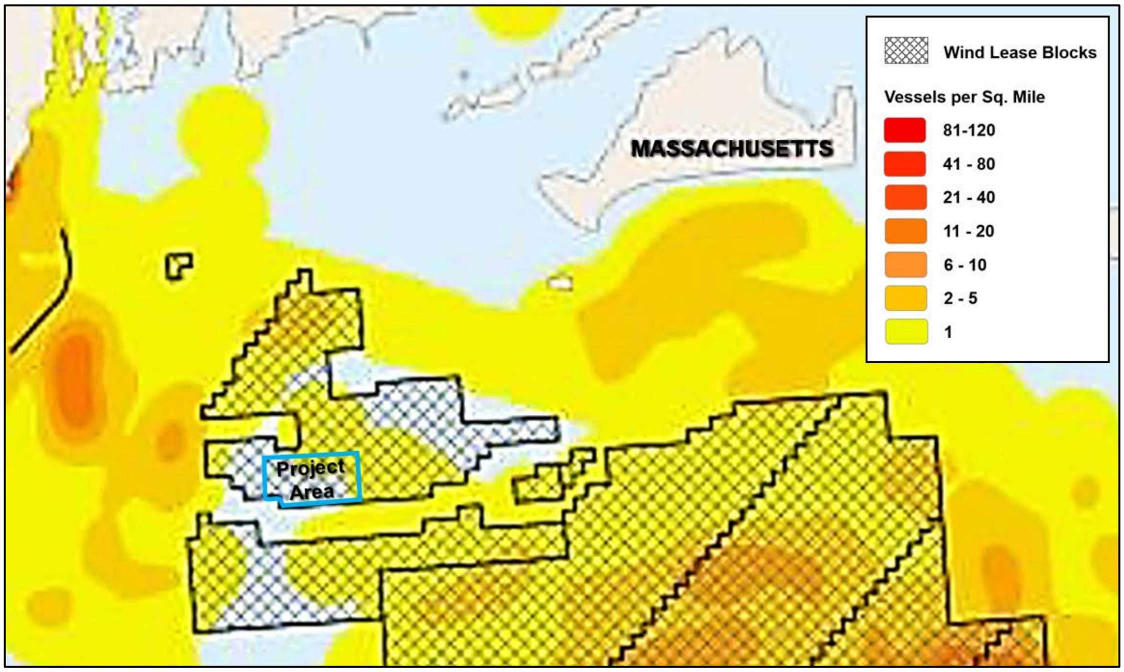


Figure 2-9 Fishing vessel density squid, mackerel, and butterfish, September 2017 (taken from USCG, 2020a)

AIS summary

Figure 2-10 presents the AIS tracks for fishing vessels in the Study Area. The fishing vessel tracks captured in the AIS data show the highest fishing vessel track density in the vicinity of the coastline (north of the Project) and off of Nantucket/Nantucket Shoals (east of the Project). The data shows relatively few fishing vessel transits south of the Project Area. The majority of vessels that fish in the vicinity of the Project berth in the major commercial fishing ports in New England (USCG, 2020a).

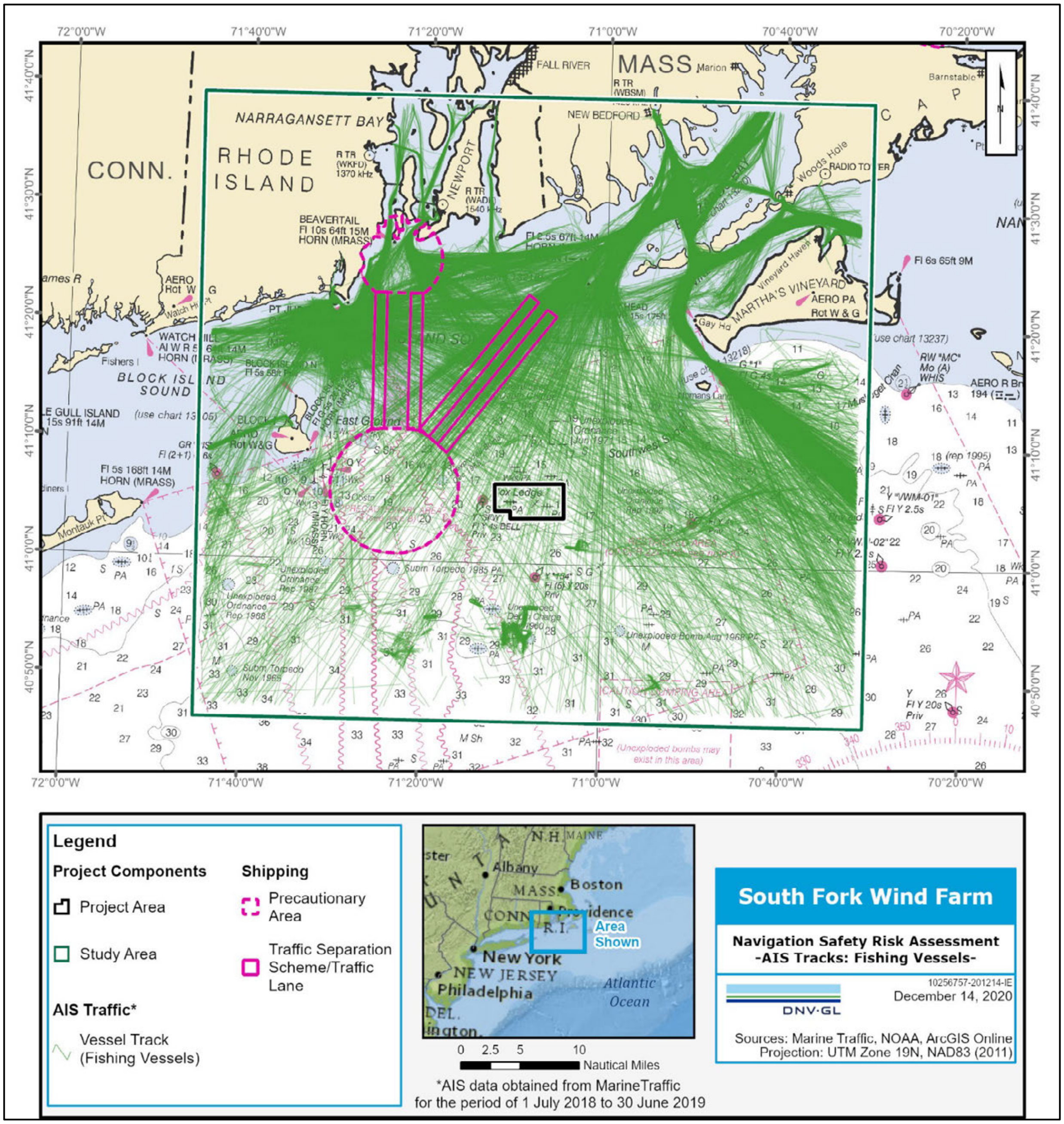


Figure 2-10 AIS tracks for fishing vessels[2]

The NSRA AIS data and the NAIS data presented in the USCG MARI PARS report (Figure 2-11) similarly show that the densest fishing vessel traffic takes a northwest to southeast route from Gay Head, Massachusetts and vice-versa.

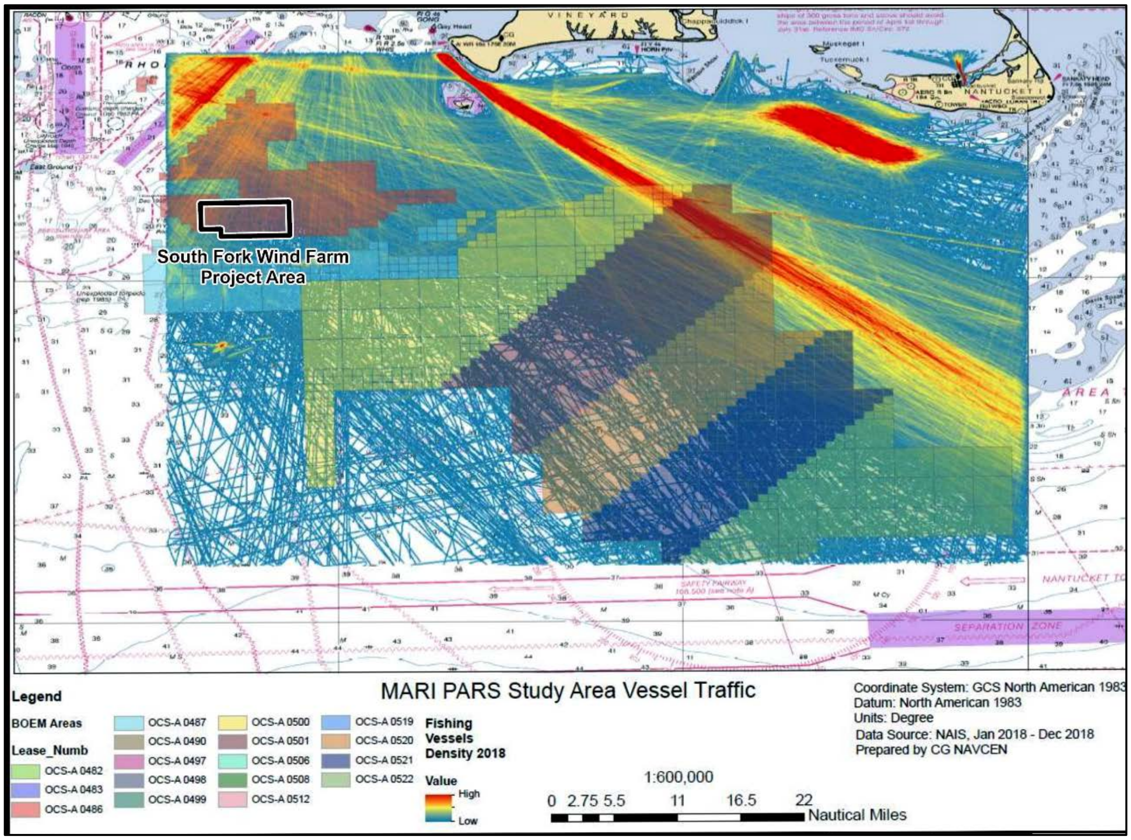


Figure 2-11 Fishing vessel density (taken from USCG, 2020a)

Traffic added to AIS for the purpose of risk modeling

Fishing vessel activity was added to the AIS data in the risk model developed to estimate the Project's effect on navigation risk to account for the lack of vessel track data for fishing vessels. The additional transits and routes are not included in Figure 2-10 or other AIS-based traffic statistics in this report.

The approach to estimate additional fishing transits was to assume that all AIS fishing traffic has length overall (LOA) greater than 65 ft and calculate the "missing" proportion of traffic based on the sizes of registered fishing vessels. Figure 2-12 shows the percentage of vessels longer than 65 ft for each home port state. Approximately 20% of the fishing fleet in the region is longer than 65 ft.

The AIS data show that most of the fishing vessel traffic in the vicinity of the Project originates at ports in Rhode Island, Connecticut, and Massachusetts. Among these three states, Massachusetts provides home ports to more vessels greater than 65 ft LOA; however, based on a review of NAIS data, a significant proportion of vessels departing Massachusetts ports stay near shore, fish in Nantucket Sound, or transit from Gay Head along Nantucket Shoals to other fishing grounds. Because of the larger sizes of vessels with home ports in Massachusetts, use of the Massachusetts data would result in fewer vessels being added to the AIS traffic in the model.

Instead of using the 20% regional average, or even the 19% Massachusetts average, this NSRA chose to use data from Rhode Island and Connecticut as inputs to the model because (1) the AIS data support that more vessels from these closer states transit in the vicinity of the Project Area and (2) inclusion of vessel size data from Massachusetts and New Jersey would be less conservative.

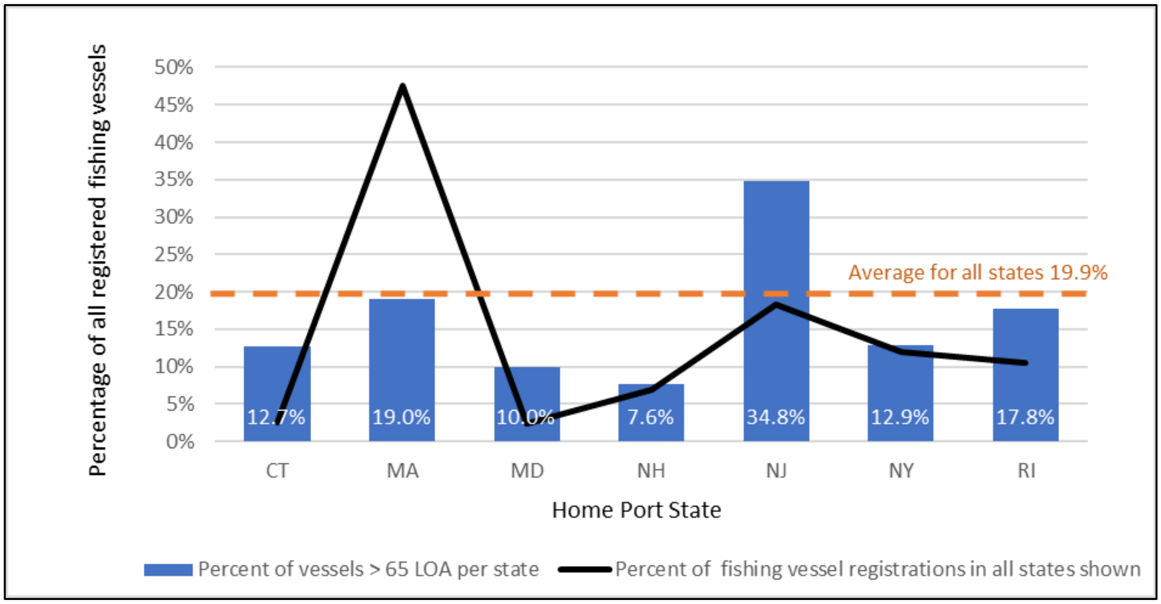


Figure 2-12 Percentage of vessels longer than 65 ft among registered fishing vessels (NOAA, 2020a)

In 2019, 16.8% of the commercial fishing vessels registered in Rhode Island and Connecticut had lengths greater than 65 ft and hence were required to use AIS (NOAA, 2020a). The number of transits in the modeling is scaled up by approximately a factor of six (1/0.0168) to account for the presumed absent 83.2% of vessel transits.

Key assumptions in the estimate are:

- All of the commercial fishing vessels with lengths of at least 65 ft are represented in the AIS data set 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.
- 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.

Table 2-3 summarizes the fishing vessel transits that were added to the model based on information from other sources.

Table 2-3 Fishing vessel (commercial) transits added to the AIS tracks for risk modeling

Vessel type and activity	Additional tracks	Routes	Model case
Non-AIS fishing transits	5.95 multiplied by the number of AIS tracks in each route that is within 12 NM of any Project structure* Based on proportion of registered vessels not required to carry AIS	All current fishing vessel routes	Base Case and Future Case

* 12 NM was selected as a maximum meaningful distance to increase the traffic without unduly increasing the Base Case grounding risk.

2.1.1.3 Passenger vessel traffic

Figure 2-13 shows tracks of both large and small passenger vessels. Large passenger vessels, such as ferries and cruise ships, follow established routes between specific local ports and transit within the Narragansett Bay TSS when approaching and departing ports in the Study Area.

Small passenger routes resemble fishing vessel routes: relatively dense near the coast and without established routes elsewhere.

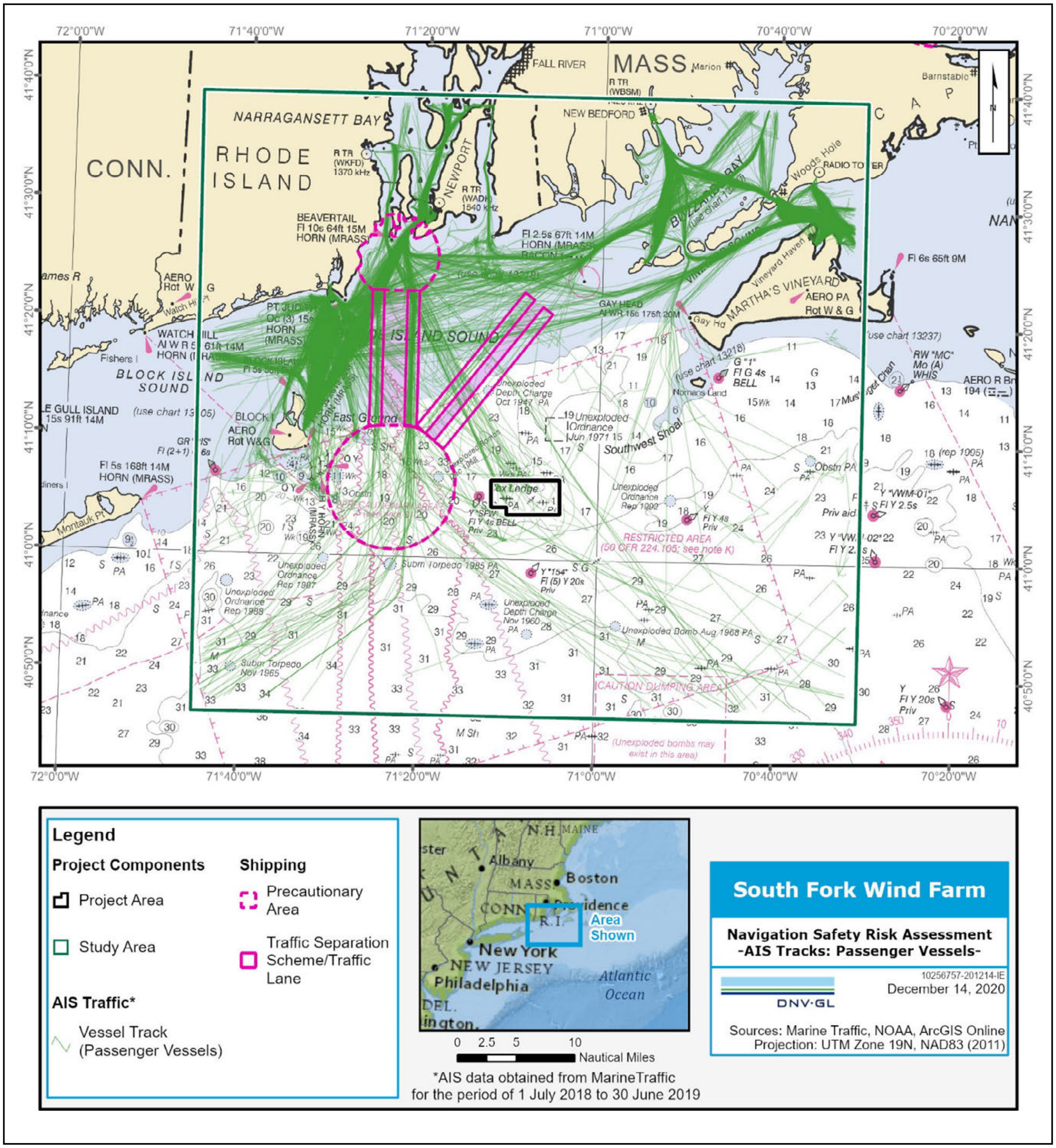


Figure 2-13 AIS tracks for passenger vessels[2]

Traffic added to AIS for the purpose of risk modeling

For the purposes of risk modeling, additional vessel transits were estimated based on USCG's review of future traffic (USCG, 2020a) and added to the AIS traffic (Table 2-4).

Table 2-4 Passenger vessel transits added to the AIS data for risk modeling

Vessel type and activity	Additional tracks	Routes	Model case
Passenger (cruise ships)	50 trips each way. USCG MARI PARS identified anticipated growth in cruise ship visits by 40 to 50 per year (USCG, 2020a)	Base Case – current inbound and outbound routes between the Narragansett Bay TSS to and from the NY Shipping Safety Fairway Future Case – strict north-south route between the Narragansett Bay TSS to and from the NY Shipping Safety Fairway (avoiding the BOEM wind energy leases)	Base Case and Future Case

2.1.1.4 Pleasure vessel traffic

Pleasure vessels include recreational boating and include AIS ship types "Pleasure Craft," "Sailing Vessel," and "Yacht". The data show pleasure and recreation vessel traffic primarily occurs near the coast (Figure 2-14), with relatively few tracks in the Project Area. Most of the AIS tracks that go through the Project Area have either northwest-southeast or southwest-northeast directionality.

To provide additional information on recreational boating, boater density was reviewed from the 2012 Northeast Recreational Boater Survey. This was a randomly selected survey of registered boaters conducted by SeaPlan, the Northeast Regional Ocean Council (NROC), states' coastal agencies, and marine trade associations (SeaPlan, 2013). AIS and the boater survey indicate that recreational traffic passes through the Project Area.

In addition to boating density, data on locations were reviewed for activities such as fishing, swimming, and scenic enjoyment from the Mid-Atlantic Boater survey (Urban Coast Institute at Monmouth University et al., 2014) identified. No activities were identified in the Project Area.

Traffic added to AIS for the purpose of risk modeling

For the purposes of risk modeling, additional vessel transits were estimated based on the possibility that there will be public interest in the Project that could lead to pleasure tours of the wind farm and an increase in recreational traffic (including recreational fishing). It is difficult to estimate a precise number of vessels per year that will be added to local traffic patterns. To incorporate the potential tours, excursion, and recreational (including recreational fishing) traffic surrounding the Project, it is assumed that there will be 100 trips per year. This is a conservative 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 or may be replaced by fishing activity. This study aims to present the conservative case with the most probable traffic, as opposed to an average traffic scheme over a longer period. The additional traffic in the Future

Case is included in the Pleasure vessel category and is allocated a new route from Narragansett Bay to the Project Area.

Table 2-5 Passenger vessel transits added to the AIS data for risk modeling

Vessel type and activity	Additional tracks	Routes	Model case
Pleasure	Increase the AIS tracks by scaling by the same factor used for fishing vessels, approximately a factor of six (1/0.168)	All routes within 5 NM (9.3 km) of the Project Area. This distance was chosen to capture traffic between the Project and Buzzards Bay TSS.	Base Case and Future Case
Pleasure	100 additional tracks each way	Equally assigned to two routes ending along a centerline in the Project Area. One route originates in Nantucket Bay and the other at Pt. Judith.	Future Case

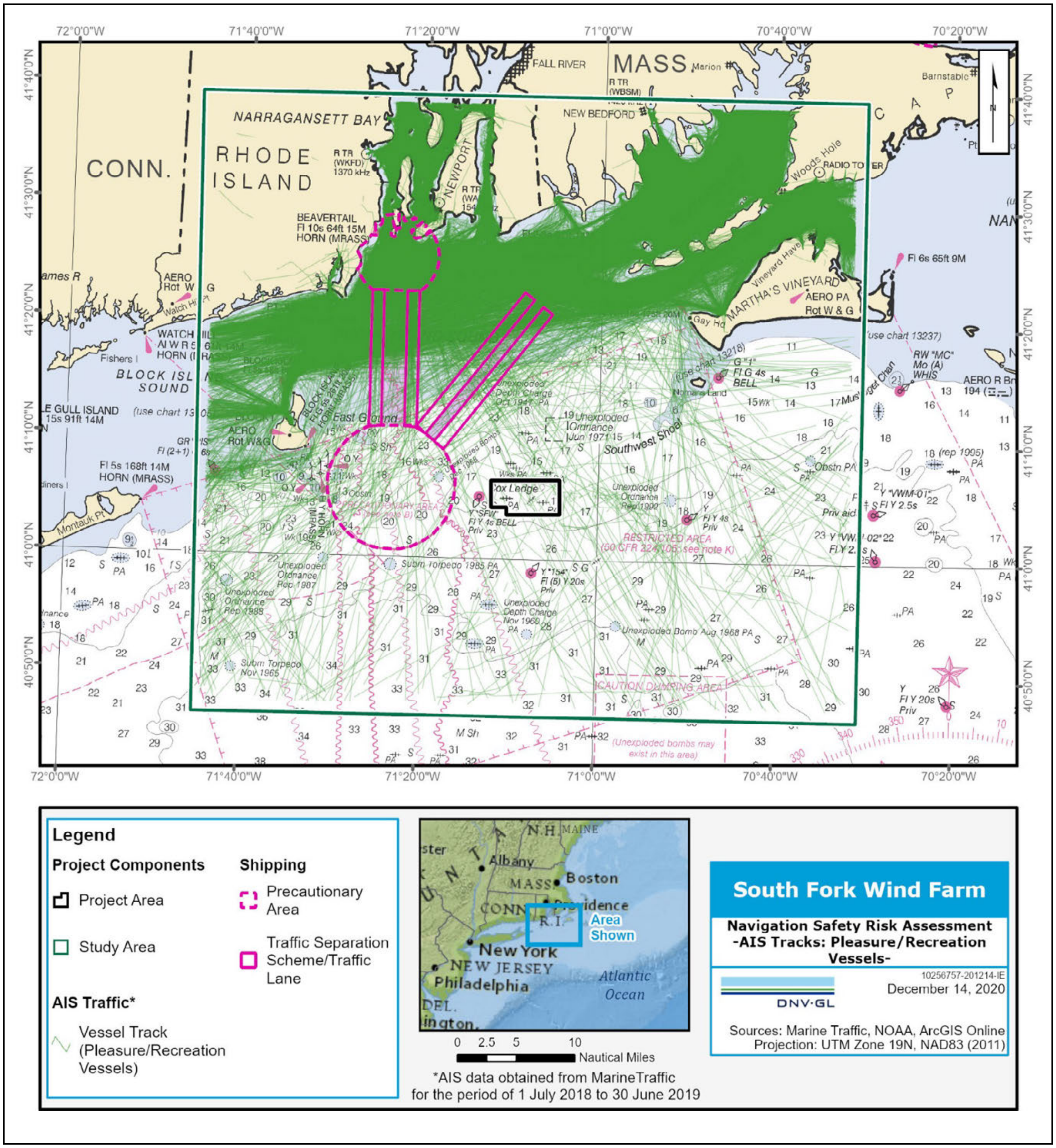


Figure 2-14 AIS tracks for pleasure / recreation vessels[2]

2.1.1.5 Tug/Service traffic

The AIS tracks for tugs and service vessels show distinct patterns, as seen in Figure 2-15. Nearly all tug tracks transit coastwise and do not enter the Project Area. Tugs are the primary identifiable vessel type taking the Buzzards Bay TSS northwest of the Project.

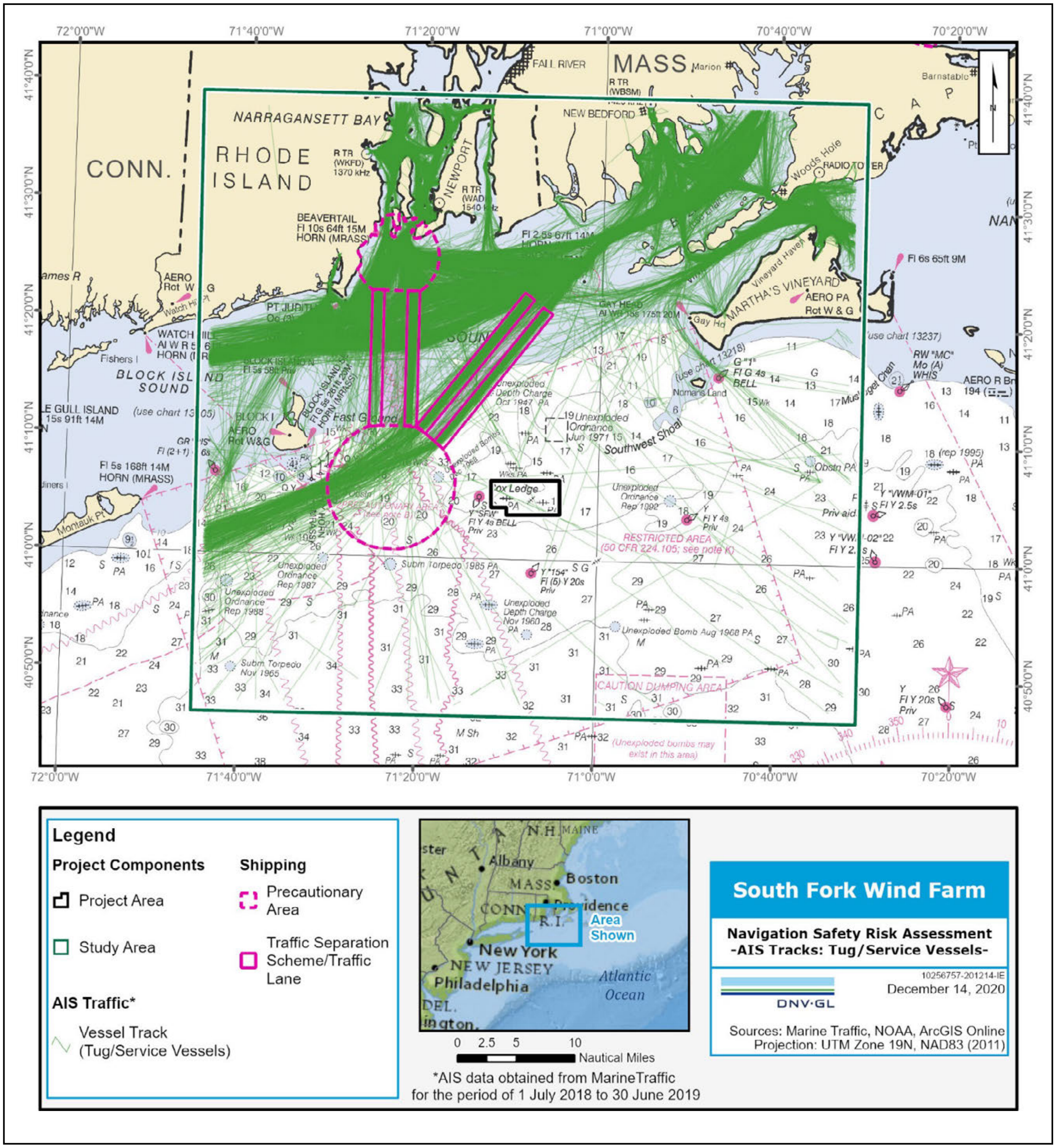


Figure 2-15 AIS tracks for tugs[2]

2.1.1.6 Other vessel traffic

AIS tracks for “Other” vessel types are presented in Figure 2-16. 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 Area. Vessel tracks outside the Project Area are likely to also include commercial fishing vessels headed to common fishing areas (USCG, 2020a).

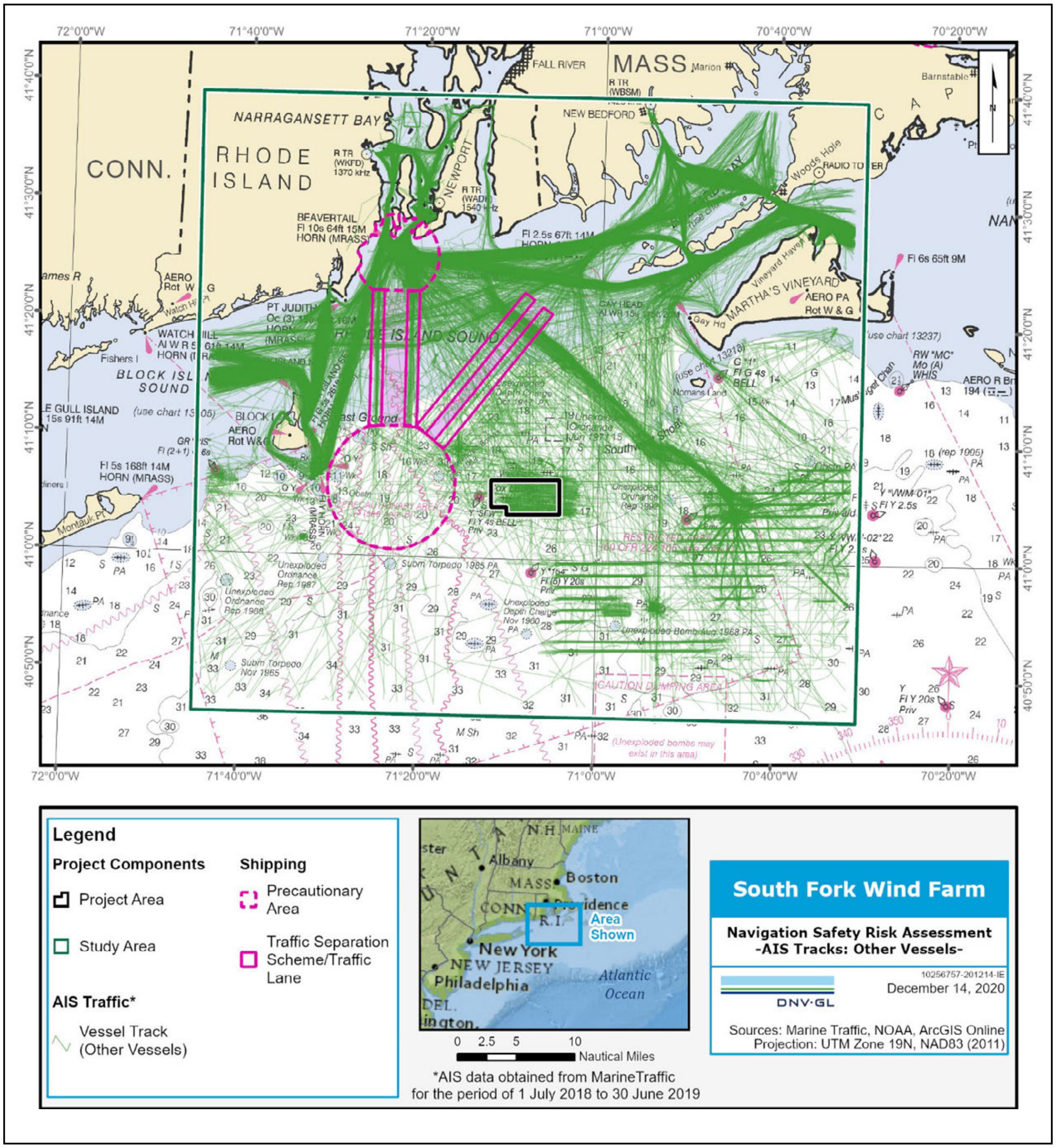


Figure 2-16 AIS tracks for other vessels[2]

Figure 2-17 shows the tracks of research/data-gathering vessels in the Project Area. These were included in the risk model because their tracks can account for maintenance vessel activity during the operational phase.

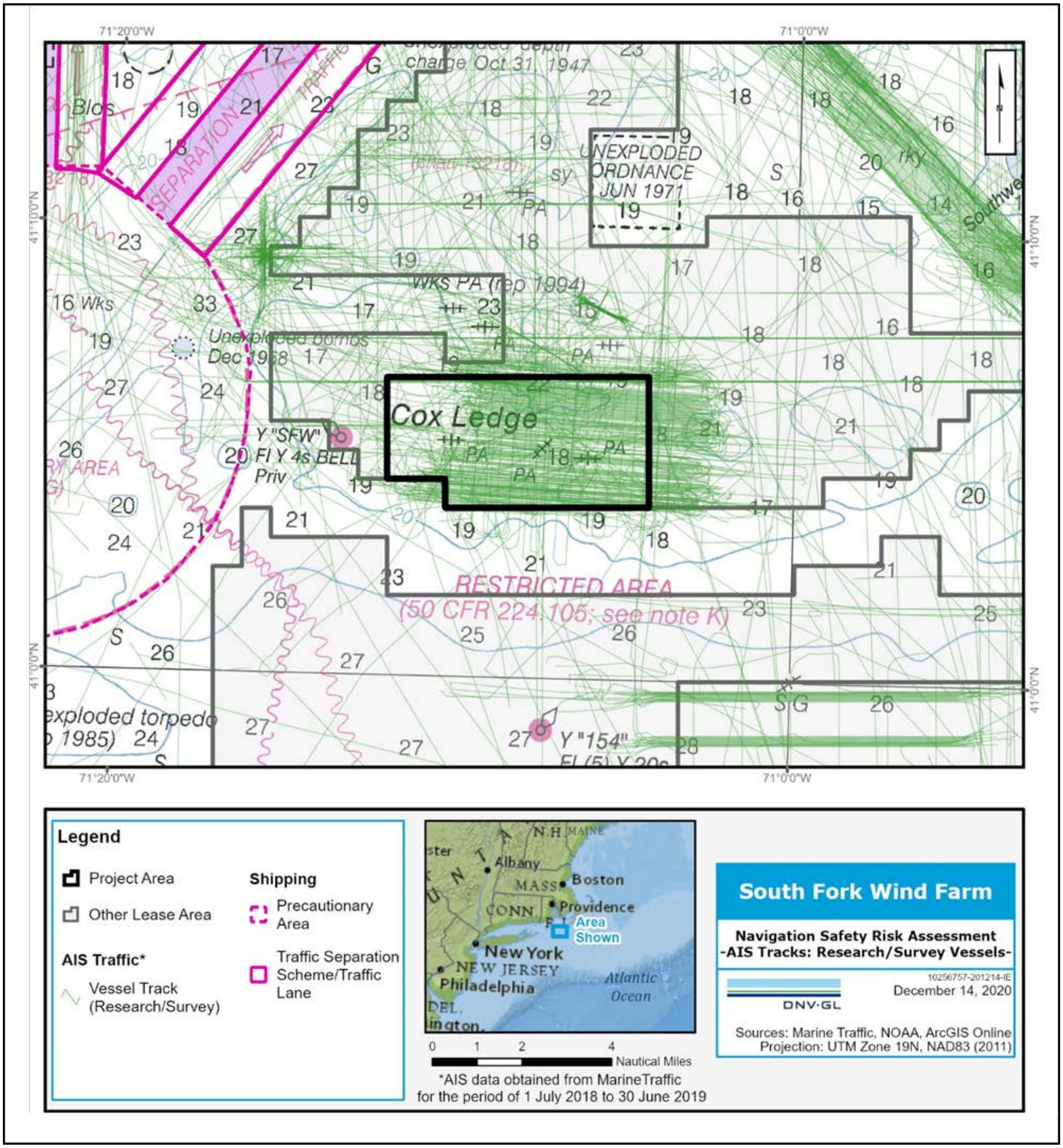


Figure 2-17 AIS tracks for research/survey vessels[2]

2.1.2 Traffic density

Figure 2-18 presents a density heat map for all AIS points in the Study Area. The traffic density shows that vessels are significantly closer together in space and time near the coast and in the TSS. Density maps for each ship type are provided in Appendix B.

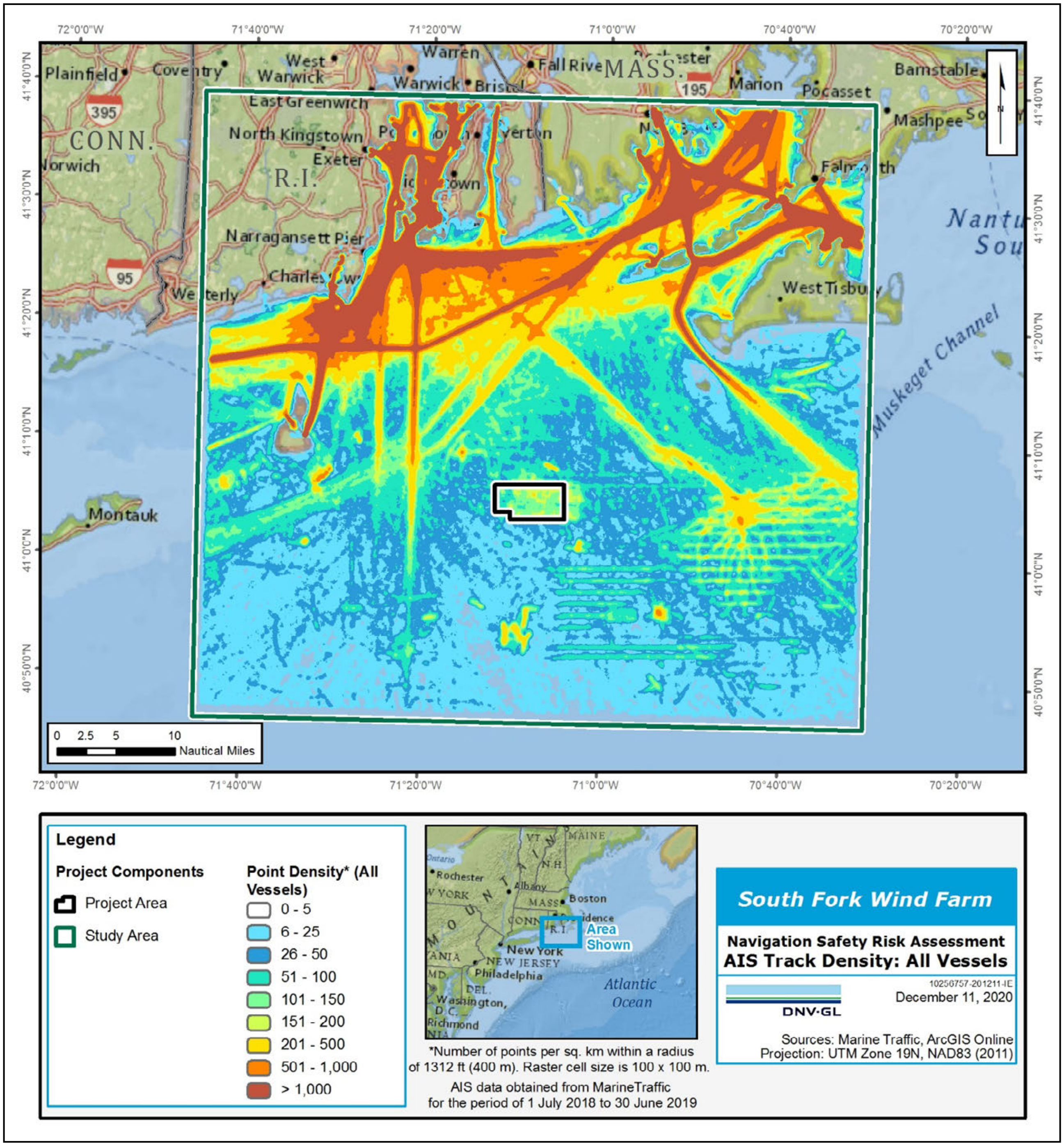


Figure 2-18 AIS point density[2]

2.1.3 Traffic statistics

This section presents the traffic statistics of the 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 and pleasure vessel counts may underrepresent the actual level of activity.

2.1.3.1 Transit counts

Transit counts per transect

Figure 2-19 shows the transects defined for this traffic analysis. The locations of the transects were selected to evaluate the major routes in the 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.

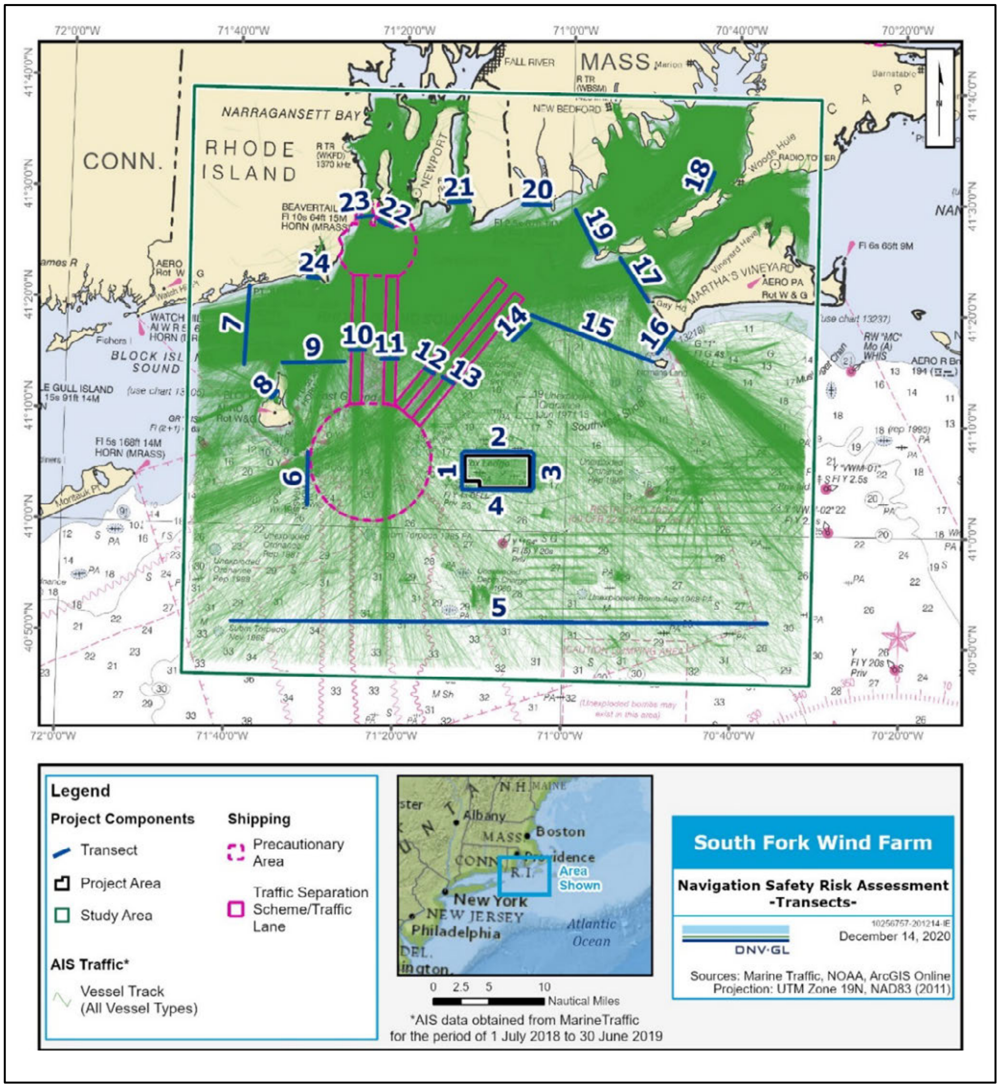


Figure 2-19 Transects used for statistical analysis of traffic[2]

Figure 2-20 presents the total number of transits per transect in the year of AIS data, July 2018 through June 2019.

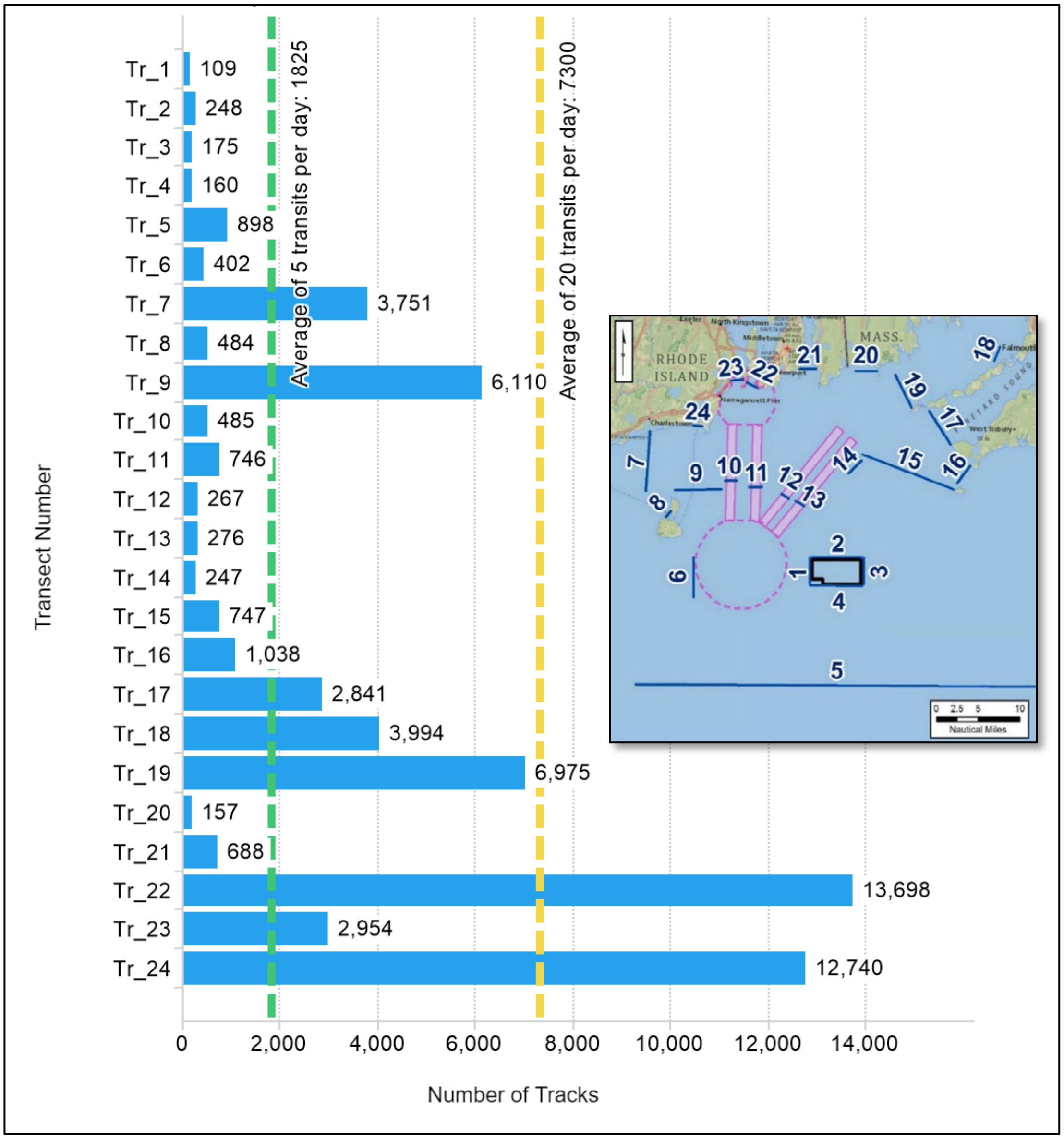


Figure 2-20 Annual number of vessel tracks per transect[2]

More than two-thirds of the transects have very low average traffic levels of less than 5 transits per day (less than 1,825 transits per year). Transects 22 (entrance of Narragansett Bay via East Passage) and 24 (Pt. Judith) have a comparatively higher level of traffic, each with an average of 35 to 38 transits per day, approximately 13,000 per year.

The transects across the TSSs (10 through 13) average 2 tracks per day in the Narragansett Bay inbound lane and less than one track per day in the Buzzards Bay inbound lane.

Of the four transects that surround the Project Area, the largest number of transits is the northern transect (2), with 248 transits. If all 248 occurred in the summer months, it would represent less than 3 transits per day across this transect.

Figure 2-21 through Figure 2-23 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 (including Project survey) vessel types.

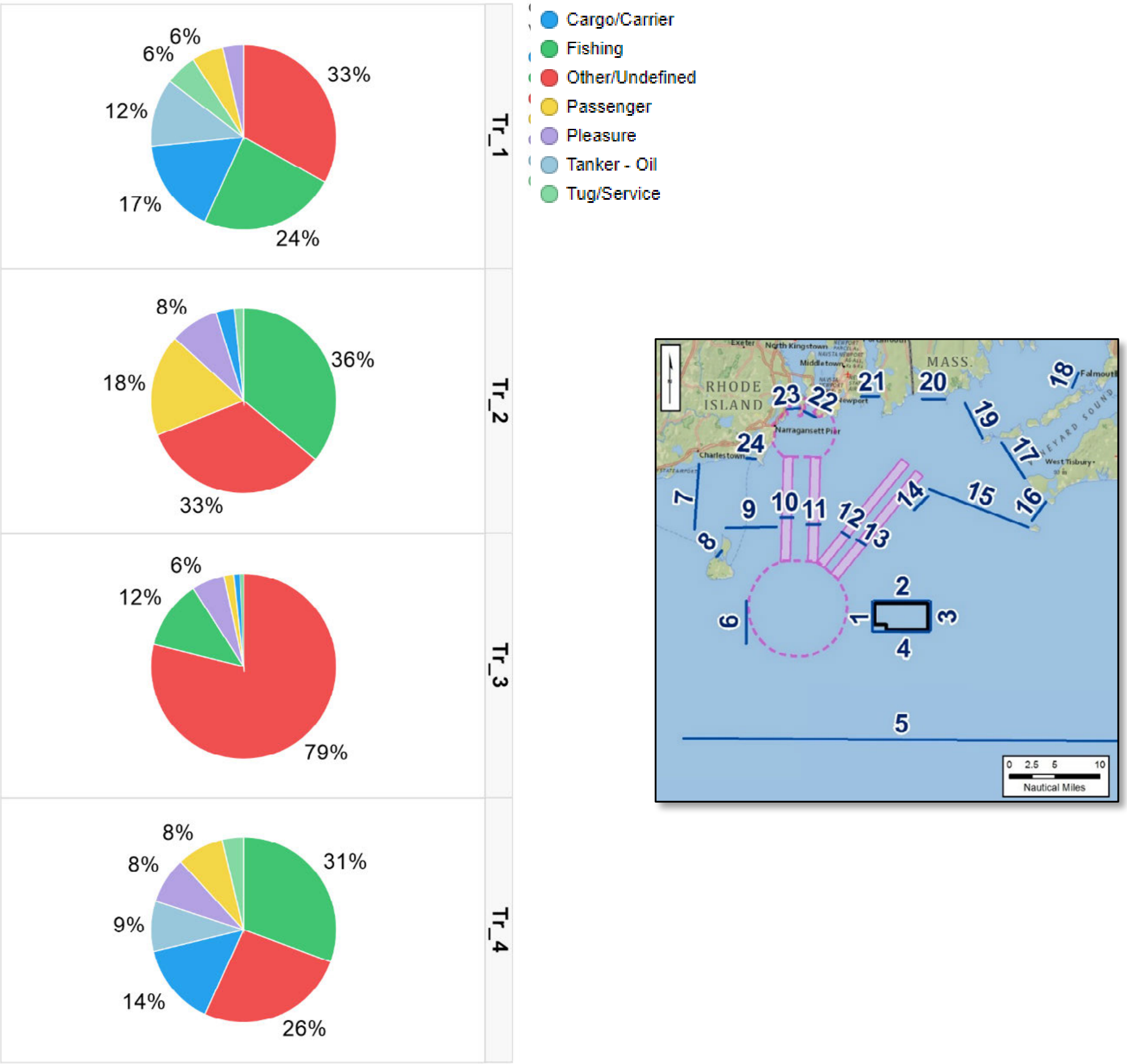


Figure 2-21 Traffic distributions for Transects 1 to 4[2]

In the Narragansett Bay TSS (transects 10 and 11), cargo and carrier vessels comprise a significant portion of the traffic, while in the Buzzards Bay TSS (transects 12 and 13), tugs are the predominant vessel type.

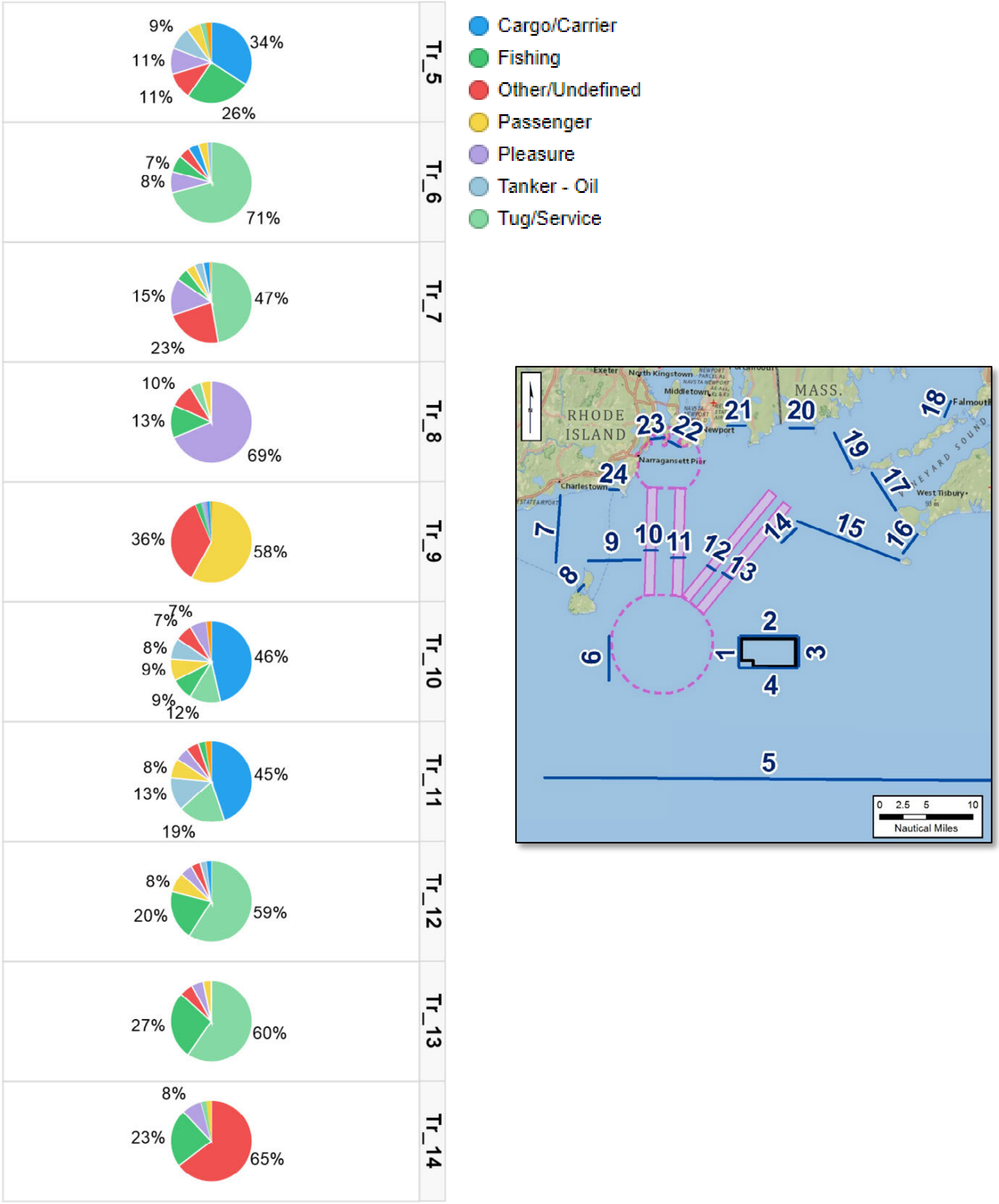


Figure 2-22 Traffic distributions for Transects 5 to 14[2]

Near shore transects show that most of the local port traffic consists of fishing and pleasure vessels.

