DNV·GL

SOUTH FORK WIND FARM

Navigational Safety Risk Assessment

Deepwater Wind South Fork, LLC

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Abbreviation	Meaning
AIS	Automatic Identification System
AtoNs	Aids to Navigation
BOEM	Bureau of Ocean Energy Management
CG	Coast Guard
COLREG	International Regulations for Preventing Collisions at Sea
COP	Construction and Operations Plan
DWSF	Deepwater Wind South Fork, LLC
DWT	Dead Weight Tonnage
ESP	Electric Service Platform
GIS	Geographic Information System
HAT	Highest astronomical tide
HF	High Frequency
Hi	High
LAT	Lowest astronomical tide
LOA	Length Overall
MARCS	Marine Accident Risk Calculation System
MCA	Maritime & Coastguard Agency
Med	Medium
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MSL	Mean sea level
NMFS	National Marine Fisheries Services
NNDC	NOAA National Data Center
NOAA	National Oceanic and Atmospheric Administration
NROC	Northeast Regional Ocean Council
NSRA	Navigational Safety Risk Assessment
NVIC	Navigation and Vessel Inspection Circular
OREIs	Offshore Renewable Energy Installations
OSU	Oregon State University
RACONS	Radar Beacons
RI SAMP	Rhode Island Ocean Special Area Management Plan
SAR	Search and Rescue
SFEC	South Fork Export Cable
SFWF	South Fork Wind Farm
UHF	Ultra-High Frequency
US	United States
USCG	United States Coast Guard
VHF	Very High Frequency
VMD	Virtual Met Data
VMS	Vessel Monitoring System
VTS	Vessel Traffic Service
WTG	Wind Turbine Generator

List of units

Unit	Meaning
dB	decibels
ft	feet
GHz	Gigahertz or 10^9 Hertz
Hz	Hertz
km	kilometers
km^2	square kilometers
Kt	knots
kV	kiloVolts
m	meter
MJ	Megajoule or 10^6 Joules
mph	miles per hour
NM	Nautical Miles
m/s	Meters per second
s	seconds

EXECUTIVE SUMMARY

This document presents the Navigational Safety Risk Assessment (NSRA) of Deepwater Wind South Fork LLC's South Fork Wind Farm (SFWF). The wind farm will be located approximately 30 nautical miles (NM) east of Montauk.

This NSRA was conducted per the guidance in United States Coast Guard (USCG) *Navigation and Vessel Inspection Circular No. 02-07* ("NVIC 02-07")[1] and covers the specified elements:

- Waterway characteristics description (Section 2)

- Maritime traffic and vessel characteristics description (Section 3)

- Collision, striking, and grounding assessment (Section 4)

- Navigation considerations including but not limited to navigation within SFWF, visual navigation, noise impact, and project structure navigation impact (Sections 5 and 6)

- Marine navigational marking discussion Section 7)

- Communications, radar, and positioning systems assessment Section 8)

- USCG mission considerations (Section 9)

The NSRA did not identify any major areas of concern regarding SFWF impact on marine navigation. SFWF is located in open water, and more than 4 NM from high-vessel density deep draft commercial shipping lanes. The SFWF is approximately 15 NM from the closest land mass (Block Island) and approximately 19 NM from the main land.

Due to the large distance between wind turbine generators (WTG) and the grid-like pattern of WTG placement, this study concludes that the structures are not anticipated to significantly increase risk to vessels operating within the boundaries of SFWF. The calculated risk increase is considered negligible and does not include potential mitigation measures that Deepwater is planning to employ. These include installing best available AIS technology within the wind farm and the commitment to provide frequent notices to mariners regarding construction, operation and decommissioning of SFWF.

The green box in the below figure indicates the area studied in this assessment (referred to as the *Study Area*). The blue outline indicates the purchased federal lease for potential offshore wind development, and the red outline indicates the SFWF. The assessment team selected a large study area to assure the assessment covered the full scope of the NVIC guidance.

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[1] United States Coast Guard. Navigation and Vessel Inspection Circular No. 02-07.
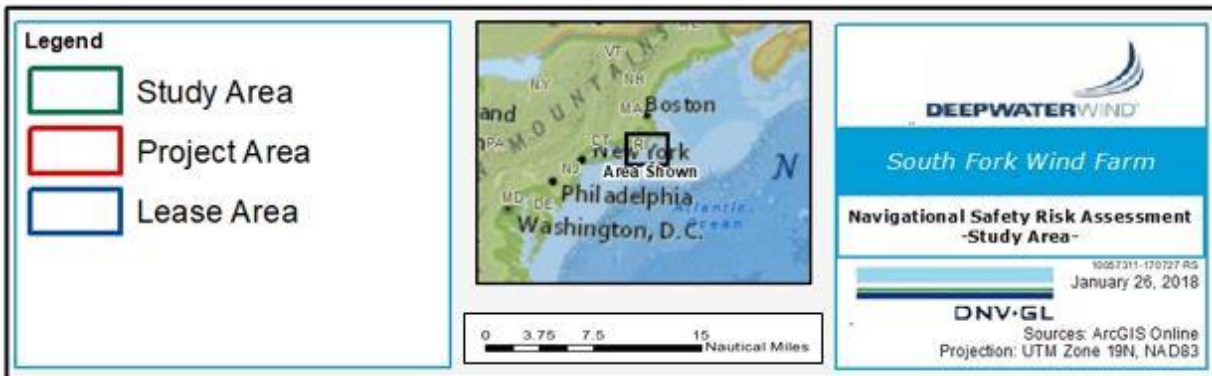