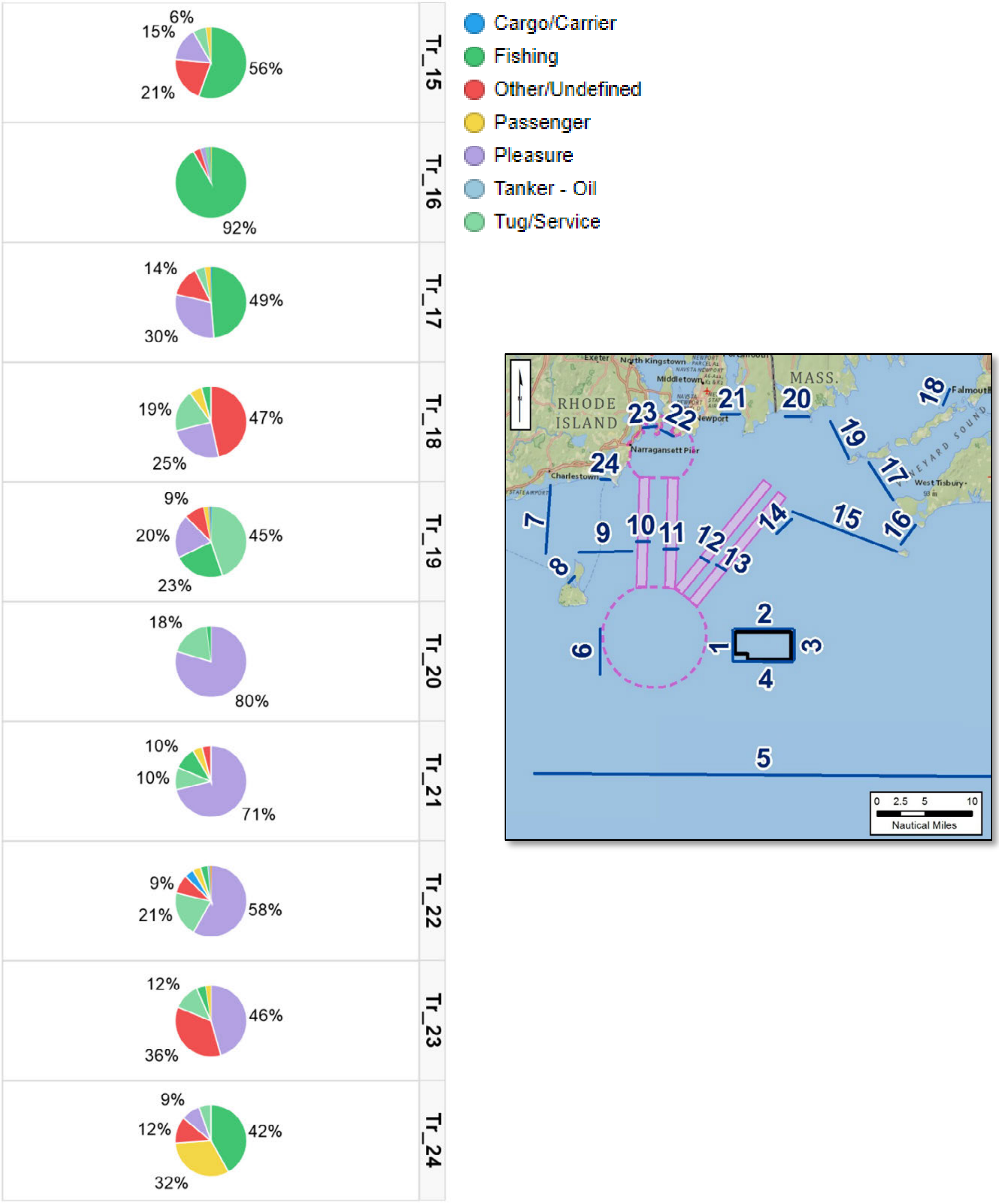


Figure 2-23 Traffic distributions for Transects 15 to 24[2]

2.1.3.2 Vessel size

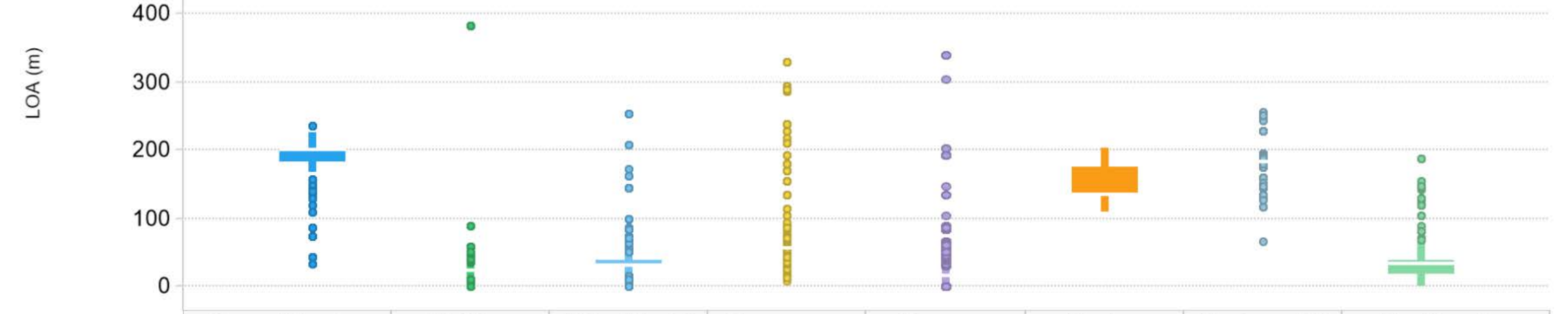
Vessel sizes were evaluated for the entire Study Area and also for an area surrounding the Project to provide clarity concerning the regional and local traffic. A 5-statute-mile area (4.34 NM, 8 km) was defined around the Project for this evaluation based on precedent. Modeling results and analysis of 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. On a percentage basis, vessels without mandatory AIS carriage have less complete AIS data and the 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% 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 DWT in the data is larger than the true average.

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

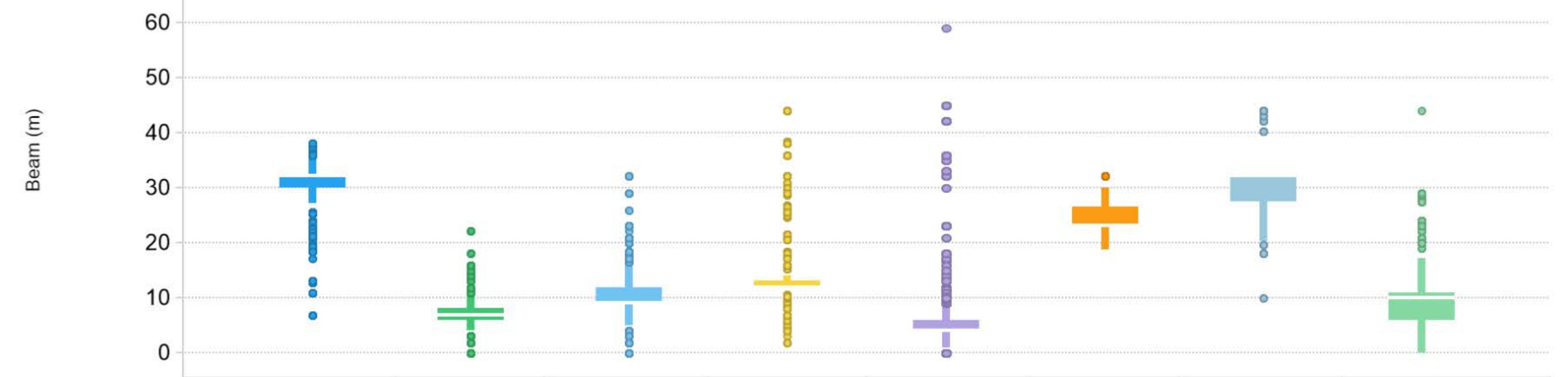
- They provide a general sense of the range of vessel sizes in the general area and close to the Project.
- The ship’s breadth and length are used in the powered and drift allision models, respectively.
- They provide a value for average DWT that is used to estimate allision energies described in Section 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 vessels within the Study Area for LOA, beam, and DWT are provided in Figure 2-24 to Figure 2-26. The highest user inputs for passenger vessels’ LOA and beam have been truncated because these values were likely entered in error.



	Cargo/Carrier	Fishing	Other/Undef	Passenger	Pleasure	Tanker	Tanker - Oil	Tug/Service
Avg	186	23	35	56	19	150	184	32
Median	200	22	30	57	15	133	183	32
Max	236	383	768	330	789	202	256	187

Figure 2-24 LOA distribution in Study Area (m)[2]

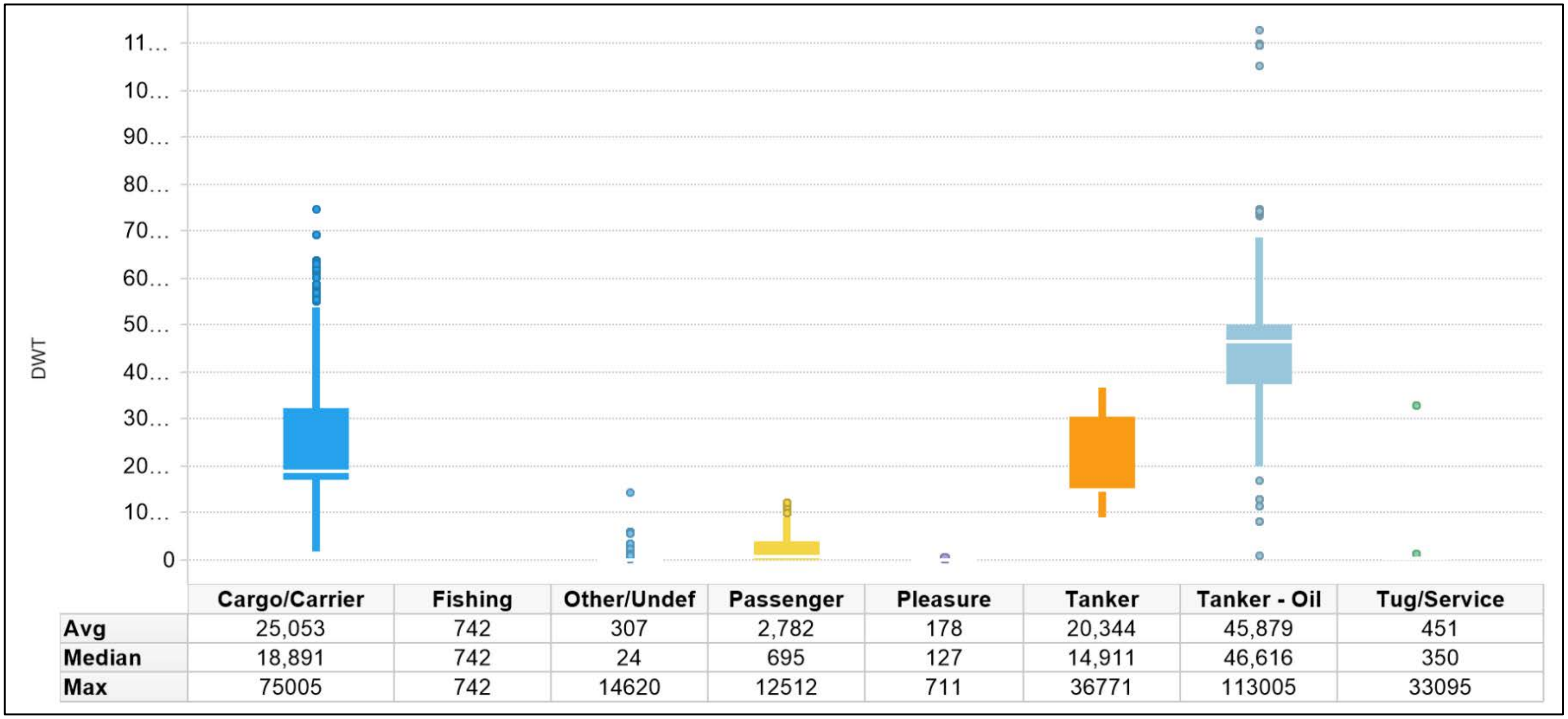


	Cargo/Carrier	Fishing	Other/Undef	Passenger	Pleasure	Tanker	Tanker - Oil	Tug/Service
Avg	31	7	10	12	5	25	30	9
Median	32	7	9	12	4	23	32	10
Max	38	22	32	44	97	32	44	44

Figure 2-25 Beam distribution in Study Area (m)[2]

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% of the transits included credible data in the LOA and beam fields. However, only 18% of the data entries included a DWT value. DWT entries were consistently present for cargo/carrier and tanker vessels; however, only a low percentage of the data included DWT for fishing, pleasure, passenger, tug/service, and other vessel types.

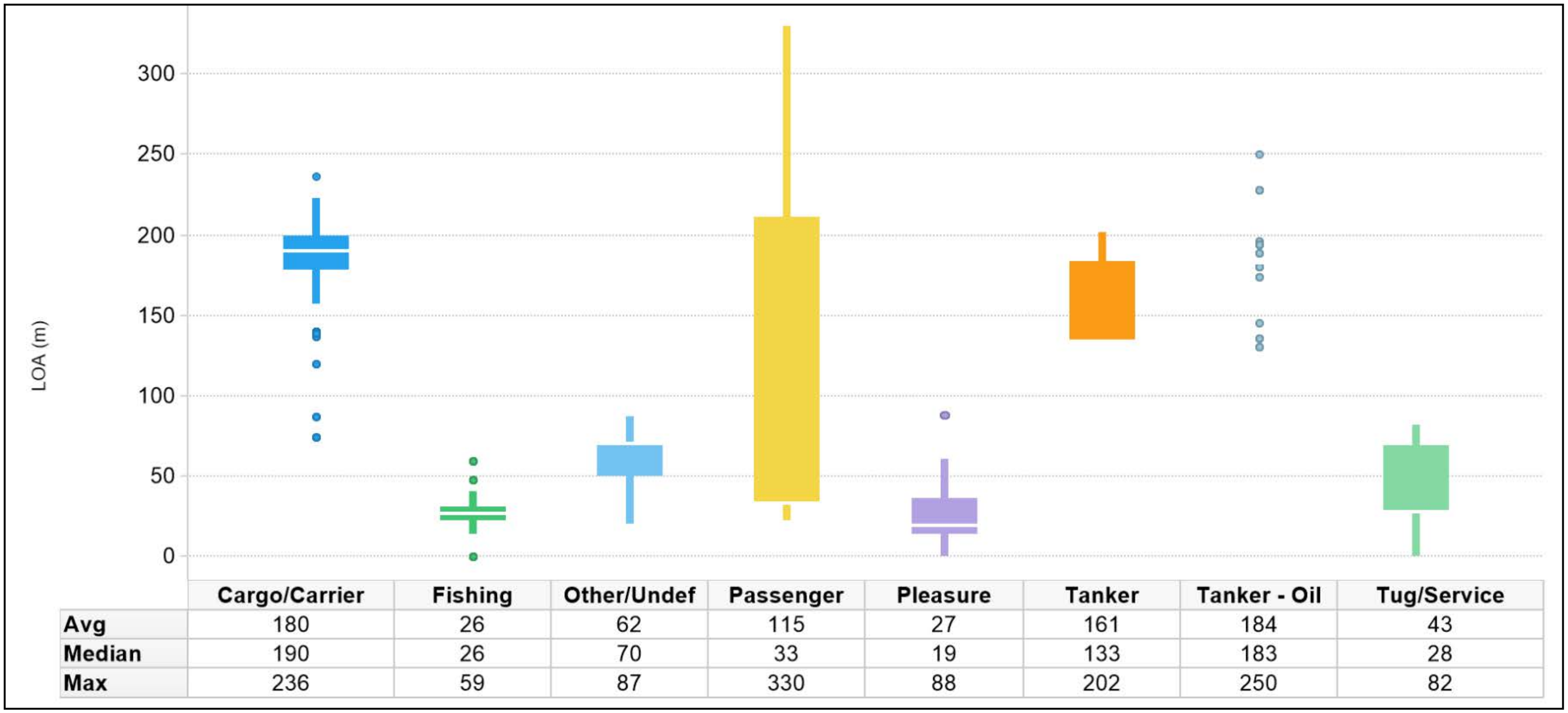
The average and maximum DWT of vessels in the Study Area are shown in Figure 2-26.



	Cargo/Carrier	Fishing	Other/Undef	Passenger	Pleasure	Tanker	Tanker - Oil	Tug/Service
Avg	25,053	742	307	2,782	178	20,344	45,879	451
Median	18,891	742	24	695	127	14,911	46,616	350
Max	75005	742	14620	12512	711	36771	113005	33095

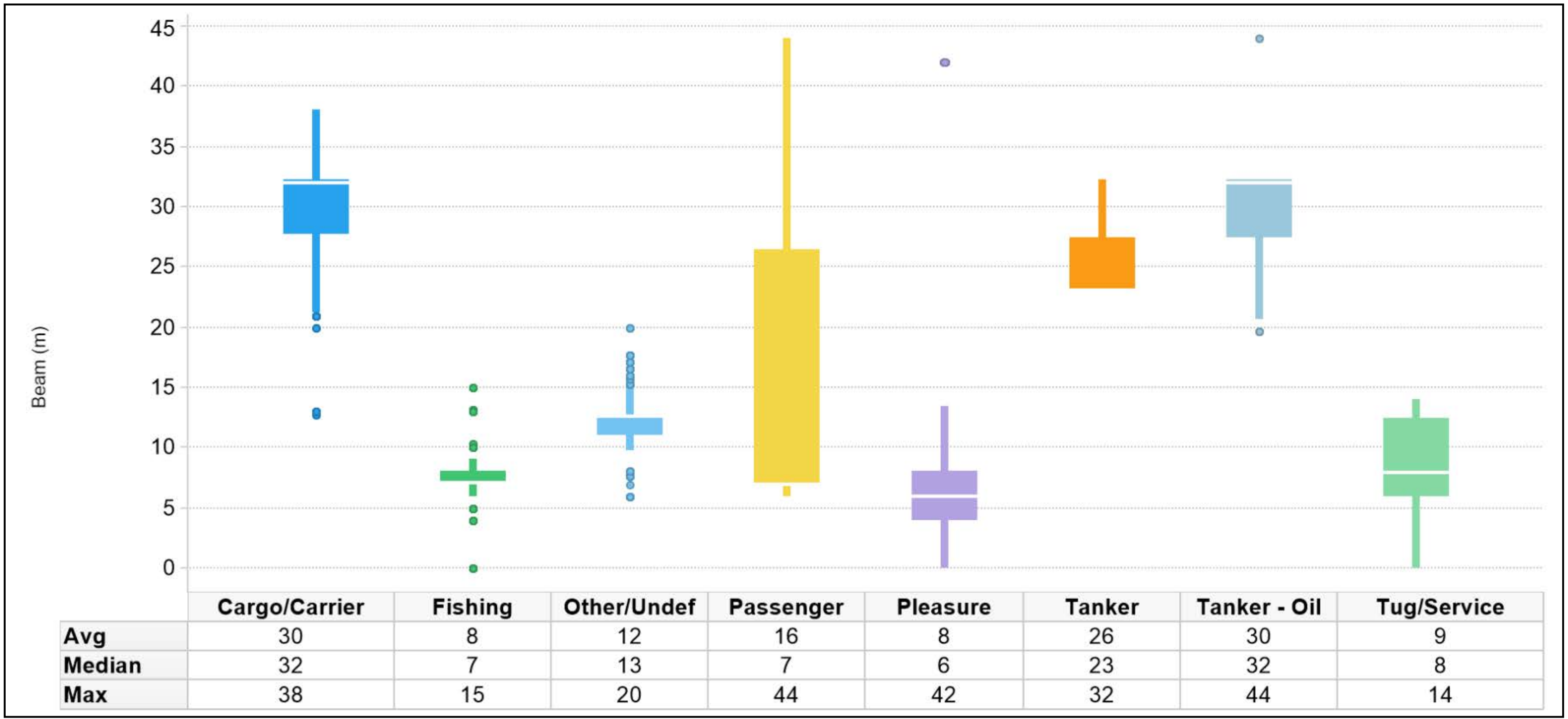
Figure 2-26 DWT distribution in Study Area [2]

Figure 2-27 through Figure 2-29 present statistics for vessels in the vicinity of the Project. The average vessel sizes here are similar to those in the Study Area, with the exception of passenger vessels. Proportionately fewer cruise ships transit in the larger study area than in the nearby Narragansett Bay TSS.



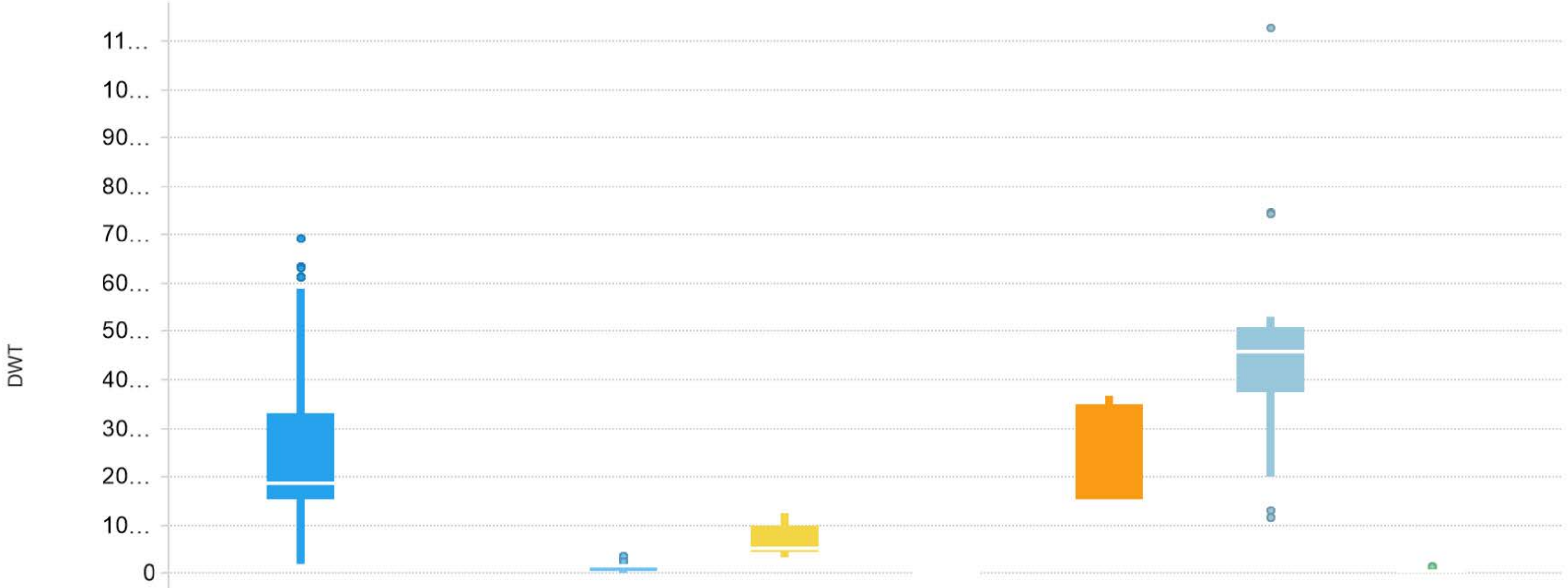
	Cargo/Carrier	Fishing	Other/Undef	Passenger	Pleasure	Tanker	Tanker - Oil	Tug/Service
Avg	180	26	62	115	27	161	184	43
Median	190	26	70	33	19	133	183	28
Max	236	59	87	330	88	202	250	82

Figure 2-27 LOA distribution within 4.34 NM (8 km) of Project Area[2]



	Cargo/Carrier	Fishing	Other/Undef	Passenger	Pleasure	Tanker	Tanker - Oil	Tug/Service
Avg	30	8	12	16	8	26	30	9
Median	32	7	13	7	6	23	32	8
Max	38	15	20	44	42	32	44	14

Figure 2-28 Beam distribution within 4.34 NM (8 km) of Project Area[2]



	Cargo/Carrier	Fishing	Other/Undef	Passenger	Pleasure	Tanker	Tanker - Oil	Tug/Service
Avg	25,609	742	1,266	6,710	150	24,555	44,395	415
Median	18,668	742	1,350	5,013	183	14,911	45,726	350
Max	69304	742	3561	12512	234	36681	113005	1388

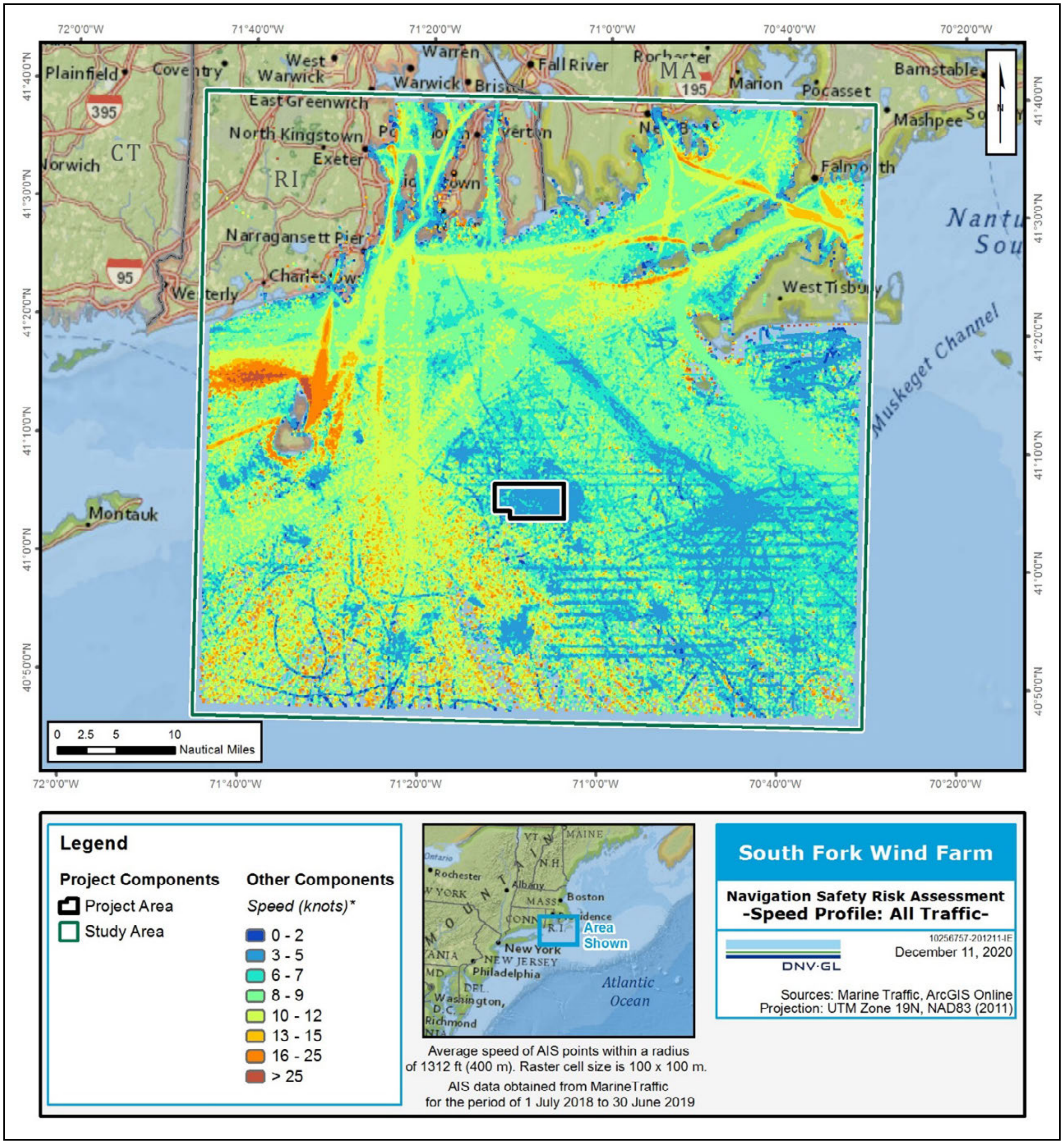
Figure 2-29 DWT distribution within 4.34 NM (8 km) of Project Area[2]

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

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 Study Area.

2.1.3.3 Vessel speed

This section characterizes vessel speeds in the Study Area. Figure 2-30 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.



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

Figure 2-30 Vessel speeds in the AIS data[2]

The speed of 75% of the vessels in the Study Area is between 5 and 15 kt (between 2.6 and 7.7 m/s). Passenger vessels have the highest average speed. Figure 2-31 shows the traffic speed distribution for each vessel type.

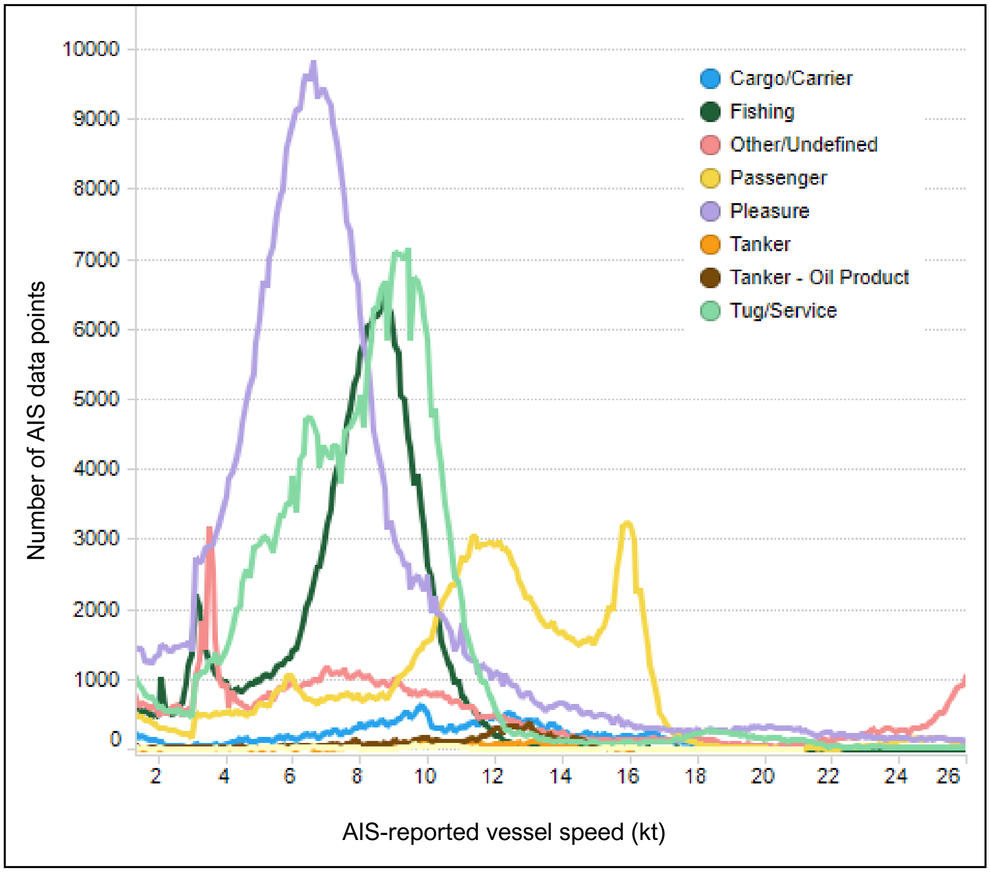


Figure 2-31 Speed profile for each vessel type in the AIS data[2]

2.1.4 Types of cargo

The cargoes arriving and departing at ports in the Study Area include (USACE, 2016 and USACE, 2018):

- 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 2-32 shows the navigation chart around the Project Area and Figure 2-33 shows the export cable route. Analysis of hazards related to the export cable is provided in Section 3.1 and Section 4.

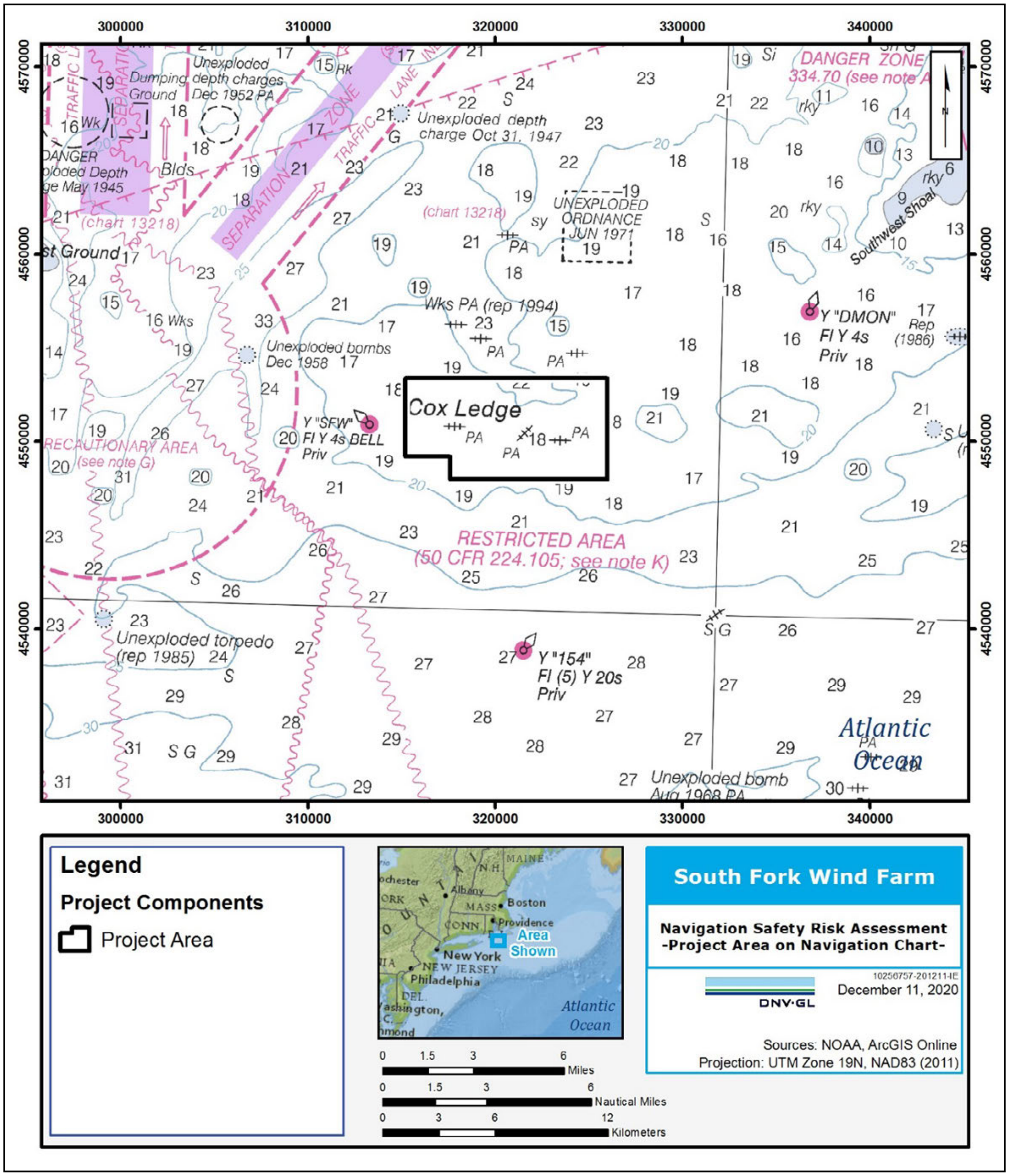


Figure 2-32 Navigation chart in the vicinity of the Project Area

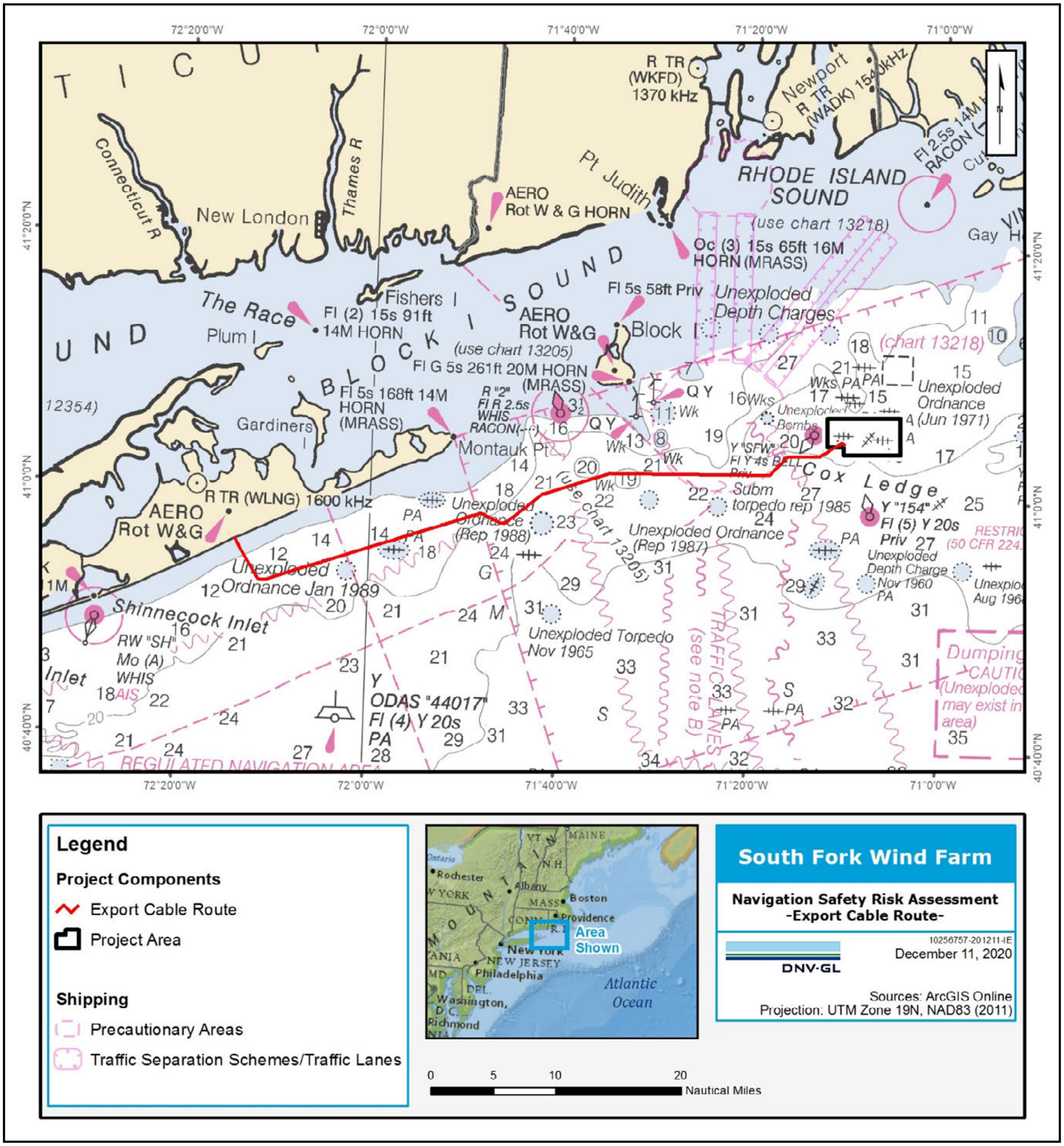


Figure 2-33 Export cable route

2.2.1 Proximity to non-transit waterway uses

This section provides an overview of the Project's proximity to non-transit uses of the waterway:

Section 2.2.1.1 Fishing (recreational and commercial)

Section 2.2.1.2 Day cruising of leisure craft (pleasure and passenger)

Section 2.2.1.3 Racing

Section 2.2.1.4 Wildlife viewing

No offshore mining activity was identified within 100 NM (185 km) of the Project

2.2.1.1 Fishing

The Project is co-located with use of fixed and mobile fishing gear for commercial and recreational fishing. Rhode Island has collected data and created map layers concerning ocean uses. Based on this data set, fixed gear fishing occurs year-round in the Project Area. Fixed gear consists of lobster pots, fish pots, and gill nets and are either placed on the bottom or kept afloat using buoys. Figure 2-34 illustrates the fishing grounds in which commercial fixed gear is used (RI OceanSAMP, 2009a).

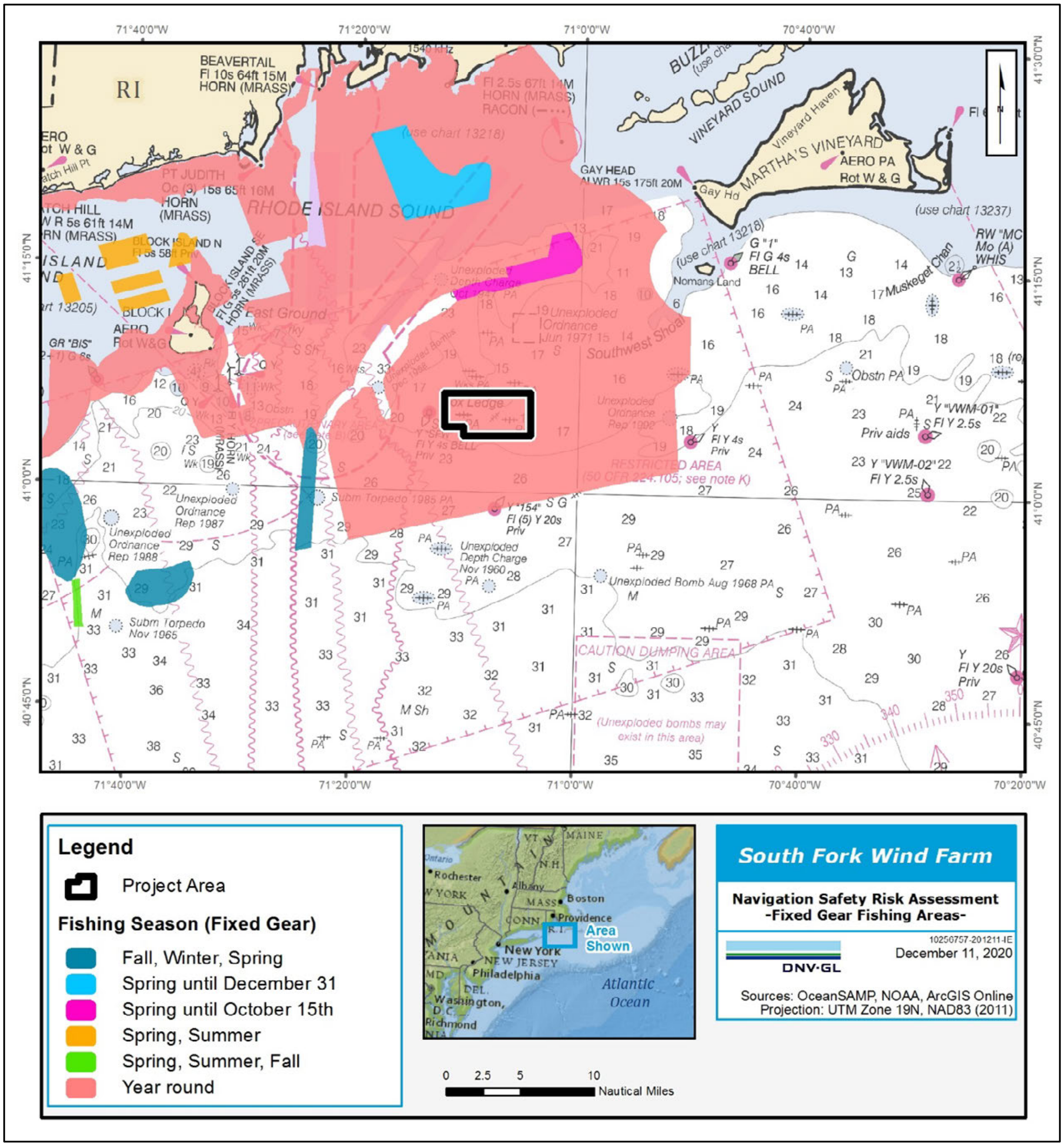


Figure 2-34 Fixed gear fishing areas by season in Rhode Island waters (RI OceanSAMP, 2009a)

Fishing with mobile gear also occurs year-round in the Project Area. Figure 2-35 illustrates the fishing grounds that are fished using mobile gear (RI OceanSAMP, 2009b). Mobile gear consists of trawling and scallop dredging (see Section 3.1 and Section 5 for further discussion on fishing gear interactions with Project components).

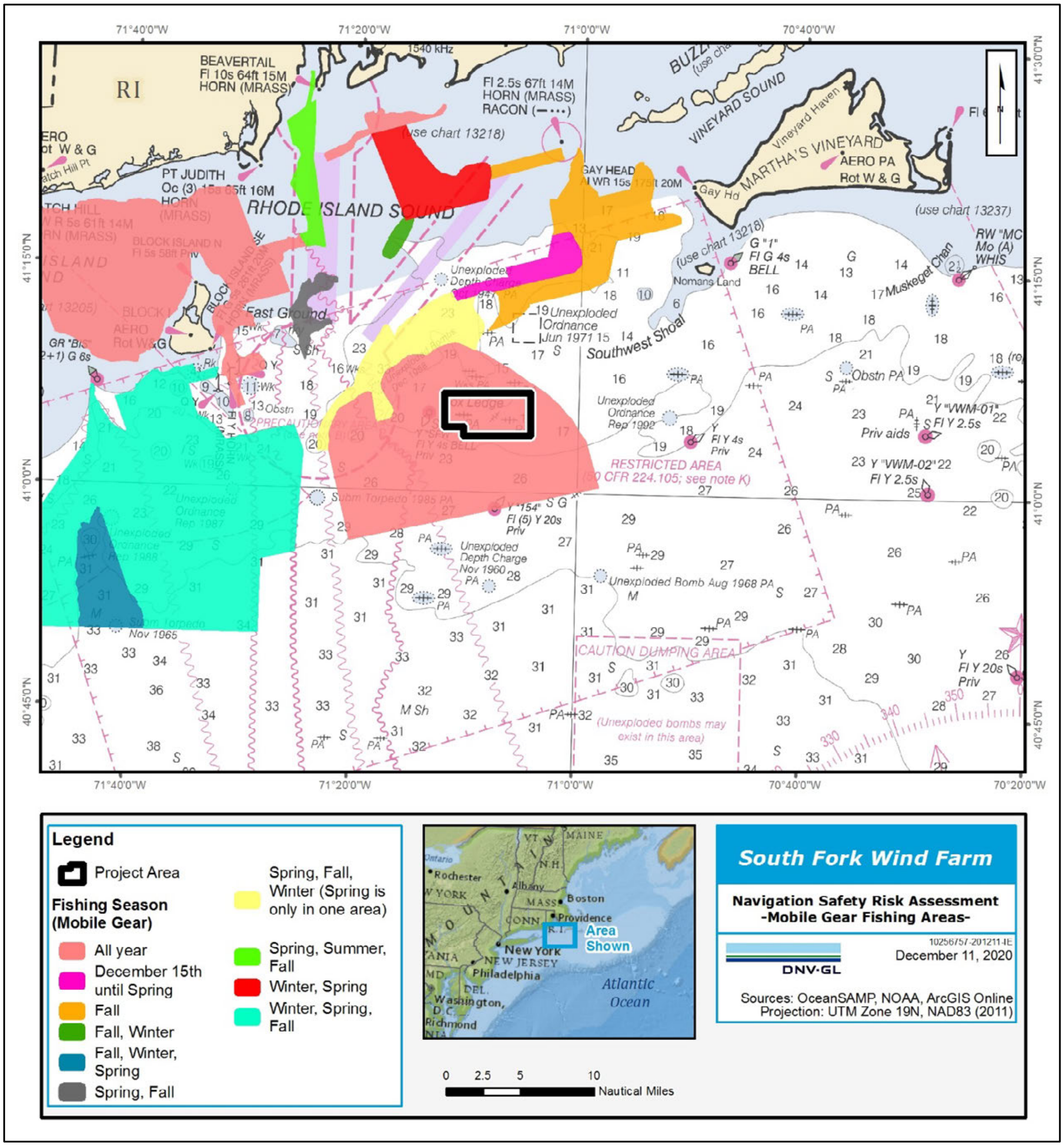


Figure 2-35 Mobile gear fishing areas by season in Rhode Island waters (RI OceanSAMP, 2009b)

Recreational fishing occurs in the Project Area. Common fishing techniques for recreational fishing include line fishing and angling. These types of fishing are typically conducted from relatively small vessels, usually while drifting. Figure 2-36 illustrates the fishing grounds that are fished recreationally (RI OceanSAMP, 2009c).

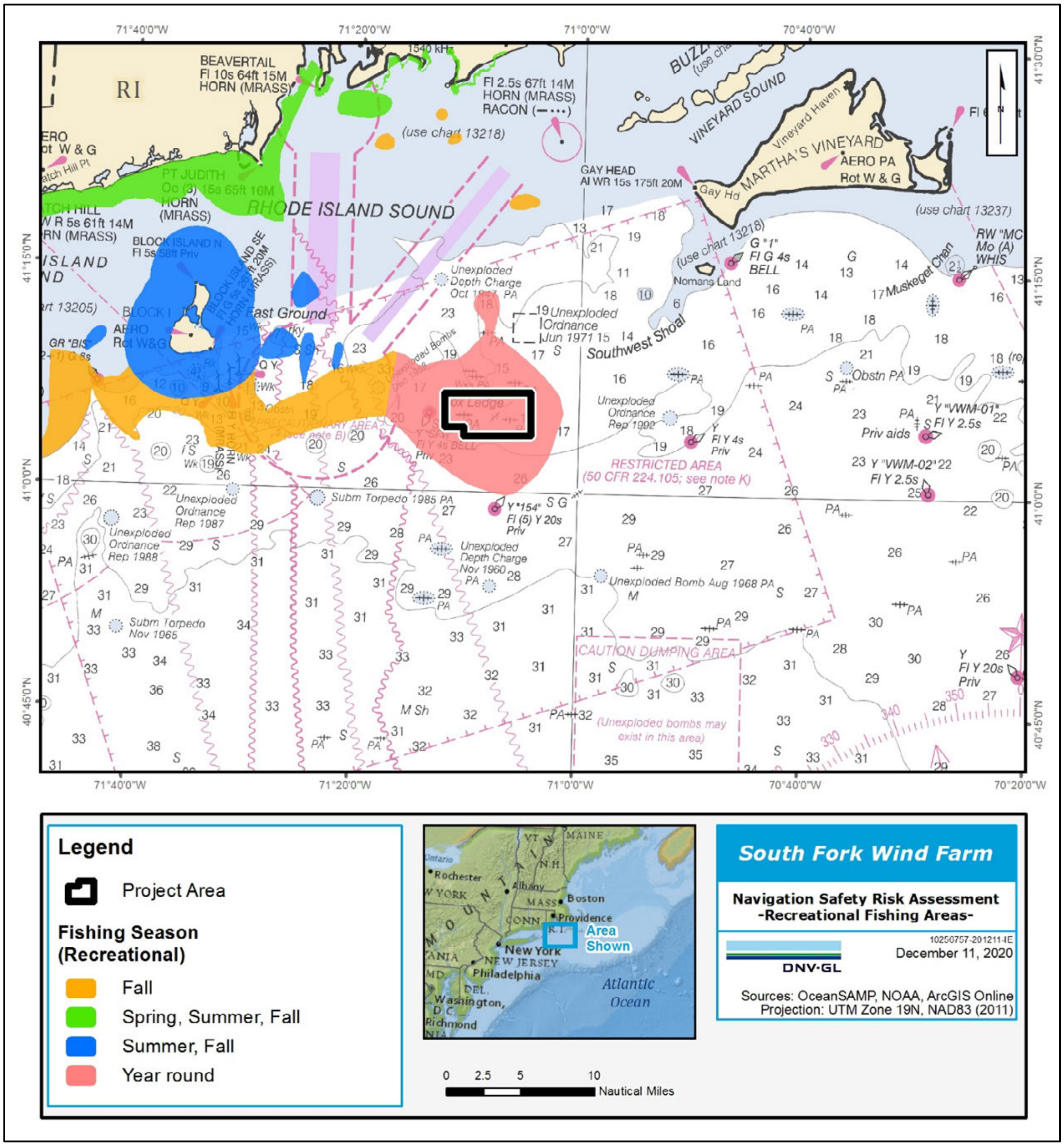


Figure 2-36 Recreational fishing areas by season in Rhode Island waters (RI OceanSAMP, 2009c)

2.2.1.2 Day cruises

Commercial day cruises occur in the Study Area, although no specific routes were identified in the Project Area. Identified day cruises include:

- Rhode Island Lighthouse Tour
- Sightseeing cruises and sunset cruises on Narragansett Bay
- Current and prospective future support transferring crew and cargo during construction and operations phases of offshore wind farm(s).

Pleasure craft transit in the vicinity of the Project Area is described in Section 2.1.1.4 and in Section 2.2.

2.2.1.3 Sailing and racing courses

Figure 2-37 illustrates the typical routes of distance sailing races, some of which have historically transited through the Project 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 Project Area have indicated the event tracklines would avoid the Project Area. Though safety is one factor, the primary reason for avoiding the Project Area is to promote a leisurely recreational event in open water. (South Fork Wind, 2020).

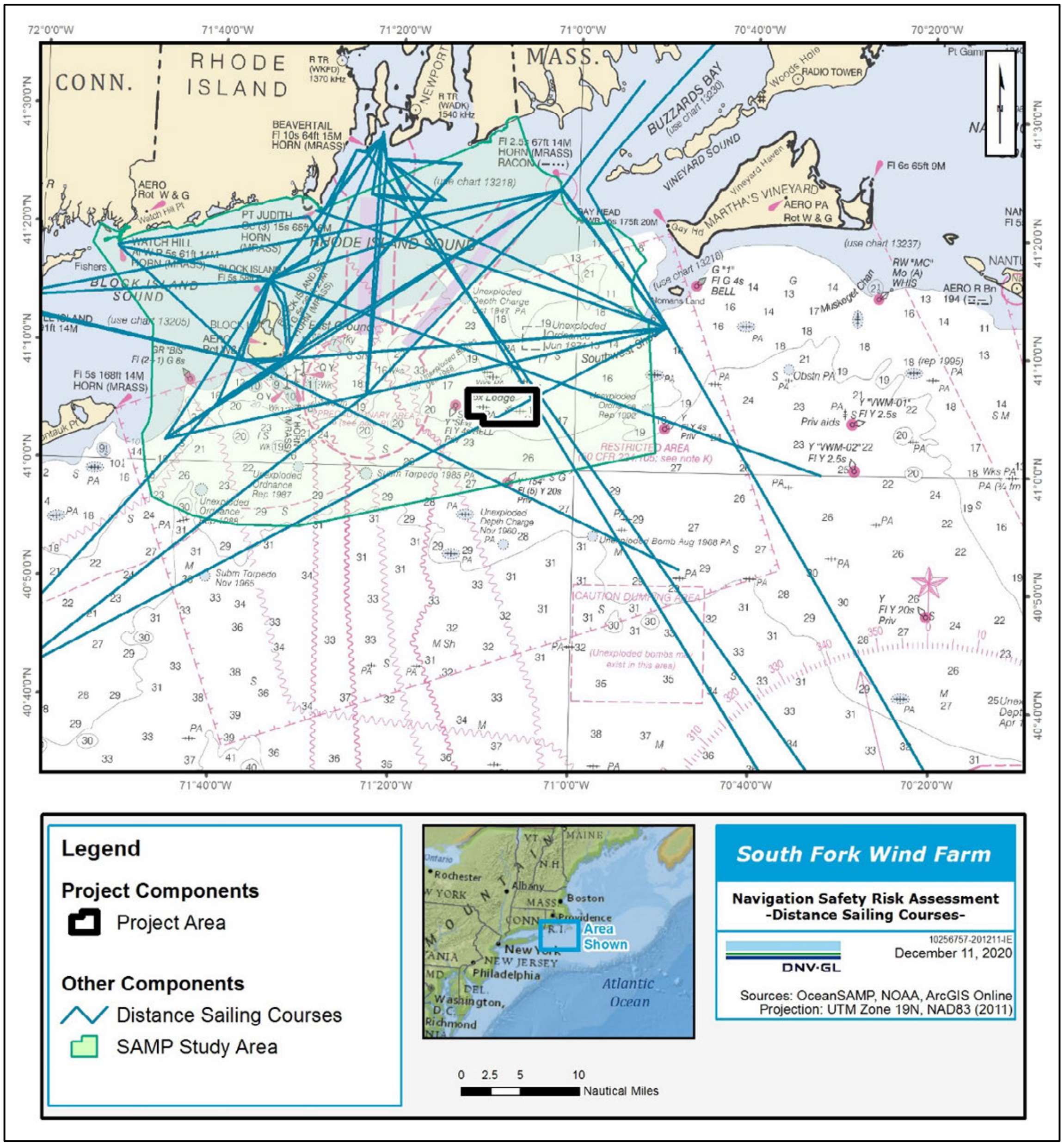


Figure 2-37 Distance sailing racecourses from Rhode Island ports (RI OceanSAMP, 2016a)

2.2.1.4 Wildlife viewing

Figure 2-38 illustrates the Rhode Island Sound Offshore Wildlife Viewing Areas in the vicinity of the Project Area, including bird watching, shark cage diving and whale watching (RI OceanSAMP, 2016b/c/d). Wildlife viewing activities and transiting to viewing areas occur in the Project Area.

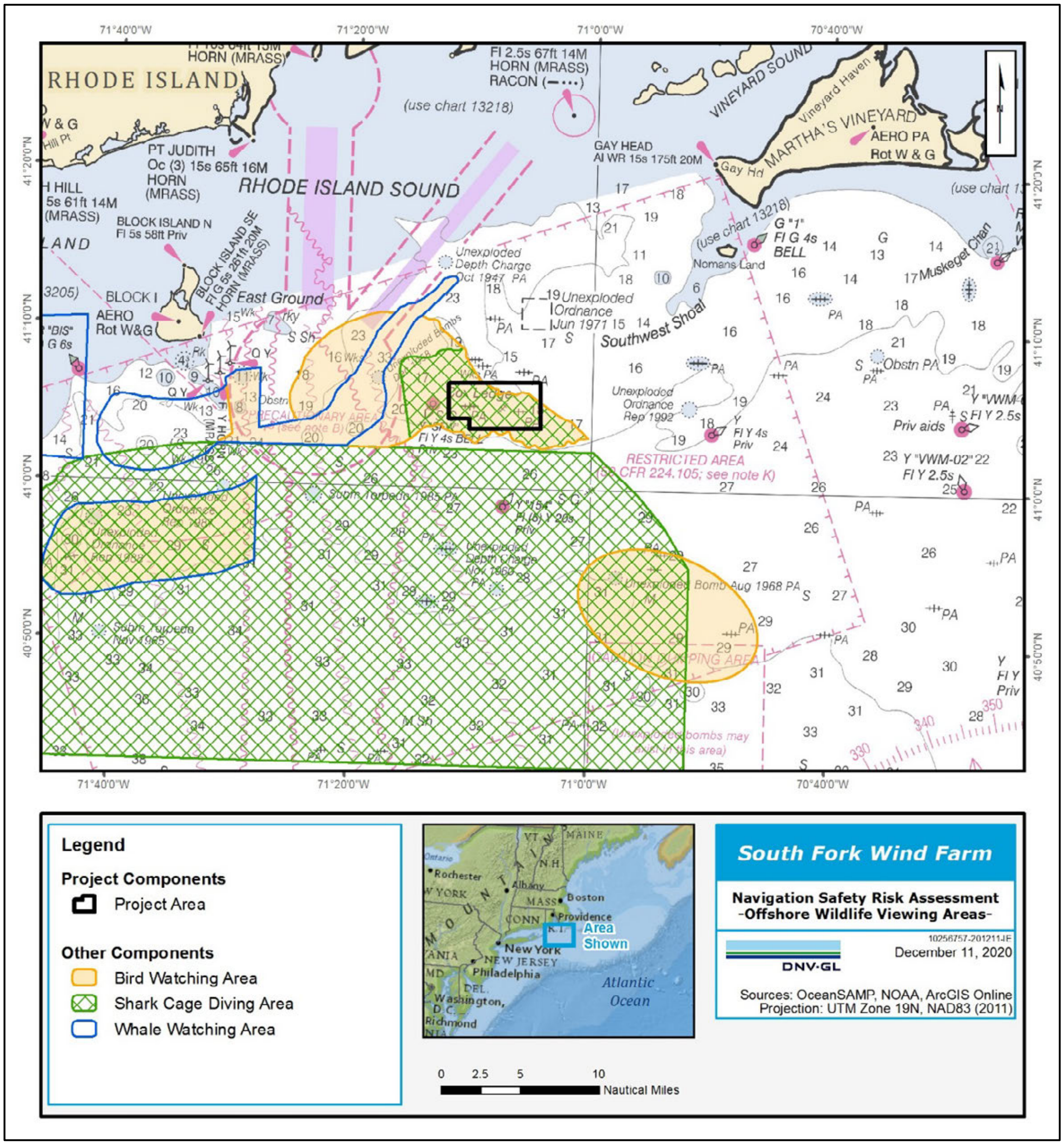


Figure 2-38 Offshore wildlife viewing areas (RI OceanSAMP, 2016b/c/d)[3]

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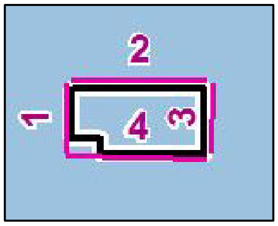
[3] There are apparent differences in wildlife viewing areas between the above OceanSAMP GIS layers, OceanSAMP downloadable paper maps (RI OceanSAMP, 2009d), and the 2010 OceanSAMP report (RI, 2010). This NSRA used the GIS layers.

2.2.2 Proximity to transit-related waterway uses

This section summarizes the Project's proximity to transit-related uses of the waterway, including:

Section 2.2.2.1	Transit routes used by coastal or deep-draft vessels, ferry routes
Section 2.2.2.2	Transit routes used by fishing vessels
Section 2.2.2.3	Shipping routes
Section 2.2.2.4	Routing measures, precautionary areas, and separation zones
Section 2.2.2.5	Anchoring, safe havens, port approaches, pilot areas

2.2.2.1 Coastal, deep-draft, and ferry routes



Transit routes used by coastal vessels (tugs), deep-draft vessels (cargo/carrier, tanker, and some passenger vessels), and ferries (passenger vessels) are described in Section 2.1.1. The influence of Project structures on the routes of these vessels is limited to those with tracks passing through or near (defined here as within 1 NM of) the Project Area. 38 tracks of these vessel types passed through transects 1, 2, 3, or 4.

Because of the traffic associated with the Narragansett Bay TSS, 143 deep draft[4] vessel tracks came within 4.3 NM (8 km) of the Project Area.

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

2.2.2.2 Transit routes used by fishing vessels

A summary of the available information about transit routes used by fishing vessels is presented in Section 2.1.1.2. The regional fishing "areas of mass transit" (USCG, 2020a) are located east of the Project Area (see previous Figure 2-11).

2.2.2.3 Shipping routes

International shipping traffic uses the established TSS:

- Buzzards Bay – inbound lane is 5.3 NM (9.8 km) from the nearest Project structure.
- Narragansett Bay – inbound lane is 8.3 NM (15 km) from the nearest Project structure.

2.2.2.4 Routing measures, precautionary areas, and separation zones

NVIC 01-19 suggests a risk-based review of safe distances from routing measures, which is provided in this section. The closest routing measure is the Buzzards Bay inbound lane, which is a minimum of 5.3 NM (9.8 km) from any Project structure. The closest precautionary area is the Narragansett and Buzzards Bay Precautionary Area, which is a minimum of 3.5 NM (6.5 km) from any Project structure. The Separation Zone between the Buzzards Bay TSS lanes is 6.3 NM (12 km) from the closest Project structure.

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[4] In this context, deep draft was defined as greater than 10,000 DWT.

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, to which the evaluated Project layout conforms.

b) 5 NM from the entry/exit (terminations) of a Traffic Separation System, to which the evaluated Project layout conforms.

The Marine Planning Guidelines are based on general risk principles; their primary intent is to inform marine spatial plans. Risk-informed decisions benefit from higher resolution risk analyses such as this NSRA, to support decision making. 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.

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

- 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
- General currents
- Mixing of vessel types
- Complex vessel interactions
- Routing measures as utilized by vessels

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

NVIC 01-19 also provides a list of potential risk mitigation measures, which either currently exist or are proposed in association with the Project, copied below. Although Project-specific mitigations are not factored into model calculations, these and the risk control measures listed in Section 11.3 are included here for potential consideration in the USCG’s As Low As Reasonably Practicable (ALARP) review.

“(a) Mitigating factors include aids to navigation, pilotage, vessel traffic services, precautionary areas, areas to be avoided, anchorages, limited access areas, and other routing measures. 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.”

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 Area. The risk of an allision exists within the Project Area; however, outside the Project Area, the Project poses zero allision risk.

2.2.2.5 Anchorages, safe havens, approaches, or pilot areas

Figure 2-39 shows the designated anchorages in the region. The closest anchorage is Brenton Point, located more than 12 NM (22 km) from the Project; therefore, no measurable effects are anticipated related to anchorages. No significant deep draft vessel anchorage activity in the Project Area was indicated by a review of the AIS data.

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

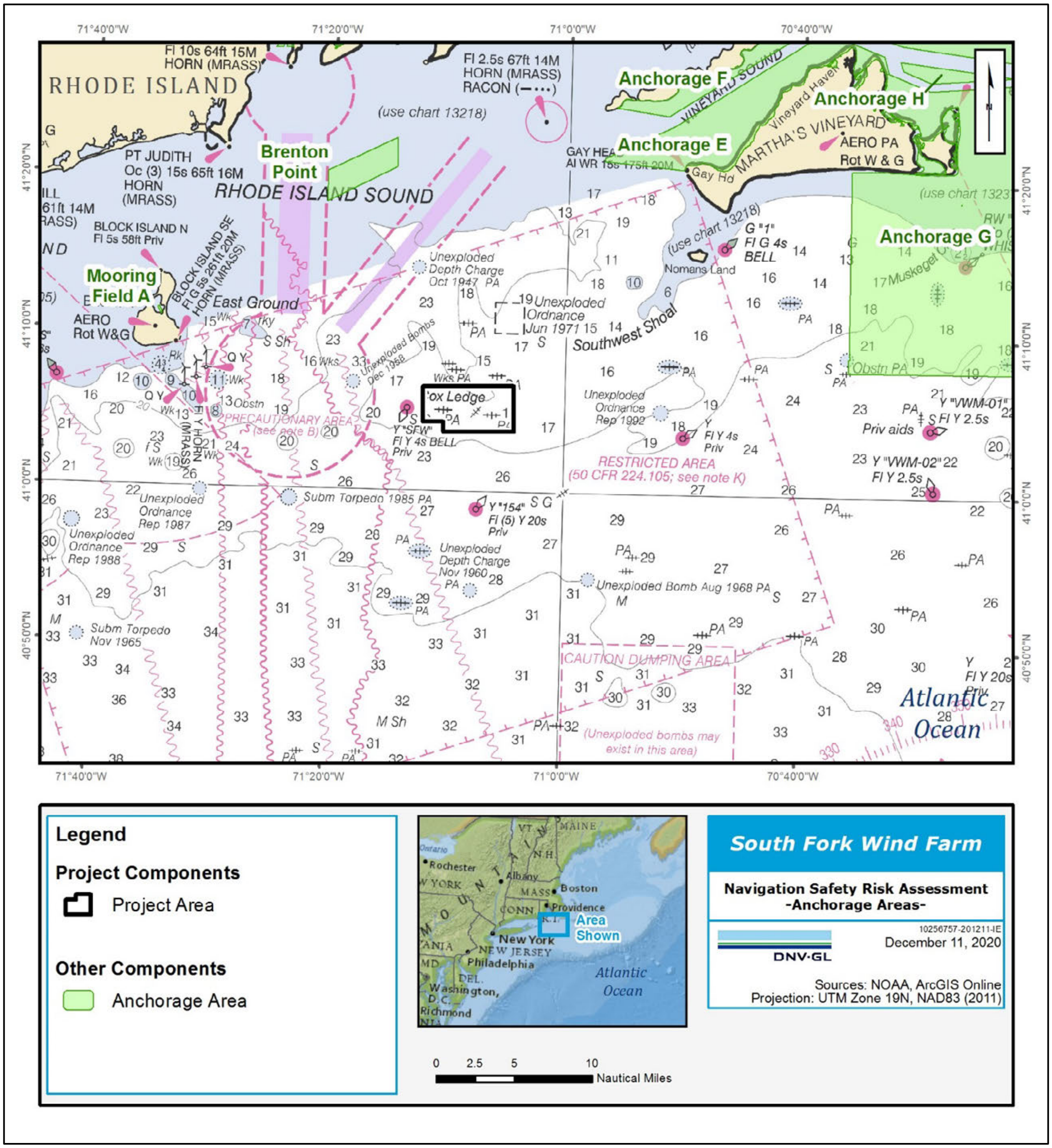


Figure 2-39 Anchorage areas

Figure 2-40 shows nearby pilot boarding areas. The Project is more than 12 NM (22 km) from the closest pilot boarding area.

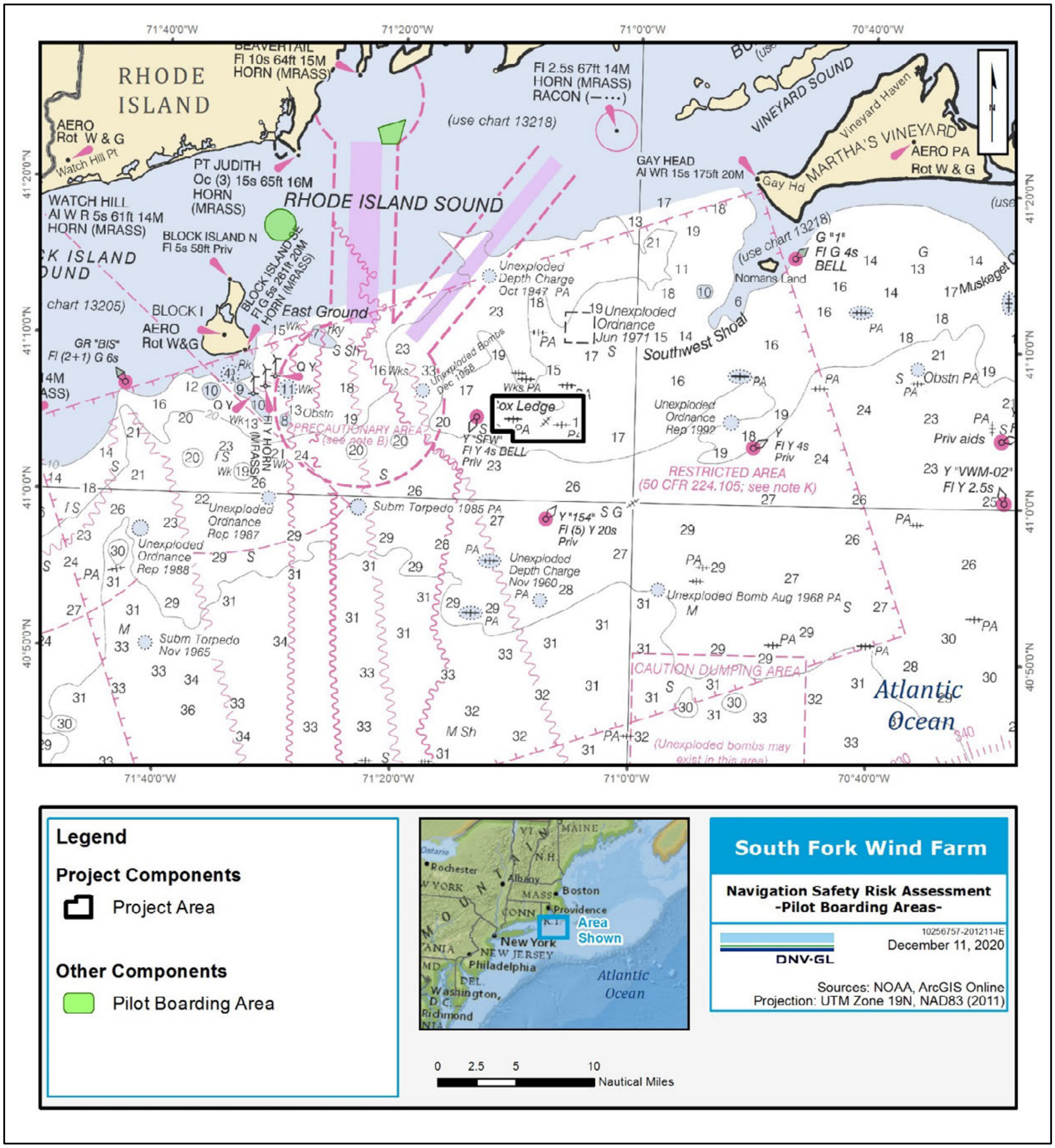


Figure 2-40 Pilot boarding areas

2.2.3 Proximity to other uses of interest

Table 2-6 describes the proximity of the Project to other uses of interest.

Table 2-6 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 Area boundary)
Fishing grounds or routes used by fishing vessels to fishing grounds	Fishing grounds lie within the Project Area and are discussed in Section 2.1.1.2. Routes that fishing vessels take through the Project Area, for example, to fishing areas near the edge of the OCS, are distributed across the Project Area. Fishing vessel transit risk is included in the collision, allision, and grounding risk modeling presented in Section 11. An overview of fishing in the Project Area is provided in Section 2.1.1.2 for commercial fishing and in Section 2.2.1.1 for recreational fishing. A qualitative assessment of risks associated with fishing activities is provided in Section 3.1.
Within the jurisdiction of a port or navigation authority	None identified within the footprint.
Offshore firing/bombing ranges or areas used for military purposes	The Project Area is within the Narragansett Military Operations Area. No specific military activities have been identified within the Project Area; however, aircraft and submarine use occur nearby. The closest identified military use are submarine transit lanes 9.9 NM (18 km) from the Project Area.
Existing or proposed offshore renewable energy facility, gas platform, or marine aggregate mining	None identified within the Project Area. Figure 2-41 shows nearby energy-related facilities. The closest identified existing renewable energy facility is Block Island Wind Farm, more than 12 NM (22 km) from the Project. The closest proposed energy facility is Revolution Wind Farm, which borders the Project on three sides. 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 Study Area.
Existing or proposed structure developments or existing designated offshore disposal areas	No existing or proposed non-energy structures were identified within the Study Area. No existing designated disposal areas were identified within the Project Area; the closest area is Rhode Island Sound Disposal Site - Dredged Material Disposal (NOAA, 2010), which is in the Separation Zone 10 NM (19 km) from any Project structure.

Type of waterway use	Closest proximity to the proposed maximum footprint of the Project (measured from the Project Area boundary)
Aids to navigation (ATON) and/or Vessel Traffic Services	No private aids to navigation (PATON) are within the Project Area. The “SFW” Bell buoy, a PATON, is approximately 1 NM west of the Project Area. The closest federal ATONs are more than 12 NM (22 km) from the Project Area: • The G”1” Squibnocket Lighted Bell Buoy 1 east of Nomans Land, marking shoal water near Martha’s Vineyard • The Block Island Southeast Light and Mariner Radio Activated Sound Signal (MRASS) (USCG, 2020b) 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.

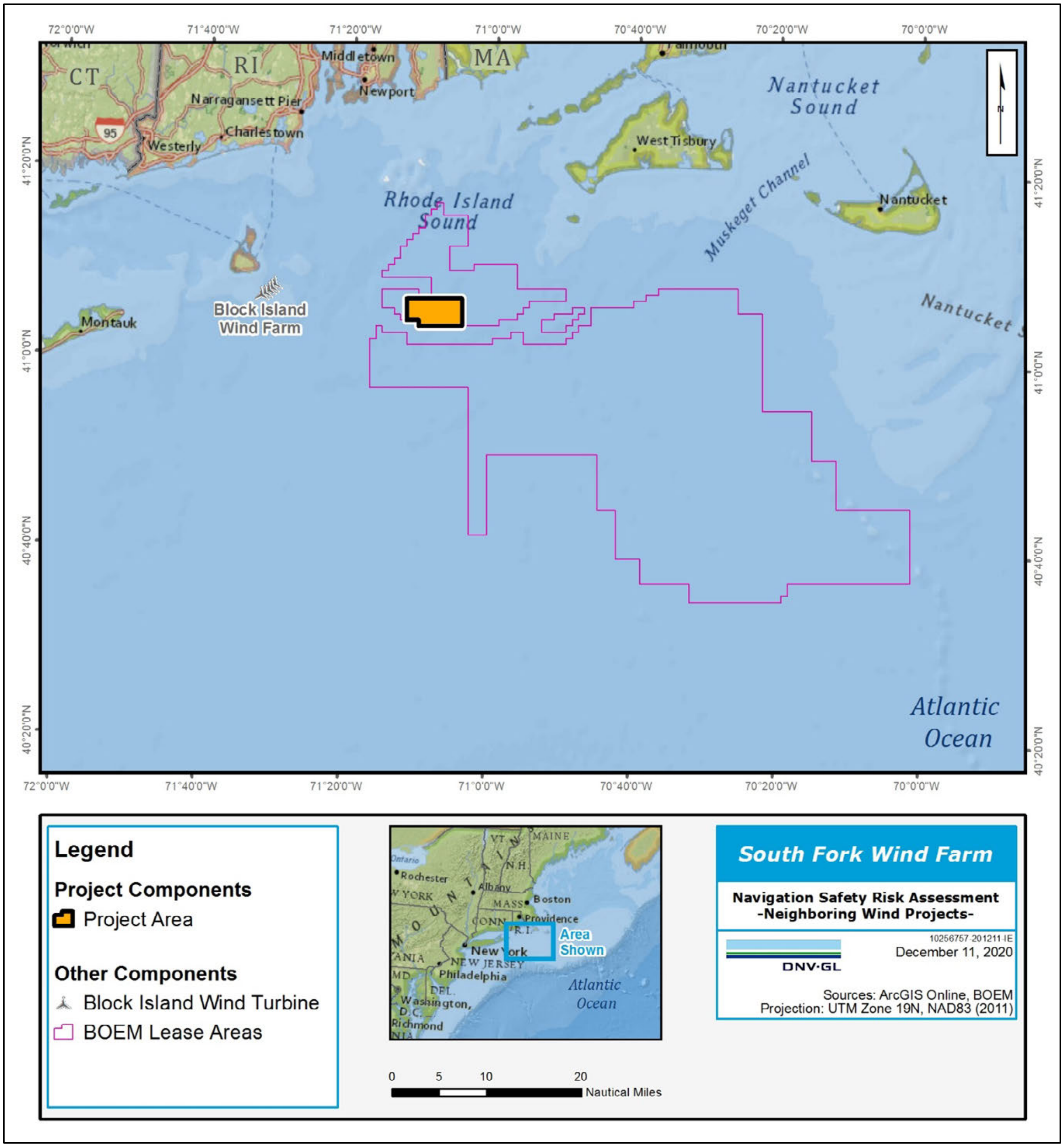


Figure 2-41 Operational and proposed neighboring wind energy projects

2.3 Anticipated changes in traffic from the Project

The risk model built for this assessment in the Marine Accident Risk Calculation System (MARCS) model includes a representation of the Study Area marine traffic in a Base Case, before the construction of the Project, and in a Future Case, after the Project is constructed.

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

1. Additional non-Project traffic that might be generated by the presence of the offshore wind farm.
2. Alternative traffic routes anticipated to be used instead of the Base Case routes. The following vessel types are anticipated to choose routes around an offshore wind farm:
    - Cargo/carriers
    - Large passenger vessels (cruise ships) defined as >150 m (492 ft) LOA
    - Tankers including those carrying oil products
    - Tugs

Each is described below.

In addition, Project-related construction, operations and maintenance, and inspections traffic will increase the number of vessel transits to/from the Project Area while cessation of Project surveys will reduce them. Project-related vessels are not added to the model because 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 model, within the Project Area.

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

The USCG 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 USCG MARI PARS report comprised:

- Six to eight new LPG tanker transits to and from Providence. This study assumes that an additional eight LPG vessels per year enter the AIS 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 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 offshore wind farms: the construction traffic will be relatively short-lived in terms of the risk being assessed in this study. The Project-related vessel traffic for maintenance and operations will have different characteristics than the other types of non-wind farm traffic and is not included in new Future Case baseline traffic being modeled in this assessment. The Project-related vessels will transit to take personnel to structures, have very few other vessel movements, and are likely to spend most of the time offshore adjacent to Project structures.

Modification of current traffic routes for the Future Case

The Future Case 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 transit the Project Area. Many deep draft vessels (cargo, tanker, tanker oil products, and cruise ships) as well as tug/service vessels are expected to choose not to navigate through the wind farm. At this time, the extent to which they will adjust their course is a matter of speculation.

Alternative routes were developed to model these vessel types as avoiding the BOEM lease areas shown in Figure 2-41 above. For the purposes of modeling, alternative routes were developed for these vessels based on general principles of (1) avoiding the Project Area by 1 NM (1.9 km), (2) minimizing the additional distance transited, and (3) accounting for existing routing measures.

Deep draft ships (e.g., cargo/carrier, tanker, cruise, and tanker oil products) as well as tug/service vessels that transit through the lease areas in the Base Case were re-allocated to these alternative routes for the model's Future Case. Other traffic types (fishing, other, shallow draft passenger, and pleasure) were modeled as continuing to navigate through the wind farm in the Future Case.

2.4 Effect of vessel emission requirements on traffic

The IMO specifies limits on vessel sulfur oxide (SO_x) emissions in the defined Emission Control Areas (ECA) in North America and other locations (IMO, 1997). Additional fuel restrictions came into effect on 1 January 2020. The International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI (IMO, 1997) contains a global requirement regarding fuels used in ships in international trade. Such ships using fuel oil in an ECA must have a maximum of 0.50% (mass basis) sulfur content in the fuel in use, or else be fitted with an approved equivalent means of compliance, such as a scrubber.

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

Figure 2-42 Project Area and boundary of the North American Emission Control Area

2.5 Seasonal variations in traffic

The AIS data set used in this assessment covers a time span of one year. Seasonal variations in the Study Area were analyzed for each vessel type, visualized in Figure 2-43 and Figure 2-44.

Traffic is significantly higher in the summer, with the largest seasonal increases shown by pleasure vessels. The summer peak was in July and August, with approximately 11,500 tracks each month, equivalent to an average of 371 tracks per day in the Study Area. All of the vessel types show peak track volumes for at least one month in the summer. The low was in February with just under 2,000 tracks.

Seasonal variations in the smaller Project Area are shown in Figure 2-45. The largest number of tracks and greatest variations were in the other/undefined vessel type, which included survey vessels contracted by South Fork Wind. The seasonal trends in the Study Area were mirrored in the Project Area, with a few notable exceptions:

- Cargo/carrier vessels had more transits in the spring than in the summer
- Fishing vessels had a secondary peak in February
- Passenger vessels had more transits in the fall than in the summer.

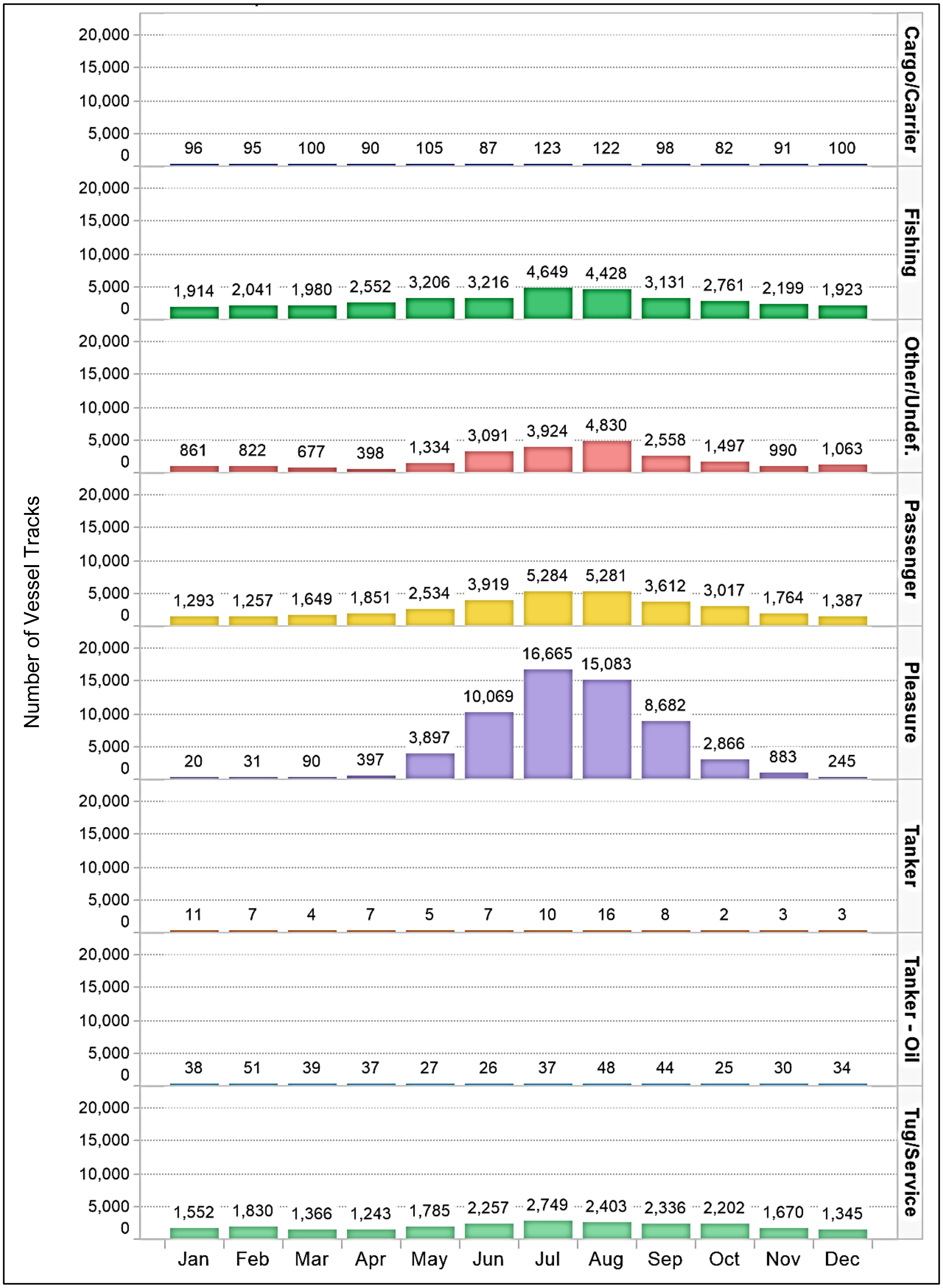


Figure 2-43 Seasonality of vessel transits per vessel type[2]

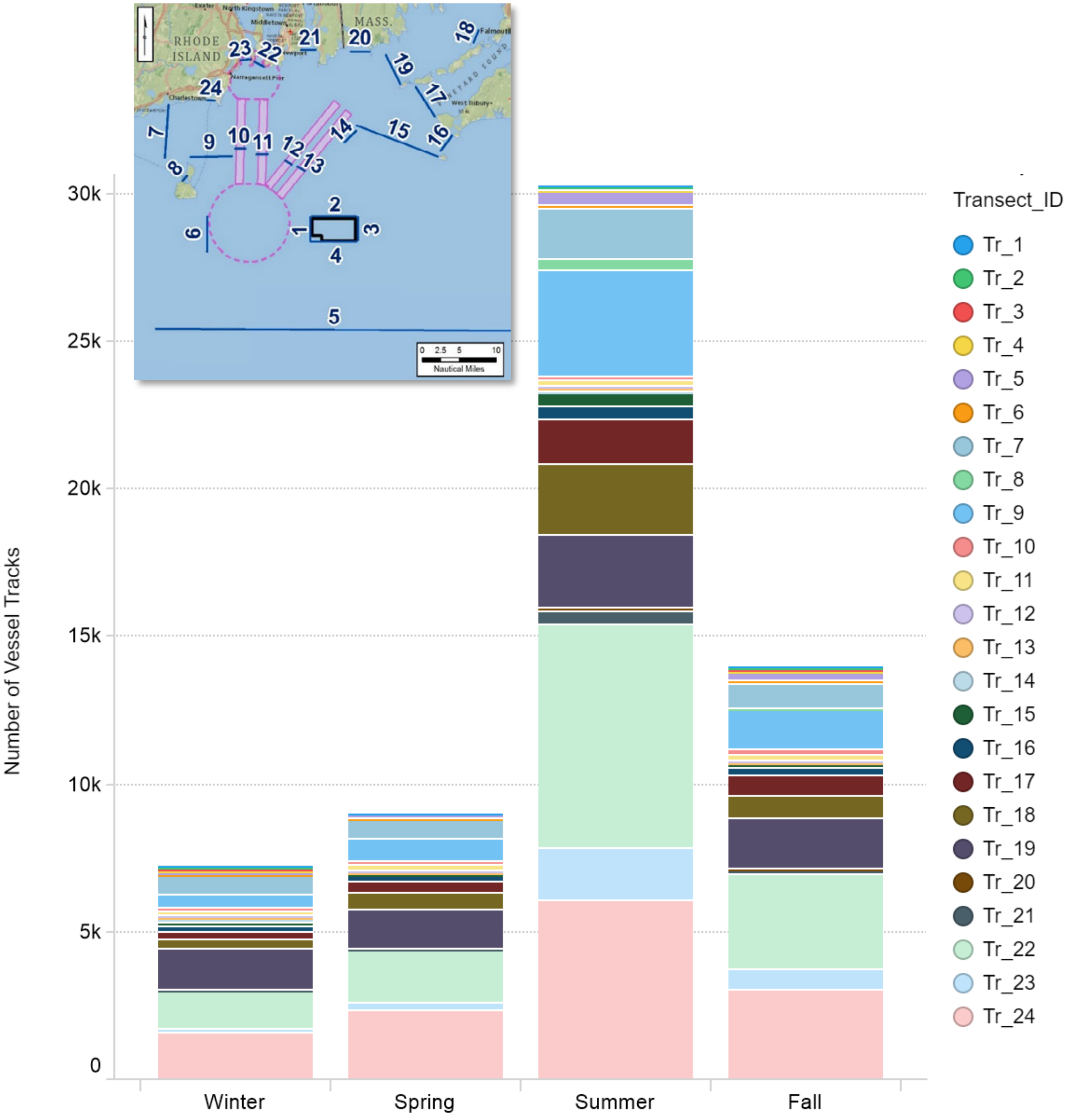


Figure 2-44 Seasonality of vessel tracks crossing all route transects[2]

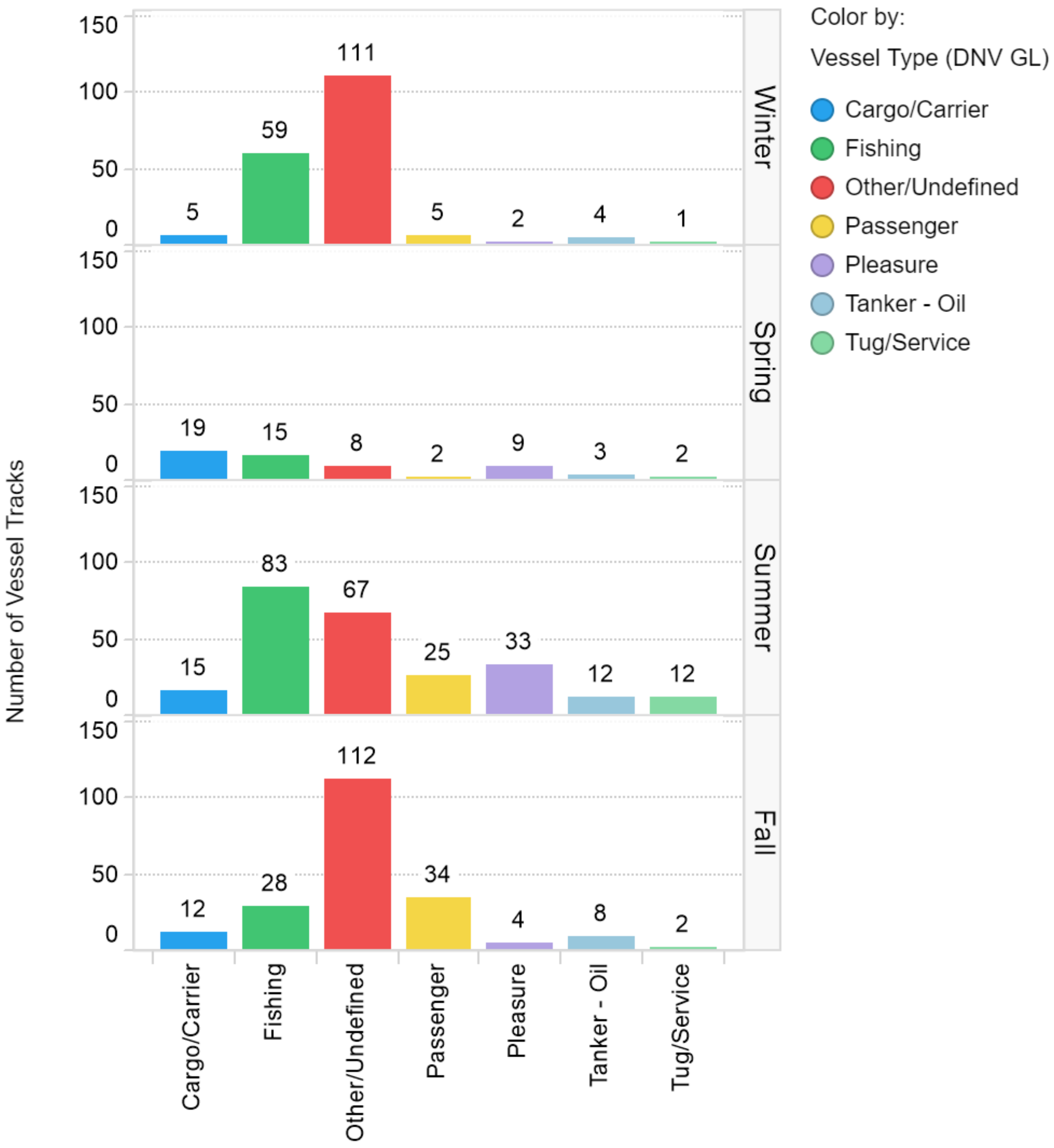


Figure 2-45 Seasonality of vessel tracks in the Project Area[2]

3 OFFSHORE ABOVE WATER STRUCTURES

This section describes:

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

3.1 Hazards to vessels and activities(? As stated in Table 2-6?)

The main hazards posed to vessels and activities from the Project are:

- Air gap (clearance) – WTG blades could pose a hazard to a vessel with a mast or other structural component taller than 24.9 m (81.7 ft) above MHHW from the WTGs, which results in the smallest air gap compared to the other classes of WTGs in the PDE. Similarly, the OSP could pose a hazard to a vessel taller than 44.1 m (145 ft). Section 3.2 discusses this risk.
- Subsea (buried) cable – A subsea cable could pose a hazard to a vessel if an anchor or fishing gear contacted a cable. See further discussion below.
- Stationary object at/near the waterline – The sea level portion of a foundation with associated external components, such as 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 11.2.3 discusses the consequences of an allision with a Project structure and Section 11.1.2 presents an estimate of the frequency of an allision with a Project structure.
- Fishing using mobile bottom gear – Mobile bottom gear is used in the vicinity of the Project. These fishing techniques might penetrate the seabed, contact unburied cables that are otherwise protected, or contact cables that have become unburied over time, potentially resulting in damage to the gear, a hazard to the vessel, and/or damage to Project submarine power cables. The fishing activities that pose a risk include bottom trawling and dredging. Both activities are expected in the vicinity of the Project Area and export cable.

  Assurance that cables are 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, BOEM recommends a minimum burial depth of 3.28 ft (1 m) and at least a single armor layer (BOEM, 2011).

  South Fork Wind, LLC has committed to burying cables to a target depth of 1.2 to 1.8 m (4 to 6 ft) deep where practical. Cable protection measures will be employed where adequate cable burial depth is not attained. To ensure the risk is sufficiently mitigated, a separate cable burial risk assessment will be conducted for the Project, and the results of that study will inform the depth of burial as well as cable protection measures for the Project. (South Fork Wind, 2020)

- Fishing using rod/reel – Drift fishing and trolling are common recreational fishing techniques used on Cox Ledge. There is a possibility that fishing lines or other gear may catch on Project structures or scour protection around the base of the foundation and be damaged or lost. It is unlikely that a vessel will be endangered, although it is possible that minor damage to a vessel may occur where the rod holder is mounted. Snagged gear could pose a hazard to a Project vessel on station at a WTG.
- 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.

3.2 Vessel clearances from project components

The minimum air gap for WTGs is 24.9 m (81.7 ft) and for the OSP is 44.1 m (145 ft) from MHHW. Figure 3-1 illustrates the minimum air gap for the Project WTGs.

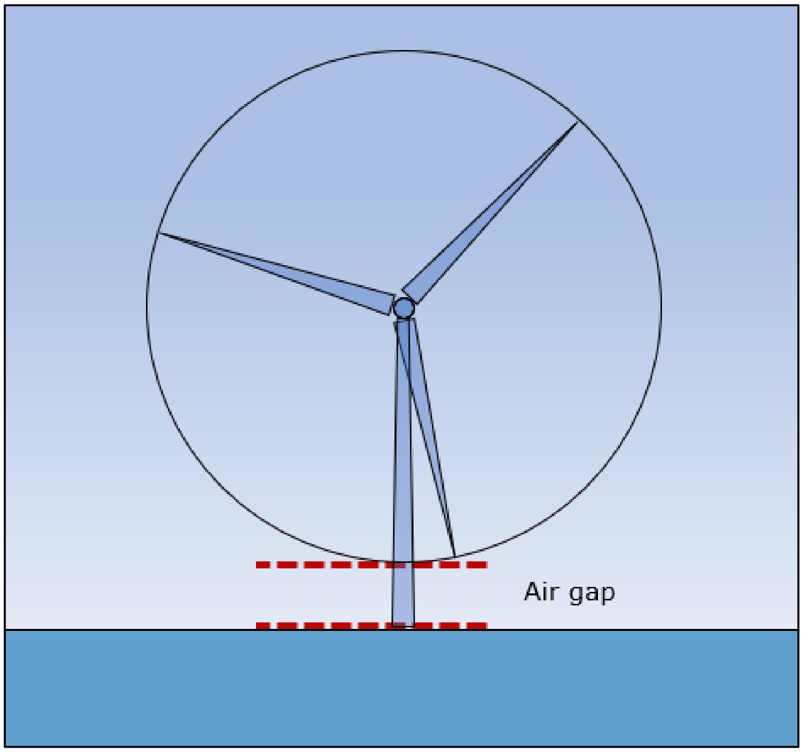


Figure 3-1 Illustration of WTG air clearance

The restricted air space exists only within a narrow range of distance from a WTG monopile foundation. An indicative distance is available for the tips of WTG blades on an 8 MW turbine, which are about 10 m to 25 m (33 to 82 ft) away from a monopile (Ostachowicz et al., 2016).

All foundations will indicate the as-built air gap on the structure, similar to the markings for Block Island Wind Farm, shown in Figure 3-2.

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

Comparing this distance to the types of vessels in the AIS data set, 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).

3.3 Emergency rescue activities and project components

The USCG will provide Search and Rescue (SAR) services in and around offshore wind farms in U.S. waters, including the Project Area. 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, both table-top and operational exercises were conducted with the USCG at the Block Island Wind Farm. These exercises demonstrated the USCG's capability to search in the vicinity of WTGs with both vessels and aircraft, and rescue (extract) an injured person from a WTG nacelle. Additionally, Ørsted hosted USCG 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 (South Fork Wind, 2020).

The maximum height of Project WTGs is 257 m (842 ft) from LAT.

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 Project:

- 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 search and rescue operations: South Fork Wind, LLC has committed to an indicative layout scenario with WTGs and OSS-AC/OCS-DC sited in a uniform east-west/north-south grid with 1 NM by 1 NM spacing. (South Fork Wind, 2020)

The USCG MARI PARS (USCG, 2020a) report also examined potential navigation safety and SAR issues associated with anticipated offshore wind farm development in the area. The USCG 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 USCG's ability to conduct SAR operations within the project 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 USCG will implement a safety zone around construction-related vessels and activities (see Section 5.1 for more detail about safety zones). Noise levels outside the safety zone are not expected to have negative effects on navigation safety or USCG missions.

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

International Regulations for Preventing Collisions at Sea (COLREGs) Annex III (IMO, 1972) describes the required sound signal intensity and range of audibility for vessels by length. Table 3-1 summarizes the requirements. The COLREGS requirements assume an average background noise level at the listening posts of a vessel to be 68 dB (IMO, 1972).

Table 3-1 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 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. 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.

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). According to the study, 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 allision 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.

Given the range of vessel sizes (Table 3-2) and speeds (Table 3-3) found in the AIS data set, a range of impact energies is estimated for each vessel type.

Table 3-2 Vessel sizes in the Study Area[2]

Vessel type	DWT (metric tons)		
	Low	Average	High
Cargo/Carrier	1,750	25,053	75,005
Commercial Fishing	500	500*	742
Other/Undefined	20	307	14,620
Passenger	70	2,782	12,512
Pleasure	1	178	711
Tanker	9,240	20,344	36,771
Tanker-Oil Products	1,241	45,879	113,005
Tug/Service	1	451	33,095

* Estimated based on vessel LOA and beam

The speeds in Table 3-3 are based on the speed profiles in the AIS data set used in MARCS. 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% of the representative speed based on AIS data. The low speed is half of the representative speed.

Table 3-3 Assumed vessel speed when allision occurs

Vessel type	Speed (kt)		
	Low	Representative[2]	High
Cargo/Carrier	4.8	9.5	11.4
Commercial Fishing	3.8	7.5	9.0
Other/Undefined	5.7	11.3	13.6
Passenger	5.9	11.7	14.0
Pleasure	3.8	7.5	9.0
Tanker	5.5	11.0	13.2

Vessel type	Speed (kt)		
	Low	Representative[2]	High
Tanker-Oil Products	5.4	10.8	13.0
Tug/Service	4.3	8.5	10.2

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

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

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

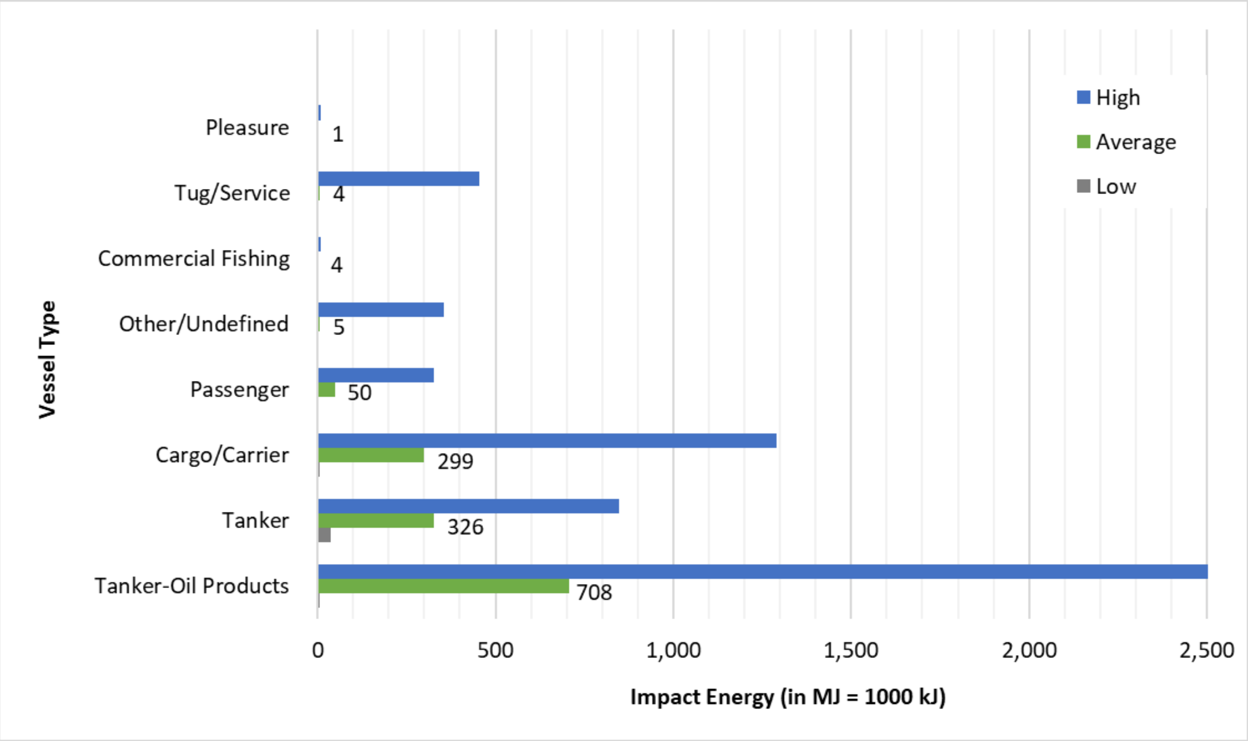


Figure 3-3 Ranges of kinetic energy per ship type

The estimated energies are considered extreme bounds because:

1. The kinetic energy is assumed to be received by the monopile/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 because of their low tonnage and average speeds. Deep draft vessels such as tankers and carriers have a greater potential to affect the integrity of a structure.

The highest postulated consequences would be from allision by a non-oil products tanker, an oil products tanker, a cargo/carrier vessel, or a cruise ship. An impact by a large vessel at average cruising speed is expected to cause severe damage. 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 presented in Section 11, the annual frequency of a powered allision with a Project structure involving a tanker (carrying oil products or not) or cargo/carrier is less than 0.002 per year; at least a 1-in-430-years event.

During construction, the primary risk is from an on-site construction vessel allision with a Project structure while transiting through the Project Area. However, construction vessels are anticipated to be travelling at low speeds and are unlikely to cause significant damage.

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 (South Fork Wind, 2020).

4 OFFSHORE UNDERWATER STRUCTURES

All structures above the seabed will extend above the water line. All cables will be buried below the seabed or otherwise protected on the seabed.

Subsea cables are a hazard to anchoring and to fishing gear; conversely, anchoring and fishing gear are hazards to Project components and potentially Project vessels. It is anticipated that deep draft vessels and tugs will avoid the wind farm and sail in historical or designated lanes; however, smaller vessels, such as pleasure vessels and commercial fishing vessels, will likely transit the wind farm. Some of these vessels will fish in the Project Area and some will transit through the Project Area.

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% of the permits and 83% of the revenue: dredge, bottom trawl, and gillnet. Longline and hand fishing combined represent about 8% of the permits and less than 1% of the total revenue.

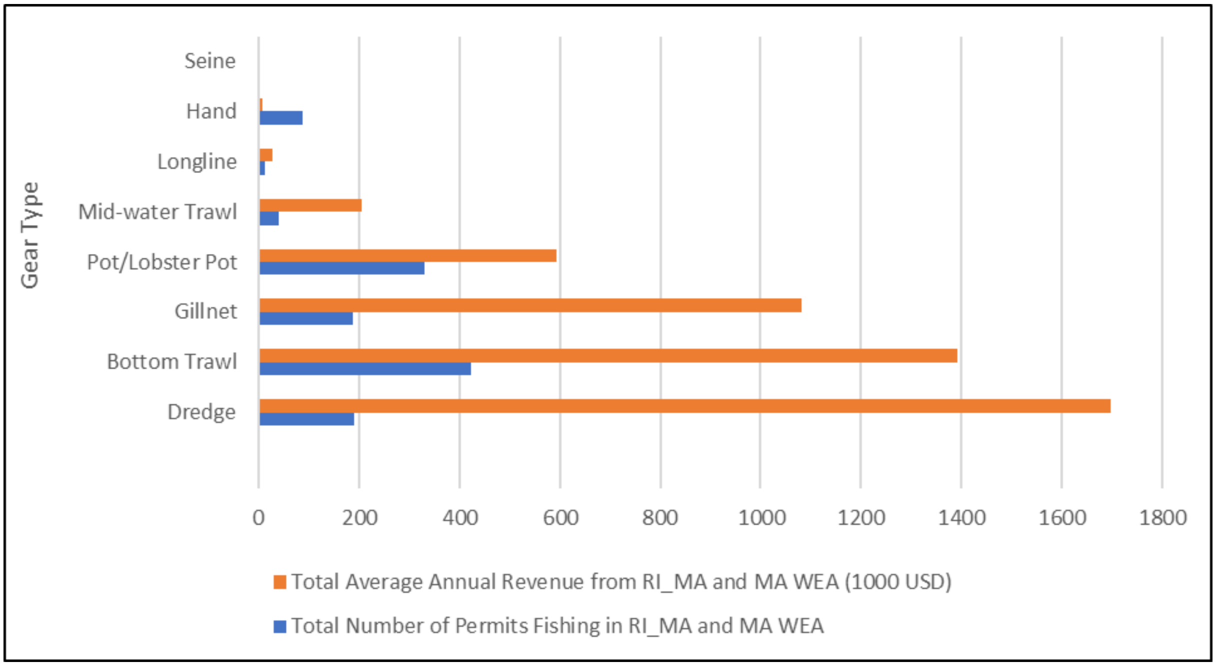


Figure 4-1 Number of commercial permits and revenue per year (2007–2012) (Kirkpatrick et al., 2017)

Anchoring, bottom trawling, and dredging pose the greatest risk of contact with a cable. The current cable target burial depth is 1.2 to 1.8 m (4 to 6 ft) deep 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

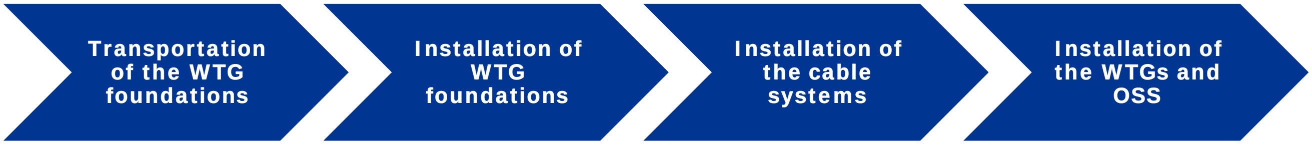
This section assesses:

- 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

South Fork Wind has an ongoing dialogue with local mariners on the potential effects of the Project, which is summarized in Appendix D.

5.1 Construction and decommissioning phase navigation risks

Project installation is scheduled to take place over a one- to two-year period. An indicative sequence of events for construction is:



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

South Fork Wind, LLC has committed to informing mariners about offshore activities related to the Project (South Fork Wind, 2020). 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 are implemented by the USCG. They protect mariners from construction hazards. It is anticipated that the USCG will implement safety zones during construction of the Project, as they did for construction of the Block Island Wind Farm (18 FR 31862).

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[5], 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 South Fork Wind's request, temporary safety zones will be established and enforced to protect mariners during construction and selected maintenance activities. South Fork 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 USCG. However, in the unlikely event that the Coast Guard cannot or will not establish and enforce safety zones, the Project will coordinate closely with the USCG to develop an alternative plan to facilitate vessel safety (South Fork Wind, 2020).

All vessels, including construction and service vessels, are required to 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 should 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)

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

- 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 outside the U.S. 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.

Additional information on construction vessels and ports is provided in the Project’s COP.

5.2 Operations phase navigation risks

This section provides a qualitative evaluation of operational risks from the Project. In contrast to safety measures during Project construction, routine safety zones are not anticipated during Project operation. Therefore, vessels will be free to navigate close to and within the Project.

Additional detail concerning operational risks is provided in:

- Section 3.1, which provides a qualitative assessment of risks to non-transiting fishing vessels in the vicinity of Project Area.
- Section 11.1, which provides a quantitative assessment of risks from all transiting (non-Project) vessels in the Study Area.

The Project will lay on charted depths of 33 to 41 m (108 to 134 ft) (NOAA, 2020c). 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.

Project-related service vessels will transit within the Project Area. Based on a qualitative review of vessel size, structure spacing, and in alignment with the evaluation in the USCG MARI PARS report (USCG, 2020a), the Project provides sufficient sea room for service vessels to transit between Project structures if the risks have been considered and vessels are transiting at a safe speed per COLREGs (IMO, 1972).

The Buzzards Bay TSS is the closest designated routing measure. Tug/service and commercial fishing vessels are the primary vessel types transiting this TSS. Most of the large deep-draft vessels in the Study Area transit the Narragansett Bay TSS as discussed in Section 2.1.1.1. On approach to and sometimes on departure from the Precautionary Area, deep draft vessels transit through the Project Area (MarineTraffic, 2019). It is anticipated that deep draft vessels will not choose to transit through the wind farm after Project construction.

Concerning safety related to the Project structure layout, risk control measures built into the Project design include a minimum distance of 1 NM (1.9 km) between offshore structures in an aligned north/south, east/west grid. As concluded in the USCG final MARI PARS report (2020a), a layout within these constraints provides sufficient room for anticipated vessels to transit through and safely maneuver within the Project.

Concerning the proximity of Project structures to traffic lanes, there are no national or international requirements regarding minimum distances between offshore wind structures and shipping routes. However, the NVIC 01-19 Enclosure 3 contains Marine Planning Guidelines, which are intended to inform the NSRA and siting of offshore wind structures, but not affect the boundaries of existing leases. 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 Marine Planning Guidelines (USCG, 2019a) and Project characteristics

USCG Guideline	Project characteristics	Comments
TSS or port approaches planning guidelines		
2 NM from the parallel outer or seaward boundary of a traffic lane (based on risk for 300 to 400 m vessels)	WTGs in the evaluated layout are more than 5.3 NM (9.8 km) 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 5.3 NM (9.8 km) from the entrance of the Buzzards Bay TSS.	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 Project Area. Sufficient sea room is available to the west of the Project Area for deep draft vessels. Revised traffic routes were used for risk modeling of the Future Case, see Section 2.3 and Appendix F.	Congruent with the guideline.
Provide inshore corridors for coastal ships and tug/barge operations	The Project Area does not overlie significant coastwise traffic.	Congruent with the guideline.
Minimize displacement of routes further offshore	The Project 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 Project Area. Available sea room for deep draft vessels is available to the west of the Project Area. Deep draft vessels could take an alternate route around the Project Area as a planned route deviation. See new traffic routes created for modeling: Section 2.3 and Appendix F.	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 Project Area as a destination. The number of pleasure vessel tracks crossing into the Project Area transmitting AIS is on the order of 25 per year[2].

USCG 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 Project Area.	Accounted for in collision, allision, and grounding risk model. The presence of multiple OREI is included in the Future Case model, see Section 11.4.
Offshore deep draft routes		
Offshore deep draft routes	The Nantucket-to-Ambrose Safety Fairway lies south of the Study Area and is outside foreseeable influence of the Project.	Not applicable to the assessment.
Navigation safety corridors		
Cross track error	In line with USCG MARI PARS conclusions (USCG, 2020a), the frequency of tug traffic is low in the Study Area. Only 8 tug/service vessel tracks entered the Project Area in the given year of AIS data[2].	Accounted for in collision, allision, and grounding risk model.
Closest point of approach	The likelihood of encounters between vessels is included in risk modeling. See Section 11 and Appendix F.	Accounted for in collision, allision, and grounding risk model.
Density of traffic	The traffic density in the Project Area is described in Section 2.	Accounted for in collision, allision, and grounding risk model.
Other site-specific considerations		
Crossing or converging routes	The risk from encounters between vessels on crossing and converging routes is quantitatively assessed. See Section 11 and Appendix F.	Accounted for in collision, allision, and grounding risk model.
Hazards on opposite sides of a route		None identified.
Severe weather/sea state	Historical distributions for metocean conditions are used to estimate effects on vessels that are adrift.	Accounted for in collision, allision, and grounding risk model. See Section 7, Section 11, and Appendix F.
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 F.	Accounted for in collision, allision, and grounding risk model.

USCG Guideline	Project characteristics	Comments
Complexity of vessel interactions	The Project Area is in an area of relatively lower traffic complexity and has fewer vessel tracks than the nearby coastal waters.	Accounted for in collision, allision, and grounding risk model.
Transit distance affected by a new hazard	The transit distance is expected to increase for those vessels choosing to route around the Project Area and adjacent leases. The types of vessels that are anticipated to be affected are discussed in Section 2.3.	Accounted for in collision, allision, and grounding risk model.
Undersized routing measures		None identified.

5.3 Project impact on anchorage areas

NVIC 01-19 guides an NSRA 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 Brenton Point, more than 12 NM (22 km) northwest of the Project. No anchorage areas lie to the south. The Project is not expected to affect normal vessel anchorage operations.

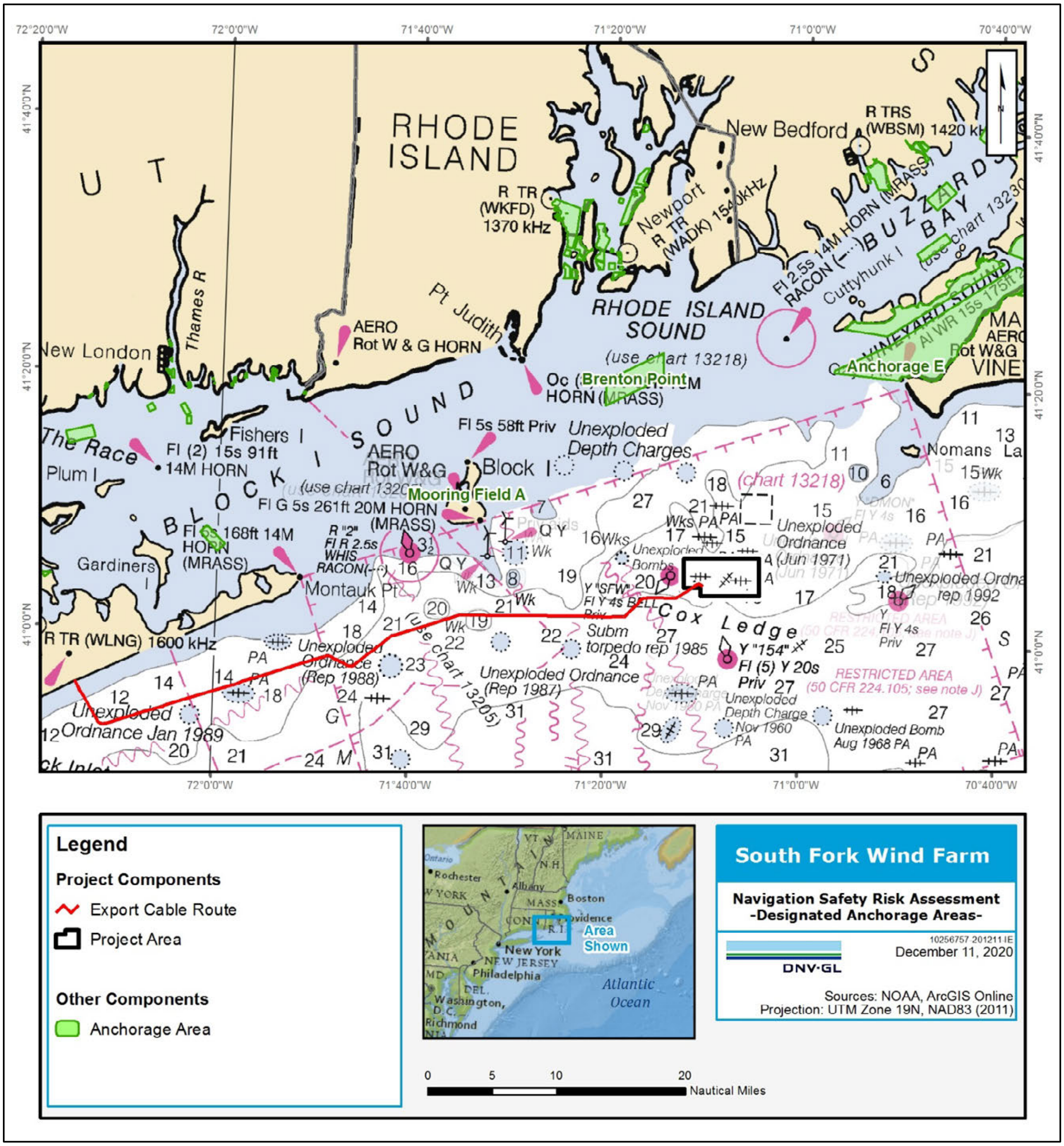


Figure 5-1 Designated anchorage areas (NOAA, 2017)

Emergency anchoring poses a potential hazard to subsea cables. Ships rarely drop anchors (even more unlikely outside of normal operations) but this can damage a cable if an anchor is dropped directly on top of the cable or dragged across the cable line (BOEM, 2011). Credible events that could impact an export cable include human or mechanical failures leading to emergency anchoring of a deep draft vessel, and commercial fishing activities discussed in Section 2.1.1.2 and Section 5.2.

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 data set (see Section 2.1.3.2), 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 Area (see previous Figure 2-29), and all deep draft vessels are expected to transit at safe distances from WTGs. All other vessels in the AIS data set 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 analysis of documented events, construction vessels are the most likely to inadvertently damage an inter-array cable during normal operations if unaware of the cable's location (BOEM, 2011). However, construction planning, safety meetings, and proper marking of the cable on applicable navigation charts will reduce this risk. South Fork Wind will publish frequent Mariners Briefings on www.us.orsted.com/mariners to provide notice to all mariners of current and planned on-site project activity. It will also provide information to the First Coast Guard District for publication in its weekly Local Notice to Mariners (South Fork Wind, 2020).

6 EFFECT OF TIDES, TIDAL STREAMS, AND CURRENTS

The Project' structures will be located sufficiently 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 (3.2 ft)	Shonting and Cook (1970)
Tide height	0.8 m (3.0 ft) mean high water 1.0 m (3.2 ft) mean higher high water	Navigation chart 13218 (NOAA, 2020c); Block Island station 8459681 (NOAA, 2019b); Montauk station 8510560 (NOAA, 2019c).
Tidal stream speed (surface)	0.6 knots (0.3 m/s) 1-year (tidal) 0.6 knots (0.3 m/s) 50-year (tidal)	South Fork Wind metocean design criteria (DNV GL, 2018)
Tidal stream direction (set)	NW (flood), SE (ebb)	South Fork Wind metocean design criteria (DNV GL, 2018)
Current speed (surface)	1.8 knots (0.9 m/s) 1-year (residual) 2.9 knots (1.5 m/s) 50-year (residual) 1.9 knots (1.0 m/s) 1-year (total) 2.9 knots (1.5 m/s) 50-year (total)	South Fork Wind metocean design criteria (DNV GL, 2018)
Current direction	NW-SE (tidal) W-E (residual)	South Fork Wind metocean design criteria (DNV GL, 2018)
Water depth	35.4 – 59.4 m (116 – 195 ft) [MSL]	NOAA National Geophysical Data Center (NGDC) (1999)
Waves	Average monthly wave heights were 0.9 - 2.1 m (2.9 – 6.9 ft) in 2018, with waves higher than 9 ft occurring with 5% frequency	Coastal Data Information Program (2019) Coast Pilot 2 (NOAA, 2020b)

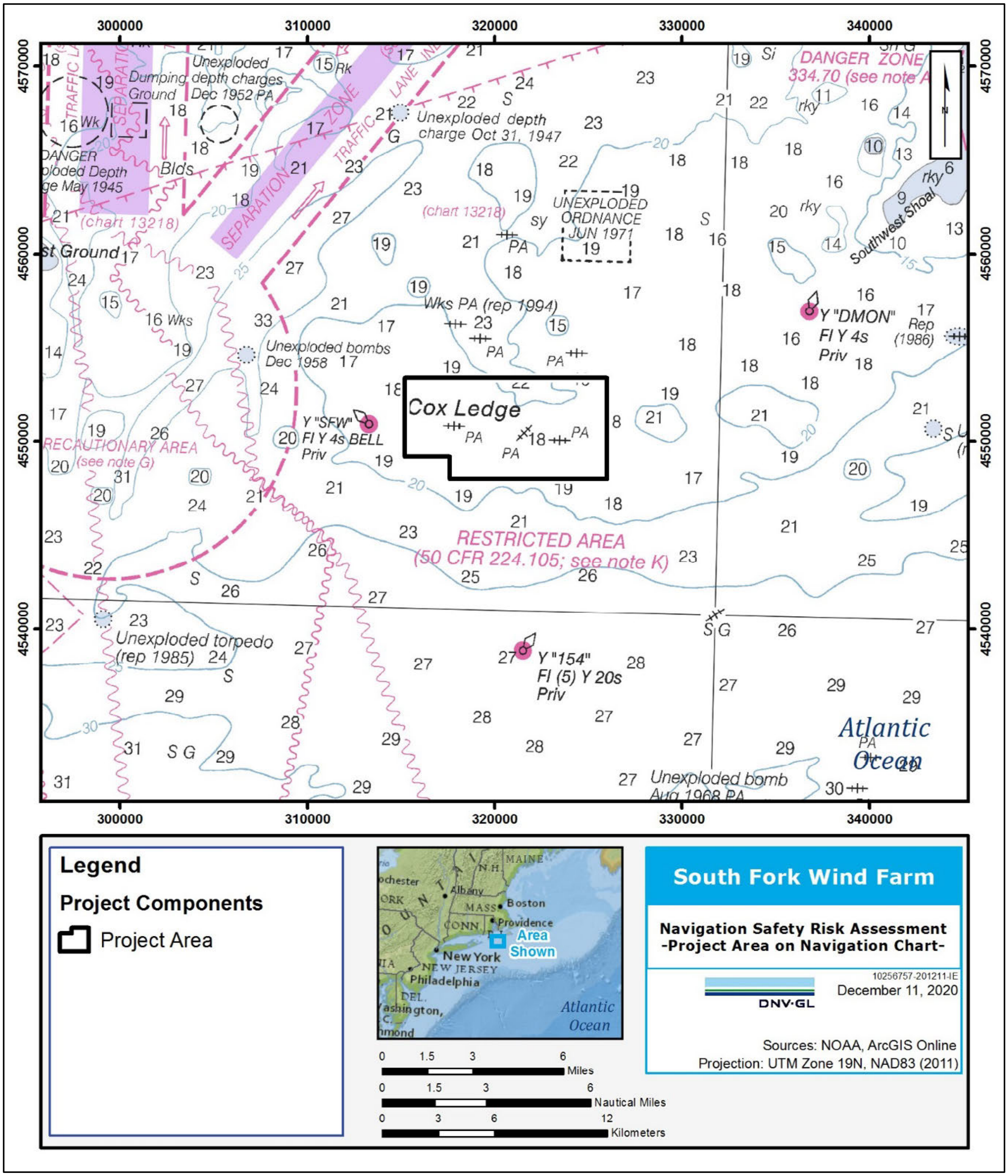


Figure 6-1 Location of the Project on a navigation chart

6.1 Tides

Tides and currents are not directly measured in the Project 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 Project (DNV GL, 2018).

For this assessment, tide heights were determined from tide height measurements from nearby NOAA stations. The closest NOAA stations to the Project 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) west-northwest and 30 NM (58 km) west of the Project 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 for the period 2010 through 2017 (NOAA 2019b).

Table 6-2 Summary of tides at Block Island (NOAA, 2019a/b)

	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)

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 Erofeeva, 2010).

Table 6-3 summarizes the tidal stream and residual current speeds based on analysis of the modeled results.

Table 6-3 Summary of tidal stream and residual current speeds within 2 NM of the Project Area

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

The South Fork Wind 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, 2020b). The axis of the wind turbine layout is a north-south, east-west aligned pattern.

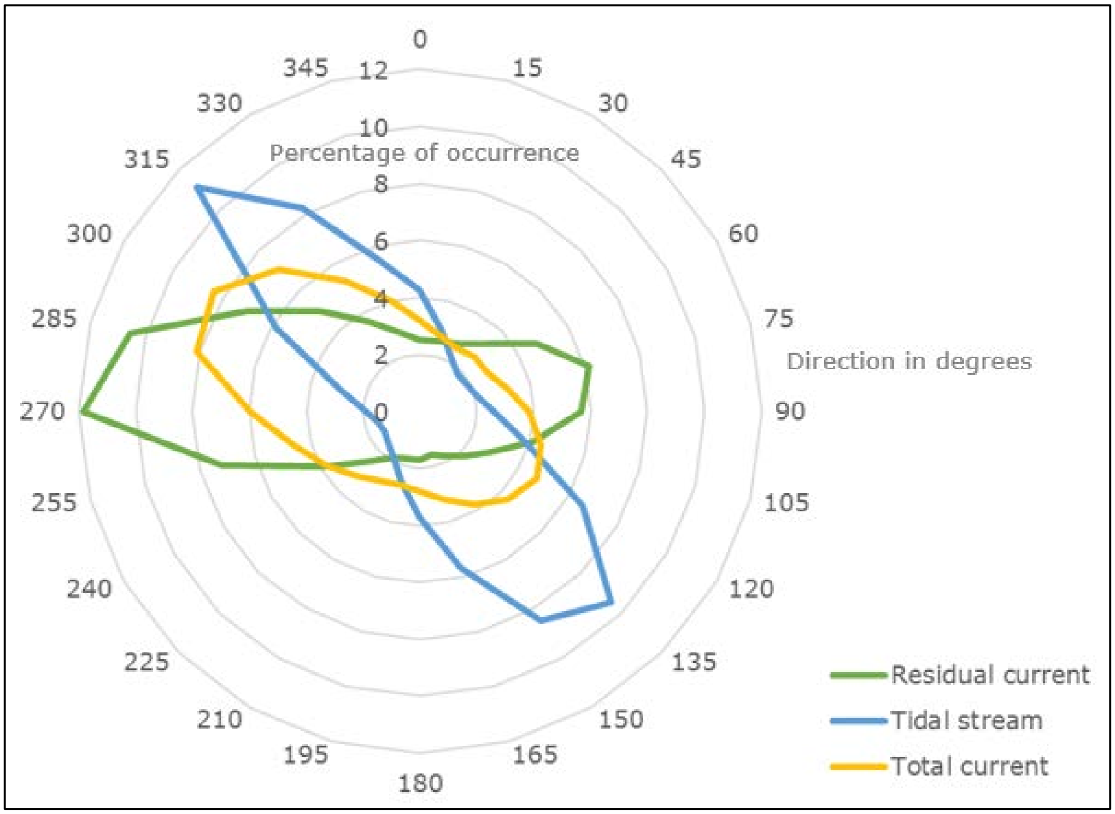


Figure 6-2 Tidal stream and current directional frequency (%) within 2 NM of the Project Area (NOAA, 2020b).

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 Project Area and is not expected to significantly affect navigation safety.

It is not anticipated that Project structures 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 Project’s COP.

6.3 Bathymetry

Charted water depths in the Project Area range from 33 to 41 m (108 to 134 ft) (NOAA, 2020c). Figure 6-3 shows detailed depth contours provided by the NGDC.

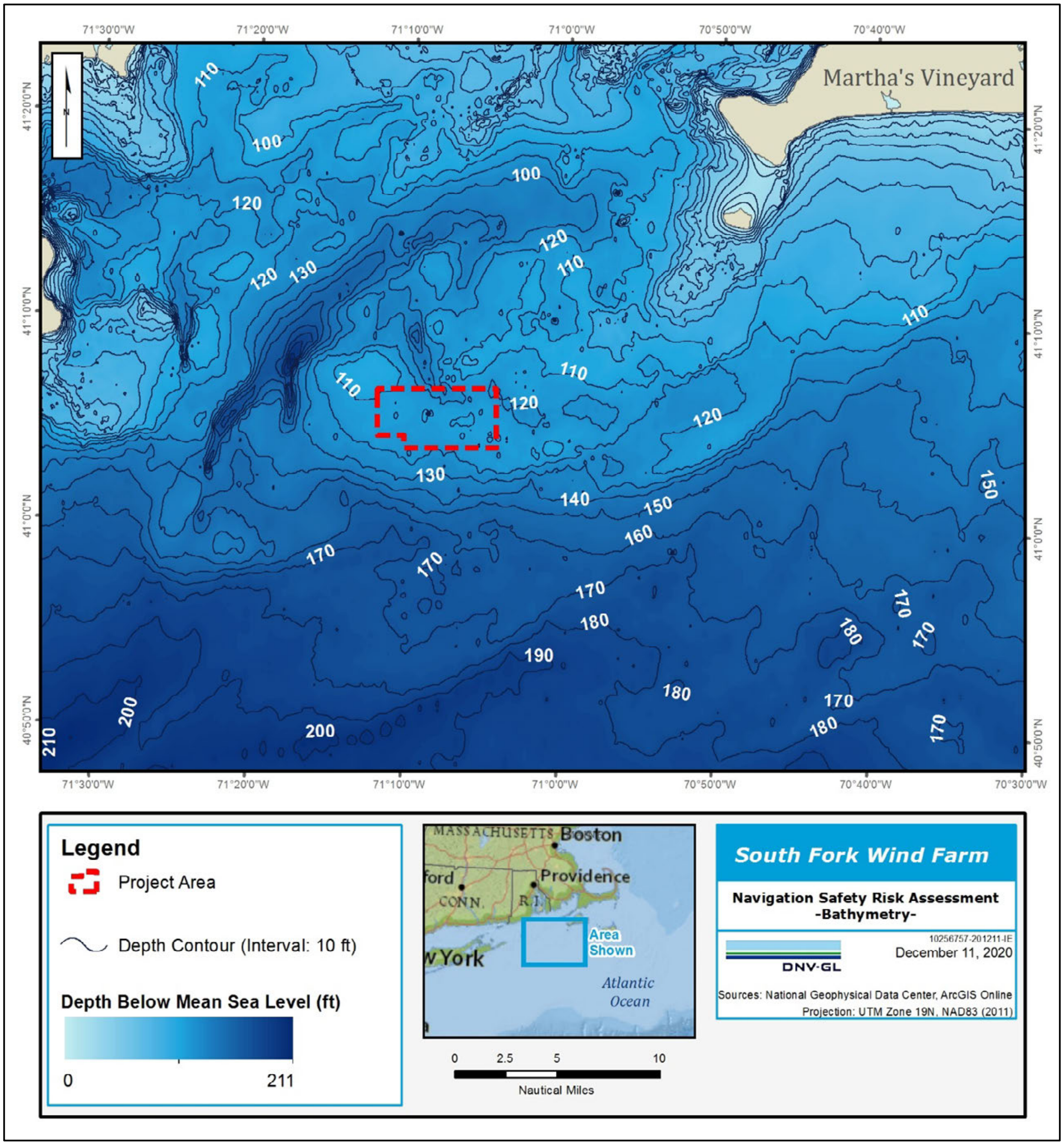


Figure 6-3 Bathymetry in and around the Project Area (depths in feet) (NOAA, 1999)

7 WEATHER

Weather, winds, and visibility are important factors for mariners to consider when planning a route in the Study Area. Table 7-1 summarizes relevant weather characteristics in the Project 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 knots (7.2 m/s) mean 55.1 knots (28.3 m/s) maximum hourly average 64.2 knots (33 m/s) 10-minute average (50-year return) 81.7 knots (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, 2019c)
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, 2020b); Rhode Island (2010); Merrill (2010)

7.1 Winds

Long-term on-site wind speed statistics for the Project Area are key inputs to risk modeling. However, long-term raw data are not available for the Project Area. As an alternative, 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 Project 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 data sets reviewed in this region.

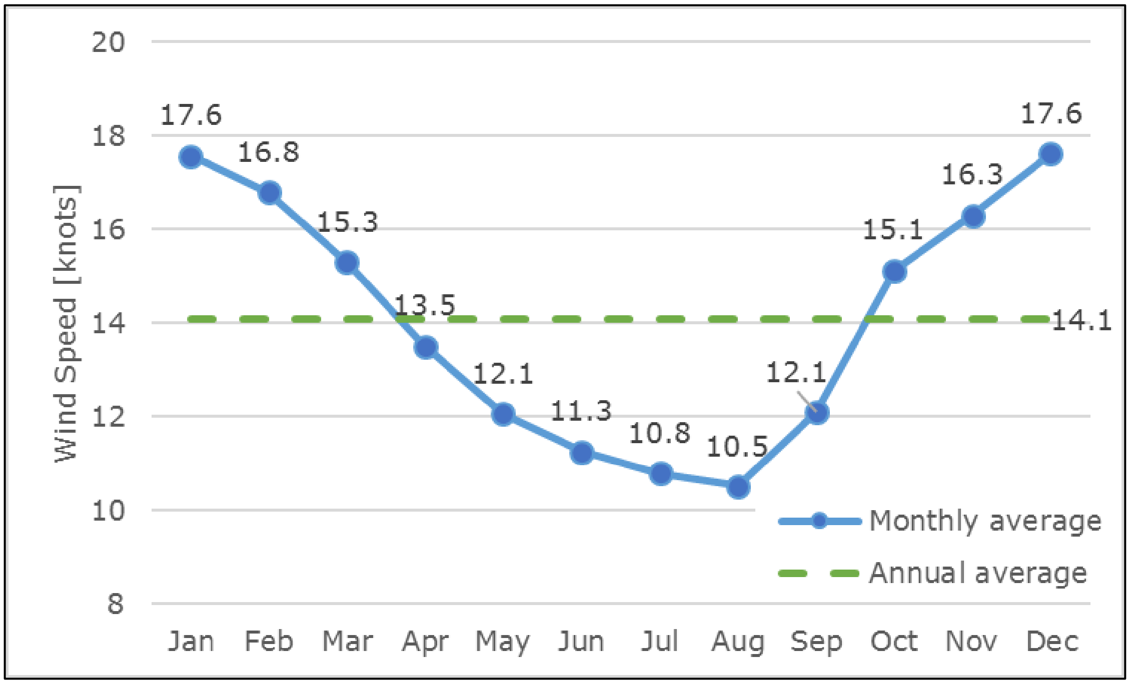


Figure 7-1 Average hourly wind speeds expected at 33 ft (10 m) height above MSL

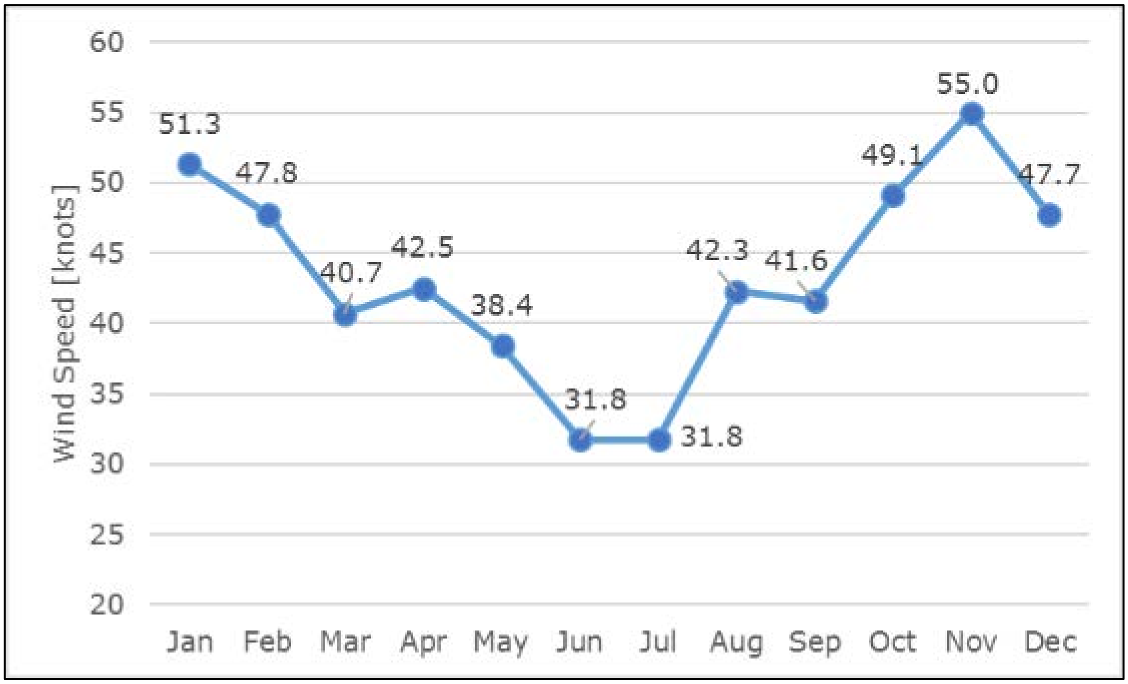


Figure 7-2 Maximum hourly winds speeds from 17.5-year VMD at 33 ft (10 m) height above MSL

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

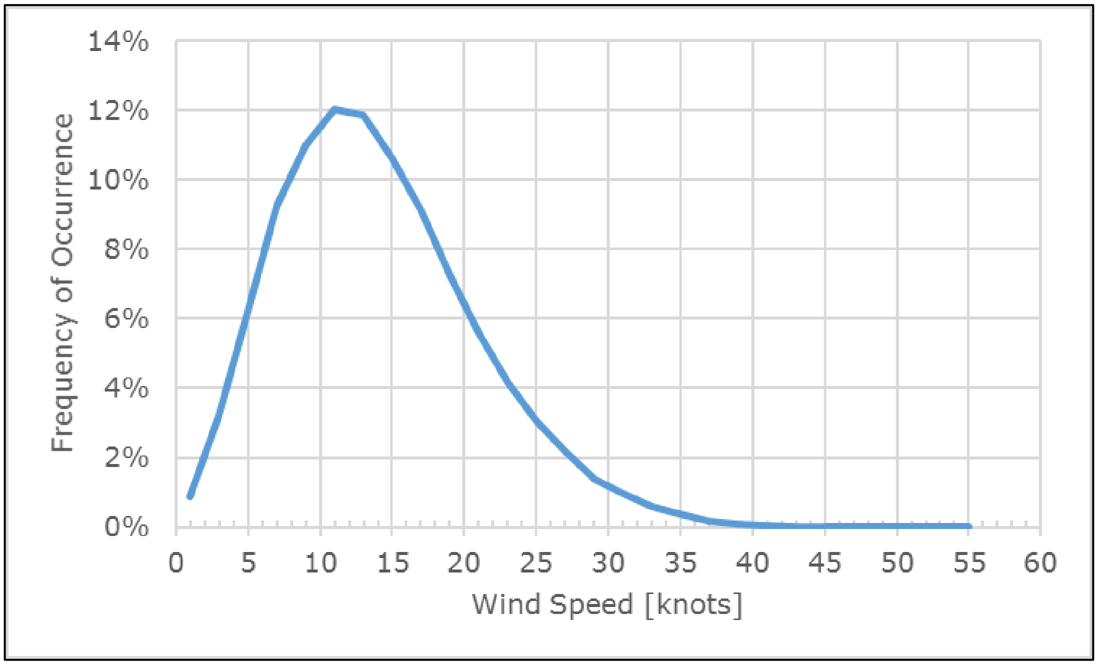


Figure 7-3 Distribution of wind speeds at 33 ft (10 m) height above MSL

The prevailing wind direction is from the west-southwest. Figure 7-4 presents the distribution of wind directions over this period. The 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.

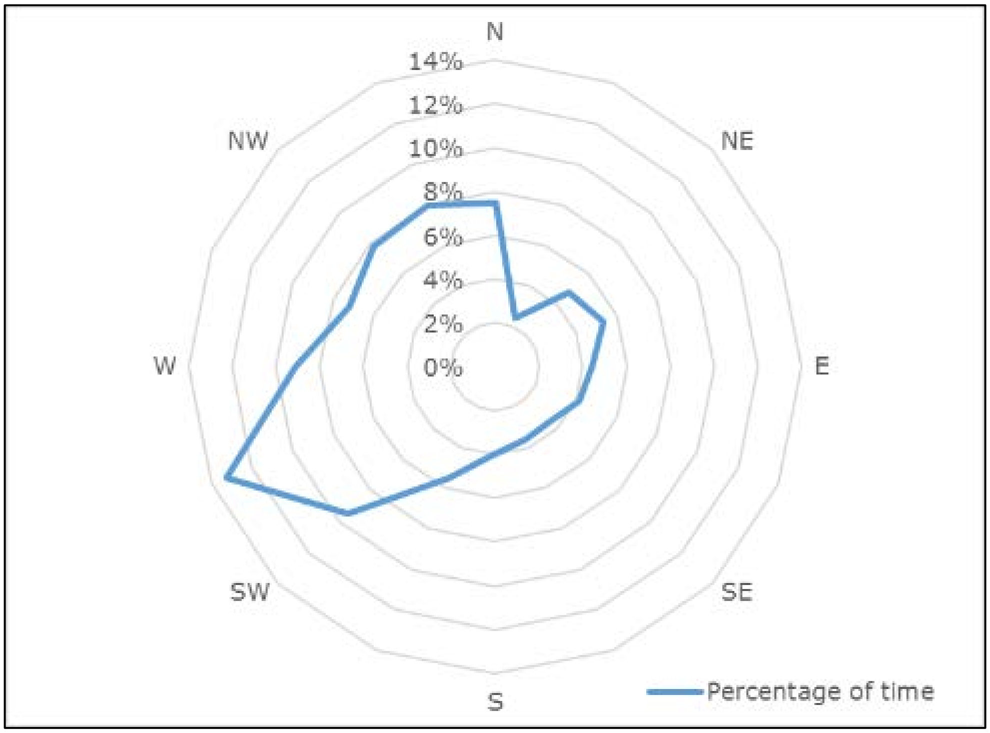


Figure 7-4 Wind direction distribution expected at 33 ft (10 m) height above MSL

There is an increased frequency 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 Project Area between 1969 and 2019 (Knapp et al., 2010) (Table 7-2 and Figure 7-5). Of the 85 storms passing within 5 degrees of the Project Area, 85% were Category 1, or lesser, tropical events.

Table 7-2 Number of cyclones within 5 degrees of the Project Area (Knapp et al., 2018)

Hurricane scale (Saffir Simpson)	Number of occurrences 1969-2019
Tropical Depression	11
Tropical Storm	39
Category 1	22
Category 2	10
Category 3	3
Category 4	0
Category 5	0
Total	**85**

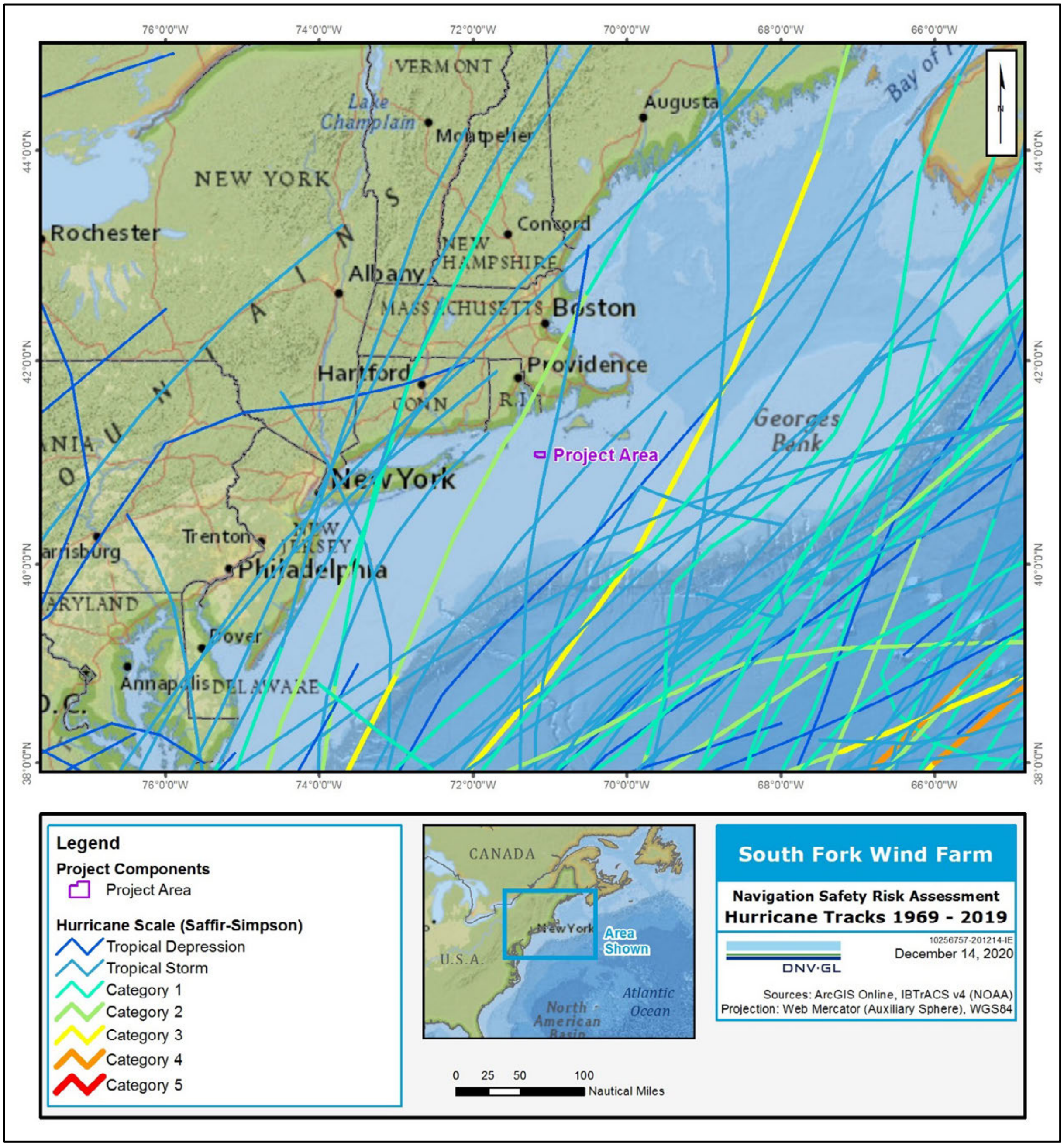


Figure 7-5 Tracks of cyclones within 5 degrees of the Project Area (1969-2019) (Knapp et al., 2018)

7.2 Consideration of vessels under sail

Vessels under sail could enter the Project Area during the Project's construction and operational phases. In line with rules of prudent seamanship, a vessel should proceed with caution near any man-made structure. 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, 2019c). 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% 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.

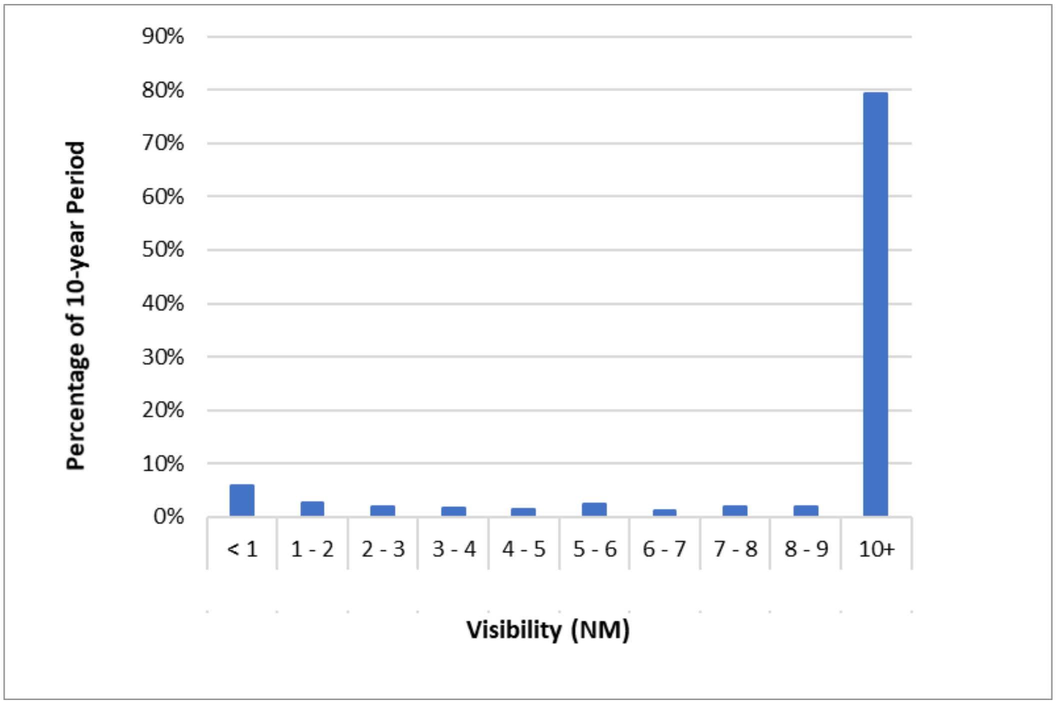


Figure 7-6 Summary of visibility measurements at Block Island State Airport (2009-2019) (NOAA, 2019c)

7.4 Ice

Ice can potentially impact navigation in an offshore wind in two ways: floating ice can cause treacherous conditions for vessels, and ice can accumulate on a WTG structure.

7.4.1 Floating ice

Coast Pilot 2 (NOAA, 2020b) 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 Area. This assessment has found no 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 the integrity of a Project WTG is anticipated from ice accumulation because should ice accumulate 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; accumulated ice will drop to the base of the WTG.

Therefore, the greatest relative risk from ice accumulation 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 would be nearby in the winter months and hit by a piece of ice.

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

Enclosure 2, Section 8 of NVIC 01-19 recommends a site-specific evaluation will be conducted of the potential impacts (both positive and negative) to SAR (Search and Rescue) services in and around the Project. This report provides input to the USCG's assessment of whether the risk to SAR missions is mitigated to ALARP (As Low As Reasonably Practical). An ALARP assessment evaluates any additional risk reduction measures with the goal of weighing the potential benefits against the costs.

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

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

Wind turbine layouts are traditionally developed based on a balance weighing many factors, including:

- Geology of the seabed. Some seabed characteristics may not allow installation of the preferred foundation type, so the layout must be modified accordingly, or a different foundation selected.
- Water depths.
- Reasonably available foundation types.
- Significant habitat, species, or cultural/historical values may be present and need to be avoided.
- The location of each turbine relative to others given the prevalent wind direction is a key design aspect. Wind turbine energy models are run to optimize the layout. All else being equal, WTGs in straight rows or columns are less ideal than offset/curved patterns because wind turbine efficiency is higher when there is less influence on the wind flow from upwind turbines and more turbines can be effectively placed in a smaller footprint.

Assuming a definite area for an offshore wind farm and WTGs of a specified size, longer distances between WTGs could reasonably result in:

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

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 the OSP. This will provide many 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 South Fork Wind have proposed development of additional wind farms in adjacent areas. The WTGs in adjacent/contiguous farms will have a congruent alignment.
- The offshore wind developers in the RI and RI/MA lease areas have proposed a layout for wind turbines across the leases in the region, a 1 NM by 1 NM (1 .9 km by 1.9 km) uniform turbine layout (Equinor Wind US, Eversource Energy, Mayflower Wind, Orsted North America, and Vineyard Wind LLC, 2019). The layout of Project structures analyzed in this NSRA conforms to the joint developers' proposal.

A list of additional risk controls that could be evaluated in USCG's ALARP process is contained in Section 11.3.

9 VISUAL NAVIGATION

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

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

View of other vessels while underway

A geometric approach was used to determine potential visual obstruction caused by Project structures, with a focus on a mariner's ability to see another vessel. The largest considered monopile foundation is the basis for this assessment.

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

The potential length of visual obstruction for a Project structure was estimated based on the effective diameter of the obstruction, plus a buffer. The largest monopile foundation being considered has a maximum diameter of 11 m (36 ft). For this evaluation, additional buffers were added to the diameter as follows:

- 1 m was added to each side to account for ancillary equipment, resulting in an effective diameter of 13 m (43 ft).
- A safety buffer of 10 m (33 ft) was added to the effective diameter to account for the uncertainty in the distance between the unseen vessel and the obstructing Project structure. The resulting evaluated diameter was 23 m (75 ft), representing the maximum obstruction size including the buffer.

For a vessel travelling at 5 kt, the visual obstruction would persist for 9 seconds. This is the period of time that a monopile structure could potentially limit a vessel's visibility of a second vessel, assuming the second vessel was equidistant on the opposite side of the structure and was not moving. A hazardous situation could exist if two vessels were transiting at speed on intersecting courses while close to the same monopile structure. Both vessels should be aware that their line of sight (LOS) was limited by the structure, and in line with COLREGS, should reduce speed and keep vigilant watch.

This is a conservative approach since the structures are spaced so far apart, both vessels would need to be transiting on a very narrow range of possible routes to lose sight of each other for the calculated number of seconds listed in Table 9-1. On more probable routes, the visual obstruction would be shorter. The distance travelled without the other vessel in sight is approximately 0.012 NM (23 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	8.9
10	4.5
15	3.0

The Project layout evaluated in this assessment (Figure 9-1) has a minimum of 1.0 NM between Project structures. This represents more than 71 vessel lengths for the average fishing vessel transiting the Study Area, which has an LOA of 26 m (85 ft)[2].

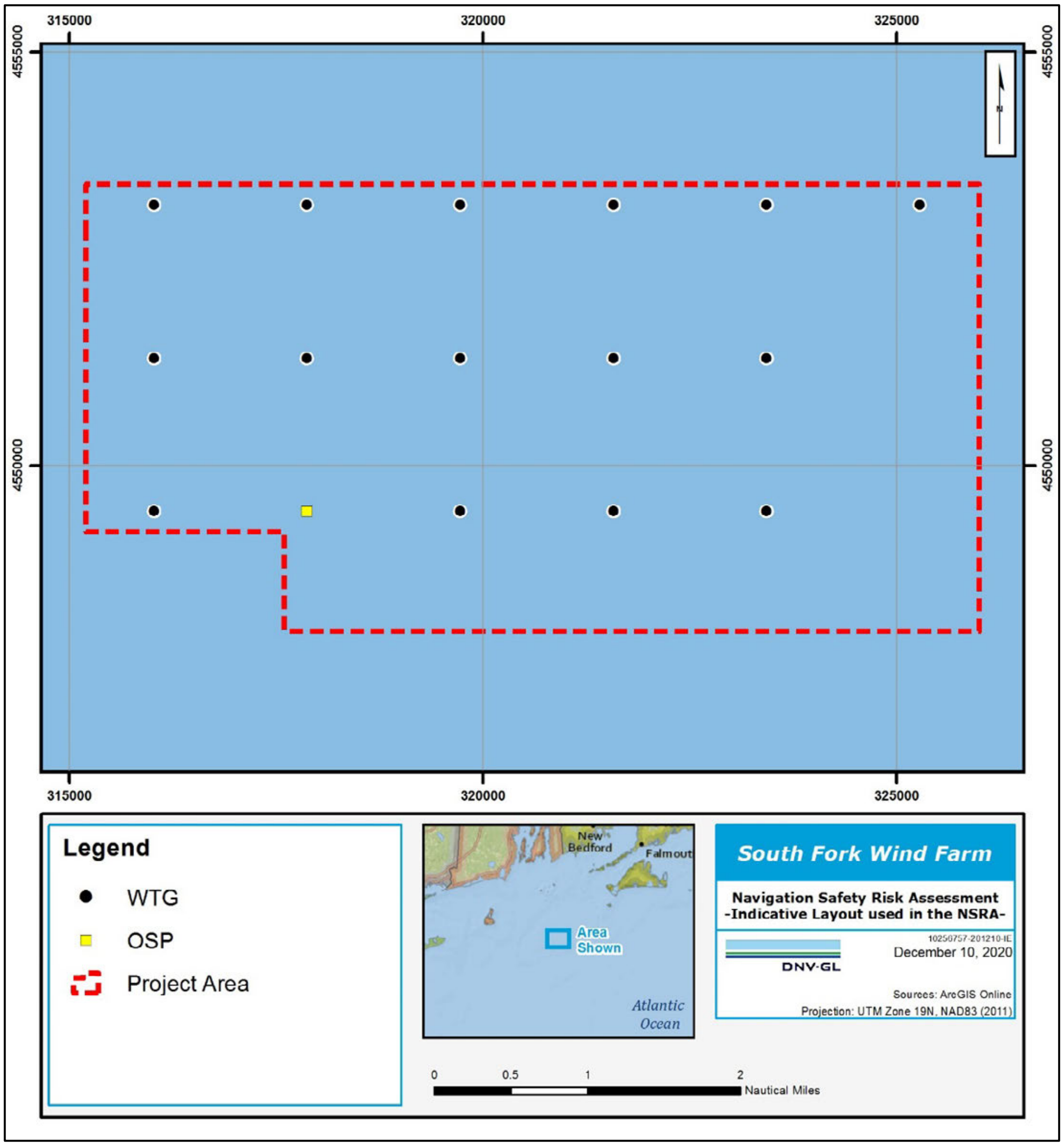


Figure 9-1 Project representative layout (structures larger than scale)

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 each one will be lighted, marked, and its location broadcast via AIS as required by applicable requirements and in conditions the USCG may impose in conjunction with its PATON permits. The prospective marking scheme for Project structures is described in Section 13.

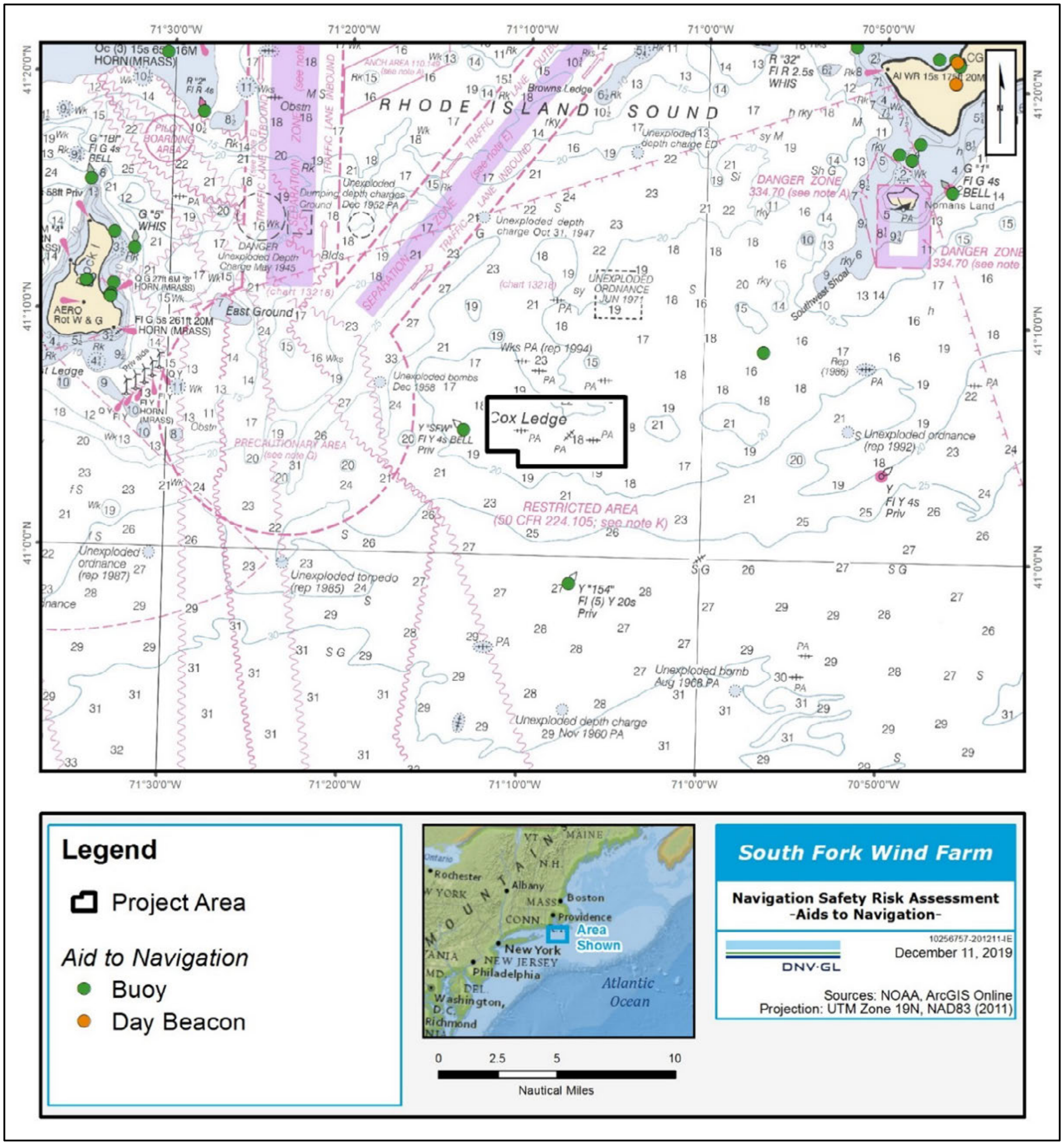


Figure 9-2 ATON in the vicinity of the Project

10 COMMUNICATIONS, RADAR, AND POSITIONING SYSTEMS

Given the current level of scientific understanding, some types of specific effects from this Project, or any other specific offshore wind farm, can be most effectively assessed after its construction. However, a general level of anticipated effect can be understood in the early design phases of a project. This section summarizes the findings of indicative studies concerning potential effects of offshore WTGs on communication and navigation systems.

In-air construction and operational noise is discussed in the relevant sections of the Project's COP.

10.1 Effects on communications

The potential effects of the Project were evaluated on marine communications systems, both ship-to-ship and ship-to-shore, including High Frequency (HF), VHF, and Ultra High Frequency (UHF) radio systems. The sections below summarize relevant studies. 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.

MRASS are also VHF-based and are expected to be deployed as part of the Project, similar to the deployment at Block Island Wind Farm (South Fork Wind, 2020).

The USCG'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.

U.S. Department of Energy

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

Horns Rev Wind Farm

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

North Hoyle Wind Farm

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

10.2 Effects on 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).

The potential effects on and mitigations for coastal land-based radar have been the subject of studies by BOEM, MIT Lincoln Laboratory, Lawrence Berkeley National Laboratory, Sandia National Laboratory, and others. For example, a public summary from 2017 (DOE, et al.) states that radar mitigations are currently in various stages of development, testing, and deployment. 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 U.S. 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 (South Fork Wind, 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 Area. QinetiQ modeled X-Band and S-Band radar systems. X-Band systems operate within a frequency range of 8.0 GHz to 12.0 GHz and are generally installed on smaller vessels. S-Band systems operate within a frequency range of 2.0 GHz to 4.0 GHz and are generally installed on large vessels.

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

<u>Radar clutter assessment</u>

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, 2017a). 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. There is limited available literature quantifying the 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:

- Use of newer radar technologies, such as solid state and pulse-compression radars which identify closer targets and provide higher target resolution.
- 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 through 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 Area from operation of the Project that builds upon earlier work conducted by the USCG (e.g., 2015 and 2020a). 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 accident frequency presented in Section 11.1, is estimated by modeling how often a marine accident may occur with and without the Project. The consequence analysis in Section 11.2 discusses how severe an accident could be if it were to happen. Risk mitigation and cumulative effects are presented in Sections 11.3 and 11.4.

It would be ideal to compare the model results to the historical accident record for offshore wind farms; however, the historical data is sparse. Offshore wind farms have been in operation in the European Union for more than 30 years (Wind Europe, 2020). 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. 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 results are presented by accident type and by vessel type. For most vessel types, risk change from the Project is estimated in terms of the difference in frequencies of marine events based on multiple data inputs into the MARCS tool. MARCS has been utilized globally to assess navigation risk of more than 20 offshore wind farms where the model's calculations and estimates have been reviewed and affirmed. 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.

11.1.1 Background information

The supplementary traffic added to the AIS data is detailed in Section summarized in Section 2.1 and Appendix F. The Project model does not include anchoring as a save mechanism for drift allision nor does it include tugs of opportunity or similar towing ships, so the drift grounding and drift allision results are certainly conservative.

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 less 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 E 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 F to this NSRA.

The decision concerning whether and how to account for nearby wind lease areas involves a trade-off. If the effects of other leases are ignored for purposes of the model, the risk estimate is purely the result of the South Fork 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 the other lease areas is that re-routed traffic (mainly deep draft ships) is more extensively modified compared to traffic routes in the historical AIS data.

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 RI and RI/MA 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 from the resulting increased traffic density around the leases.

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 some 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 PATON 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.
- Project vessels in the area conducting routine maintenance on WTGs and OSPs during the operations phase of the facility’s service life.
- 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.

11.1.2 Study Area

Figure 11-1 shows the extent of the modeled Study Area, as well as the sub-areas defined for the purpose of clarifying where the Project influences navigation safety risk.

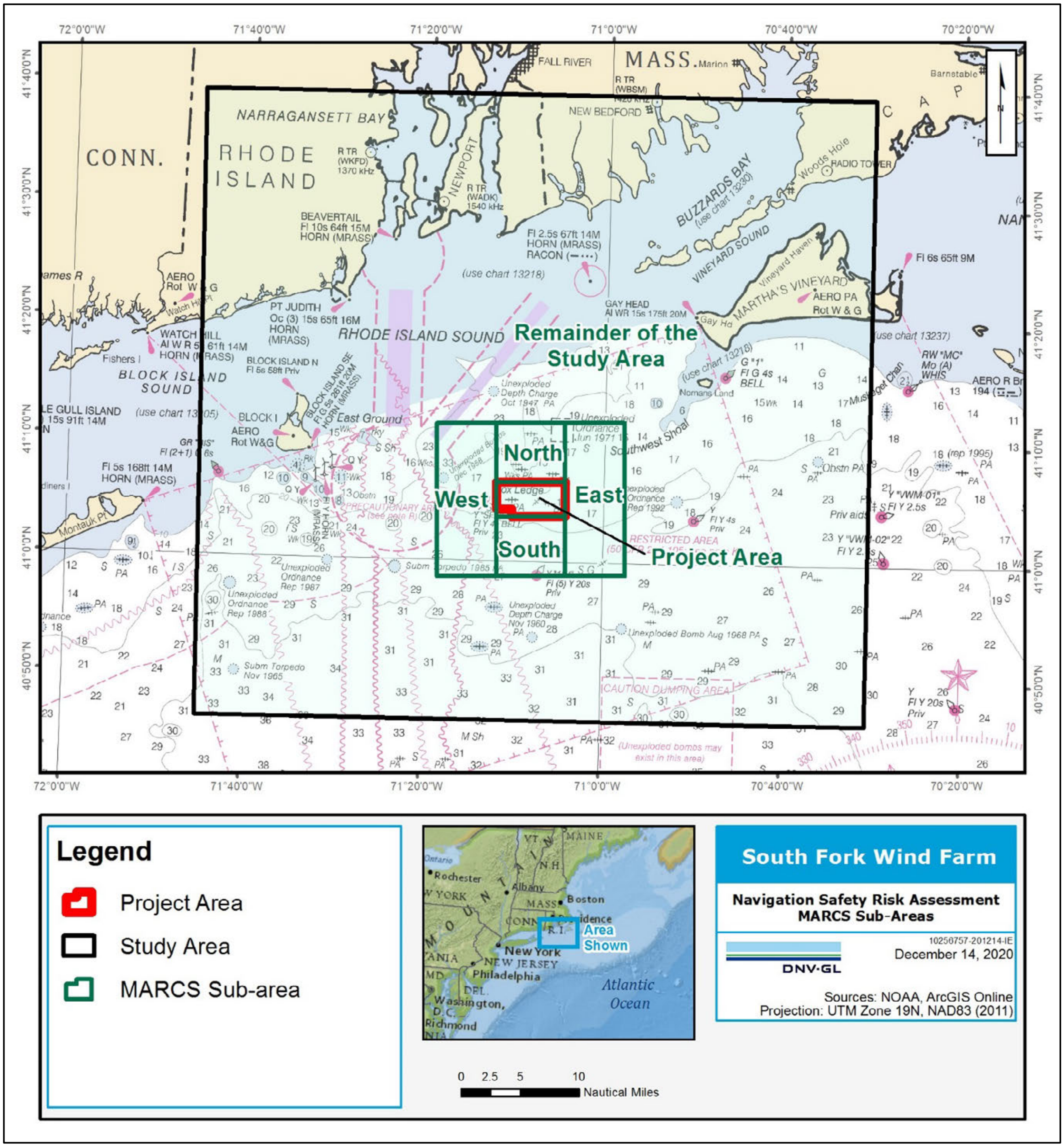


Figure 11-1 NSRA Study Area and sub-areas defined for MARCS modeling

Table 11-1 provides a summary of the incremental risk results for the Project, reported as increases in the frequency of accidents in the Study Area.

The model shows that the frequency of marine accidents increases by 0.04 accidents per year. Based on the model, most of the risk increase is allisions with Project structures. The other risk increases are related to additional pleasure vessels transiting to the Project and re-routing of deep draft and tug vessels around the lease areas.

Marine accidents involving pleasure vessels represent 48% of the increase (Figure 11-2). Note this accident frequency increase is for all accidents of any severity, including accidents with small and zero consequence such as bumping into a foundation while drifting.

Table 11-1 Modeled incremental change in accident frequencies from the Project

Vessel type	Increase in frequency of any accident (number per year)	Percentage of Total
Cargo/Carrier	0.002	5%
Fishing	0.013	32%
Other/Undef.	0.004	9%
Passenger	0.001	2%
Pleasure	0.019	48%
Tanker	<0.0005	0%
Tanker-Oil Prod.	<0.0005	1%
Tug/Service	0.002	5%
Total	**0.040**	**100%**

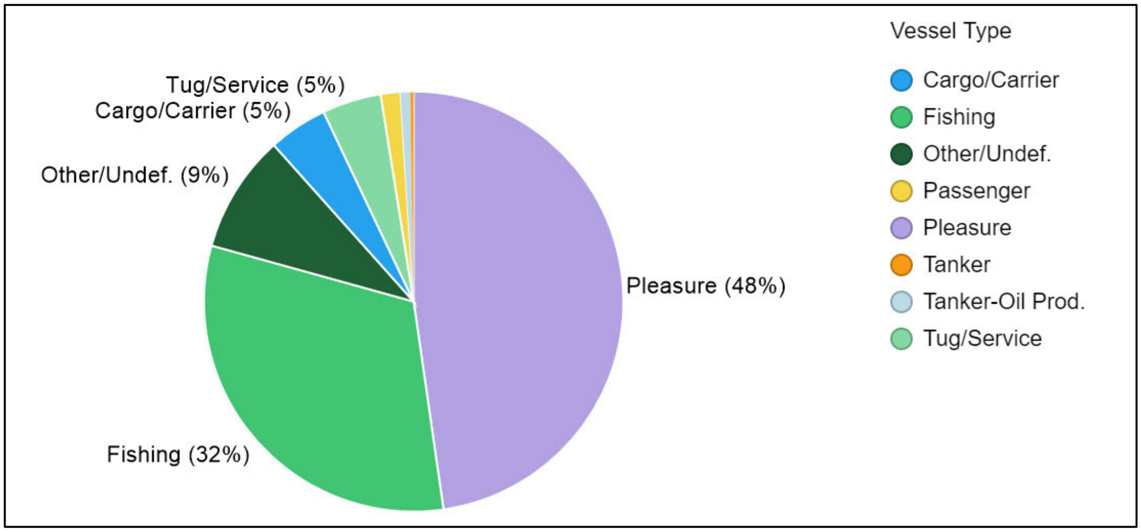


Figure 11-2 Distribution of risk per vessel type

Table 11-2 shows the same results summarized per accident type.

Table 11-2 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
Drift Allision	0.019	48%
Powered Allision	0.007	18%
Collision	0.001	2%
Drift Grounding	0.007	19%
Powered Grounding	0.005	12%
Total	**0.040**	**100%**

Allision accidents of any severity comprise 67% of the increase in risk and are predicted to occur once every 38 years, on average (Figure 11-3).

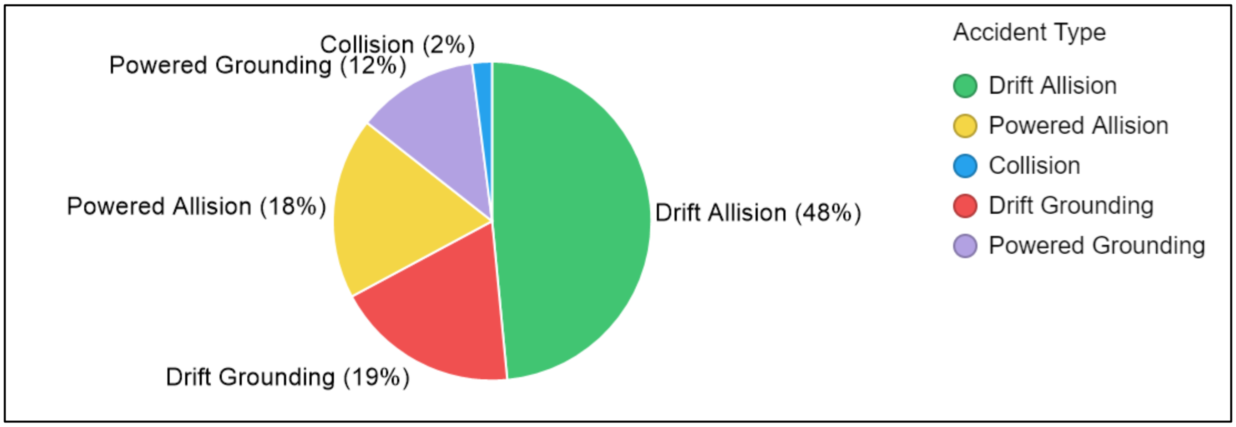
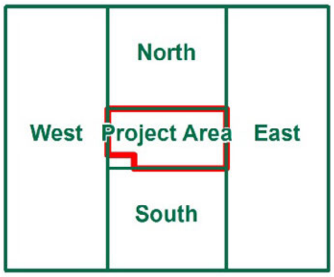


Figure 11-3 Risk contribution per accident type

The sub-areas shown in previous Figure 11-1 were selected to provide clarity on where risks change and where they do not. The sub-areas adjacent to the Project Area are simple polygons extending to 5 NM from the Project Area based on results of preliminary model runs.

Section 11.1.3 presents the modeled risk results for the Project Area. The four sub-areas adjacent to the Project Area were sized to capture risk in the vicinity of the Project. The modeling showed risk less than 0.0005 accidents per year in the North, East, South, and West sub-areas combined.



Section 11.1.4 presents the modeled risk results for the remainder of the Study Area.

11.1.3 Project Area

Table 11-3 shows the modeled risk from the Project within the Project Area (the difference between the Future Case and the Base Case). The Project Area contains all the Project structures and hence all the powered allision and all the drift allision accidents are limited to 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 11-3 Risk increase in the Project Area (annual accident frequencies)

Vessel type	Drift allision	Powered allision	Collision	Drift grounding	Powered grounding	Total
Cargo/Carrier	0.002	<0.0005	<0.0005	0	0	0.002
Fishing	0.008	0.004	<0.0005	0	0	0.012
Other/Undef.	0.002	0.001	<0.0005	0	0	0.004
Passenger	0.001	<0.0005	<0.0005	0	0	0.001
Pleasure	0.003	0.002	<0.0005	0	0	0.005
Tanker	<0.0005	<0.0005	<0.0005	0	0	<0.0005
Tanker-Oil Prod.	0.001	<0.0005	<0.0005	0	0	0.001
Tug/Service	0.002	<0.0005	<0.0005	0	0	0.002
Total	**0.019**	**0.007**	**<0.0005**	**0**	**0**	**0.027**

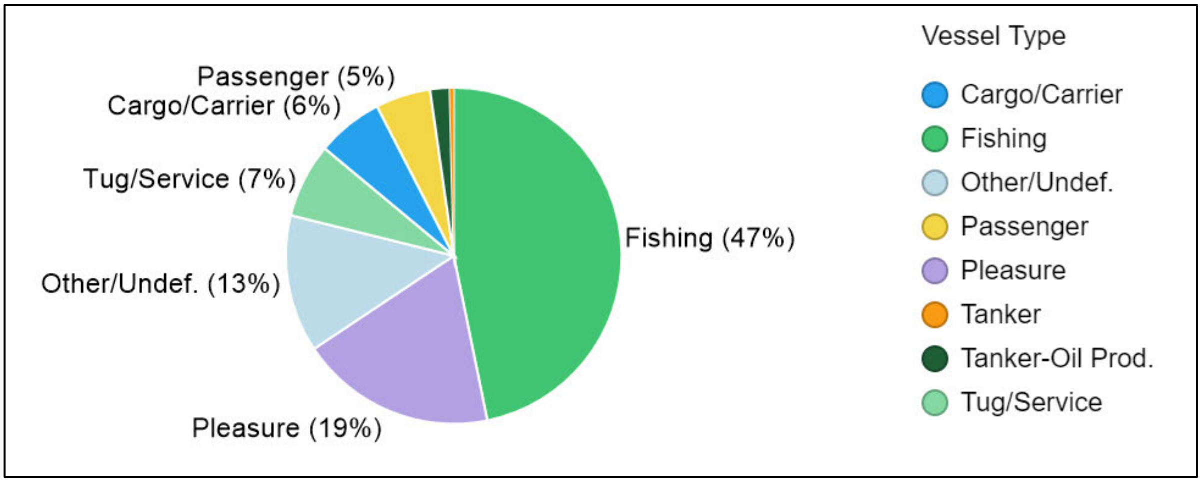


Figure 11-4 Distribution of risk per vessel type in the Project Area

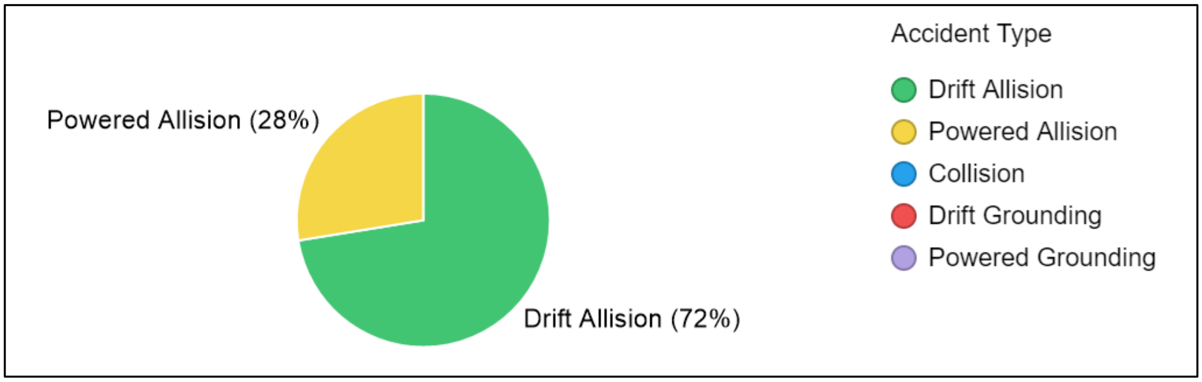


Figure 11-5 Risk contribution per accident type in the Project Area

11.1.4 Remainder of the Study Area

Risk increases from the Project in the Remainder of the Study Area are presented in Table 11-4.

Table 11-4 Risk increase in the Remainder of the Study Area (annual accident frequencies)

Vessel type	Drift allision	Powered allision	Collision	Drift grounding	Powered grounding	Total
Cargo/Carrier	-	-	<0.0005	0.001	<0.0005	<0.0005
Fishing	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Other/Undef.	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Passenger	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Pleasure	-	-	0.001	0.006	0.007	0.014
Tanker	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Tanker-Oil Prod.	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Tug/Service	-	-	<0.0005	<0.0005	<0.0005	<0.0005
Total	-	-	0.001	0.007	0.007	0.013*

* The total for pleasure vessels is greater than the total for all because deep draft powered groundings decrease a very small amount in the Future Case as a result of re-routing.

For collisions, the modeled accident frequency related to the Project increases by 1 collision in 1,000 years in the Remainder of the Study Area. Compared to a collision baseline frequency of 0.29, the effect from the Project represents less than a 1% increase.

Groundings of the pleasure vessels contribute 50% of this increase (Figure 11-6). This is a result of the additional pleasure vessel transits to the Project Area in the Future Case.

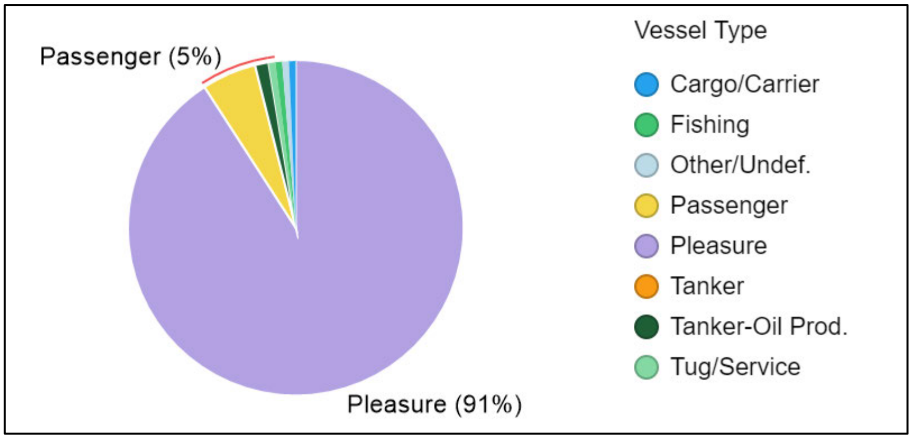


Figure 11-6 Distribution of risk per vessel type in the Remainder of the Study Area

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 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 OSP. 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 the Project include:

- Generally low traffic density in the Project Area compared to areas nearer to shore
- Predominantly smaller vessels in the Project Area
- Sufficient distance from ports, coastlines, and shoaling water to allow safe transit around the Project Area
- Enhanced navigation aids such as Project ATON, lighting, marking, and AIS 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 USCG, which has the primary responsibility to ensure safety of life and property at sea. The USCG administers navigation and vessel inspection laws and regulations governing marine safety and environmental protection. The USCG accomplishes this by prescribing regulations published in CFR Titles 33, 46, and 49. These regulations incorporate international laws to which the United States is a signatory, as well as various classification society and industry technical standards.

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

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

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 (USCG, 2020a)
- Atlantic Coast Port Access Route Study (USCG, 2015)
- Buzzards Bay Port Access Route Study (USCG, 2004)

Ongoing PARS in the area include:

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

Results in PARS reports, including recommendations,

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

The Project PDE conforms to the recommendations in the USCG’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." (USCG, 2020a)

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

NOAA also plays an important role in marine safety, providing weather reports, forecasts, warnings, 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 USCG 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 11.3.2 and 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 USCG 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[6], 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 (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.

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[6] Note that current USCG policy for U.S. navigable waters will not allow avoidance measures to be implemented in offshore wind farms, per NVIC 01-19.

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

This study has identified various risk mitigation measures that are used in some jurisdictions. These are not necessarily standard or best practices, nor are they necessarily intended for use by the Project, and are listed in alphabetical order:

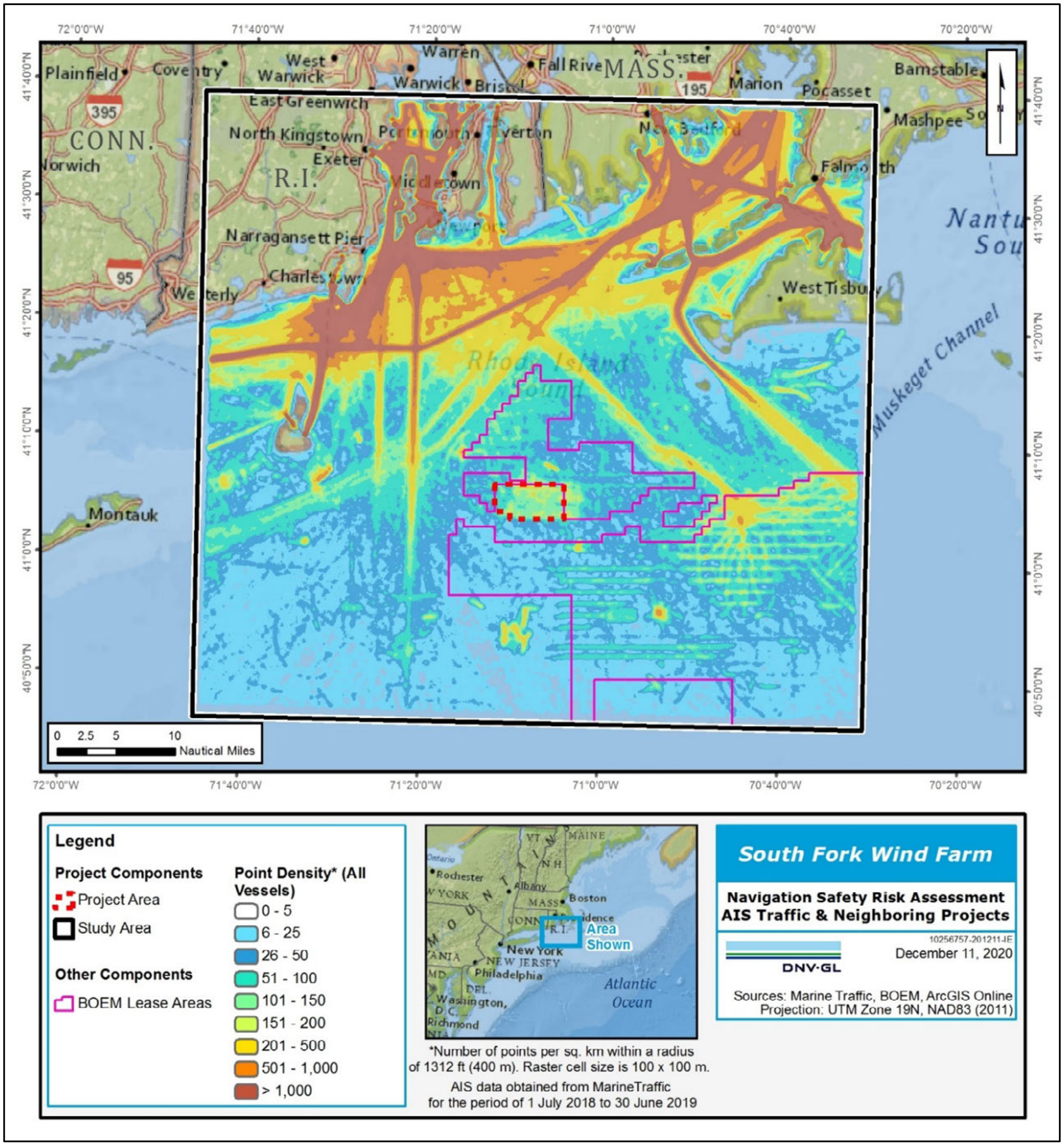
- Additional ATON
- AIS transponders on Project structures
- Additional cable protection measures, such as armored ducting, rock placement, or concrete mattresses
- Communications repeaters on Project structures
- Designation of additional anchorages
- Designation of additional routing measures
- Designation of areas to be avoided or limited access areas
- Designation of routes for specific vessel types
- Emergency response planning and exercises
- Extension of cellular service
- Fishing / transits limited to daytime
- Highly robust subsea cable protection
- Ice hazard protocol
- Increased requirements for life safety equipment onboard all vessels
- Maximum LOA for vessels allowed to transit the wind farm
- Measures to reduce safety risk for highest risk vessels in the area, i.e., USCG inspections
- Offshore cameras (to facilitate SAR)

- Offshore structures are accessible and can be used as a potential place of refuge
- Pilotage of deep draft vessels near the Project
- Project structures along perimeter equipped with radar beacon to allow clear identification via radar
- Real-time vessel monitoring in the wind farm
- Require that only specified designs/kinds of commercial fishing gear can be used in the wind farm
- Safety zone of 500 m (1,642 ft) around construction vessels during wind farm construction
- Safety zone of 500 m (1,642 ft) around offshore structures during wind farm operations
- Transit or fishing only with a functioning and active VHF and AIS installation
- Tug on standby to assist vessels in distress
- Vessel design and equipment maintenance requirements for all vessels entering a wind farm
- Vessel traffic services
- Visible and consistent marking and lighting of each structure

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

11.4 Cumulative effects

This section presents a qualitative assessment of cumulative effects from proposed wind farms on navigation for the lease areas within the Study Area (Figure 11-7). Because the risk modeling accounted for the other lease areas, the quantified cumulative effects on collision, allision, and grounding risk are included in the quantified risk presented in Section 11.



*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

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

Figure 11-7 AIS point density[2] and leases for renewable energy development

Potential effects related to navigation safety resulting from development of the leases in combination may include:

1. Effects on navigation risk

   Although transit through the Project Area will be permissible under current law and regulations, commercial fishing traffic that currently transits through the lease areas could elect to avoid them and take routes around the lease areas. Note that the collision, allision, and grounding risk described in Section 11 assumes that fishing traffic continues to transit through the lease areas.

   - Collision risk – Fishing vessels generally avoid TSS, per Coast Pilot guidance (NOAA, 2020b). Deep draft vessels and tugs transit the TSS. Therefore, if fishing vessels take alternate routes east or west of the leases, the number of interactions between the deep draft and fishing vessels may increase, which could also increase the risk of a collision.
   - Risk of an adrift vessel – 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 critical propulsion and steerage equipment, which may increase the potential of a vessel becoming adrift.

2. Effects on fishing patterns

   Changes to commercial and recreational fishing patterns may occur as a result of buildout of the leases. The changes and the effects from such changes are largely unpredictable at this time.

3. Effects on SAR

   In bad visibility or in high seas, SAR efforts could be more challenging and may require different approaches than are currently used in the lease areas. In its final MARI PARS report the USCG 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

This section summarizes available information related to USCG SAR and marine environmental protection/response to allow the USCG to evaluate potential effects on its missions from the Project.

The USCG MARI PARS (2020a) report provides a summary of SAR incident data from 2005 through 2018. The number and types of cases discussed below are taken from that report. Figure 12-1 and Figure 12-2 show the number of cases per year in the USCG MARI PARS study area and the distribution of the types of cases occurring in the area from 2005 through 2018.

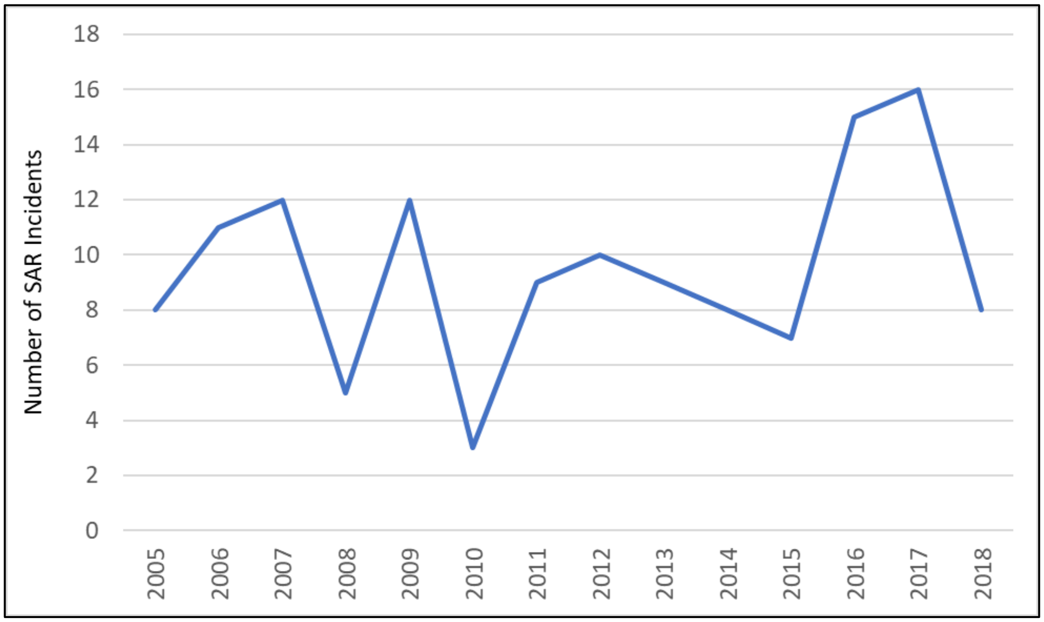


Figure 12-1 Number of SAR cases per calendar year in the USCG MARI PARS study area (USCG, 2020a)

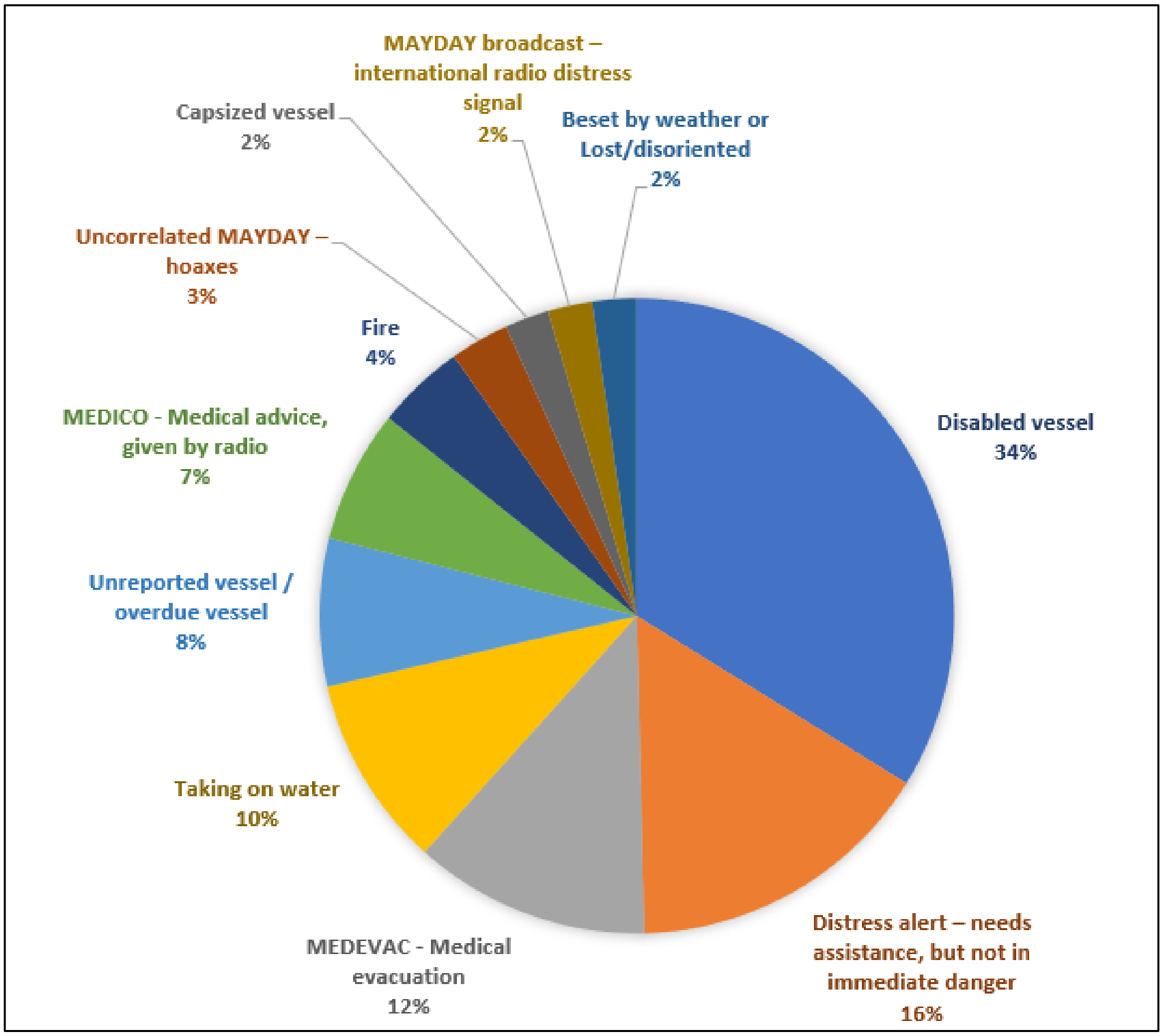


Figure 12-2 Percentage of SAR cases by type in the USCG MARI PARS study area (2005 through 2018) (USCG, 2020a)

The layout of the Project is a factor that will be considered when planning SAR activities in the Project Area. The USCG 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 grid pattern, 1 NM apart. This conforms to the USCG helicopter pilot recommendation for minimum spacing between structures along a search path (USCG, 2020a) and visual flight rules in 14 CFR 91.155 that specify a minimum of ½-statute-mile visibility in daytime without clouds.

Table 12-1 lists the information requested in NVIC 01-19 to be considered when evaluating emergency response. It includes SAR cases that were recorded in the Project Area over a 14-year period, an average of 0.18 per year (USCG, 2020a).

In addition, the USCG provided this NSRA with data on missions that have occurred near the Project Area from 2006 through 2016 (USCG, 2017b). Over that period, a total of 26 USCG missions were recorded in the vicinity. The missions are plotted in GIS and overlaid with the AIS tracks and Project Area in Figure 12-3. A cluster of missions occurs to the west of the Project Area.

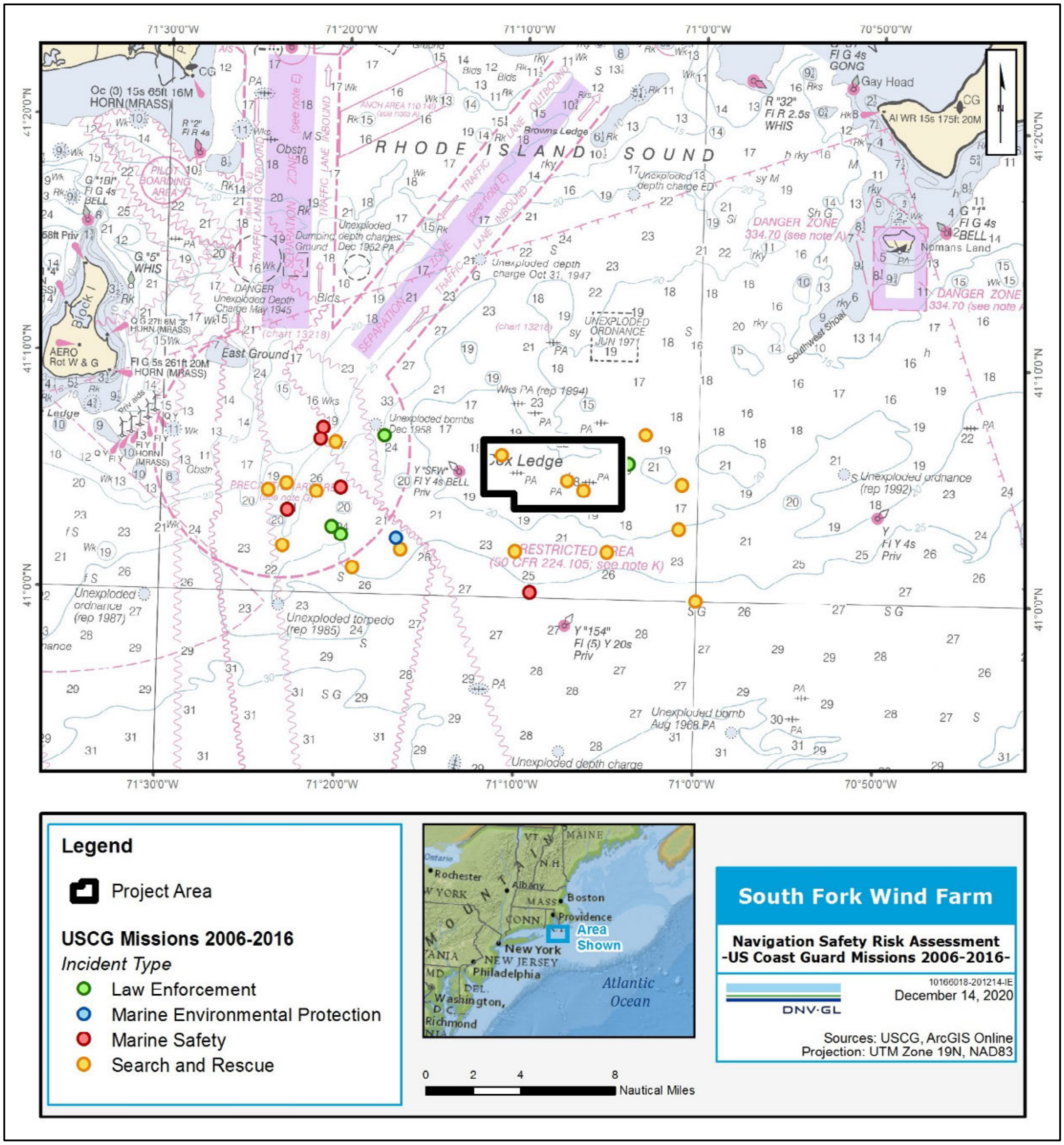


Figure 12-3 USCG mission data from 2006 - 2016 plotted by incident type (USCG, 2017b)

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. Additionally, a single USCG-designed marking and labeling protocol is anticipated to be used by all developers in the MA/RI WEA, further aiding mariners in passing their location to the USCG in times of distress, and facilitate the USCG's search efforts. 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 USCG in the proposed Project Area	2-3 cases over 14 years, 2005 through 2018 (USCG, 2020a) (USCG, 2017b)
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
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	0.03 allisions per year, with the vast majority not requiring USCG assistance (conservative maximum estimate based on modeling presented in Section 11).

Concerning the safety of SAR missions, the USCG final MARI PARS report (2020a) 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."

13 FACILITY CHARACTERISTICS

In general, marking of offshore wind farm structures is specified in international standards and USCG 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” (USCG, 2020c)

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

- Identification marking
- Lighting
- Sound signals
- AIS transponder signals
- Other appropriate aids to navigation

In 2019, BOEM published “Draft Proposed Guidelines for Providing Information on Lighting and Marking of Structures Supporting Renewable Energy Development” (BOEM, 2019). Should BOEM finalize these guidelines by the time of COP approval, the Project will comply (South Fork Wind, 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. Per PATON permits issued by the Coast Guard, aall PATON will be maintained to meet the USCG’s availability standards. Procedures will be put into place to respond to and correct any deficiencies within required timeframes (South Fork Wind, 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 (South Fork Wind, 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 OSPs and fix/maintain the position of the turbine blades and hub in an emergency situation (South Fork Wind, 2020).

Emergency operating procedures for the monitoring center will be agreed in consultation with the USCG and other emergency support services. Offshore enclosed spaces will be capable of being opened from the outside to allow emergency access (South Fork Wind, 2020).

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 (South Fork Wind, 2020)

The Project operator will ensure that all applicable USCG 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 (South Fork Wind, 2020).

16 OPERATIONAL PROCEDURES

South Fork Wind anticipates that the USCG will recommend, and BOEM will include, a condition in the Project's permit (if issued) to submit to the USCG an acceptable emergency shutdown procedure/plan (South Fork Wind, 2020). These may be similar to requirements in the Block Island Wind Farm permit issued by the U.S. Army Corps of Engineers. Additionally, South Fork Wind will work in conjunction with the USCG to develop an acceptable emergency shutdown procedure and emergency response plan that draw on the lessons learned from emergency shutdown exercises conducted with the USCG at the Block Island Wind Farm (South Fork Wind, 2020).

17 CONCLUSIONS AND PROJECT RISK MITIGATIONS

17.1 Conclusions

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.
2. Traffic survey
    - Vessel traffic is denser near the coast than it is offshore, particularly in the summer. Seasonal pleasure and recreational fishing vessel traffic adds to the volume of traffic. Vessel traffic in the Project Area is sparse in comparison.
    - Among the vessel types, pleasure (e.g., recreational) vessels represented the greatest proportion of the AIS-recorded vessel tracks in the Study Area, 26%.
    - Fishing (commercial), tugs / service vessels, other / undefined vessels, and passenger vessels each comprised 15-19% of the AIS-recorded vessel tracks in the 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.
    - Deep draft vessels and tugs are anticipated to avoid the Project Area.
3. Offshore above water structures
    - Project structures could pose an allision hazard to vessels passing close by, and vessels could pose a hazard to the structures. Allision risk is specifically discussed in (11) below.
    - The air gap of Project structures could be smaller than the air drafts of vessels in the Project Area. 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 (South Fork Wind, 2020).
    - A subsea cable could pose a hazard to a vessel if an anchor or fishing gear contacted a cable. The assessment of cable burial risk suggests that risk to fishing 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 USCG 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 “mariners

	desiring to transit the area should use extra caution, ensure proper watch, and assess risk prior to entering an offshore wind farm." (USCG, 2020a) • 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.
4. Offshore under water structures	• The Project components will not affect underkeel clearance for vessels transiting in the Project Area.
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 Project 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 the vicinity of the Project Area. 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	The layout of offshore structures can have a significant influence on operational and navigation risks experienced during operations. An optimal configuration of Project structures is being sought through balancing many risk factors, including physical, environmental, technical, economic, commercial, 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[7] with all Project structures.
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. • Due primarily to the quality of radars and the proficiency of professionally licensed crew, radar operations on commercial ships are not anticipated to be adversely affected by the Project. • Smaller vessels operating in the vicinity of the Project may experience radar clutter and shadowing. Risk controls relevant to this effect are: vessel operator awareness and competence regarding radar effects and corrections; placement of radar antenna at a favorable position on a vessel; regular communications regarding changes and activities in the wind farm; and, safety broadcasts from vessels operating in the vicinity of the wind farm.
11. Risk of collision, allision, or grounding	• In this assessment, the modeled increase in risk is 0.4 accidents per year. This is DNV GL's best estimate of the additional risk from the presence of the Project. - 67% of the increase is risk of allision with a Project structure. - 31% of the increase is grounding risk, pleasure vessels, and the risk is not near the Project. The additional risk is due to a modeling assumption that additional pleasure vessels would transit to the Project Area. • A list of risk controls and risk mitigations being considered by South Fork Wind is provided below.
12. Emergency response considerations	• Based on allision risk modeling, an additional maximum of 0.3 SAR missions are anticipated per year in the Project Area.

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[7] The five New England offshore wind leaseholders proposed 1 NM spacing between WTGs in fixed east-to-west rows and north-to-south columns to create a 1 NM by 1 NM grid arrangement in November 2019 (Equinor et. al, 2019).

13. Facility characteristics	• The Project will comply with USCG requirements for lighting, sound signals, marking, and AIS on structures, as applicable and as determined in consultation with the USCG (South Fork Wind, 2020). • No effects are anticipated to existing Federal ATON near the Project. • PATON will be maintained to meet conditions the USCG may impose in conjunction with its PATON permits (South Fork Wind, 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 (South Fork Wind, 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 USCG and other relevant agencies (South Fork Wind, 2020).
16. Operational procedures	• Emergency procedures will be developed and reviewed with relevant agencies, including the USCG (South Fork Wind, 2020).

17.2 Potential Project mitigation measures

Table 17-1 summarizes the navigation risk mitigation measures that the Project may implement (South Fork Wind, 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.

Table 17-1 Summary of potential Project mitigation measures (South Fork Wind, 2020)

Type *	Threat or hazard	Primary mitigation(s)
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 1.2 to 1.8 m (4 to 6 ft), and the cables include various protective armoring and sheathing to protect it from external damage and keep it watertight. Cable protection measures will be employed where target cable burial depth cannot be achieved. 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; USCG locating a vessel	Lighting, marking, and AIS signaling 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	USCG established and enforced safety zones around Project construction activities. Project safety vessel(s) on scene to advise mariners of construction activity.
P	Vessel not aware of high level of activity in the Project Area	Notices to Mariners during construction, operation, and decommissioning activities. These may be published on and broadcasted though regular radio communications, online information for mariners, and Notices to Mariners from the USCG.

Type *	Threat or hazard	Primary mitigation(s)
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. On-scene Project safety vessels will advise mariners of construction activities and request a wide berth by passing vessels to ensure safety.
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. Automatic shutdown of turbines if icing (imbalance) is detected and issuance of a Notice to Mariners. 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 USCG 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 • Minimum twice-daily updates on VHF channels.
O	Fishing gear snag on Project component	Project process for gear-loss/damage claims.
O	Ineffective emergency procedures	USCG-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 PROJECT OFFSHORE STUCTURE COORDINATES

Table A-1 lists the locations of the offshore Project structures evaluated in this NSRA. Universal Transverse Mercator (UTM) coordinates provided by South Fork Wind, LLC (2020) and WGS84 latitude and longitude are shown.

Table A-1 Structure Coordinates

	Structure Type	NAD83 (2011) UTM Zone 19 (m)		WGS84 (Decimal Degrees)	
		Easting	Northing	Latitude	Longitude
1.	WTG	316022	4553148	41.108795	-71.191104
2.	WTG	317874	4553148	41.109212	-71.169062
3.	WTG	319726	4553148	41.109625	-71.147021
4.	WTG	321578	4553148	41.110034	-71.124978
5.	WTG	323430	4553148	41.110439	-71.102935
6.	WTG	325282	4553148	41.110839	-71.080892
7.	WTG	316022	4551296	41.092124	-71.190550
8.	WTG	317874	4551296	41.092541	-71.168514
9.	WTG	319726	4551296	41.092954	-71.146477
10.	WTG	321578	4551296	41.093363	-71.124441
11.	WTG	323430	4551296	41.093767	-71.102403
12.	WTG	316022	4549444	41.075453	-71.189996
13.	WTG	319726	4549444	41.076283	-71.145935
14.	WTG	321578	4549444	41.076691	-71.123904
15.	WTG	323430	4549444	41.077095	-71.101872
16.	OSP	317874	4549444	41.07587	-71.167965

APPENDIX B – AIS MAPS

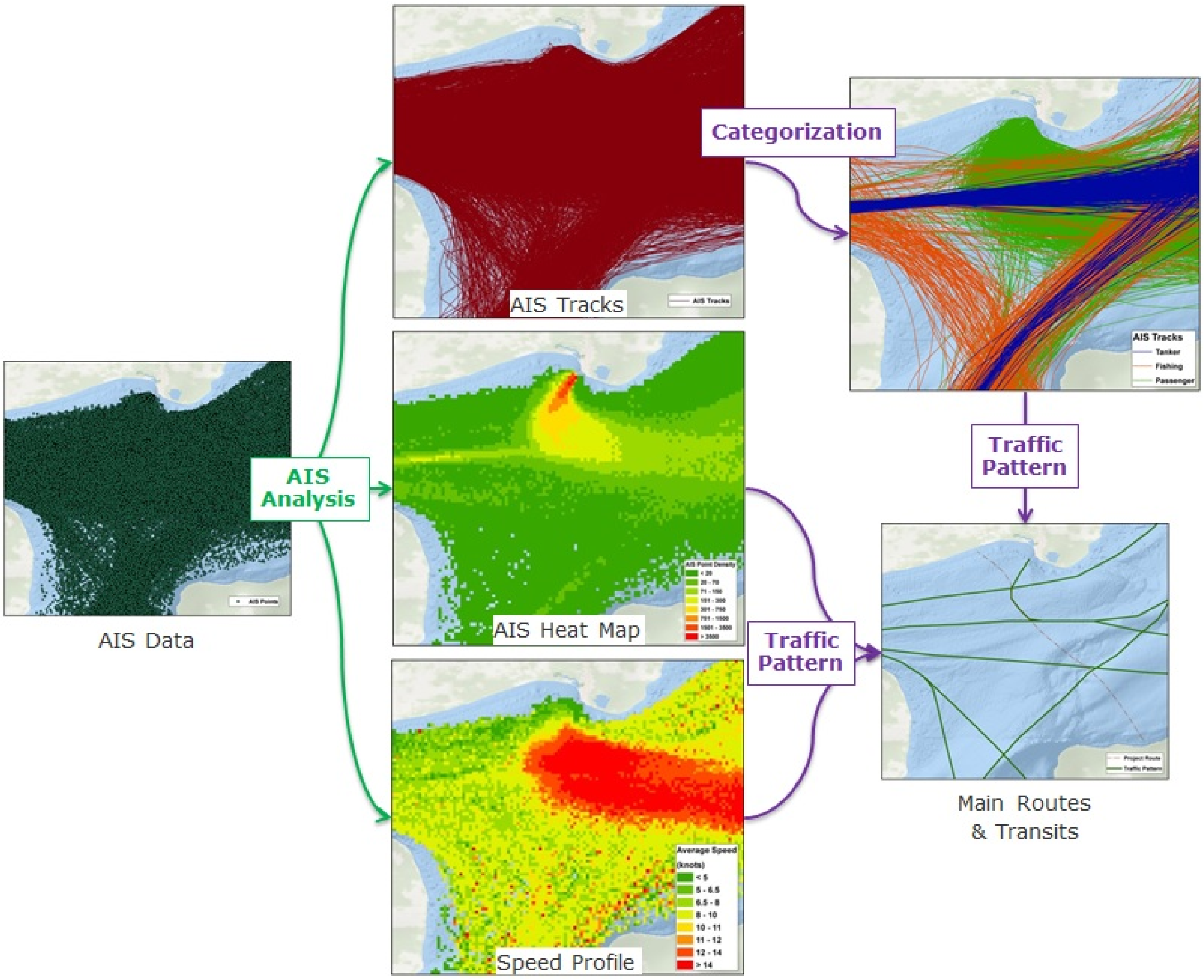
This appendix contains maps of marine traffic showing AIS tracks, AIS density, and vessel speed.

AIS data analysis

The marine patterns and traffic statistics in the Study Area were determined utilizing AIS data. One year of AIS data typically provides a quantifiable and reliable set of data to determine the primary traffic patterns and analyze the size, speed, and movements of vessels in a region. For the Marine Traffic Study Area, AIS data were evaluated for a full-year period, 1 July 2018 to 30 June 2019 (MarineTraffic, 2019).

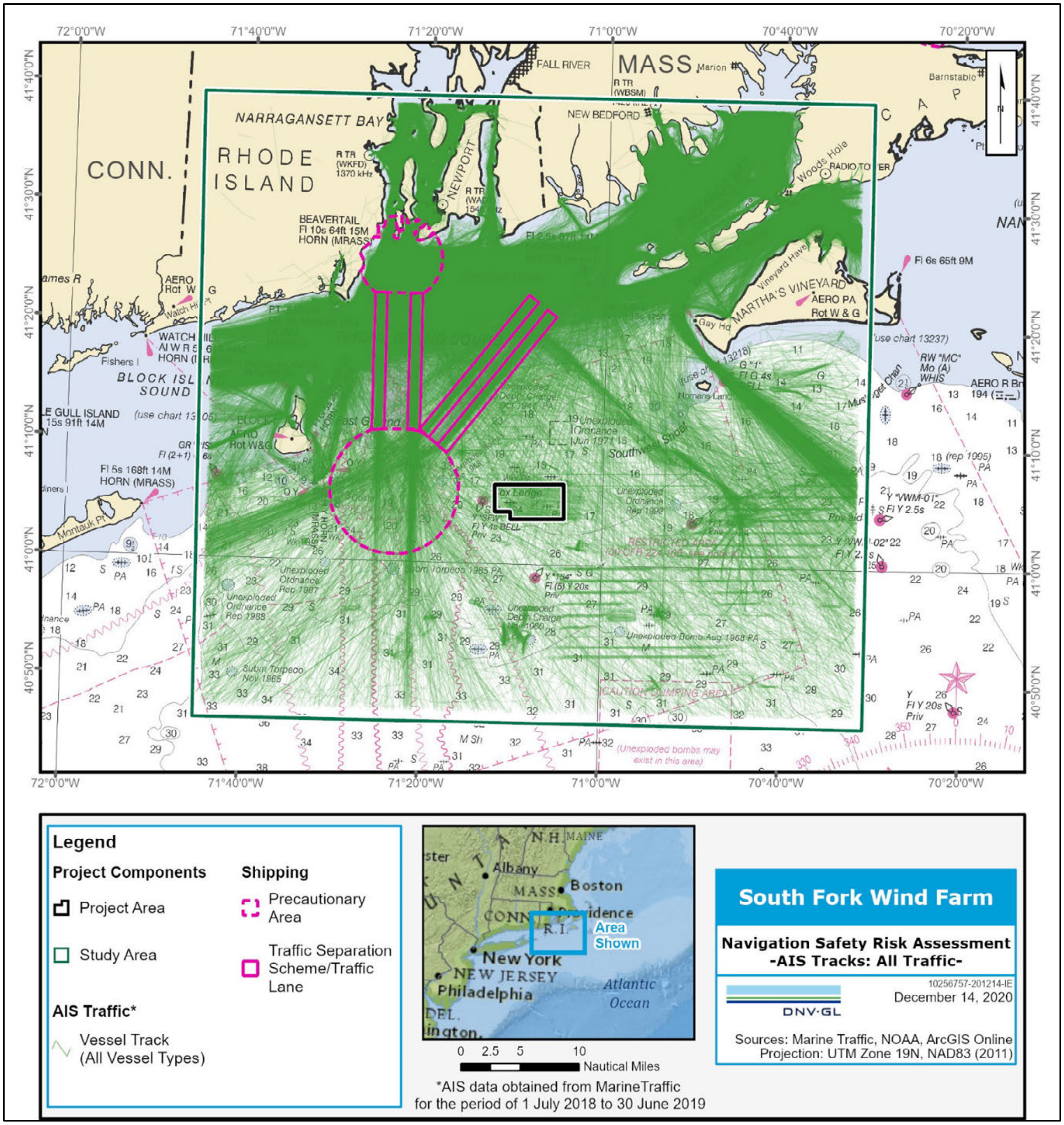
AIS data were converted into vessel tracks (Section A.1) and point densities (Section A.2). Speed profiles were also developed from the data (Section A.3)

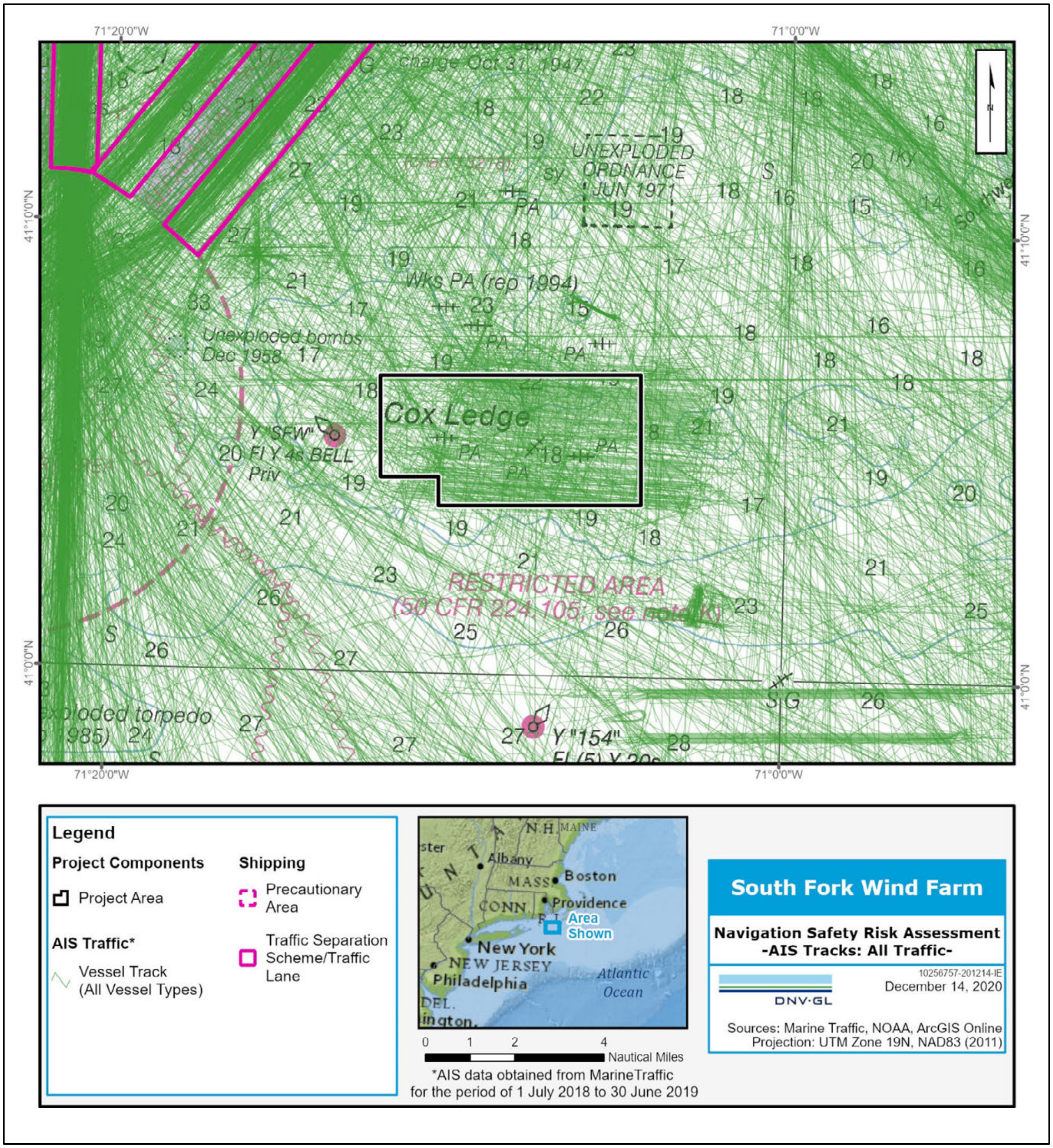
The AIS treatment methodology is schematically represented below:

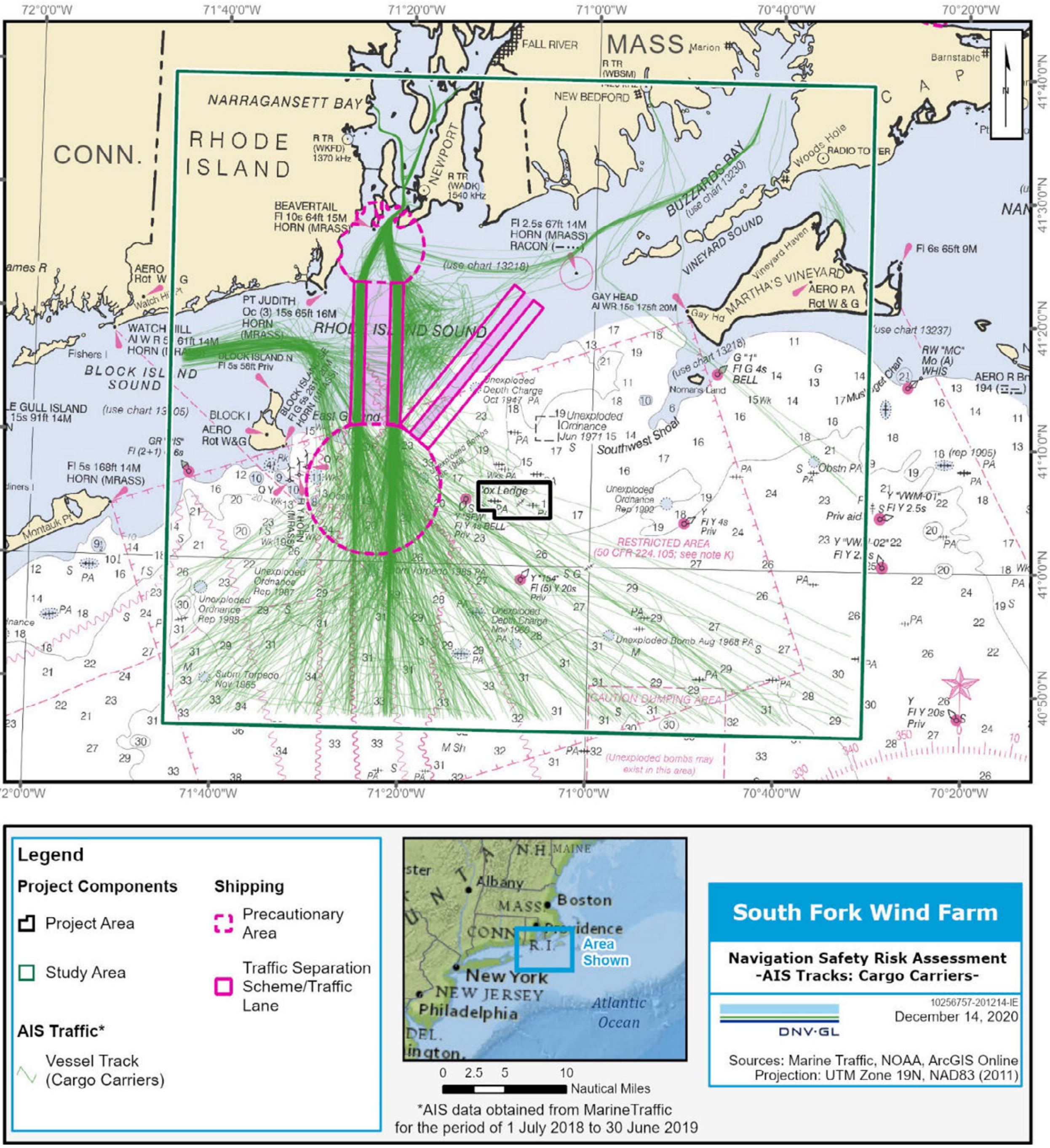


B.1 AIS track maps by vessel type

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




71°20'0"W
71°0'0"W
41°10'0"N
41°0'0"N
Cox Ledge
UNEXPLODED ORDNANCE JUN 1971
Unexploded bombs Dec 1958
Wks PA (rep 1994)
Y "SFW" Fl Y 4s BELL Priv
RESTRICTED AREA (50 CFR 224.105; see note K)
Y "154" Fl (5) Y 20s
Unexploded torpedo (1985)
Legend
Project Components
Project Area
AIS Traffic*
Vessel Track (All Vessel Types)
Shipping
Precautionary Area
Traffic Separation Scheme/Traffic Lane
Albany
Boston
Providence
New York
Philadelphia
NEW JERSEY
MASS
CONN
N.H.
MAINE
Area Shown
Atlantic Ocean
0 1 2 4 Nautical Miles
*AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019
South Fork Wind Farm
Navigation Safety Risk Assessment -AIS Tracks: All Traffic-
10256757-201214-IE
December 14, 2020
DNV·GL
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)



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

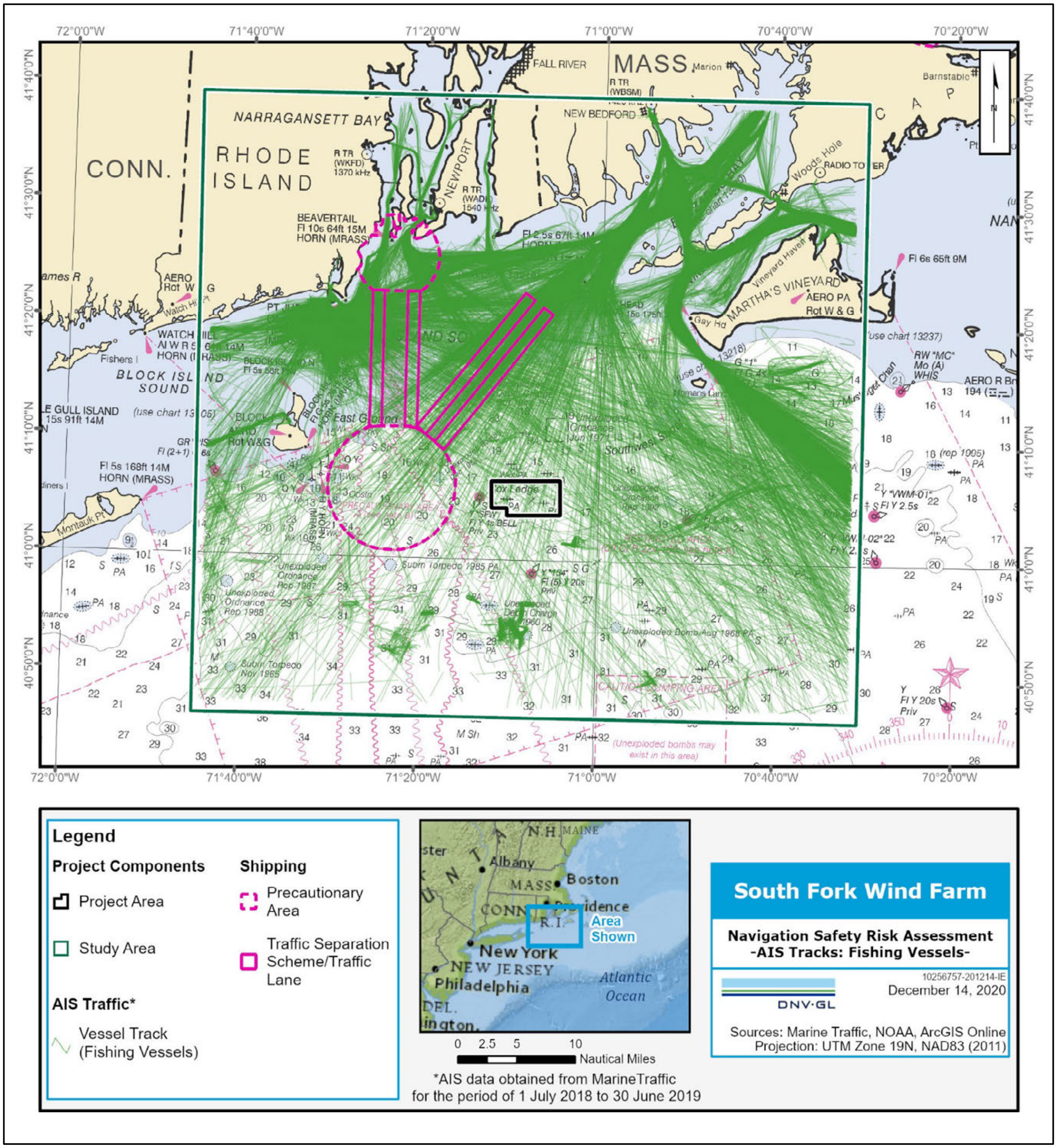
South Fork Wind Farm

Navigation Safety Risk Assessment
-AIS Tracks: Cargo Carriers-

10256757-201214-IE
December 14, 2020

DNV·GL

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



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

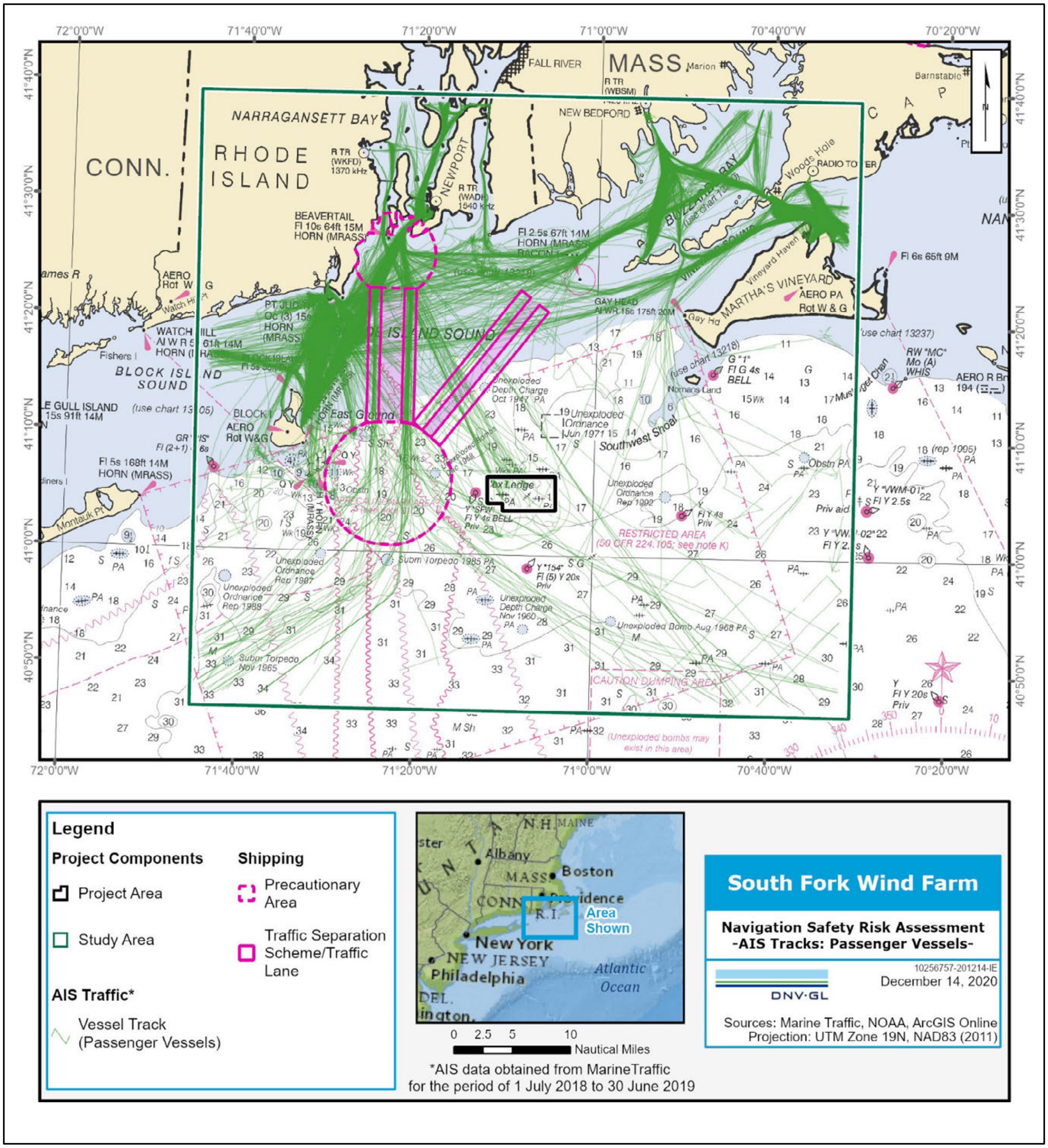
South Fork Wind Farm

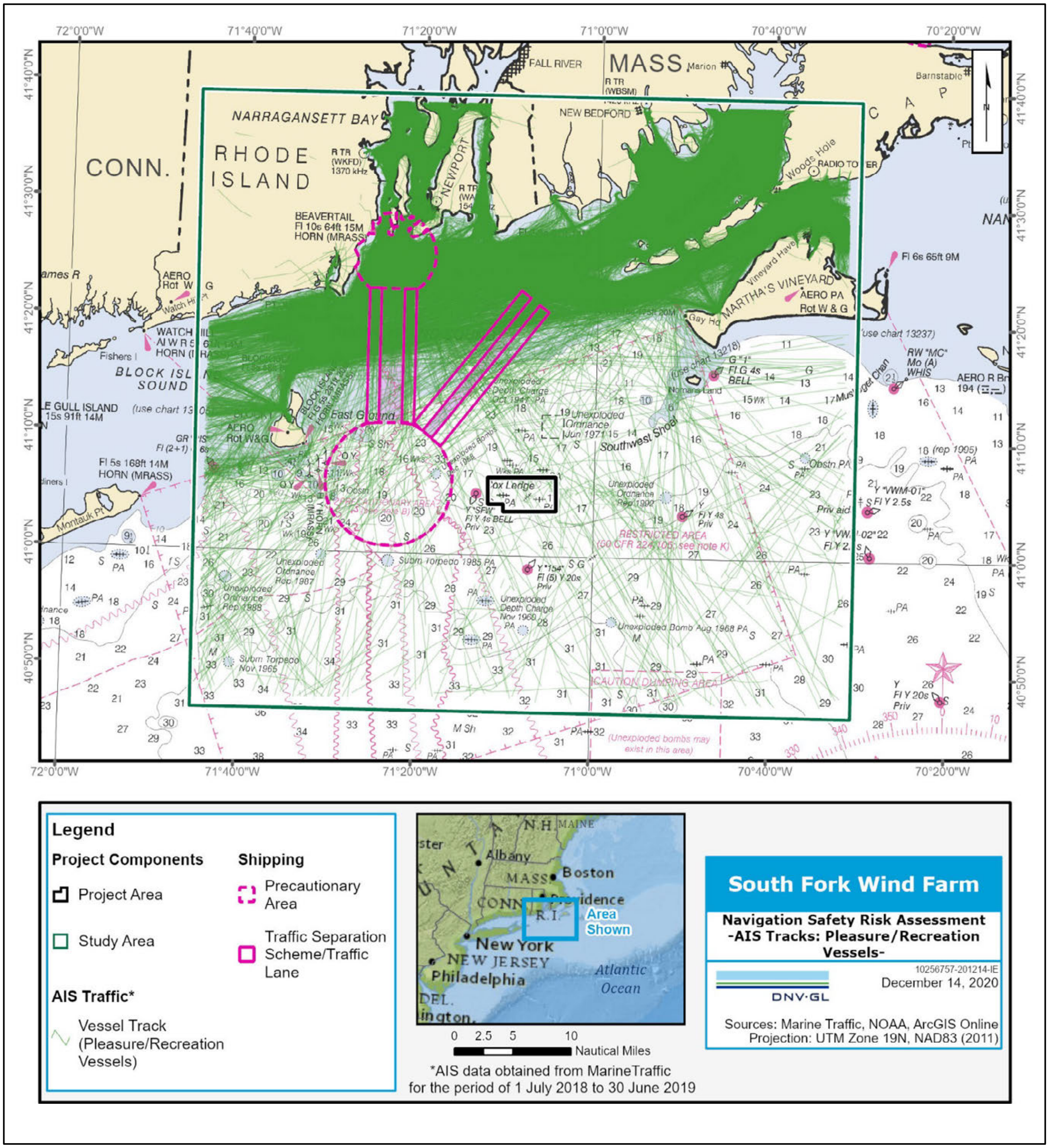
Navigation Safety Risk Assessment
-AIS Tracks: Fishing Vessels-

10256757-201214-IE
December 14, 2020

DNV·GL

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
CONN.
RHODE ISLAND
MASS
NARRAGANSETT BAY
NEWPORT
FALL RIVER
NEW BEDFORD
BLOCK ISLAND SOUND
RHODE ISLAND SOUND
BUZZARDS BAY
Vineyard Haven
MARTHA'S VINEYARD
Gay Hd
Nomans Land
Woods Hole
Southwest Shoal
Cox Ledge
Montauk Pt
Fishers I
East Ground
RESTRICTED AREA (50 CFR 224.105; see note K)
CAUTION DUMPING AREA
(Unexploded bombs may exist in this area)
Legend
Project Components
Project Area
Study Area
Shipping
Precautionary Area
Traffic Separation Scheme/Traffic Lane
AIS Traffic*
Vessel Track (Passenger Vessels)
MAINE
N.H
Albany
Boston
MASS
CONN
R.I.
Providence
Area Shown
New York
NEW JERSEY
Philadelphia
DEL.
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
South Fork Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: Passenger Vessels-
10256757-201214-IE
December 14, 2020
DNV·GL
Sources: Marine Traffic, NOAA, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)



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

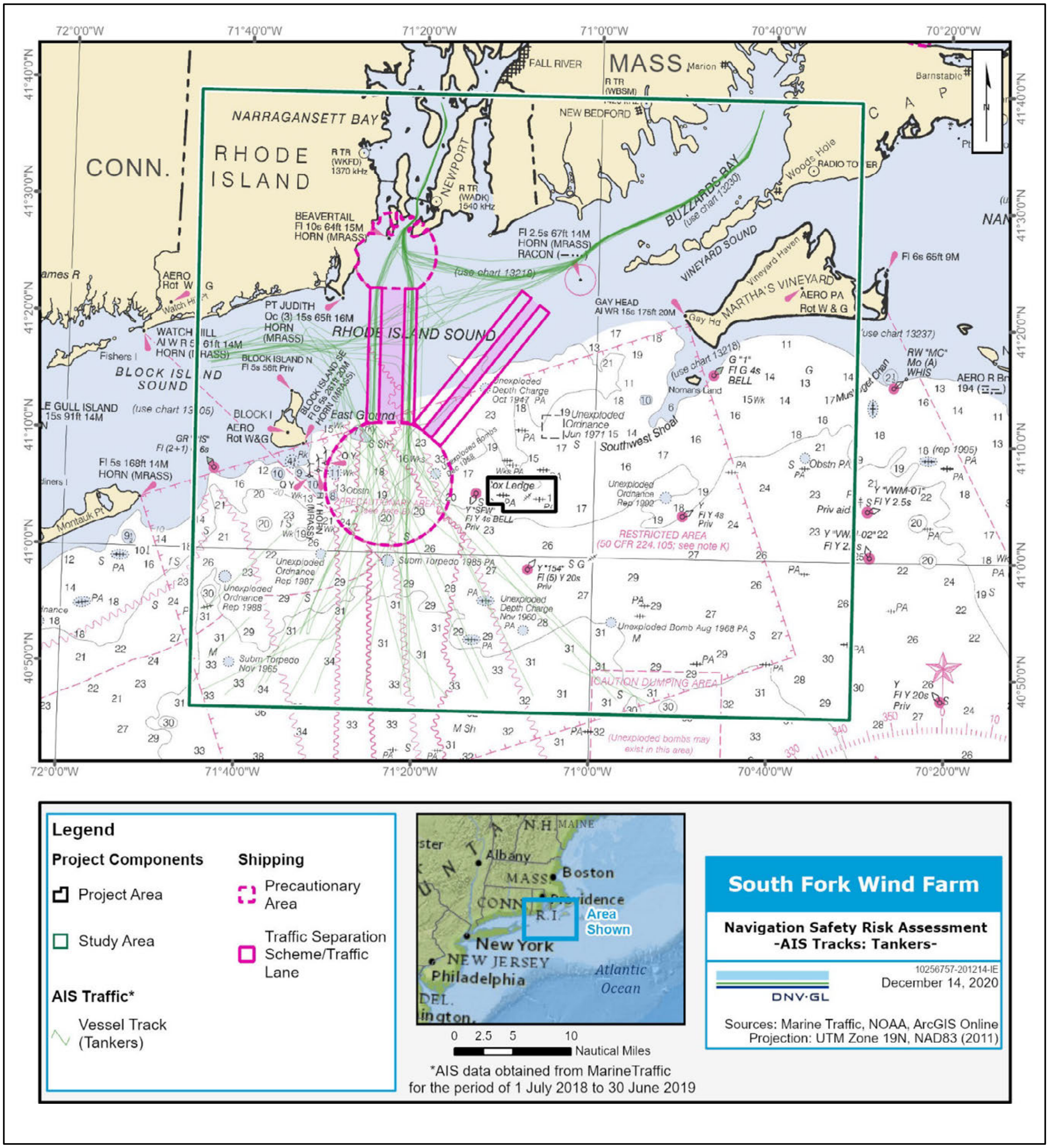
South Fork Wind Farm

Navigation Safety Risk Assessment -AIS Tracks: Pleasure/Recreation Vessels-

10256757-201214-IE
December 14, 2020

DNV·GL

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



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

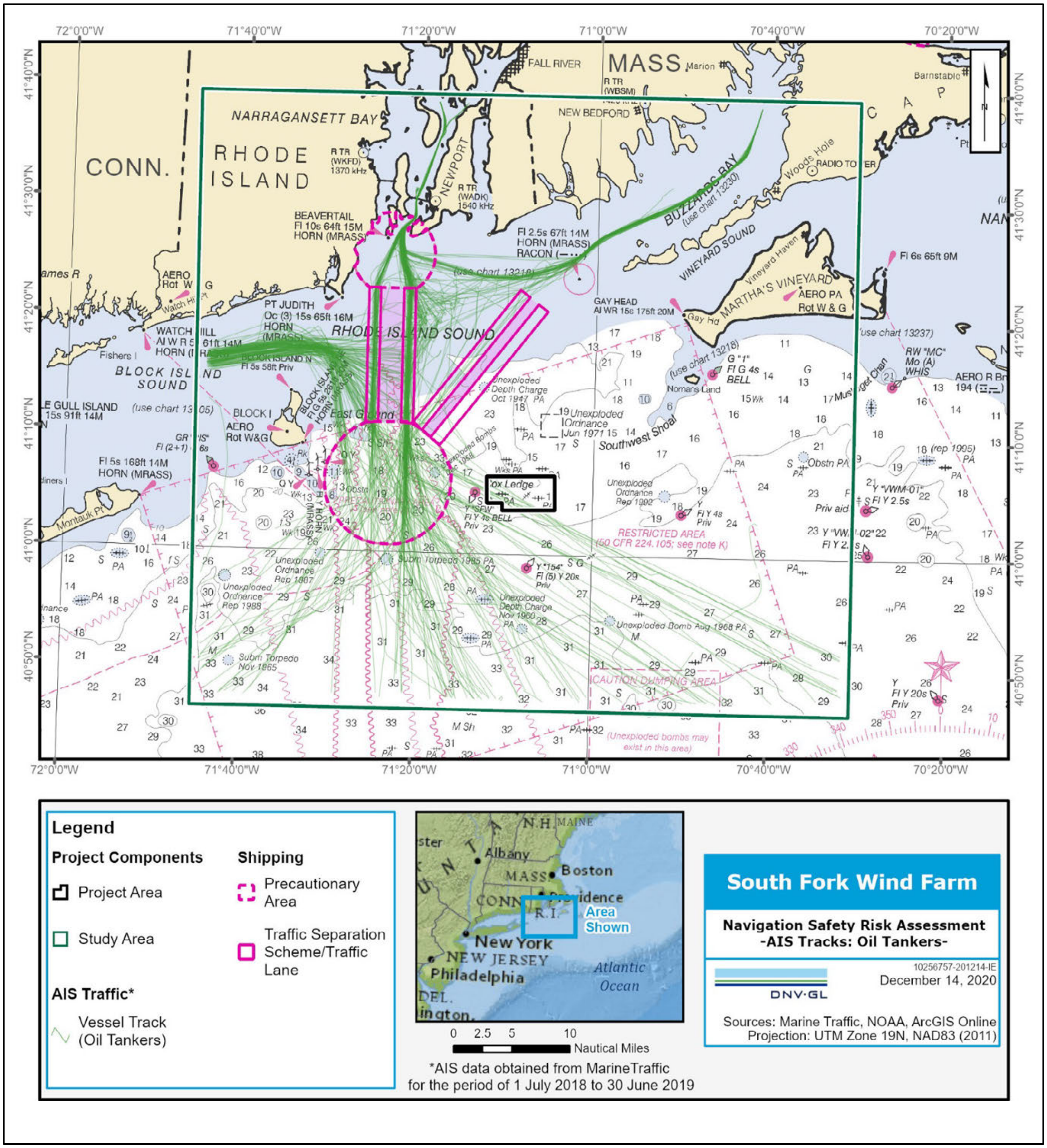
South Fork Wind Farm

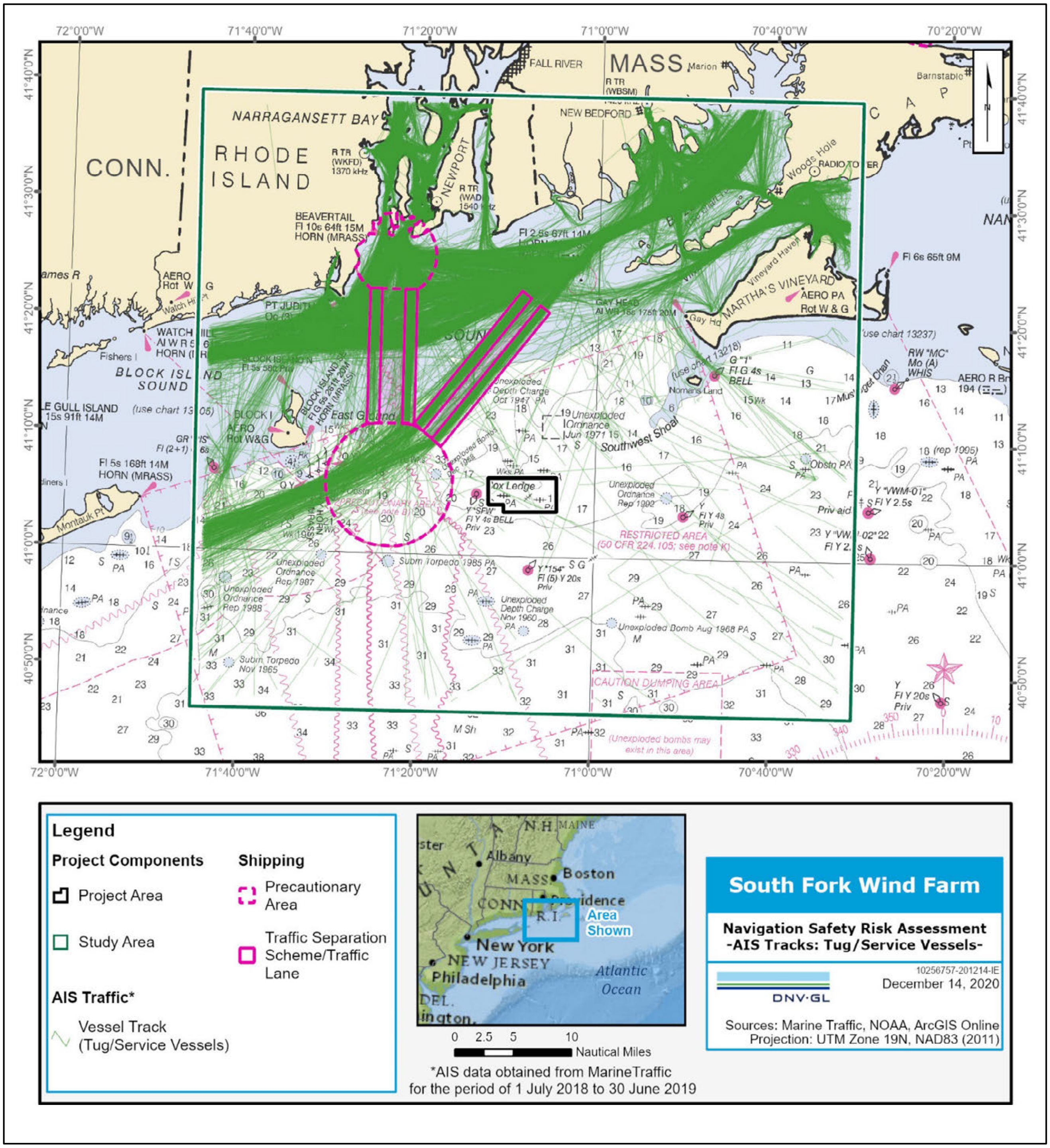
Navigation Safety Risk Assessment
-AIS Tracks: Tankers-

10256757-201214-IE
December 14, 2020

DNV·GL

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


Legend
Project Components
Project Area
Study Area
Shipping
Precautionary Area
Traffic Separation Scheme/Traffic Lane
AIS Traffic*
Vessel Track (Oil Tankers)
Area Shown
Albany
Boston
Providence
MASS
CONN
R.I.
New York
NEW JERSEY
Philadelphia
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
South Fork Wind Farm
Navigation Safety Risk Assessment
-AIS Tracks: Oil Tankers-
10256757-201214-IE
December 14, 2020
DNV·GL
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
CONN.
RHODE ISLAND
MASS
NARRAGANSETT BAY
RHODE ISLAND SOUND
BLOCK ISLAND SOUND
BUZZARDS BAY
VINEYARD SOUND
MARTHA'S VINEYARD
NEWPORT
FALL RIVER
NEW BEDFORD
Cox Ledge
Southwest Shoal
Nomans Land
BLOCK I
Montauk Pt
RESTRICTED AREA (50 CFR 224.105; see note K)
CAUTION DUMPING AREA



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

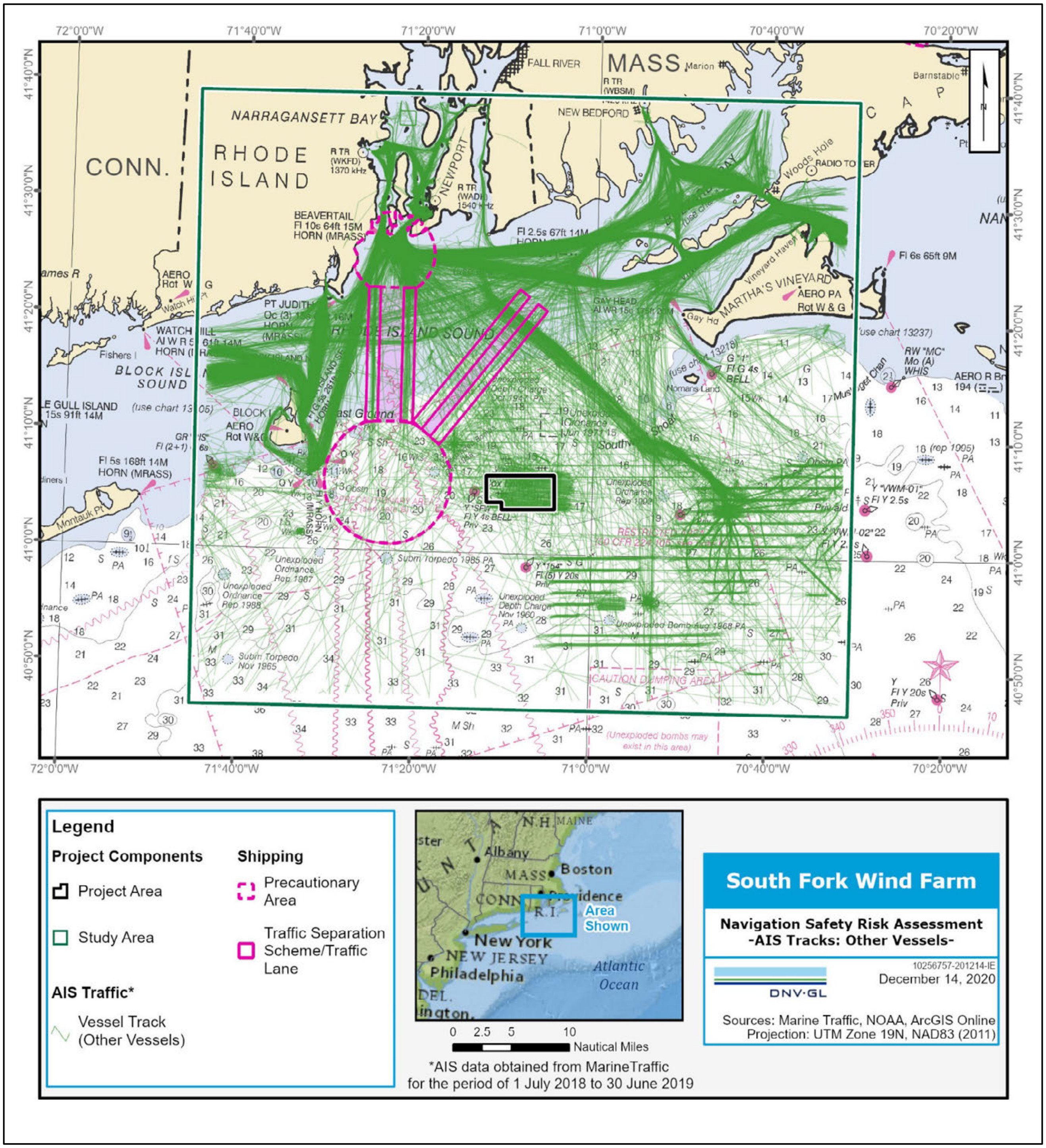
South Fork Wind Farm

Navigation Safety Risk Assessment -AIS Tracks: Tug/Service Vessels-

10256757-201214-IE

December 14, 2020

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



Legend

Project Components

□ Project Area

🟩 Study Area

Shipping

Precautionary Area

Traffic Separation Scheme/Traffic Lane

AIS Traffic*

Vessel Track (Other Vessels)

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

South Fork Wind Farm

Navigation Safety Risk Assessment -AIS Tracks: Other Vessels-

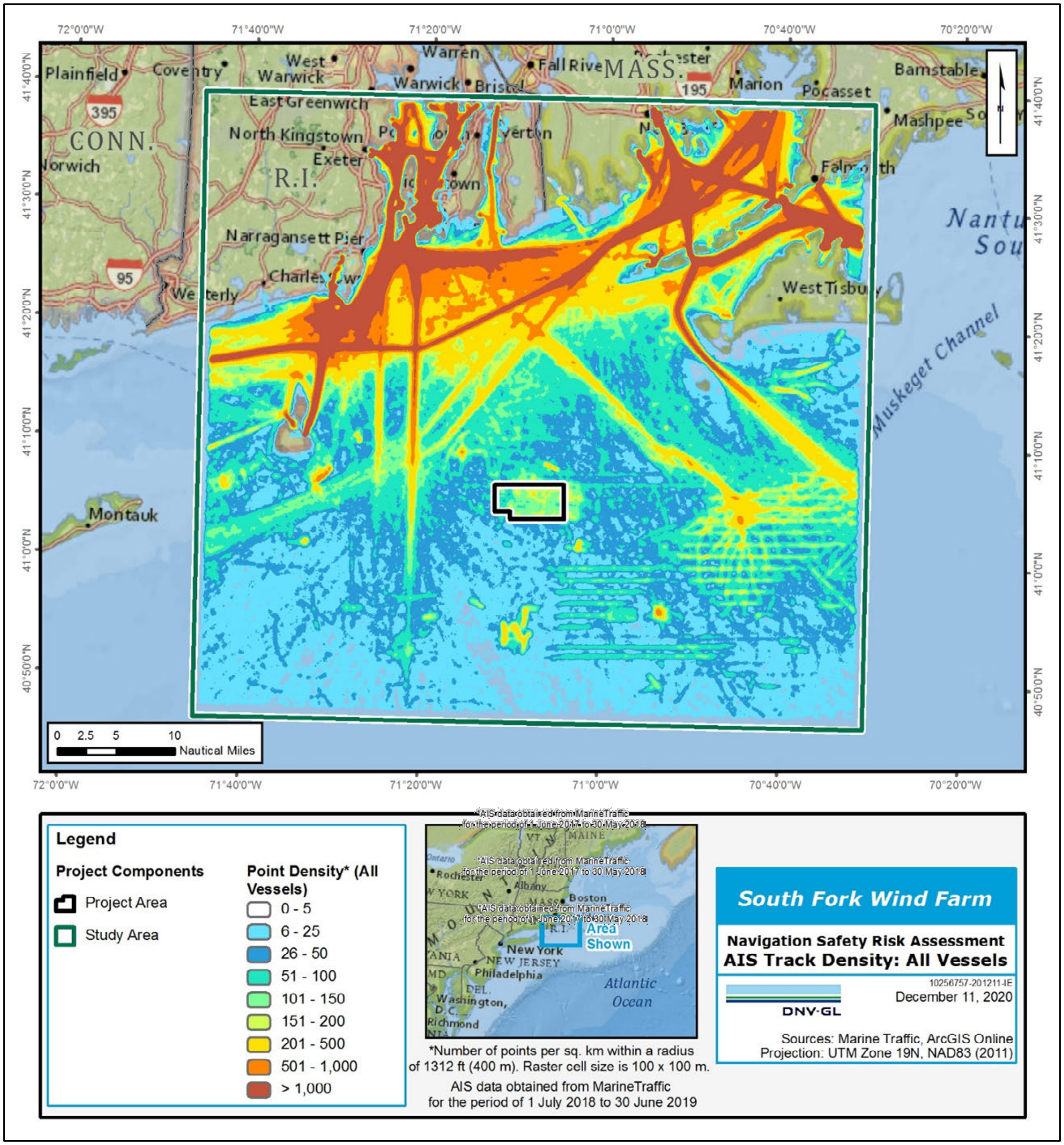
10256757-201214-IE
December 14, 2020

DNV·GL

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

B.2 AIS point density maps by vessel type

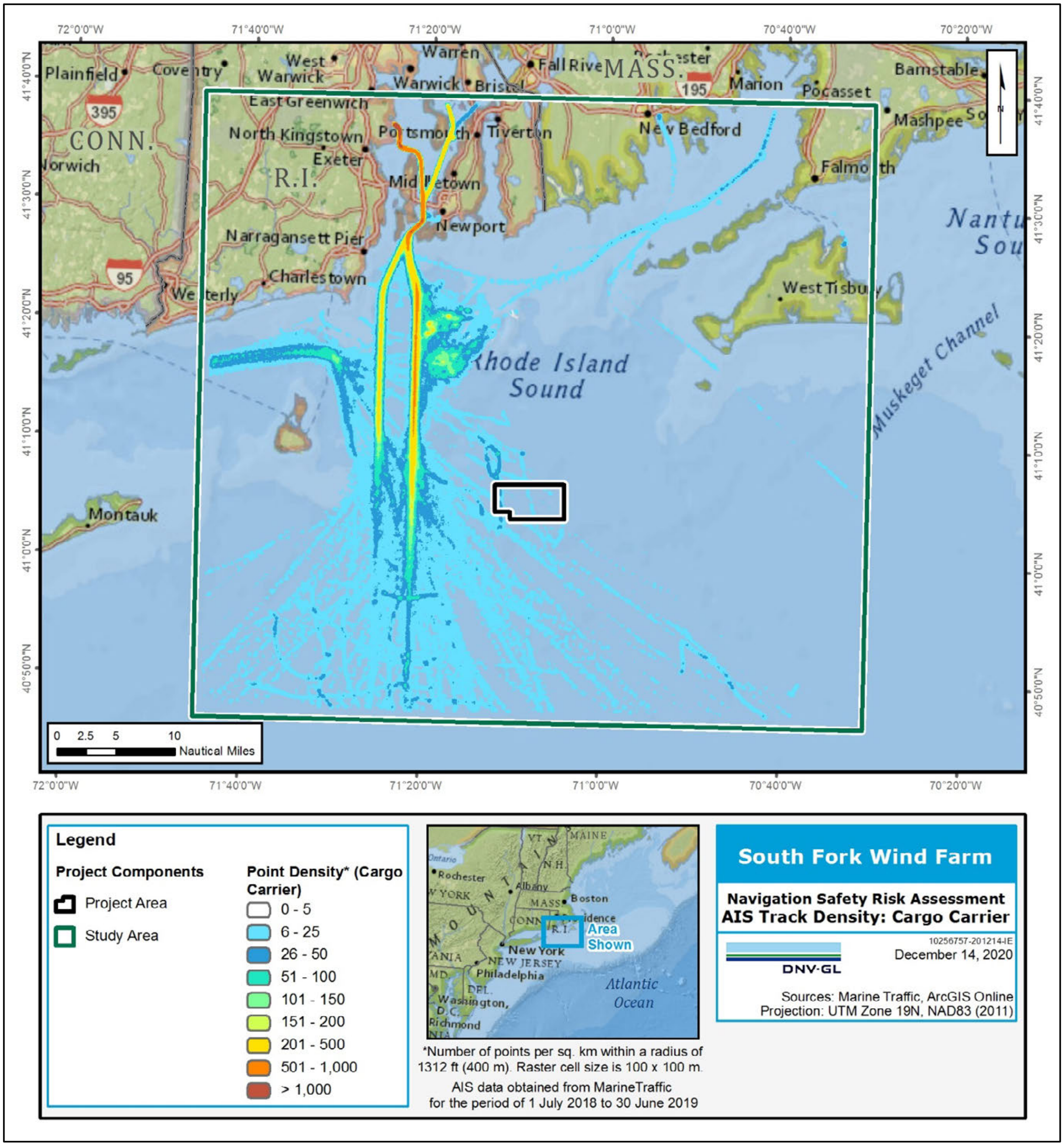
The figures in this section present density heat maps for all AIS points in the Study Area. The density is calculated by determining the number of AIS data points within a square kilometer grid cell.



*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.

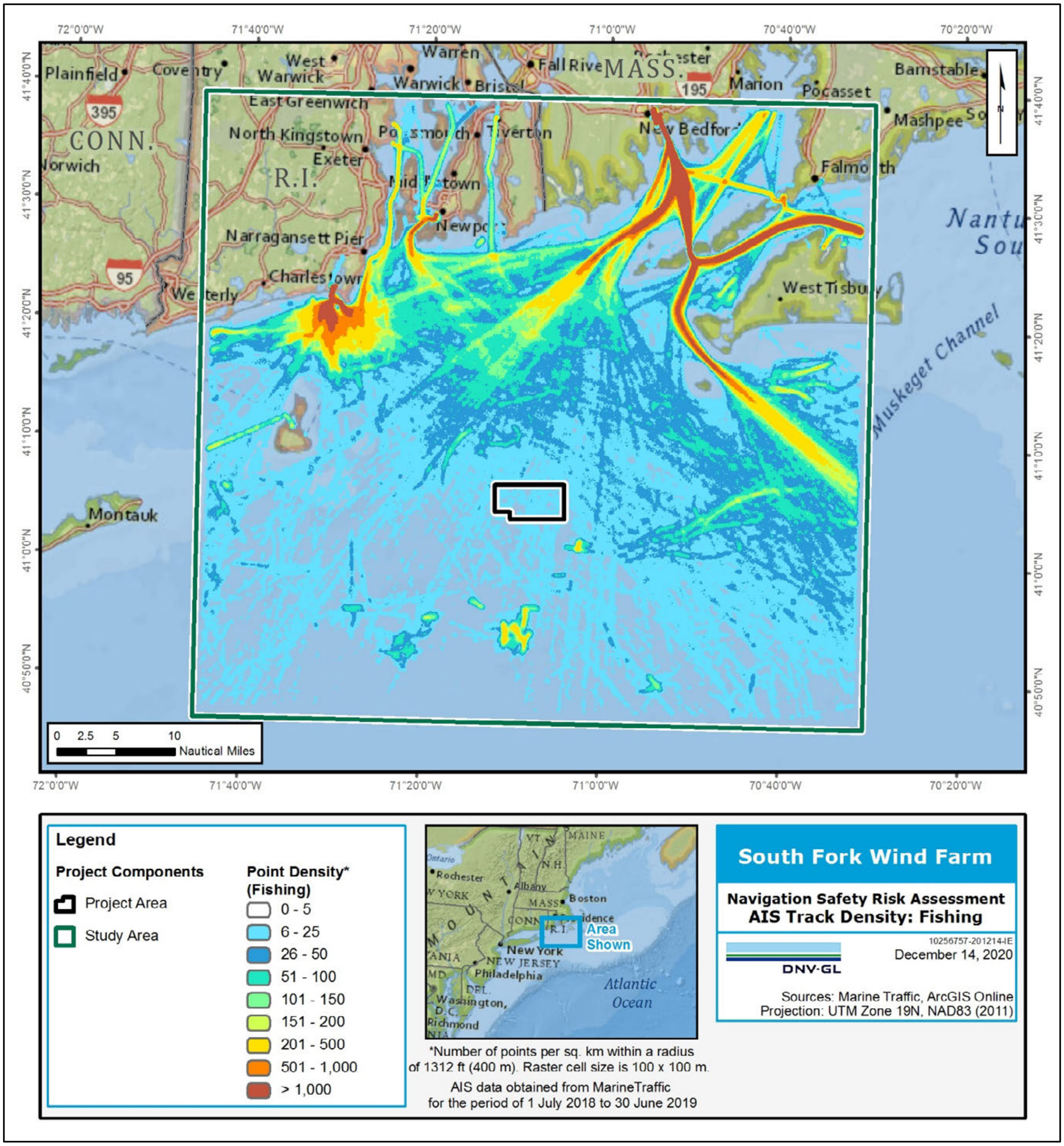
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

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



*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



*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

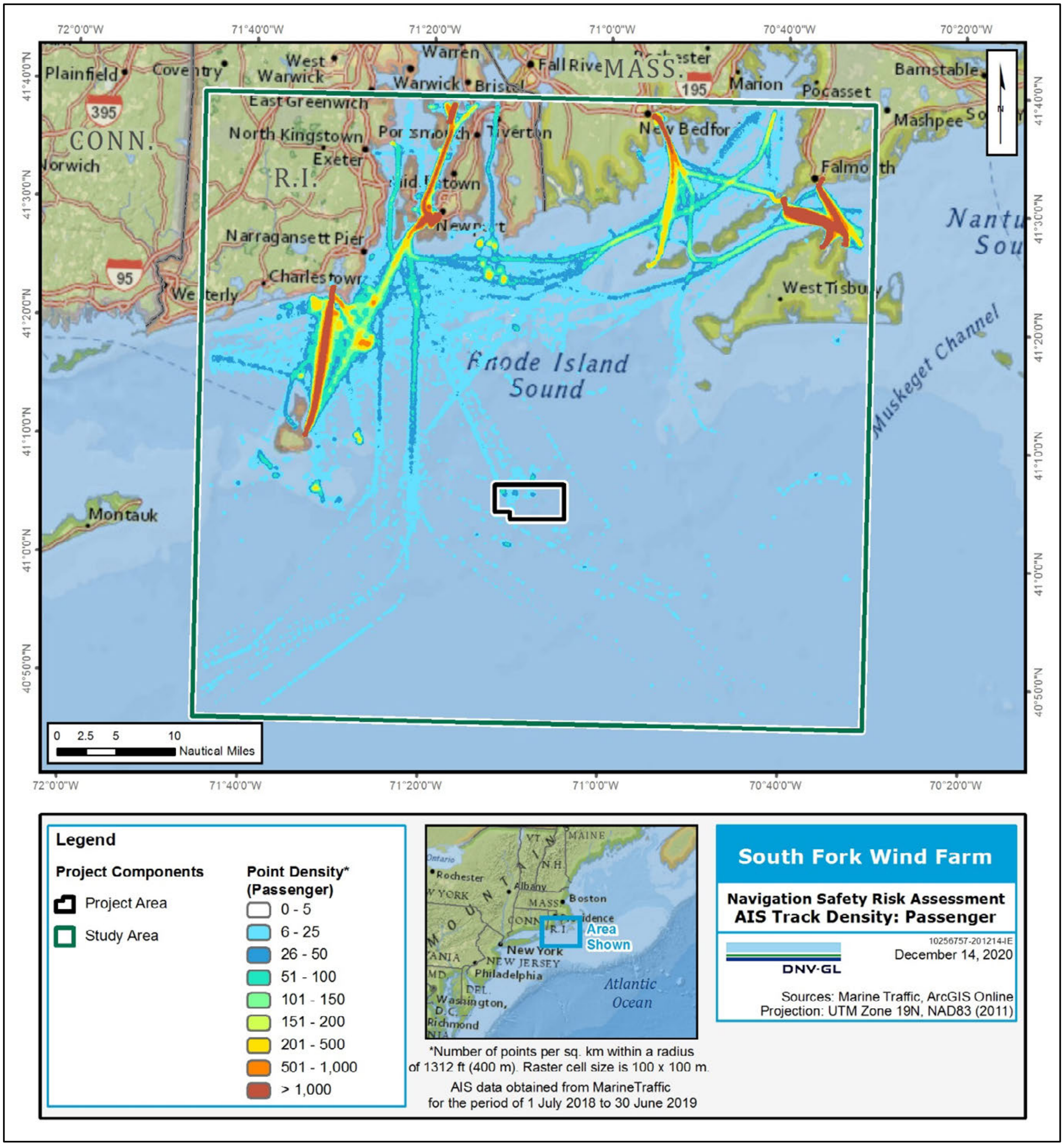
South Fork Wind Farm

Navigation Safety Risk Assessment
AIS Track Density: Fishing

10256757-201214-IE
December 14, 2020

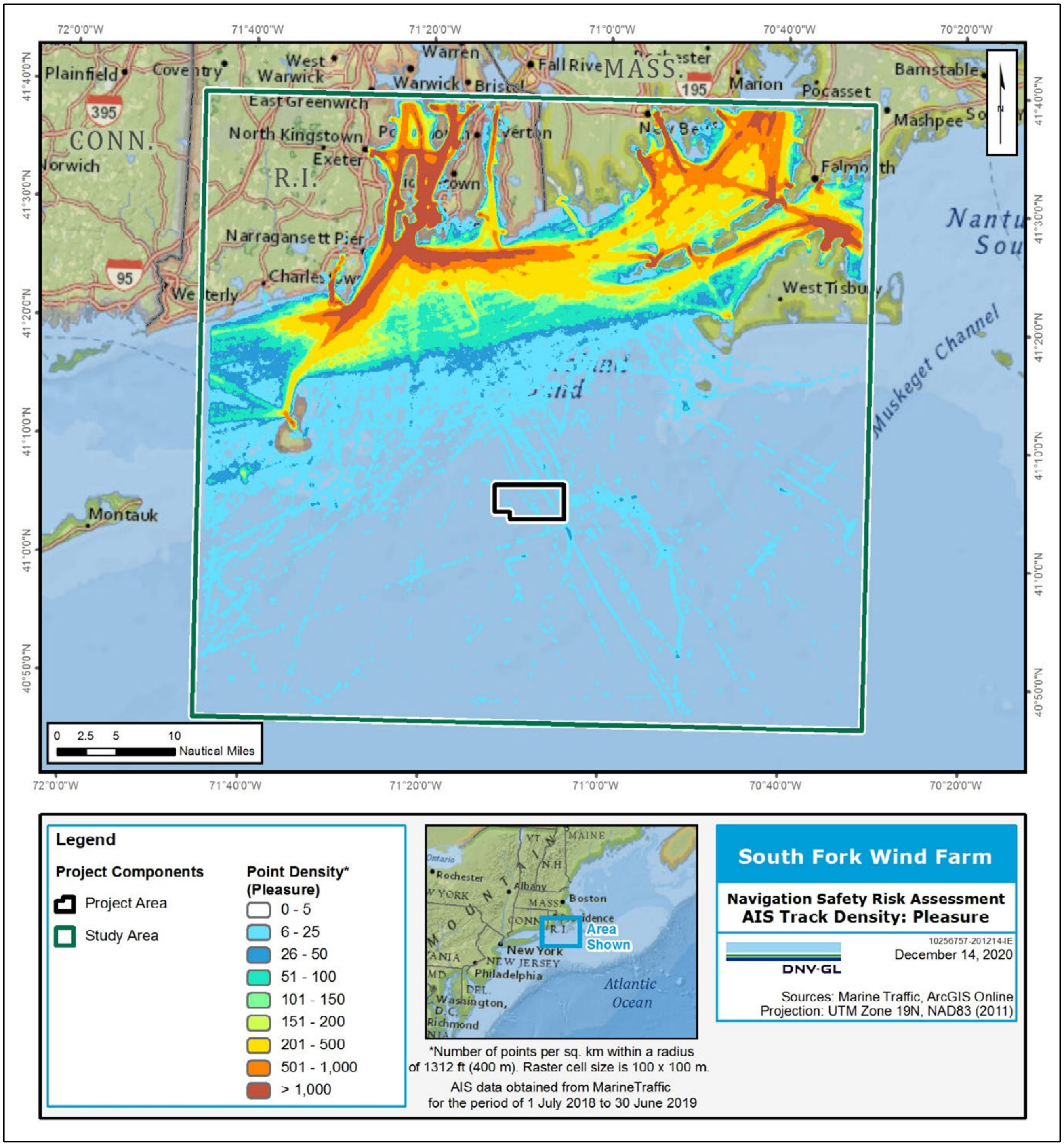
DNV·GL

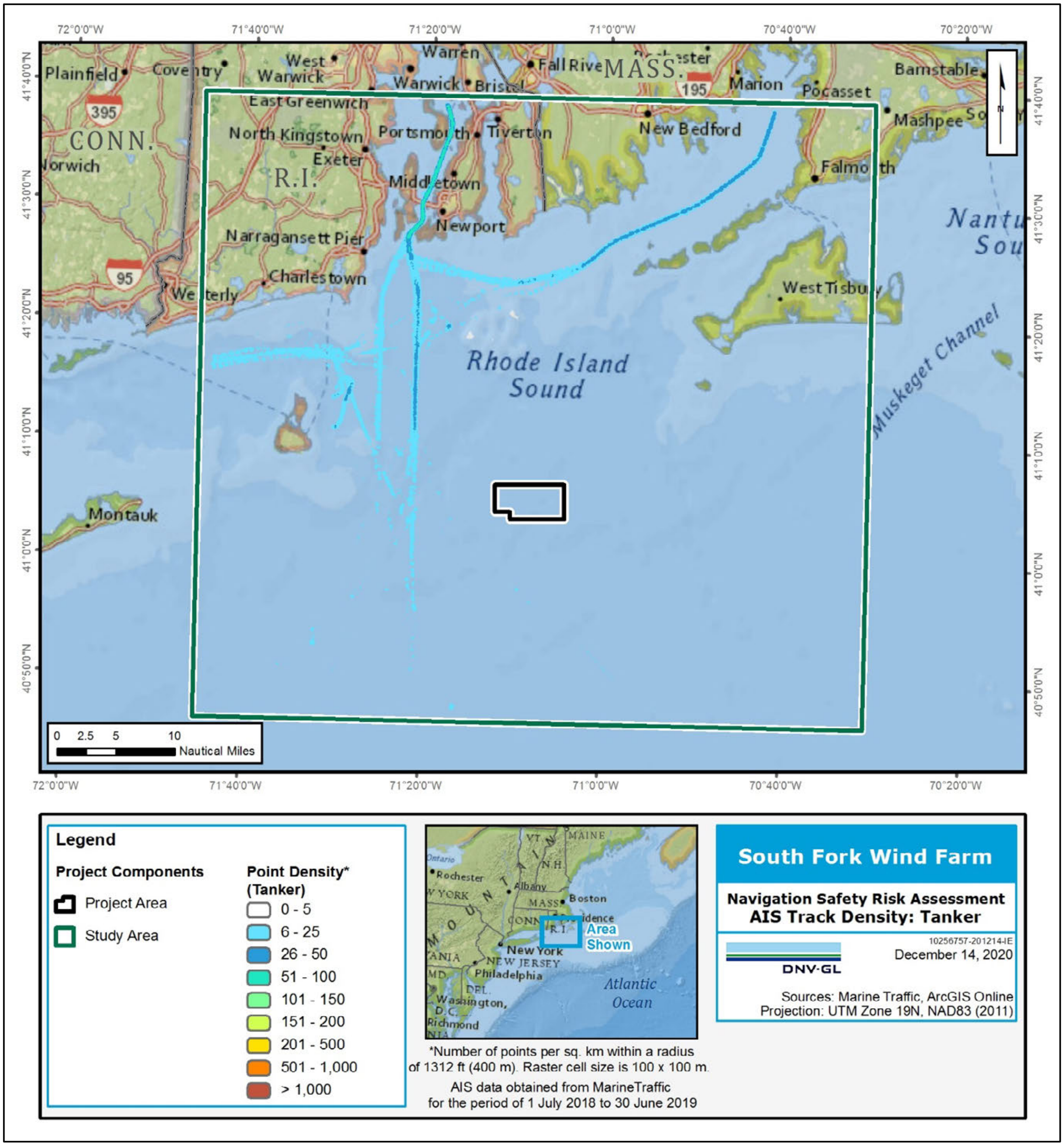
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)



*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.

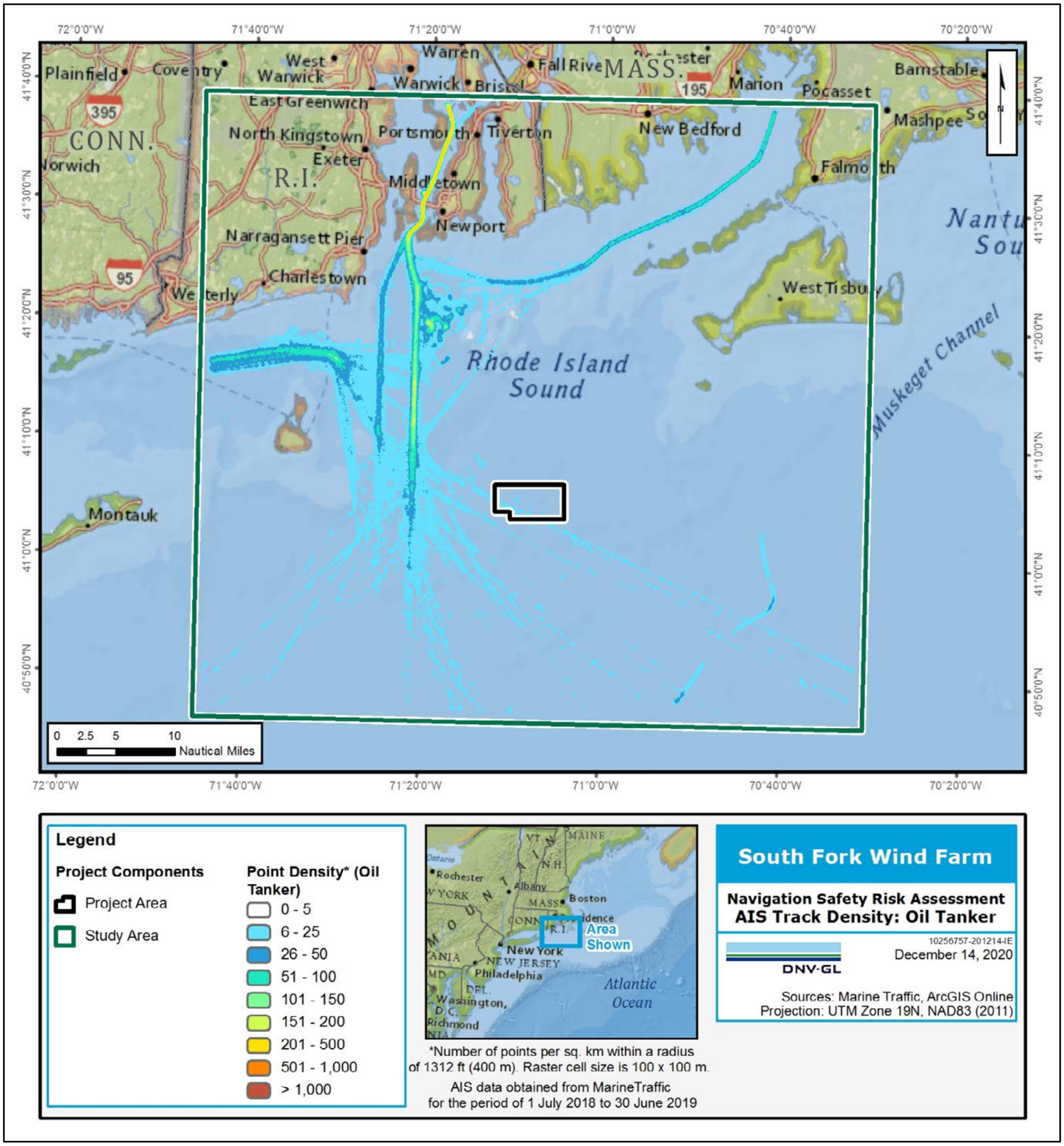
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019


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
N
Plainfield
Coventry
West Warwick
Warren
Fall River
MASS.
Rochester
Marion
Pocasset
Barnstable
Mashpee
Warwick
Bristol
195
395
CONN.
East Greenwich
North Kingstown
Exeter
R.I.
Norwich
New Bedford
Falmouth
Narragansett Pier
Charlestown
95
Westerly
West Tisbury
Nantucket Sound
Muskeget Channel
Montauk
0 2.5 5 10
Nautical Miles
Legend
Project Components
Project Area
Study Area
Point Density* (Pleasure)
0 - 5
6 - 25
26 - 50
51 - 100
101 - 150
151 - 200
201 - 500
501 - 1,000
> 1,000
MAINE
VT
N.H.
Rochester
Albany
NEW YORK
MASS.
Boston
CONN.
R.I.
Providence
Area Shown
New York
NEW JERSEY
Philadelphia
DEL.
Washington, D.C.
Richmond
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
South Fork Wind Farm
Navigation Safety Risk Assessment
AIS Track Density: Pleasure
10256757-201214-IE
December 14, 2020
DNV·GL
Sources: Marine Traffic, ArcGIS Online
Projection: UTM Zone 19N, NAD83 (2011)



*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



Legend

Project Components

- Project Area
- Study Area

Point Density* (Oil Tanker)

- 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.

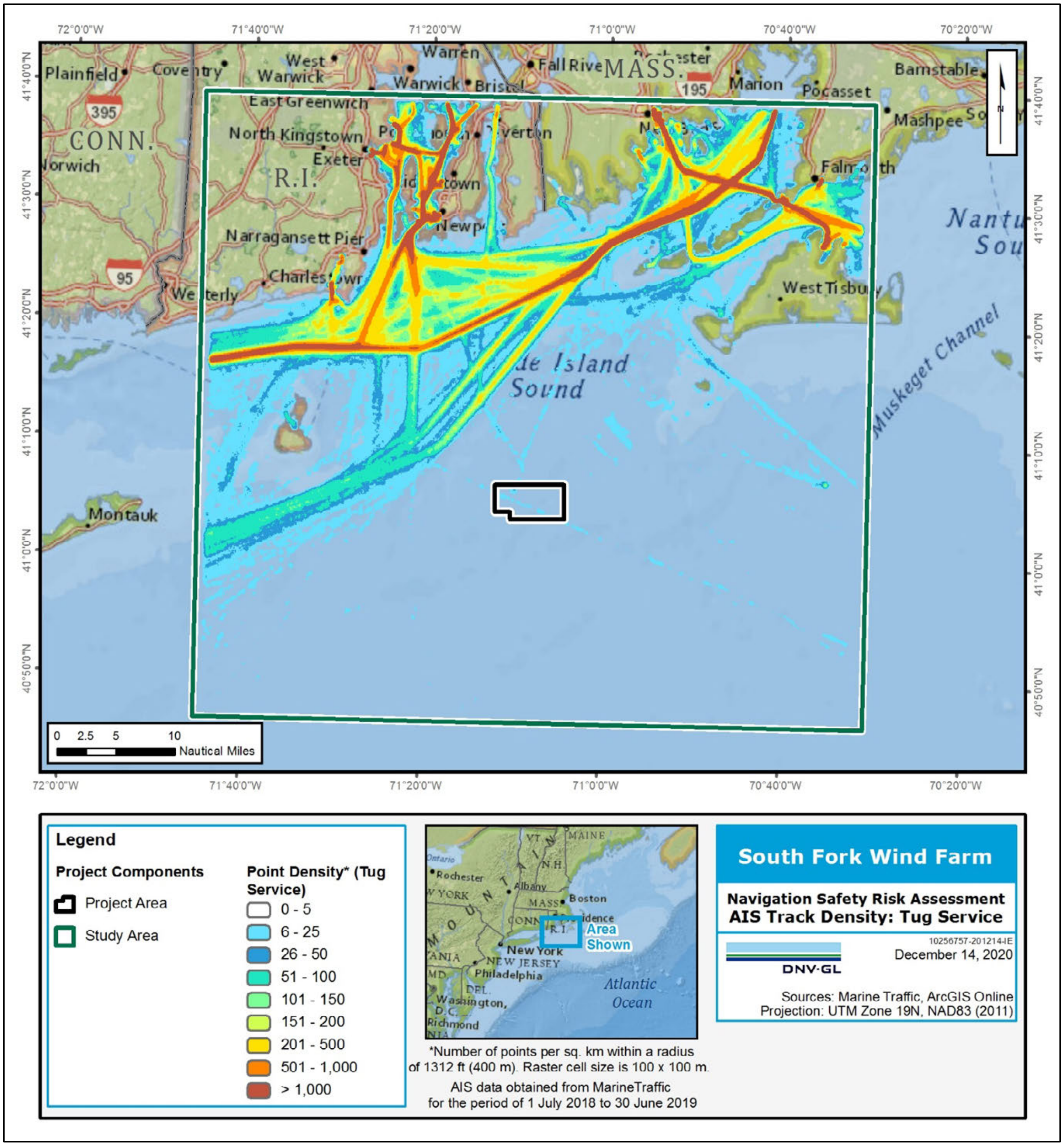
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

South Fork Wind Farm

Navigation Safety Risk Assessment
AIS Track Density: Oil Tanker

10256757-201214-IE
December 14, 2020

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



*Number of points per sq. km within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.

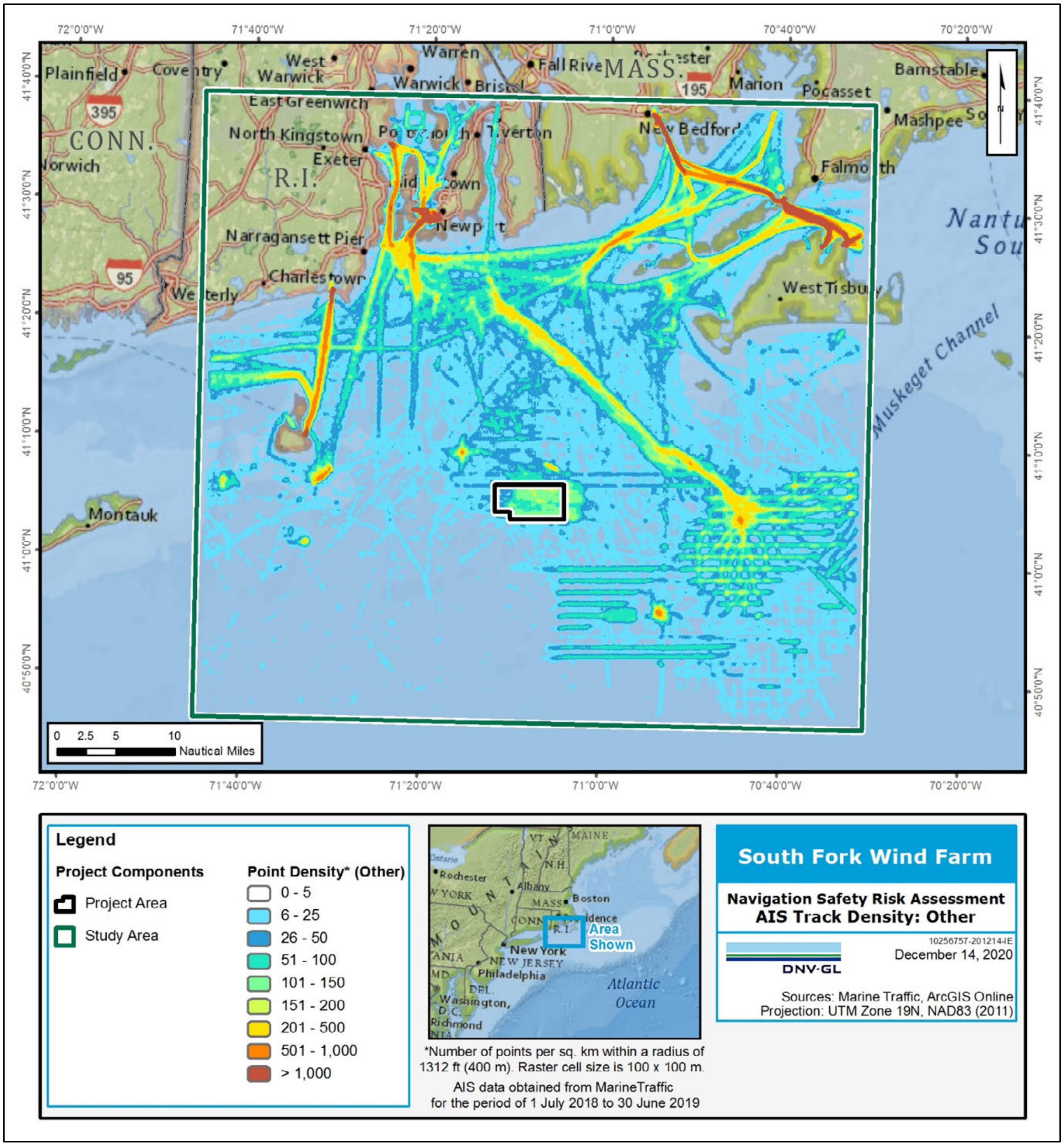
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

South Fork Wind Farm

Navigation Safety Risk Assessment
AIS Track Density: Tug Service

10256757-201214-IE
December 14, 2020

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



*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

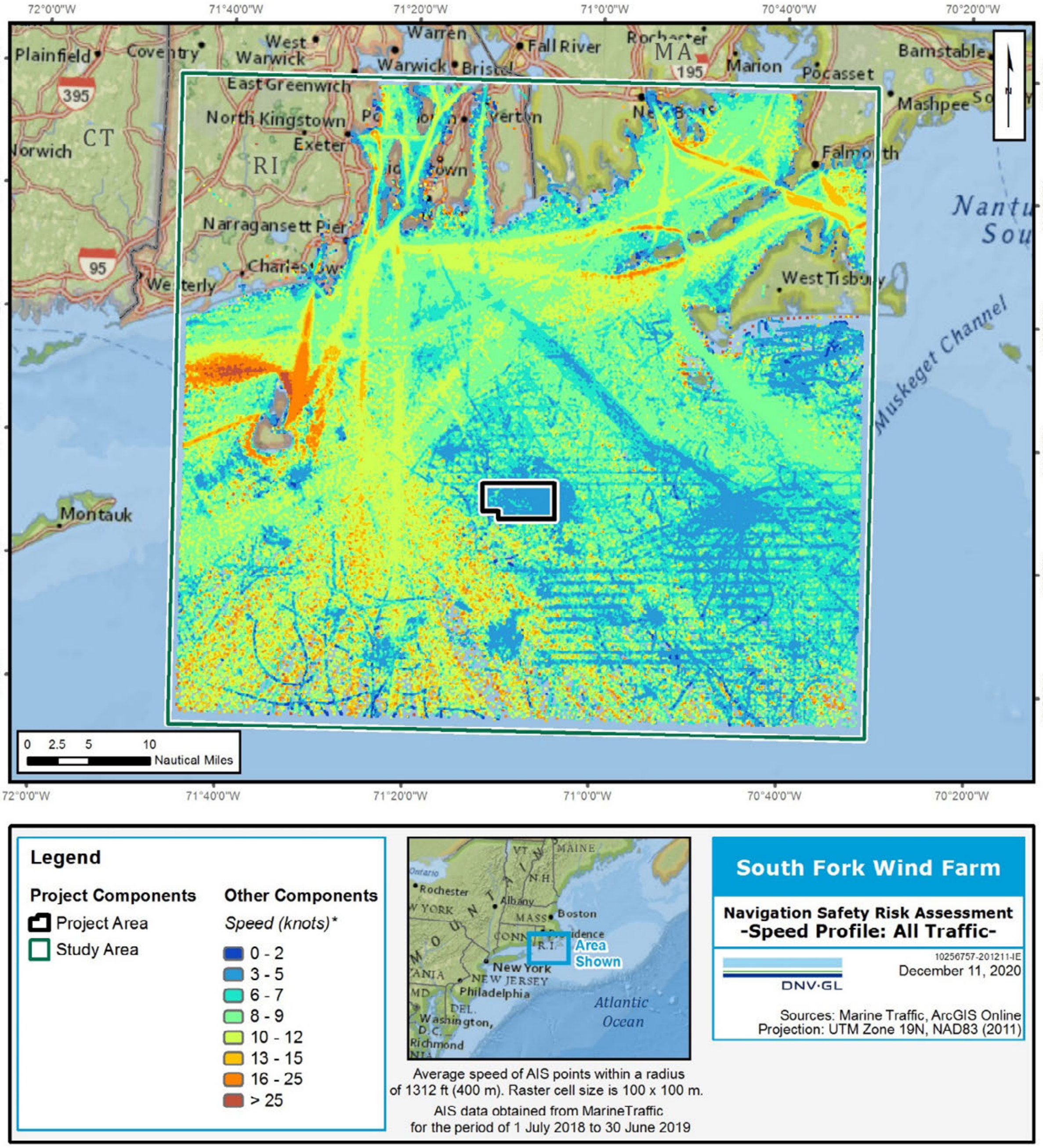
South Fork Wind Farm

Navigation Safety Risk Assessment
AIS Track Density: Other

10256757-201214-IE
December 14, 2020

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

B.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.

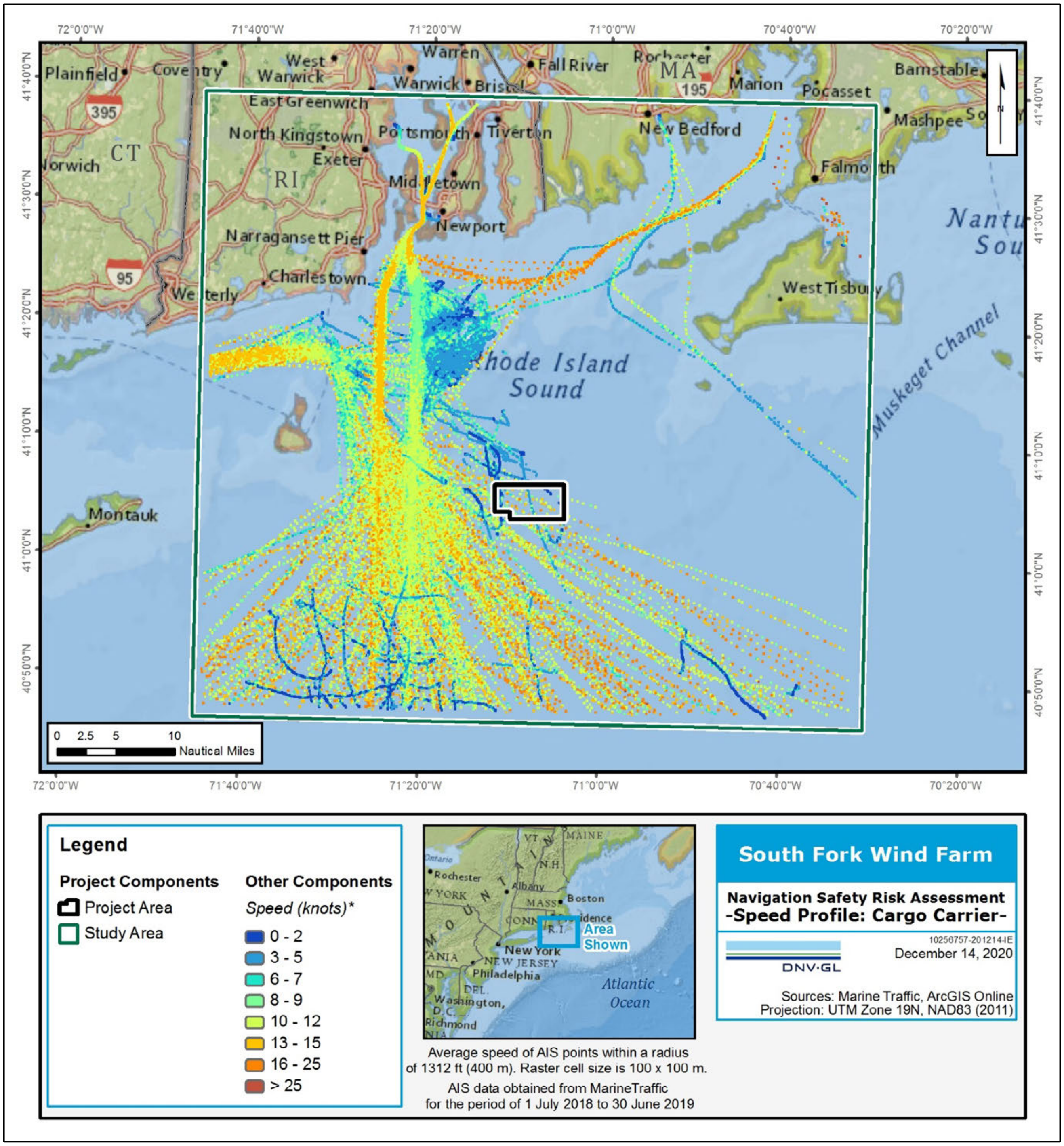
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

South Fork Wind Farm

Navigation Safety Risk Assessment
-Speed Profile: All Traffic-

10256757-201211-IE
December 11, 2020

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



Legend

Project Components

▭ Project Area

🟩 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

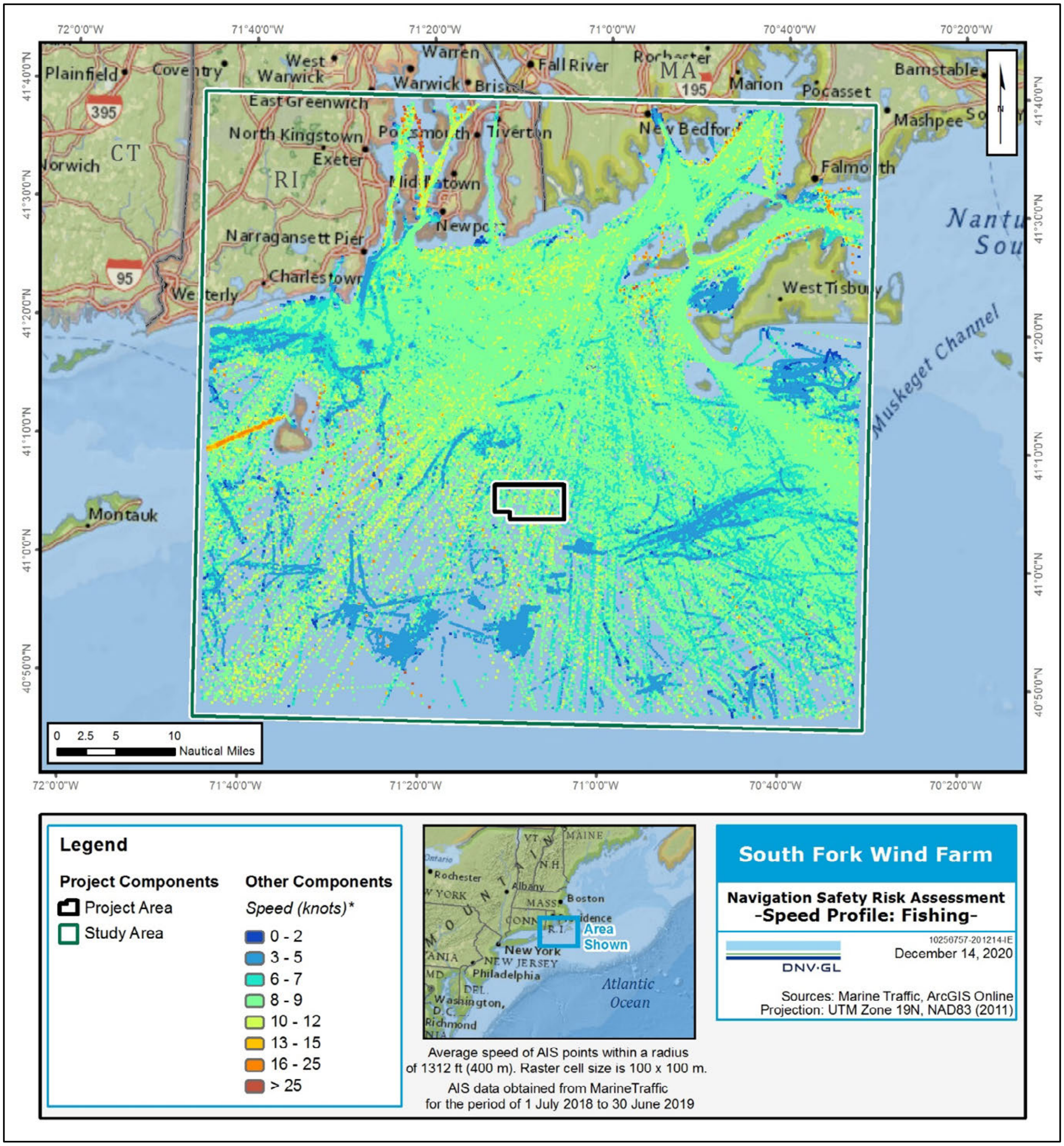
South Fork Wind Farm

Navigation Safety Risk Assessment
-Speed Profile: Cargo Carrier-

10256757-201214-IE
December 14, 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.

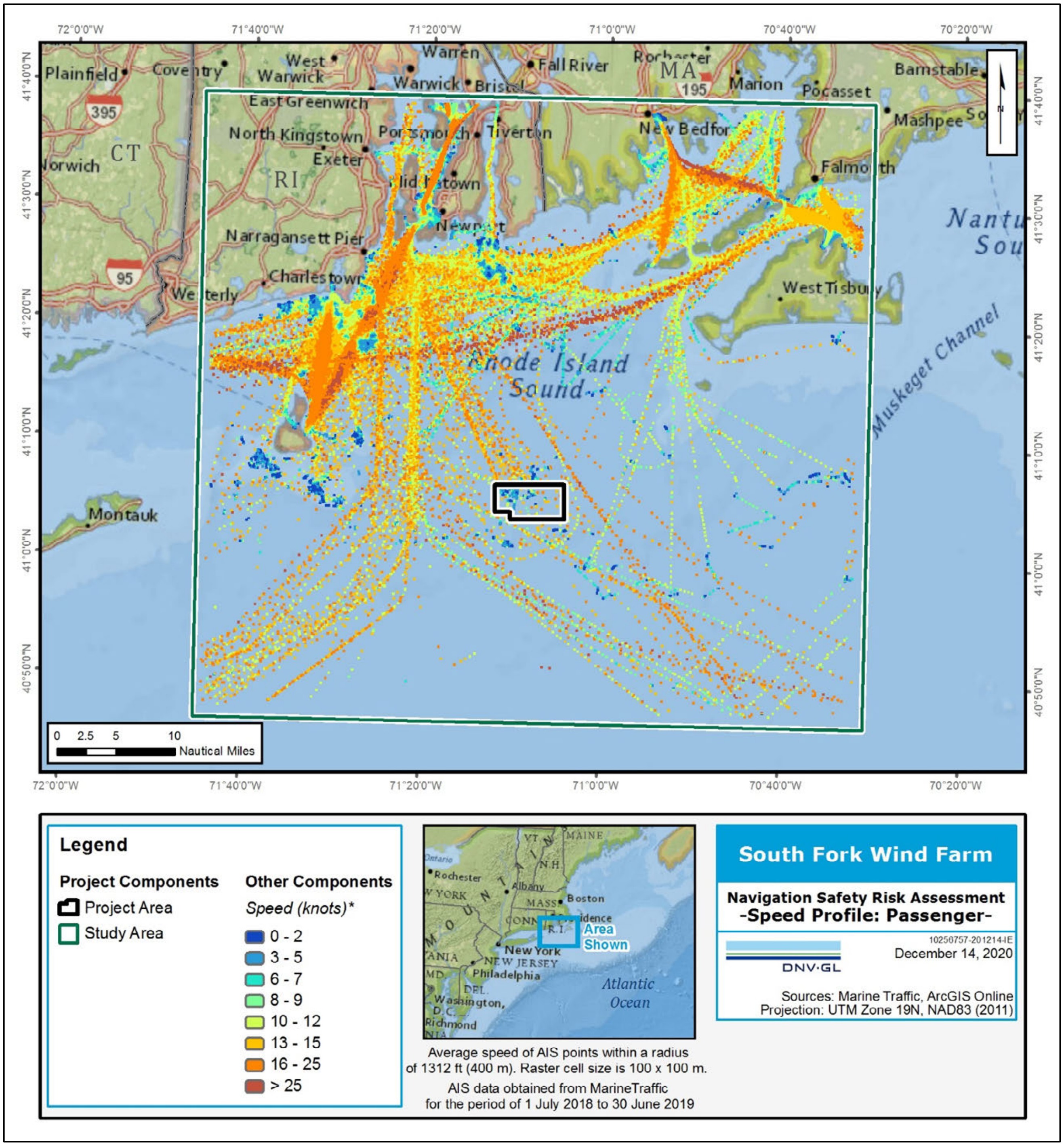
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

South Fork Wind Farm

Navigation Safety Risk Assessment
-Speed Profile: Fishing-

10256757-201214-IE
December 14, 2020

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.

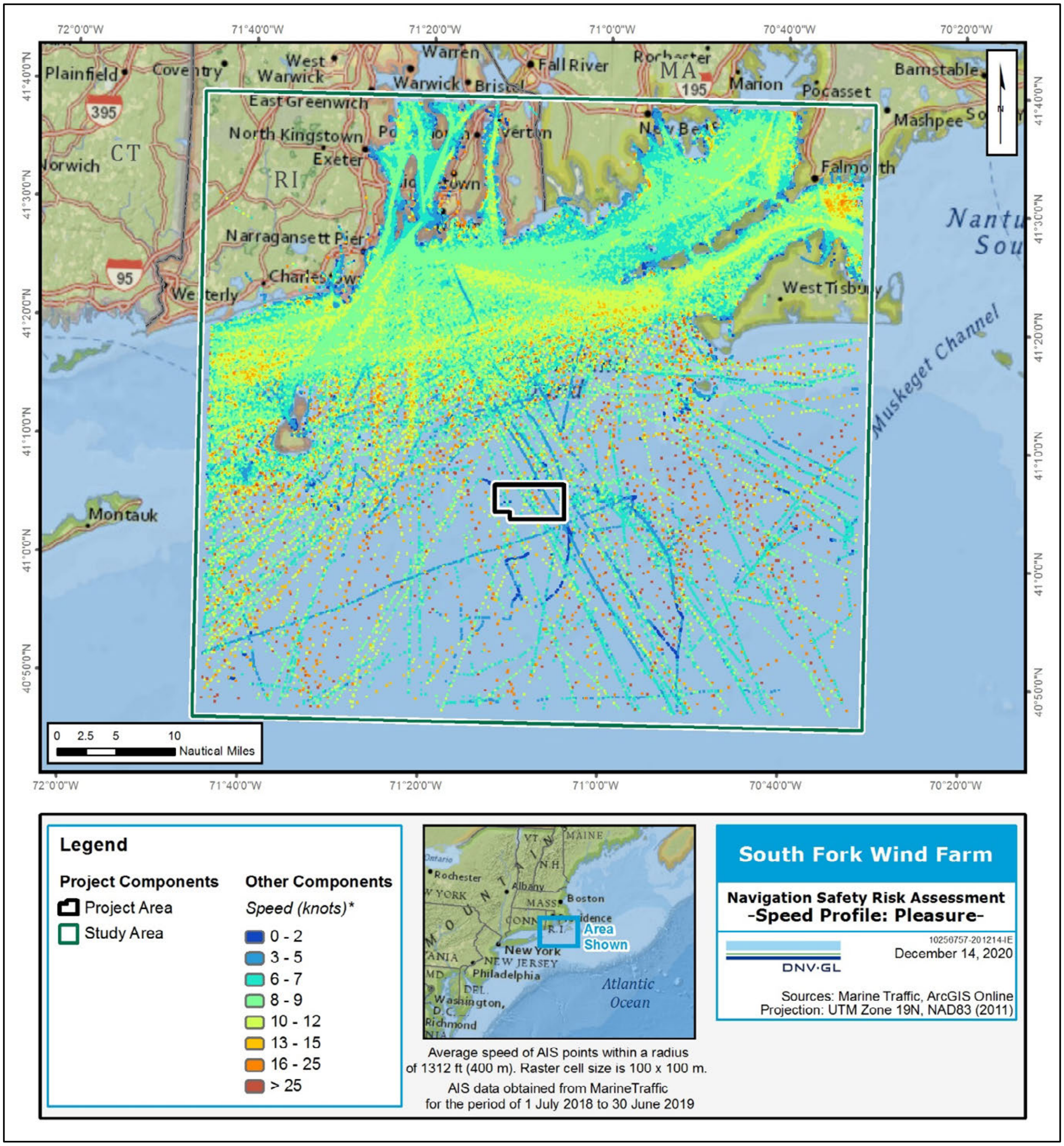
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

South Fork Wind Farm

Navigation Safety Risk Assessment
-Speed Profile: Passenger-

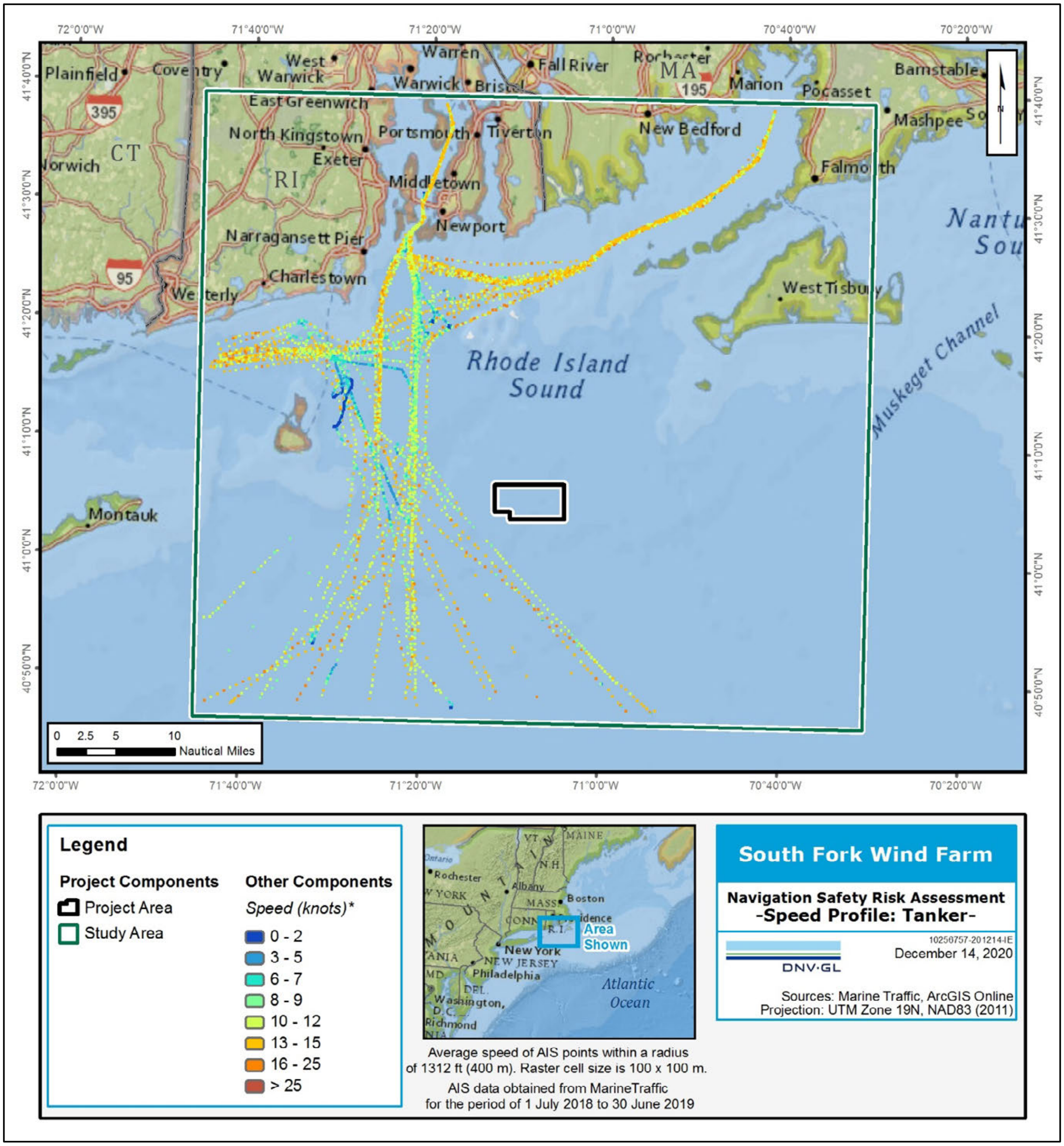
December 14, 2020

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



Average speed of AIS points within a radius of 1312 ft (400 m). Raster cell size is 100 x 100 m.

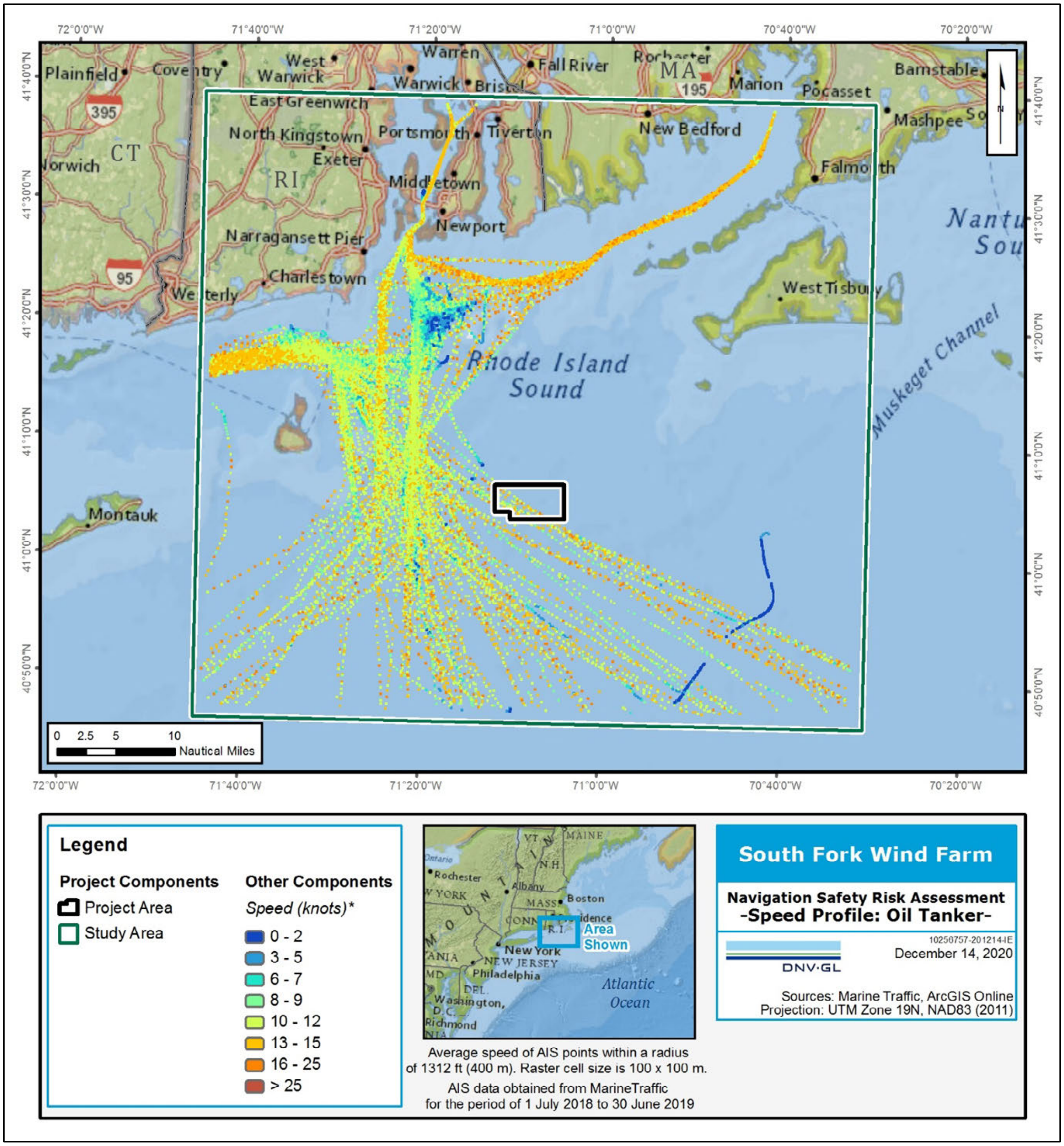
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

South Fork Wind Farm

Navigation Safety Risk Assessment
-Speed Profile: Tanker-

10256757-201214-IE
December 14, 2020

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.

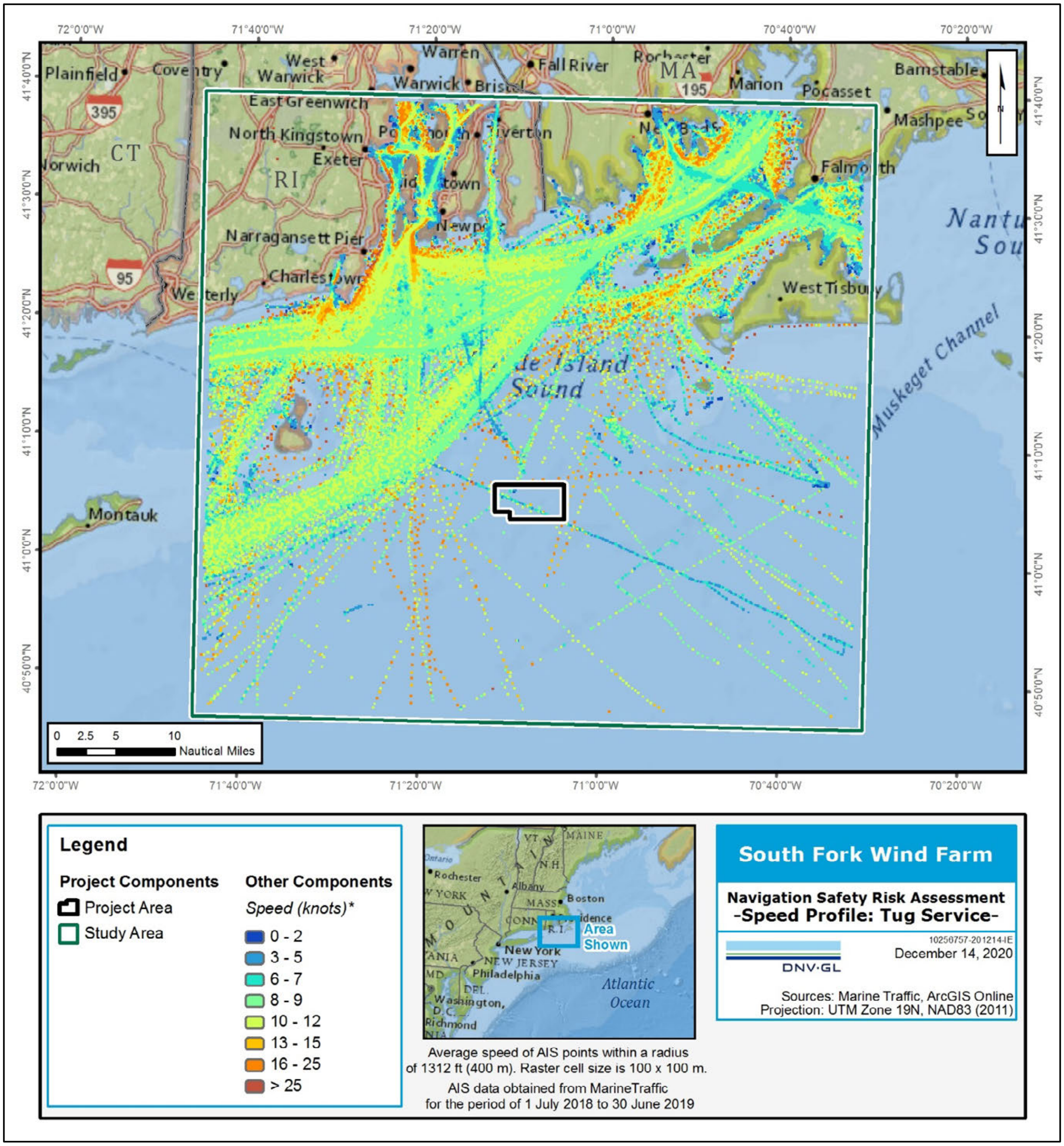
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

South Fork Wind Farm

Navigation Safety Risk Assessment
-Speed Profile: Oil Tanker-

10256757-2012141E
December 14, 2020

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.

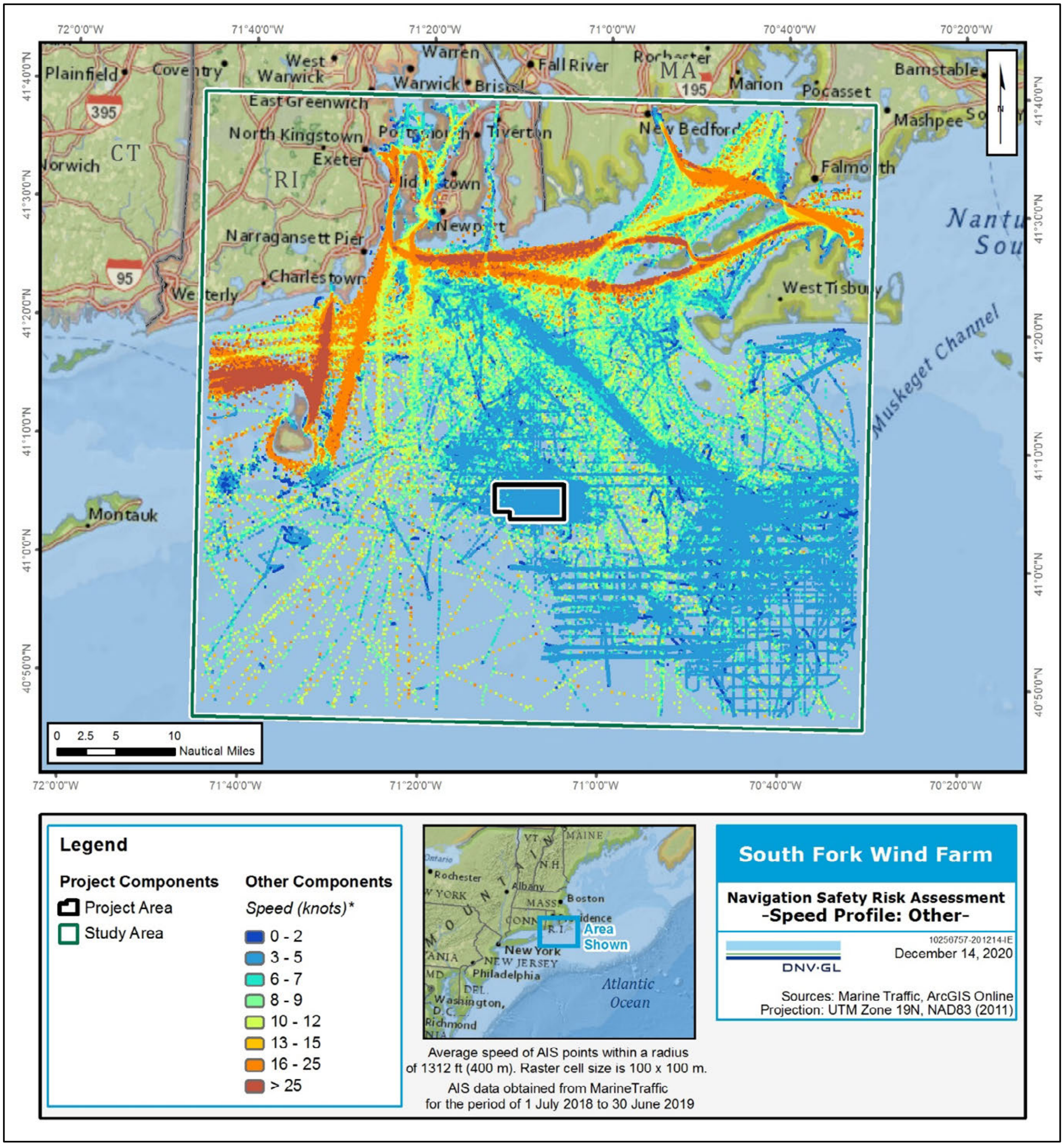
AIS data obtained from MarineTraffic for the period of 1 July 2018 to 30 June 2019

South Fork Wind Farm

Navigation Safety Risk Assessment
-Speed Profile: Tug Service-

10250757-201214-IE
December 14, 2020

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

South Fork Wind Farm

Navigation Safety Risk Assessment
-Speed Profile: Other-

10256757-201214-IE
December 14, 2020

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

B.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 C STAKEHOLDER ENGAGEMENT

Stakeholder engagement is an important aspect of assuring maritime safety. South Fork Wind, LLC has contacted the below entities regarding marine use / safety (South Fork Wind, 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 D 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 Project may have on their particular waterway uses (South Fork Wind, 2020).

Appendix C 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:

- <u>Recreational boating</u>: 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.
- <u>Recreational fishing</u>: Recreational fishing is expected to increase as fish congregate around the artificial reef associated with each foundation.
- <u>Commercial fishing</u>: 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 nautical mile separation between towers.
- <u>Commercial vessel operators/pilots</u>: Commercial vessels will make slight adjustments to their intended courses to avoid the vicinity of the Project completely.
- <u>Port authorities</u>: Port authorities are supportive of the Project and welcome the port activity and economic benefit the Project may have on port operations.

APPENDIX E DESCRIPTION OF MARCS MODEL

E.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., OSP or WTG) due to human error (steering and propulsion not impaired)
- Drift allision, where a ship strikes a man-made structure (e.g., OSP or WTG) 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 structure 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.

E.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 E-1.

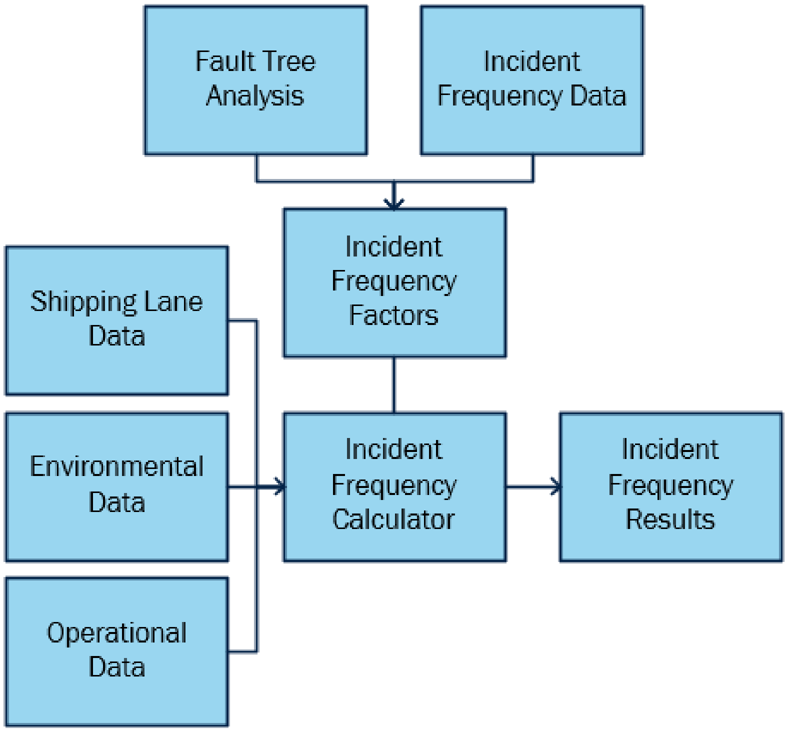


Figure E-1 Block diagram of MARCS incident frequency model

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 E-2.

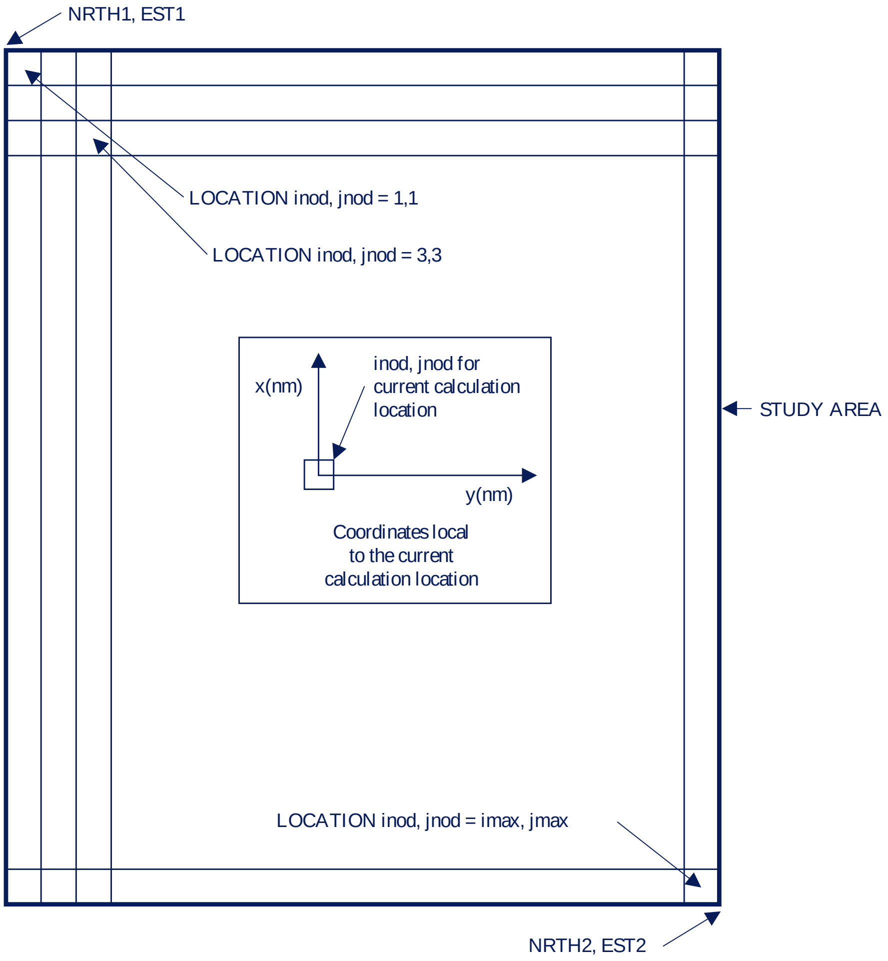


Figure E-2 Basic definitions and coordinate sets

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).

E.2.1 Critical situations

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

Fault tree analysis (Henley and 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 E-3.

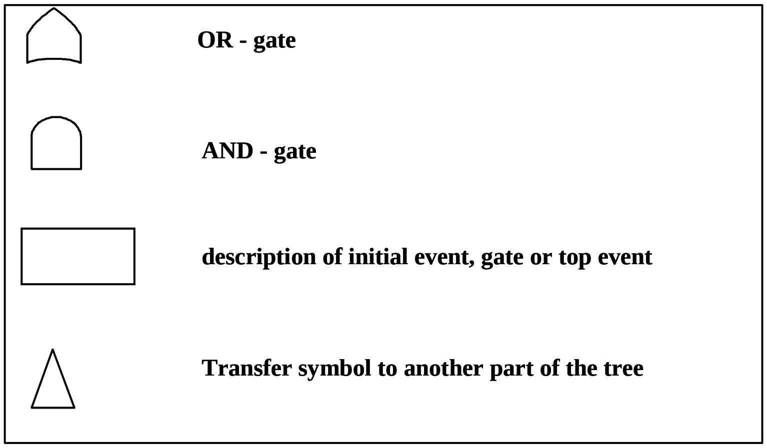


Figure E-3 Fault tree symbols

The OR gate (Figure E-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 $P1*P2 = 10^{-4}$).

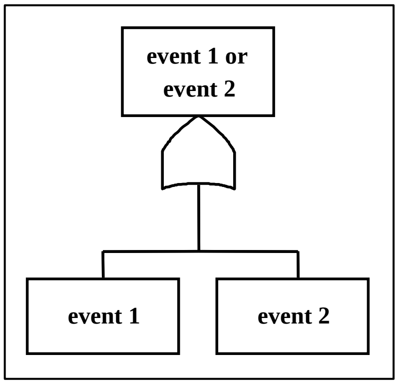


Figure E-4 OR gate

The AND gate (Figure E-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

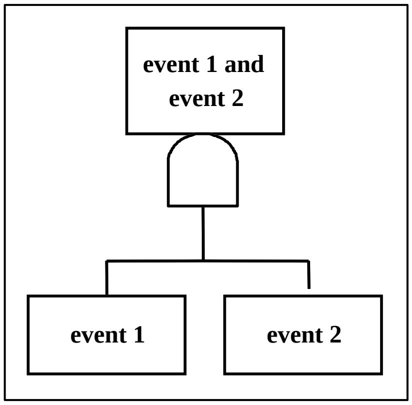


Figure E-5 AND gate

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).

E.3 Data used by MARCS

This section describes the various data inputs used by MARCS.

E.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 E-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.

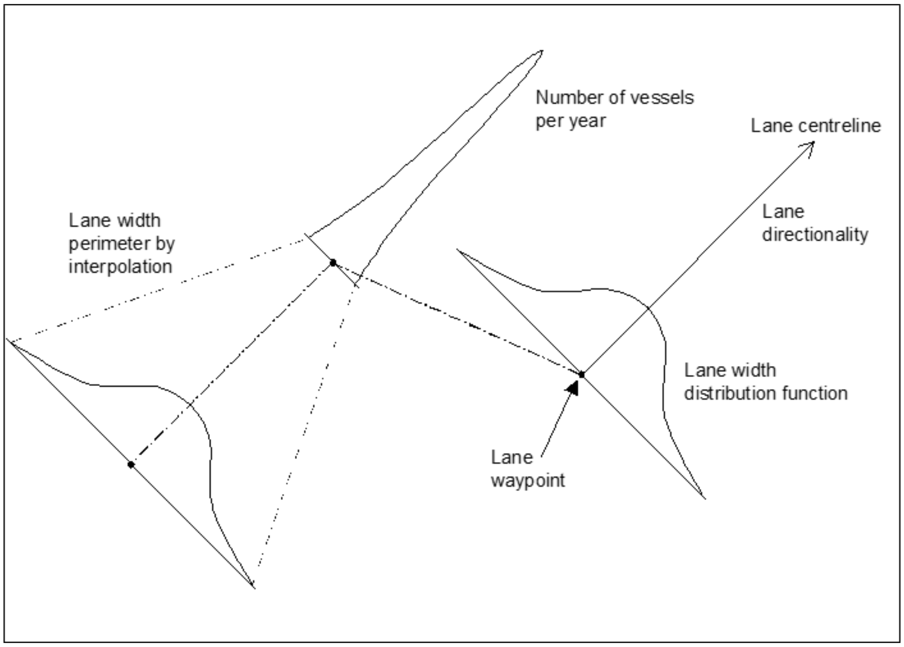


Figure E-6 Shipping lane representation used in MARCS

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 E-7.

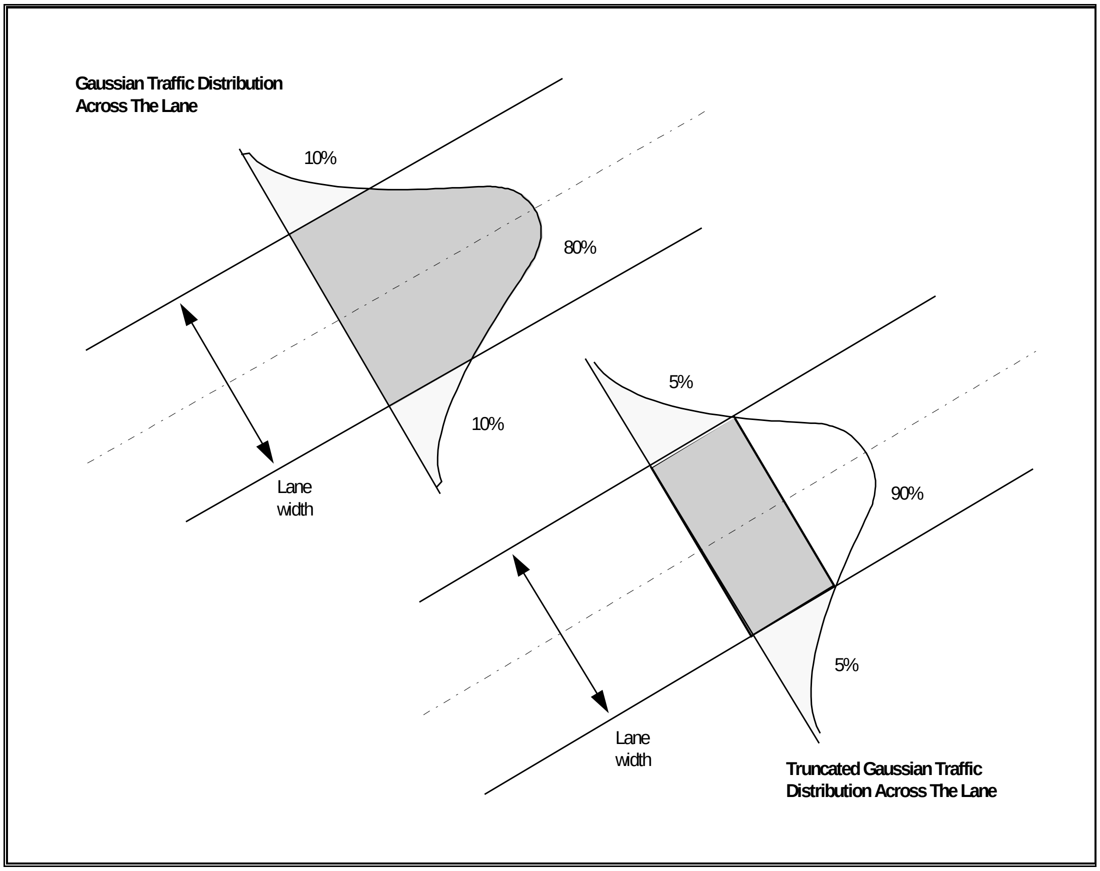


Figure E-7 Shipping lane width distribution functions used in MARCS

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

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

A rogue vessel is defined as one that fails to adhere (fully or partially) to the Collision Avoidance Rules (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.

E.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.

E.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., OSP or WTG). 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”.

E.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.

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

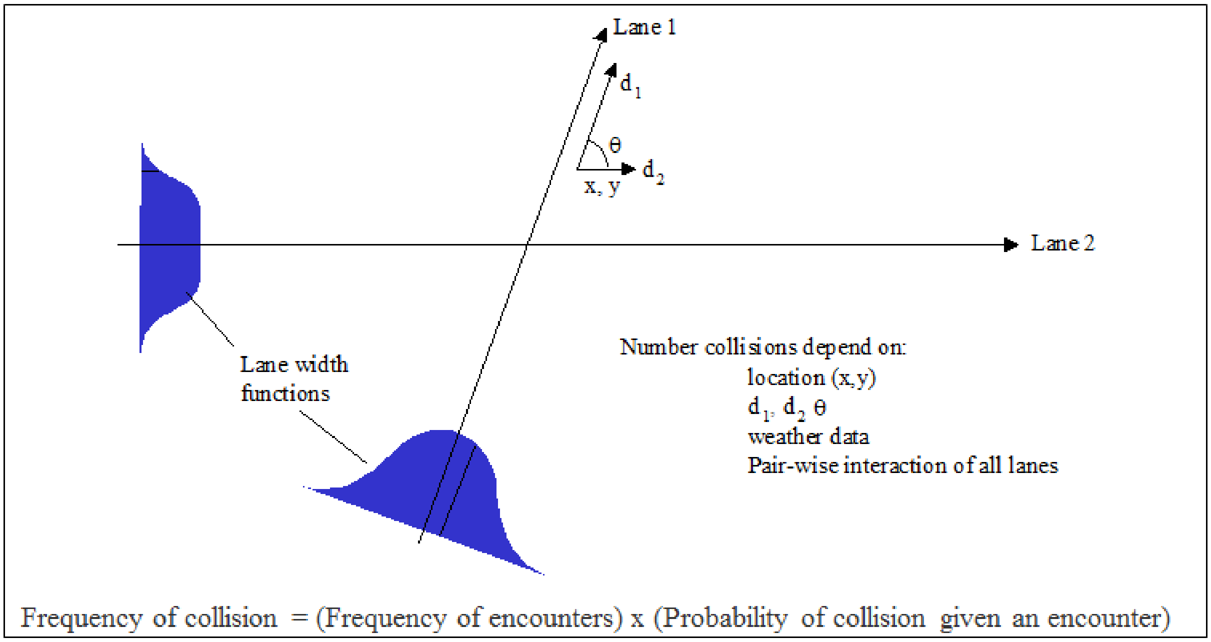


Figure E-8 Graphical representation of the collision model

In Figure E-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.

E.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 E-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.

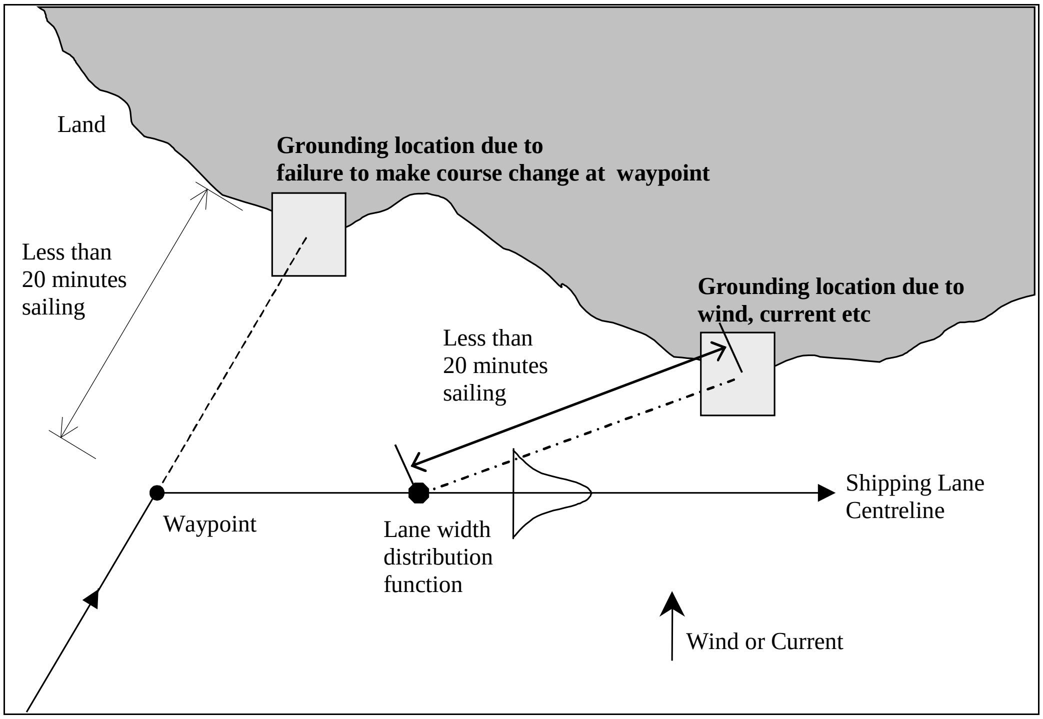


Figure E-9 Graphical representation of the powered grounding model

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 of these branches are illustrated in Figure E-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.

E.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 E-10.

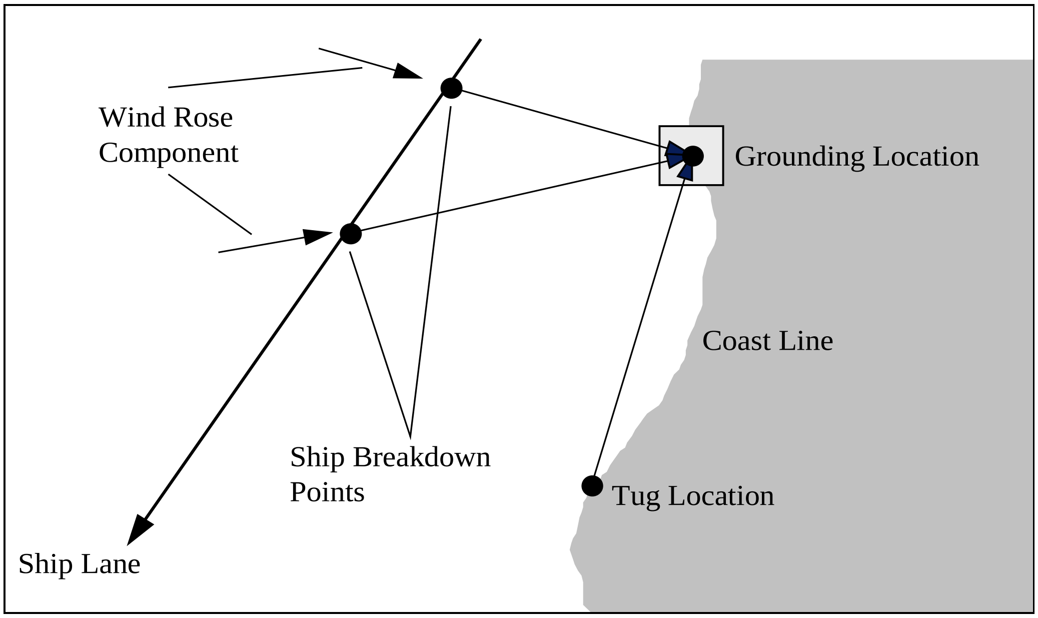


Figure E-10 Graphical representation of the drift grounding model

Implicit in Figure E-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.

E.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.

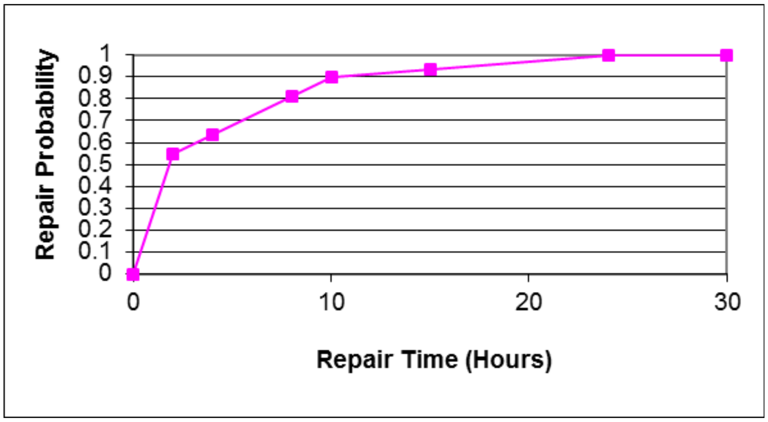


Figure E-11 Graphical representation of the self-repair save mechanism

E.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.

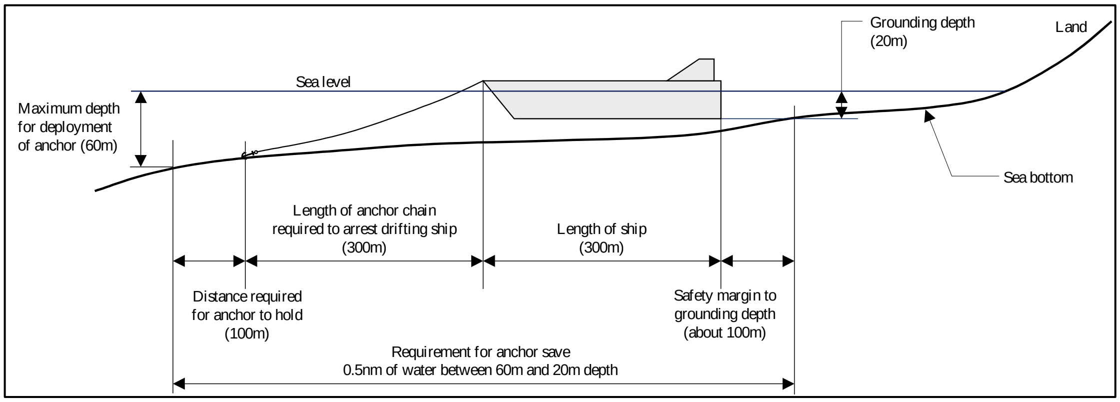


Figure E-12 Graphical representation of the anchor save mechanism

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

E.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 E-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.

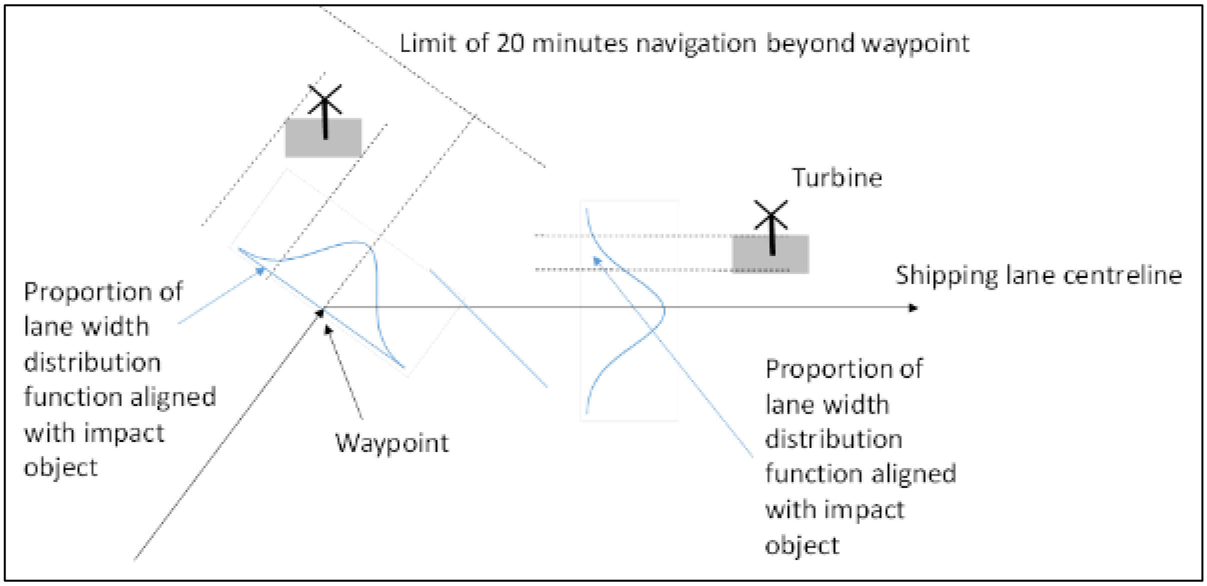


Figure E-13 Graphical representation of powered allision model

E.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 E-14.

In order to avoid over prediction of grounding or allision frequencies MARCS needs to know if a LOS[8] 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.

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[8] “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., OSP or WTG). 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.”

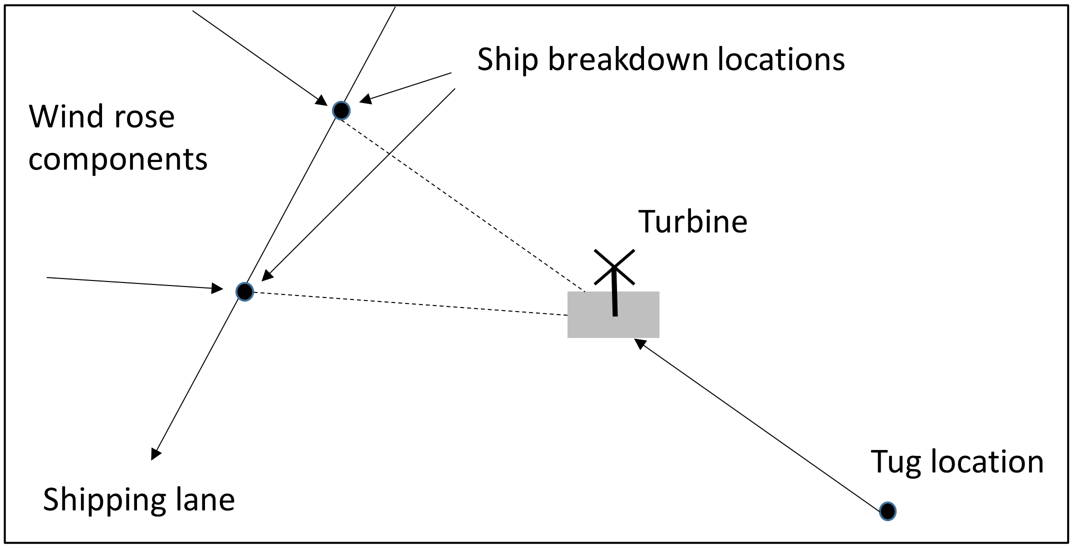

Figure E-14 Graphical representation of the drift allision model

Implicit in Figure E-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.

E.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.

E.5.1 Coastal Vessel Traffic Service

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

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% reduction) for collisions assuming both ships in the encounter participate in the vessel traffic service and for powered grounding.

E.5.2 Pilotage

The use of pilots has two main benefits:

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

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

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

A pilot's Portable 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%. The effect on collisions is assumed to be negligible. The effect of a PPU is modeled by an additional relative risk factor of 0.90 (i.e., a 10% reduction) applied to human performance errors in powered groundings and allisions when at least one pilot is present.

E.5.3 Aids to navigation

E.5.3.1 Electronic chart display and information system

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

E.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 E-1 are used over the entire length of the route studied. Causes that might be prevented by improved conventional ATON are represented by "fault/deficiency of lights/marks" and amounted to 6.4% of incidents. Improving conventional ATON would not necessarily prevent all such incidents, but might have indirect benefits on other navigational errors. Therefore, this study uses a reduction in groundings and allisions by 6%, which is justified by this data.

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

Table E-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

E.6 Additional background on MARCS

MARCS was first developed by DNV GL during the mid-1990s. Since then it has been further developed and applied to different types of projects worldwide. The number of distinct projects performed probably exceeds 100. This section lists and summarizes the more significant projects relevant to wind farm navigation safety assessments.

E.6.1 Selected navigation risk projects

North East Shipping Risk Assessment, PP042653, 2012-2013

The Australian Maritime Safety Agency (AMSA) is the Australian government agency with 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 northeast 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 southwest of Alaska is located on the major great circle marine trade route between the west coast of North America and the Far East. The region contains rich and diverse marine resources, including highly significant commercial fisheries.

In 2004 the M/V Selendang Ayu went aground off the Aleutians. The resulting fine established funding for a risk assessment managed by the U.S. National Fish and Wildlife Foundation, Alaska Department of Environmental Conservation, and the USCG. A team from Environmental Resources Management 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 MARCS model to calculate cargo and bunker fuel oil spill risks. ERM's spill trajectory model was then used to assess detailed accident consequences for a small group of agreed spill scenarios. Risk Reduction Options (RROs) were identified and subjected to an assessment of their risk reduction effectiveness, practicality, and cost effectiveness by an expert judgement process at a DNV-led 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 groups’ 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 two sub-contracting organizations. The project was completed at the start of 1997 at which time a full, public domain report was issued.

E.6.2 Selected model development projects

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

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

- To assess the marine risk reduction potential of risk reduction measures based around the theme of improved ship-to-ship and ship-to-shore communication (measures explicitly evaluated were: ship transponders; standard maritime communication phrases; and an expert system providing advice on collision avoidance maneuvers);

- To develop improved ship accident consequence models, in terms of lives lost, bunker and crude oil outflow and financial impacts;
- To demonstrate the application of marine risk assessment methods in two case study areas (the North Sea and Rotterdam Port Approach) by performing a cost-benefit analysis of possible risk reduction measures.

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

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

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

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

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

E.6.3 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 F SOUTH FORK WIND FARM MARINE ACCIDENT MODELING

F.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(s):

- 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.

F.2 Model inputs

F.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 the South Fork Wind Farm (the Project) is shown in Figure F-1. The Automatic Identification System (AIS) boundaries are identical to the Study Area boundaries.

Figure F-1 Risk Study Area Quantified in MARCS

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

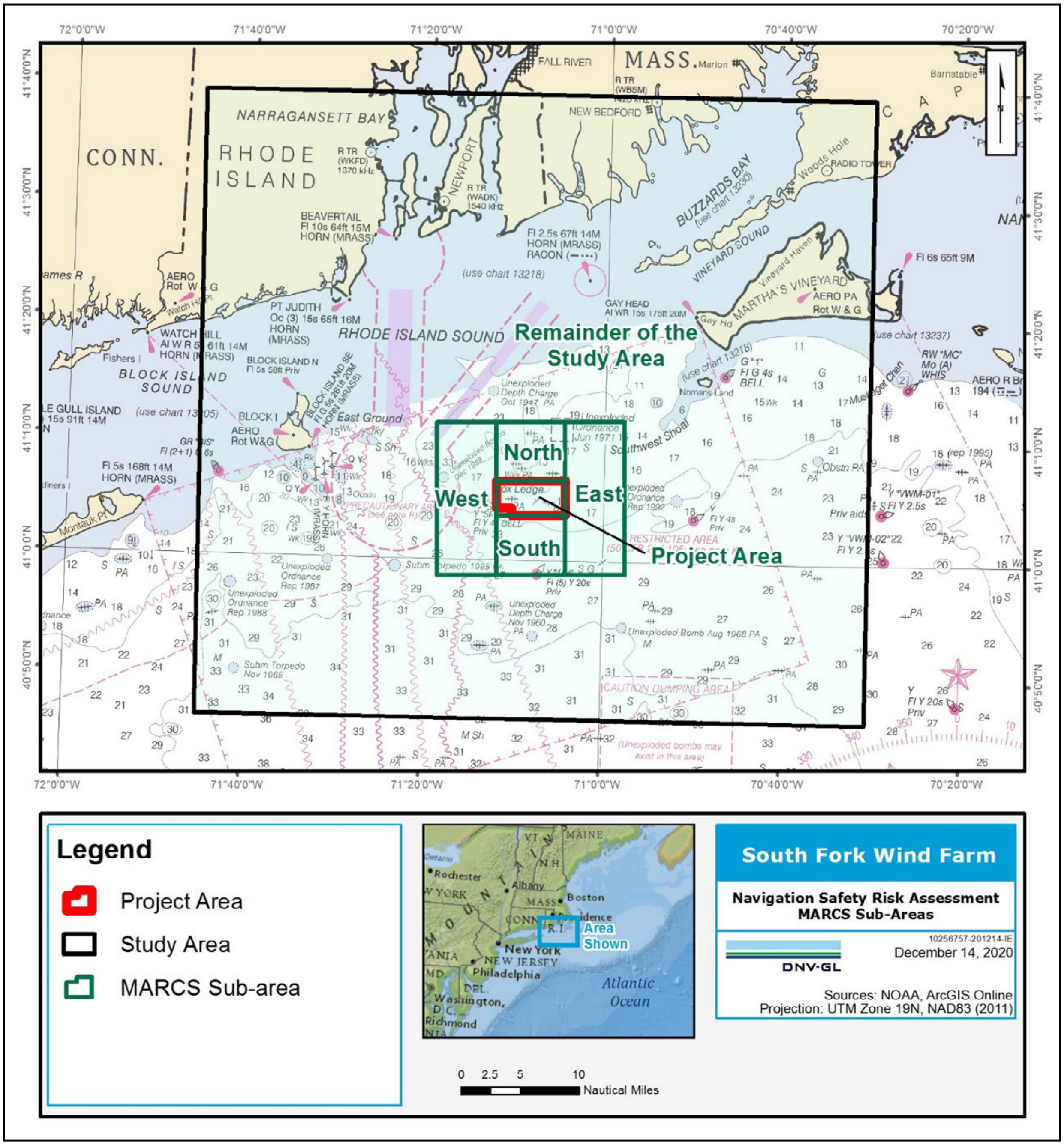

Figure F-2 Definition of Sub Areas within the Study Area

F.2.2 Wind Farm

The Project is modeled as 16 Project structures, consisting of 15 potential WTG positions, and 1 potential OSP position (Figure F-3). The Project structures are separated by a minimum distance of 1.0 NM. The WTGs are modeled as having an effective diameter of 11 m at and near sea level and the OSP as having an effective diameter of 57 m (i.e., the collision cross section is the footprint of 40 x 40 m circumscribed).

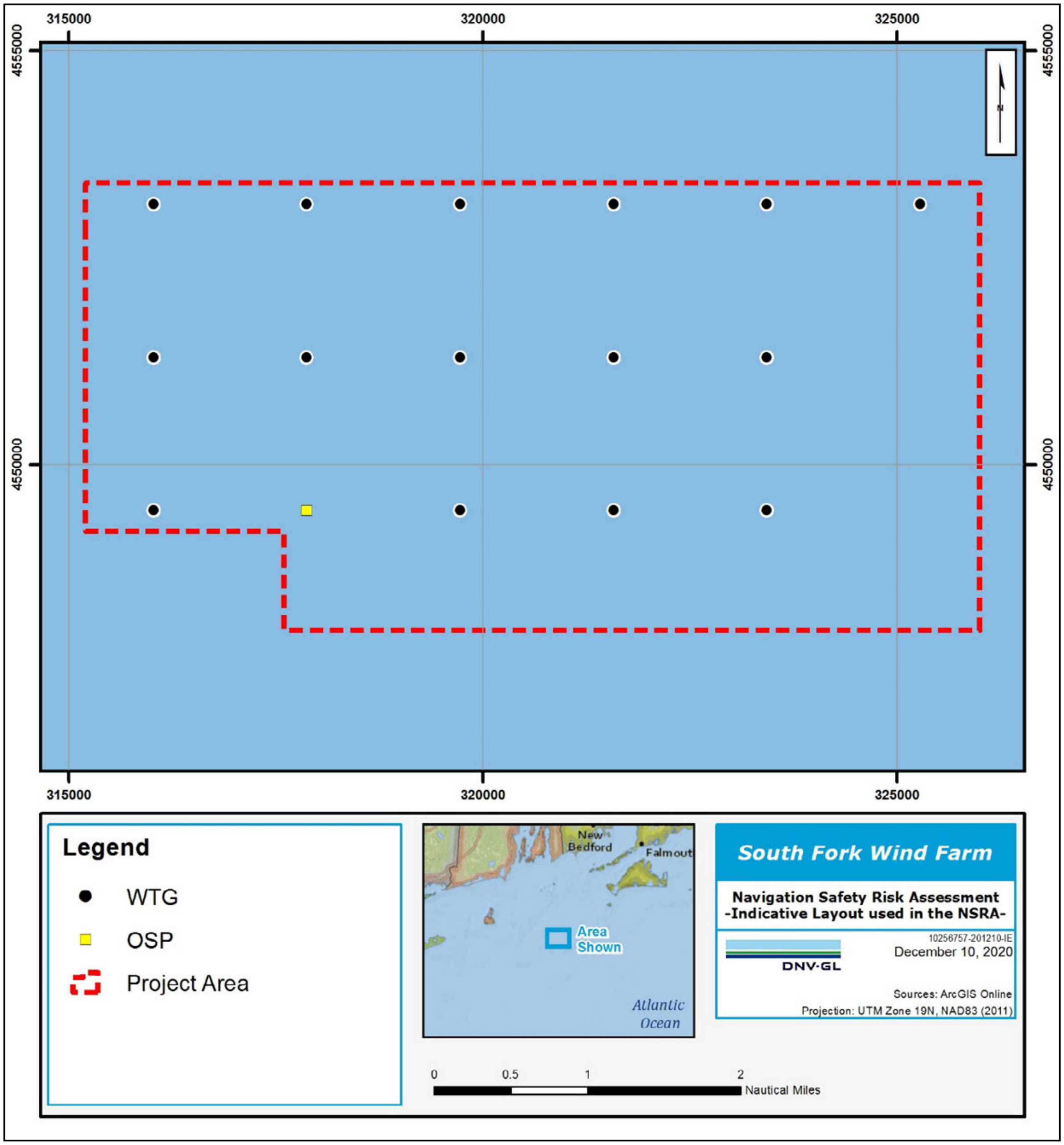

Figure F-3 Indicative layout used for risk modeling

F.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 F-1 shows the wind data described in Section 7.1 of the main report, formatted for MARCS: eight directions (North, Northeast, East, Southeast, South, Southwest, West, and Northwest) and four speed categories (Calm, Fresh, Gale, and Storm). The probabilities presented below are based on a virtual model of 17.5 years of hourly wind speed and direction data.

Table F-1 Annual wind direction and wind speed probabilities

Wind Speed in knots	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 F-2 presents the visibility data used in the MARCS model.

Table F-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 Study Area was modeled as an “open water” area because the Project 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 F-4 illustrates the shoreline used in MARCS. The defined shoreline identifies possible grounding locations for the model.

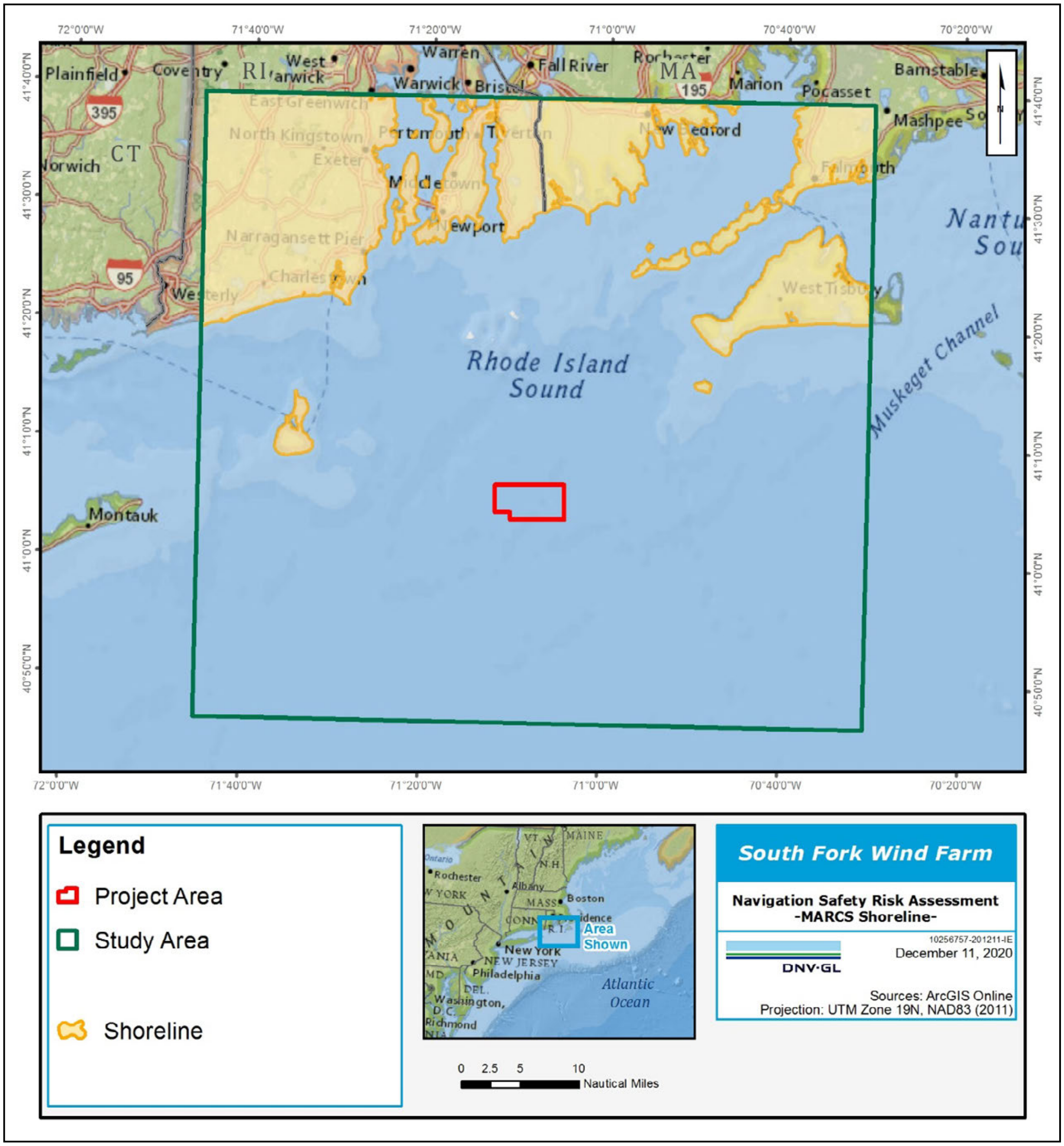

Figure F-4 Shoreline utilized in MARCS

F.2.4 Traffic data

Traffic data was derived by analysis of 3.6 million lines of 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 E) and up to 8 distinct traffic types. The traffic types selected for this analysis are shown in Table F-3. Also shown are the average vessel speeds derived from the AIS data for each vessel type.

Table F-3 Traffic types used for MARCS analysis

Id	Traffic type name	Draft	Speed (knots)
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 [a]	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

[a] Passenger ships longer than 150m LOA are re-routed in Case 2 as deep draft ships

The AIS data set was analyzed in the following stages:

- Dirty or missing data were corrected or removed.
- Each AIS ship type was mapped to the most appropriate ship type category in Table F-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 route structure was re-checked against the ship tracks and additional routes added if required.
- 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.

F.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 F-5.

Each is described below.

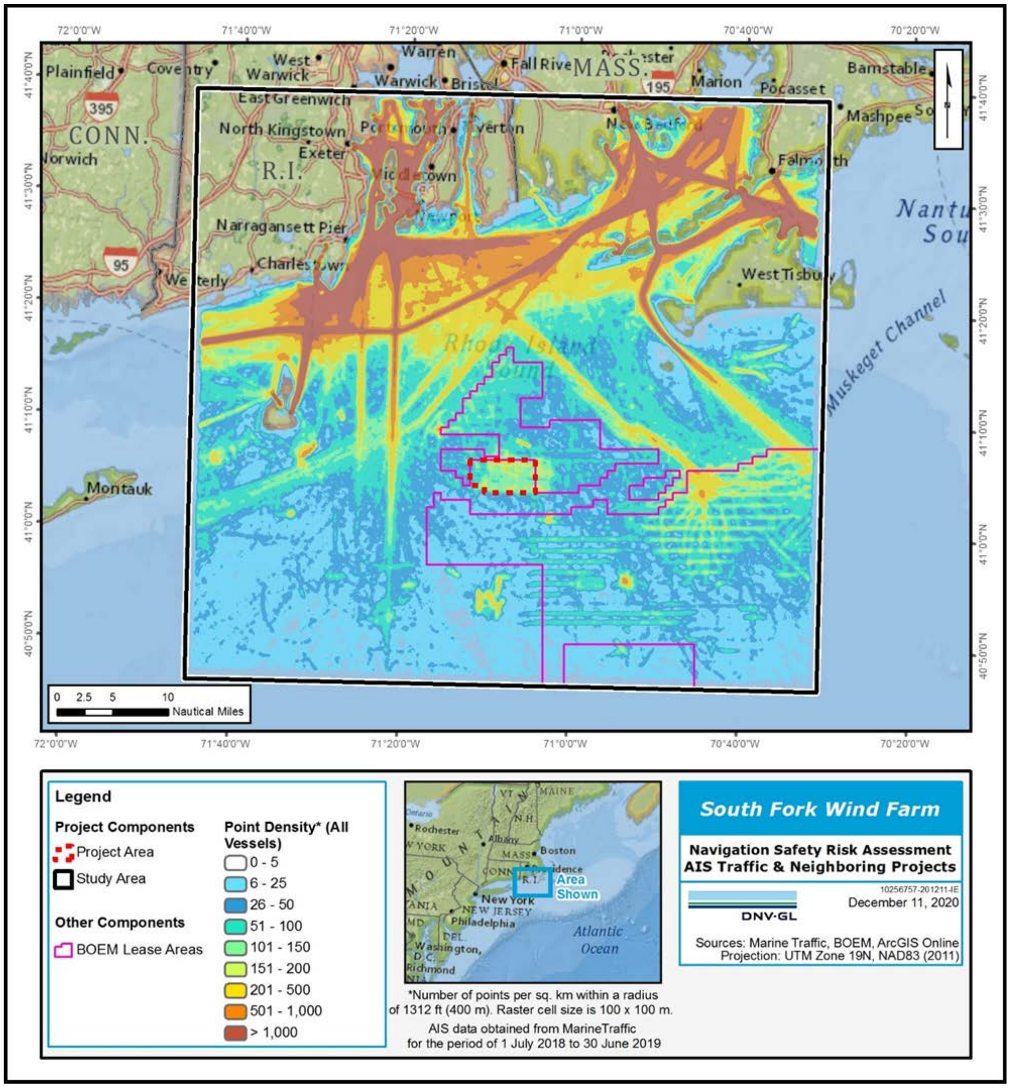

Figure F-5 Operational and proposed neighboring wind energy projects

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

The adjustment to fishing vessel and to pleasure vessel transits not in the AIS data was implemented into the MARCS model for all cases.

The AIS data set is a reliable resource for capturing the main traffic patterns from vessels equipped with AIS transmitters. However, not all vessels are required to have AIS on board per USCG regulations (see Section 2 of the NSRA main report). To achieve the most realistic results for the Study Area, special care was placed on estimated fishing and pleasure vessel traffic that may not have been captured in the AIS data set. This was done as follows.

In Section 2.1.1.2 of the main report, data was presented concerning the local fishing vessel fleet. It was concluded that 16.8% of the fishing fleet has lengths greater than 65 ft. It was assumed that all vessels over length of 65 ft are correctly represented in the AIS data set and that none less than length 65 ft are included in the AIS data set. Thus, a reasonable traffic escalation factor to represent the non-transponding smaller ships was 5.95 (1 / 0.168). Due to the absence of corresponding fleet data for pleasure vessels, this factor was applied to both fishing vessels and pleasure vessels.

There is no information about where these non-transponding vessels navigate. It was, therefore, assumed that these non-transponding vessels use the same routes as the transponding vessels. Thus the additional traffic due to non-transponding vessels is generated by applying a factor of 5.95 to the transit frequencies of each route used by the fishing and pleasure vessels as derived from the AIS data set. Furthermore, since the main concern is the allision risk with the Project structures, this escalation factor was only applied to those fishing and pleasure vessel routes with a closest point of approach to any Project structure of less than or equal to 12 NM. The routes that had the escalation factor applied to them are shown in Figure F-6. Since there are both fishing and pleasure vessels on each of these routes a separate figure is not required for fishing and pleasure vessels. The 5.95 factor is applied to all fishing and all pleasure transits on these routes.

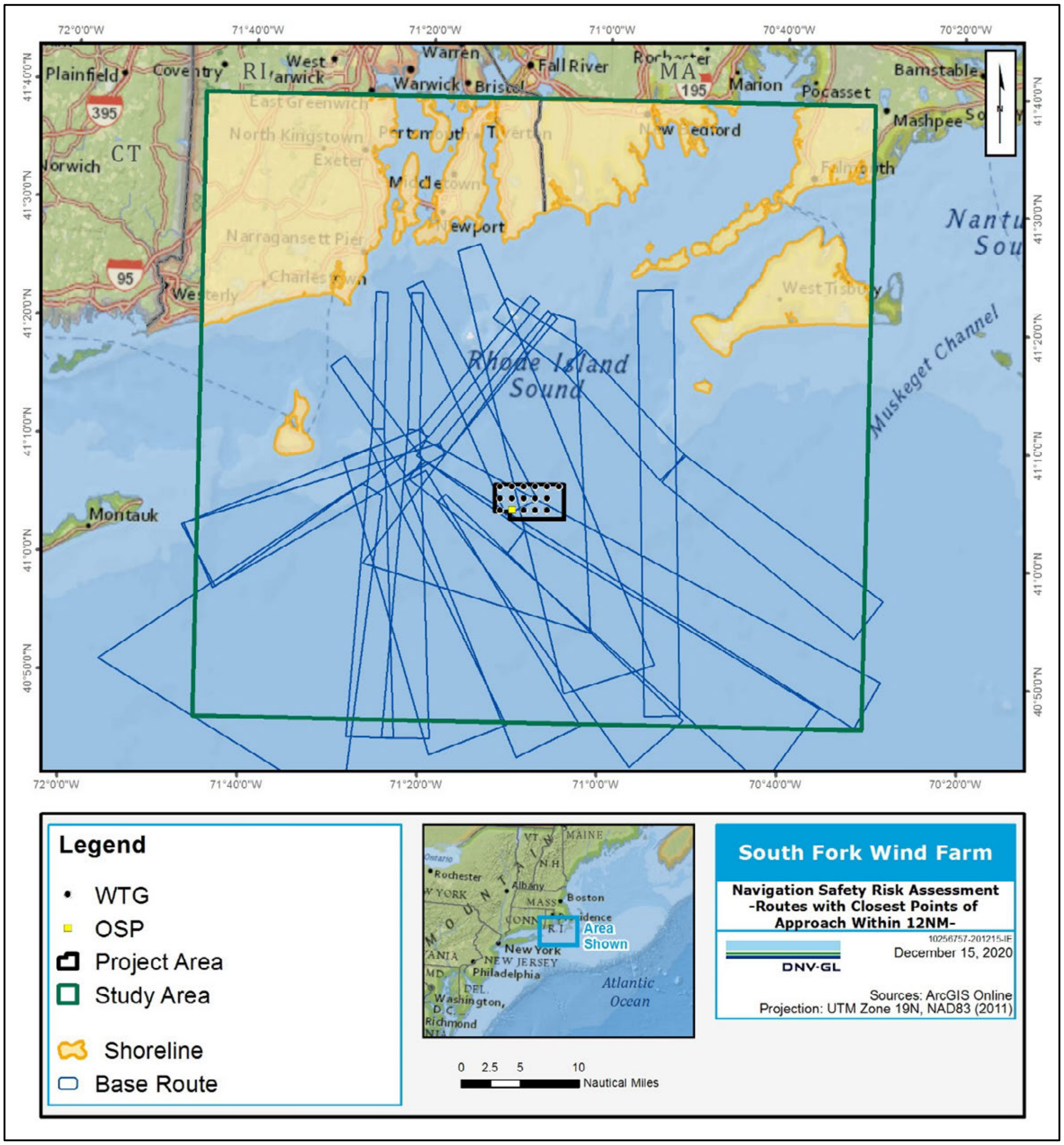

Figure F-6 Routes that have a Closest Point of Approach of less than 12 NM from the South Fork WTGs

Two additional increases in traffic not related to the Project were identified. The USCG MARI PARS report (USCG, 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 report comprised:

- Six to eight new LPG transits to and from Providence. This study assumes that an additional eight LPG vessels per year enter the AIS 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 Study Area from both the southwest and the southeast and take the Narragansett TSS on approach to Newport. This study assumes both the southwestern and 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. This study assumes a reverse route is taken on departure from the port.

Since this traffic is not a consequence of the South Fork development, this traffic is added to all the cases reported.

Additional Traffic Added to the Future Case

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

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

For the Project it is assumed that this additional traffic in the Future Case is included in the Pleasure vessel category and is allocated to two new routes, as shown in Figure F-7.

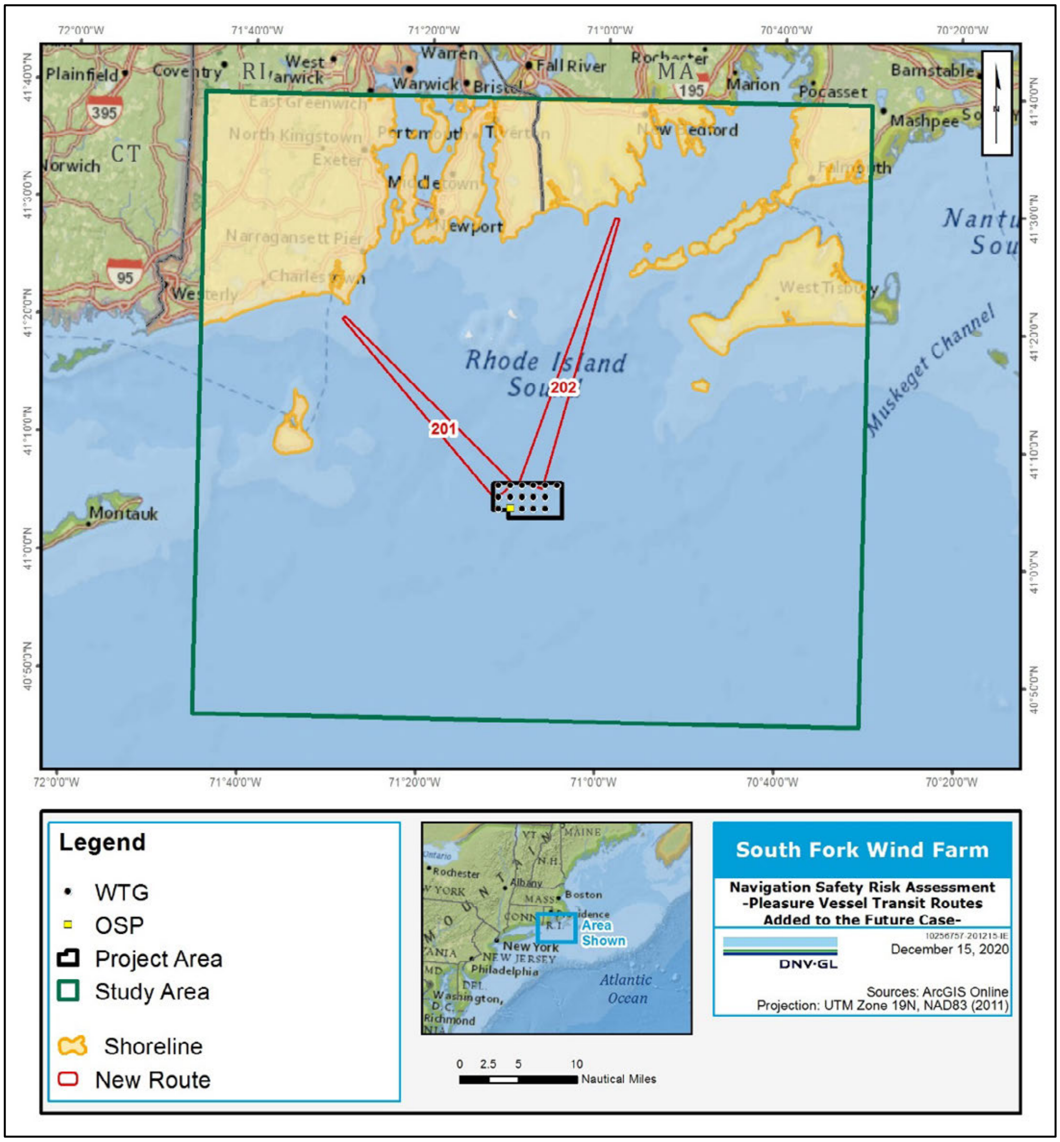

Figure F-7 New pleasure vessel transit route added to the Future Case

Modification of Traffic Routes in the Future Case

Currently, some shipping routes traverse the area where the wind farm is to be constructed. In addition, there are other wind farms under consideration in the vicinity. Many ships will choose not to navigate through these wind farms. 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 F-8 shows an example of how this modification was performed for 1 of the 12 routes that needed modification.

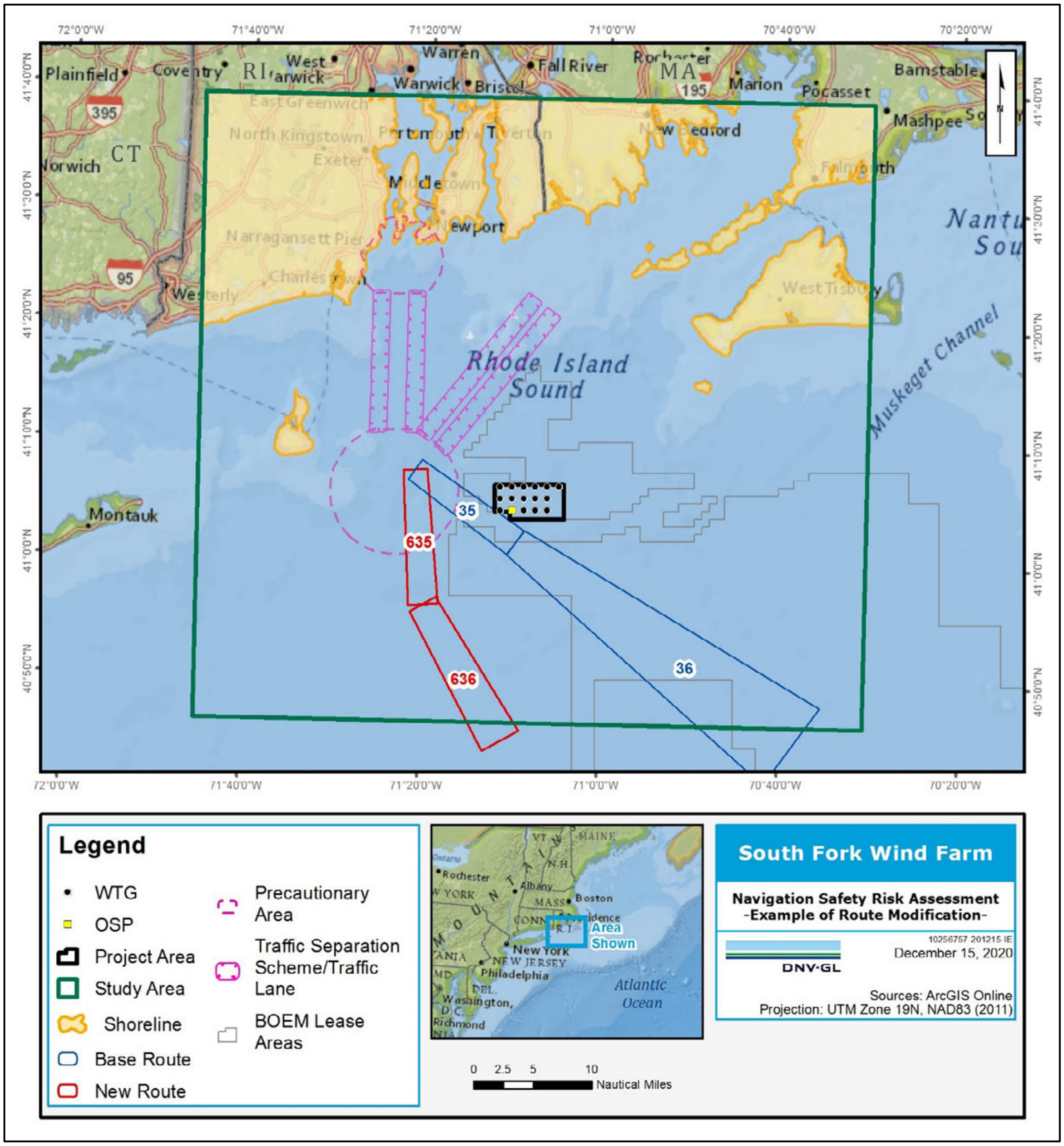

Figure F-8 Example of how one route was modified (red route was deleted, blue route was added)

Deep draft ships (Cargo, Passenger with LOA >= 150m, 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 with LOA < 150m and Pleasure) continue to navigate through the wind farm in the Future Case.

F.2.6 Operational inputs

The MARCS model can apply different risk reduction options to specific types of traffic and/or to specified areas, see Figure F-9. The risk controls applied to vessels transiting are described in Table F-4. This table shows which risk controls are applied based on vessel types and areas.

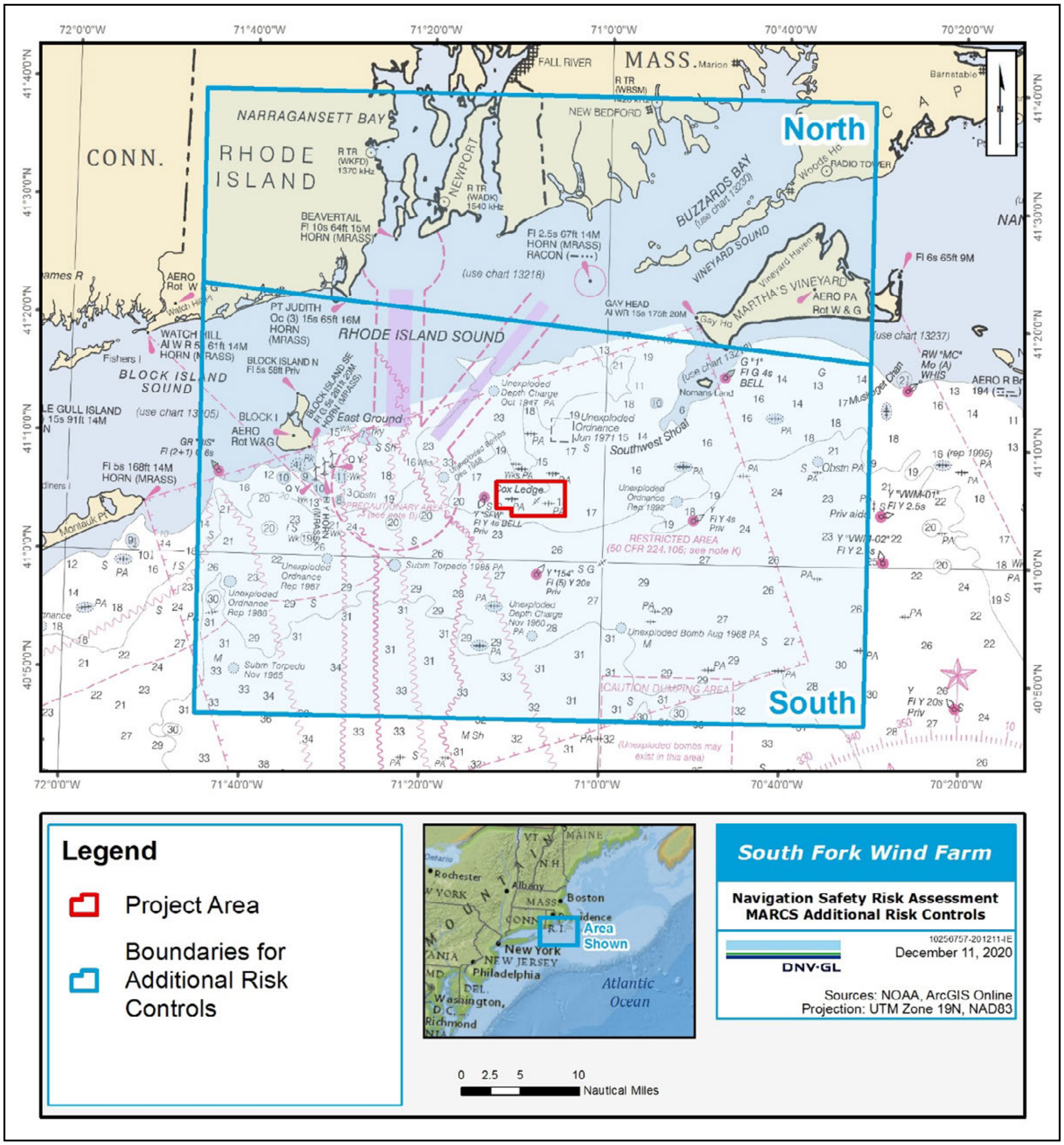

Figure F-9 Boundaries for model-specific risk controls

Table F-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 Sub-Area North in Figure F-9)
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 F-3, 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.

F.3 Collision, allision, and grounding frequency results

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

- A Base Case (Case 0) was modeled for the current conditions in the Study Area. The results from the Base Case consist of collision, powered grounding, and drift grounding accident frequencies alone since this case is an estimate of the risk levels today prior to the construction of the wind farm.

- A Base Case Plus (Case 1) was modeled for the current conditions in the Study Area plus the proposed wind farm. This provides a hypothetical estimate of the risk after construction of the wind farm but without any modifications to the traffic pattern. The Base Case Plus estimates the frequency of a collision, grounding, and allision with Project structures.
- A Future Case with the Project (Case 2). This estimates the anticipated future conditions of the Study Area. 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 F-5 summarizes these cases.

Table F-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 Project Area, the adjacent sub-areas, and the sum across them. The residual area comprises the remainder of the 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)

F.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 fishing vessels, pleasure vessels, cargo vessels, and passenger vessels as described in Section E.2.5.

Table F-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 F-6 Accident frequencies (per year) for Base Case (Case 0) in the Study Area without the Wind Farm[9]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.0012	0.0158	0.0252	0	0	0.0422
Fishing	0.0829	2.3070	1.2649	0	0	3.6548
Other/Undefined	0.0339	1.3910	0.3674	0	0	1.7923
Passenger	0.0759	2.7639	0.4734	0	0	3.3132
Pleasure	0.0544	1.2010	0.9303	0	0	2.1857
Tanker	0.0001	0.0030	0.0045	0	0	0.0076
Tanker - Oil Product	0.0005	0.0078	0.0133	0	0	0.0216
Tug/Service	0.0400	0.8205	0.7480	0	0	1.6085
Total	0.2889	8.5100	3.8270	0	0	12.6259

The modeled Base Case accident frequency today without the wind farm is estimated to be 12.6 per year, primarily involving fishing vessels and passenger 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 F-7 shows the accident return periods in years for each ship type modeled.

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

Table F-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	23.7
Fishing	0.3
Other/Undefined	0.6
Passenger	0.3
Pleasure	0.5
Tanker	131.6
Tanker - Oil Product	46.3
Tug/Service	0.6

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

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

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0	0	0	0	0	0
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	0	0	0	0	0

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

Table F-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	0	0	0	0	0
Fishing	0	0	0	0	0	0
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	0	0	0	0	0

Table F-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	0	0	0	0	0
Fishing	0.0002	0	0	0	0	0.0002
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	0.0002	0	0	0	0	0.0002

Table F-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	0	0	0	0	0
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	0	0	0	0	0

Table F-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	0	0	0	0	0
Fishing	0.0001	0	0	0	0	0.0001
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	0.0001	0	0	0	0	0.0001

Table F-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	0.0012	0.0158	0.0252	0	0	0.0422
Fishing	0.0826	2.3070	1.2649	0	0	3.6545
Other/Undefined	0.0339	1.3910	0.3674	0	0	1.7923
Passenger	0.0759	2.7639	0.4734	0	0	3.3132
Pleasure	0.0544	1.2010	0.9303	0	0	2.1857
Tanker	0.0001	0.0030	0.0045	0	0	0.0076
Tanker - Oil Product	0.0005	0.0078	0.0133	0	0	0.0216
Tug/Service	0.0400	0.8205	0.7480	0	0	1.6085
Total	0.2886	8.5100	3.8270	0	0	12.6256

F.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 F-14 shows the model results for the Study Area.

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

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.0012	0.0158	0.0252	0.0004	0.0032	0.0458
Fishing	0.0829	2.3070	1.2649	0.0042	0.0082	3.6672
Other/Undefined	0.0339	1.3910	0.3674	0.0011	0.0024	1.7958
Passenger	0.0759	2.7639	0.4734	0.0003	0.0022	3.3157
Pleasure	0.0544	1.2010	0.9303	0.0014	0.0029	2.1900
Tanker	0.0001	0.0030	0.0045	0	0.0002	0.0078
Tanker - Oil Product	0.0005	0.0078	0.0133	0.0002	0.0010	0.0228
Tug/Service	0.0400	0.8205	0.7480	0.0002	0.0023	1.6110
Total	0.2889	8.5100	3.8270	0.0078	0.0224	12.6561

Table F-15 to Table F-20 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 F-15 Accident frequencies (per year) for Case 1 in Sub-Area “Project Area”

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0.0004	0.0032	0.0036
Fishing	0	0	0	0.0042	0.0082	0.0124
Other/Undefined	0	0	0	0.0011	0.0024	0.0035
Passenger	0	0	0	0.0003	0.0022	0.0025
Pleasure	0	0	0	0.0014	0.0029	0.0043
Tanker	0	0	0	0	0.0002	0.0002
Tanker - Oil Product	0	0	0	0.0002	0.0010	0.0012
Tug/Service	0	0	0	0.0002	0.0023	0.0025
Total	0	0	0	0.0078	0.0224	0.0302

Table F-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	0	0	0	0	0
Fishing	0	0	0	0	0	0
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	0	0	0	0	0

Table F-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	0	0	0	0	0
Fishing	0.0002	0	0	0	0	0.0002
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	0.0002	0	0	0	0	0.0002

Table F-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	0	0	0	0	0
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	0	0	0	0	0

Table F-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	0	0	0	0	0
Fishing	0.0001	0	0	0	0	0.0001
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	0.0001	0	0	0	0	0.0001

Table F-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	0.0012	0.0158	0.0252	0	0	0.0422
Fishing	0.0826	2.3070	1.2649	0	0	3.6545
Other/Undefined	0.0339	1.3910	0.3674	0	0	1.7923
Passenger	0.0759	2.7639	0.4734	0	0	3.3132
Pleasure	0.0544	1.2010	0.9303	0	0	2.1857
Tanker	0.0001	0.0030	0.0045	0	0	0.0076
Tanker - Oil Product	0.0005	0.0078	0.0133	0	0	0.0216
Tug/Service	0.0400	0.8205	0.7480	0	0	1.6085
Total	0.2886	8.5100	3.8270	0	0	12.6256

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

Table F-21 Accident frequencies (per year) for Future Case (Case 2) with the Wind Farm[10]

Base Case	Collision	Powered grounding	Drift grounding	Powered allision	Drift allision	Total
Cargo/Carrier	0.0013	0.0154	0.0257	0	0.0017	0.0441
Fishing	0.0831	2.3070	1.2649	0.0042	0.0082	3.6674
Other/Undefined	0.0340	1.3910	0.3674	0.0011	0.0024	1.7959
Passenger	0.0759	2.7630	0.4735	0.0001	0.0013	3.3138
Pleasure	0.0549	1.2080	0.9367	0.0019	0.0031	2.2046
Tanker	0.0001	0.0030	0.0045	0	0.0001	0.0077
Tanker - Oil Product	0.0005	0.0075	0.0134	0	0.0005	0.0219
Tug/Service	0.0401	0.8200	0.7483	0	0.0019	1.6103
Total	0.2899	8.5149	3.8344	0.0073	0.0192	12.6657

The modeled Future Case accident frequency today with the wind farm is estimated to be 12.7 per year. Accidents involving fishing vessels are the dominant accident frequency contributor.

Table F-22 to Table F-27 show the model results for each sub-area.

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

Table F-22 Accident frequencies (per year) for Case 2 in Sub-Area “Project Area”

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0.0017	0.0017
Fishing	0	0	0	0.0042	0.0082	0.0124
Other/Undefined	0	0	0	0.0011	0.0024	0.0035
Passenger	0	0	0	0.0001	0.0013	0.0014
Pleasure	0	0	0	0.0019	0.0031	0.0050
Tanker	0	0	0	0	0.0001	0.0001
Tanker - Oil Product	0	0	0	0	0.0005	0.0005
Tug/Service	0	0	0	0	0.0019	0.0019
Total	0	0	0	0.0073	0.0192	0.0265

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[10] 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 F-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	0	0	0	0	0
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	0	0	0	0	0

Table F-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	0	0	0	0	0
Fishing	0.0002	0	0	0	0	0.0002
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	0.0002	0	0	0	0	0.0002

Table F-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	0	0	0	0	0
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	0	0	0	0	0

Table F-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	0.0001	0	0	0	0	0.0001
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	0.0001	0	0	0	0	0.0001

Table F-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	0.0013	0.0154	0.0257	0	0	0.0424
Fishing	0.0828	2.3070	1.2649	0	0	3.6547
Other/Undefined	0.0340	1.3910	0.3674	0	0	1.7924
Passenger	0.0759	2.7630	0.4735	0	0	3.3124
Pleasure	0.0549	1.2080	0.9367	0	0	2.1996
Tanker	0.0001	0.0030	0.0045	0	0	0.0076
Tanker - Oil Product	0.0005	0.0075	0.0134	0	0	0.0214
Tug/Service	0.0401	0.8200	0.7483	0	0	1.6084
Total	0.2896	8.5149	3.8344	0	0	12.6389

F.4 Model verification

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

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

F.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 0.03 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 0.008 and 0.022 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 74% of the total allision frequency is due to drift allision. This indicates that the traffic density today in, and in the vicinity of, the Project Area is very low.

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.

F.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, Passenger, 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).

F.5 Results and discussion

F.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 F-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.

The difference between the two cases for the Project Area and adjacent sub-areas shows that the total accident frequency increases 0.04 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 0.0001/year are highlighted in grey.

Table F-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	0.0001	-0.0004	0.0005	0	0.0017	0.0019
Fishing	0.0002	0	0	0.0042	0.0082	0.0126
Other & Undefined	0.0001	0	0	0.0011	0.0024	0.0036
Passenger	0	-0.0009	0.0001	0.0001	0.0013	0.0006
Pleasure	0.0005	0.0070	0.0064	0.0019	0.0031	0.0189
Tanker	0	0	0	0	0.0001	0.0001
Tanker – Oil	0	-0.0003	0.0001	0	0.0005	0.0003
Tug & Service	0.0001	-0.0005	0.0003	0	0.0019	0.0018
Total	0.0010	0.0049	0.0074	0.0073	0.0192	0.0398

F.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 F-29 shows the modeled difference in risk from the Project in the sub-area “Project Area”. The Project 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 0.0001/year are highlighted in grey.

Table F-29 Risk difference: Project Area (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0.0017	0.0017
Fishing	0	0	0	0.0042	0.0082	0.0124
Other & Undefined	0	0	0	0.0011	0.0024	0.0035
Passenger	0	0	0	0.0001	0.0013	0.0014
Pleasure	0	0	0	0.0019	0.0031	0.0050
Tanker	0	0	0	0	0.0001	0.0001
Tanker – Oil	0	0	0	0	0.0005	0.0005
Tug & Service	0	0	0	0	0.0019	0.0019
Total	0	0	0	0.0073	0.0192	0.0265

Table F-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 0.0001/year are highlighted in grey.

Table F-30 Risk difference: South (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0	0	0	0	0	0
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	0	0	0	0	0	0
Tug & Service	0	0	0	0	0	0
Total	0	0	0	0	0	0

Table F-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 F-31 Risk difference: West (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0	0	0	0	0	0
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	0	0	0	0	0	0
Tug & Service	0	0	0	0	0	0
Total	0	0	0	0	0	0

Table F-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 F-32 Risk difference: East (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0	0	0	0	0	0
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	0	0	0	0	0	0
Tug & Service	0	0	0	0	0	0
Total	0	0	0	0	0	0

Table F-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 F-33 Risk difference: North (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0	0	0	0	0	0
Fishing	0	0	0	0	0	0
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	0	0	0	0	0	0
Tug & Service	0	0	0	0	0	0
Total	0	0	0	0	0	0

Table F-34 Risk difference: Other (annual accident frequencies)

Vessel Type	Collision	Powered Grounding	Drift Grounding	Powered Allision	Drift Allision	Total
Cargo/Carrier	0.0001	-0.0004	0.0005	0	0	0.0002
Fishing	0.0002	0	0	0	0	0.0002
Other & Undefined	0.0001	0	0	0	0	0.0001
Passenger	0	-0.0009	0.0001	0	0	-0.0008
Pleasure	0.0005	0.0070	0.0064	0	0	0.0139
Tanker	0	0	0	0	0	0
Tanker – Oil	0	-0.0003	0.0001	0	0	-0.0002
Tug & Service	0.0001	-0.0005	0.0003	0	0	-0.0001
Total	0.0010	0.0049	0.0074	0	0	0.0133

F.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, 0.04 accidents per year, is our best estimate of the extra risk that results from the presence of the Project. The Project poses very little risk outside the Project Area: over 66% of the estimated risk increase occurs in the Project Area (within the sub-area “Project Area”).

The quantified risk assessment of the navigation risk for the Project concludes there is a small risk increase due to the Project.

APPENDIX G CHECKLIST FOR NSRA DEVELOPMENT AND REVIEW

Enclosure (6) to NVIC 01-19 contains the below checklist for review and development of an NSRA. This appendix provides the checklist that was completed during development of this NSRA.

ISSUE	Covered in the NSRA?	COMMENTS
1. SITE AND INSTALLATION COORDINATES		
Has the developer ensured that coordinates and subsequent variations of site perimeters and individual structures are made available, upon request, to interested parties at all, relevant project stages?	Yes, for current project stage	See Section 1.3 and Appendix G.
Has the coordinate data been supplied as authoritative Geographical Information System (GIS) data, preferably in Environmental Systems Research Institute (ESRI) format? Metadata should facilitate the identification of the data creator, its date and purpose, and the geodetic datum used. For mariners' use, appropriate data should also be provided with latitude and longitude coordinates in WGS84 datum.	Yes	See Appendix G.
2. TRAFFIC SURVEY		
Was the traffic survey conducted within 12 months of the NSRA?	Yes	See Section 2
Does the survey include all vessel types?	Yes	See Section 2 See details per vessel type in Section 2.1
Is the time period of the survey at least 28 days duration?	Yes	See Section 2
Does the survey include consultation with recreational vessel organizations?	Yes	See Section 2, Appendix C, and Appendix D
Does the survey include consultation with fishing vessel organizations?	Yes	See Section 2, Appendix C, and Appendix D
Does the survey include consultation with pilot organizations?	Yes	See Section 2, Appendix C, and Appendix D
Does the survey include consultation with commercial vessel organizations?	Yes	See Section 2, Appendix C, and Appendix D
Does the survey include consultation with port authorities?	Yes	See Section 2, Appendix C, and Appendix D
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
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

ISSUE	Covered in the NSRA?	COMMENTS
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
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 F
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		

ISSUE	Covered in the NSRA?	COMMENTS
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 and Section 14
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 and relevant section of the COP
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
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

ISSUE	Covered in the NSRA?	COMMENTS
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
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

ISSUE	Covered in the NSRA?	COMMENTS
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
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	Yes	See Section 8 and Section 10

ISSUE	Covered in the NSRA?	COMMENTS
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.		
Each OREI layout design will be assessed on a case-by-case basis.	Yes	See Section 8
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	See Section 8 and Section 11
9. VISUAL NAVIGATION. Does the NSRA contain an assessment of the extent to which:		
Structures could block or hinder the view of other vessels underway on any route?	Yes	See Section 9
Structures could block or hinder the view of the coastline or of any other navigational feature such as aids to navigation, landmarks, promontories?	Yes	See Section 9
Structures and locations could limit the ability of vessels to maneuver in order to avoid collisions?	Yes	See Section 9 and Section 11
10. COMMUNICATIONS, RADAR AND POSITIONING SYSTEMS. Does the NSRA provide researched opinion of a generic and, where appropriate, site specific nature concerning whether or not:		
Structures could produce interference such as shadowing, reflections or phase changes, with marine positioning, navigation, or communications, including Automatic Identification Systems (AIS), whether ship borne, ashore, or fitted to any of the proposed structures?	Yes	See Section 10

ISSUE	**Covered in the NSRA?**	**COMMENTS**
Structures could produce radar reflections, blind spots, shadow areas or other adverse effects in the following interrelationships: • Vessel to vessel; • Vessel to shore; • Vessel Traffic Service radar to vessel; • Radio Beacons (RACONS) to/from vessel; and • Aircraft and Air Traffic Control?	Yes	See Section 10
Structures, in general, would comply with current recommendations concerning electromagnetic interference?	Yes	See Section 10
Structures might produce acoustic noise or noise absorption or reflections which could mask or interfere with prescribed sound signals from other vessels or aids to navigation?	Yes	See Section 10.1, Section 3.4, and relevant section of the COP
Structures, generators, and the seabed cabling within the site and onshore might produce electro-magnetic fields affecting compasses and other navigation systems?	Yes	See Section 10 and relevant section of the COP
The power and noise generated by structures above or below the water would create physical risks that would affect the health of vessel crews?	Yes	See Section 10 and relevant section of the COP
11. RISK OF COLLISION, ALLISION, OR GROUNDING. Does the NSRA, based on the data collected per paragraph 2 above, provide an evaluation that was conducted to determine the risk of collision between vessels, risk of allisions with structures, or grounding because of the establishment of a structure, including, but not limited to:		
• Likely frequency of collision (vessel to vessel); • Likely consequences of collision ("What if" analysis); • Likely location of collision; • Likely type of collision; • Likely vessel type involved in collision; • Likely frequency of allision (vessel to structure) • Likely consequences of allision ("What if" analysis); • Likely location of allision; • Likely vessel type involved in allision; • Likely frequency of grounding; • Likely consequences of grounding (" What if" analysis); • Likely location of grounding; and • Likely vessel type involved in grounding?	Yes	See Section 11
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.	Yes	See Section 12 summarizing the available data and relevant model results

ISSUE	Covered in the NSRA?	COMMENTS
• 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?		
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
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	Yes	See Section 13

ISSUE	**Covered in the NSRA?**	**COMMENTS**
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?		
The procedures that need to be put in place to respond to and correct discrepancies to the aids to navigation, within the timeframes specified by the Coast Guard?	Yes	See Section 13
How the marking of the structure will impact existing Federal aids to navigation in the vicinity of the structure?	Yes	See Section 13
14. DESIGN REQUIREMENTS. Is the structure designed and constructed to satisfy the following recommended design requirements for emergency shut-down in the event of a search and rescue, pollution response, or salvage operation in or around a structure?		
All above surface structure individual structures should be marked with clearly visible unique identification characters (for example, alpha-numeric labels such as "Al," "B2."). The identification characters should each be illuminated by a low-intensity light visible from a vessel, or be coated with a phosphorescent material, thus enabling the structure to be detected at a suitable distance to avoid a collision with it. The size of the identification characters in combination with the lighting or phosphorescence should be such that, under normal conditions of visibility and all known tidal conditions, they are clearly readable by an observer, and at a distance of at least 150 yards from the structure. It is recommended that, if lighted, the lighting for this purpose be hooded or baffled so as to avoid unnecessary light pollution or confusion with navigation aids. (Precise dimensions to be determined by the height of lights and necessary range of visibility of the identification numbers).	Yes	See Section 14
All generators and transmission systems should be equipped with control mechanisms that can be operated from an operations center of the installation.	Yes	See Section 14
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	Yes	See Section 14

ISSUE	Covered in the NSRA?	COMMENTS
account the prevailing wind, wave, and tidal conditions.		
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
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

ABOUT DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas and energy industries. We also provide certification services to customers across a wide range of industries. Combining leading technical and operational expertise, risk methodology and in-depth industry knowledge, we empower our customers' decisions and actions with trust and confidence. We continuously invest in research and collaborative innovation to provide customers and society with operational and technological foresight. Operating in more than 100 countries, our professionals are dedicated to helping customers make the world safer, smarter and greener.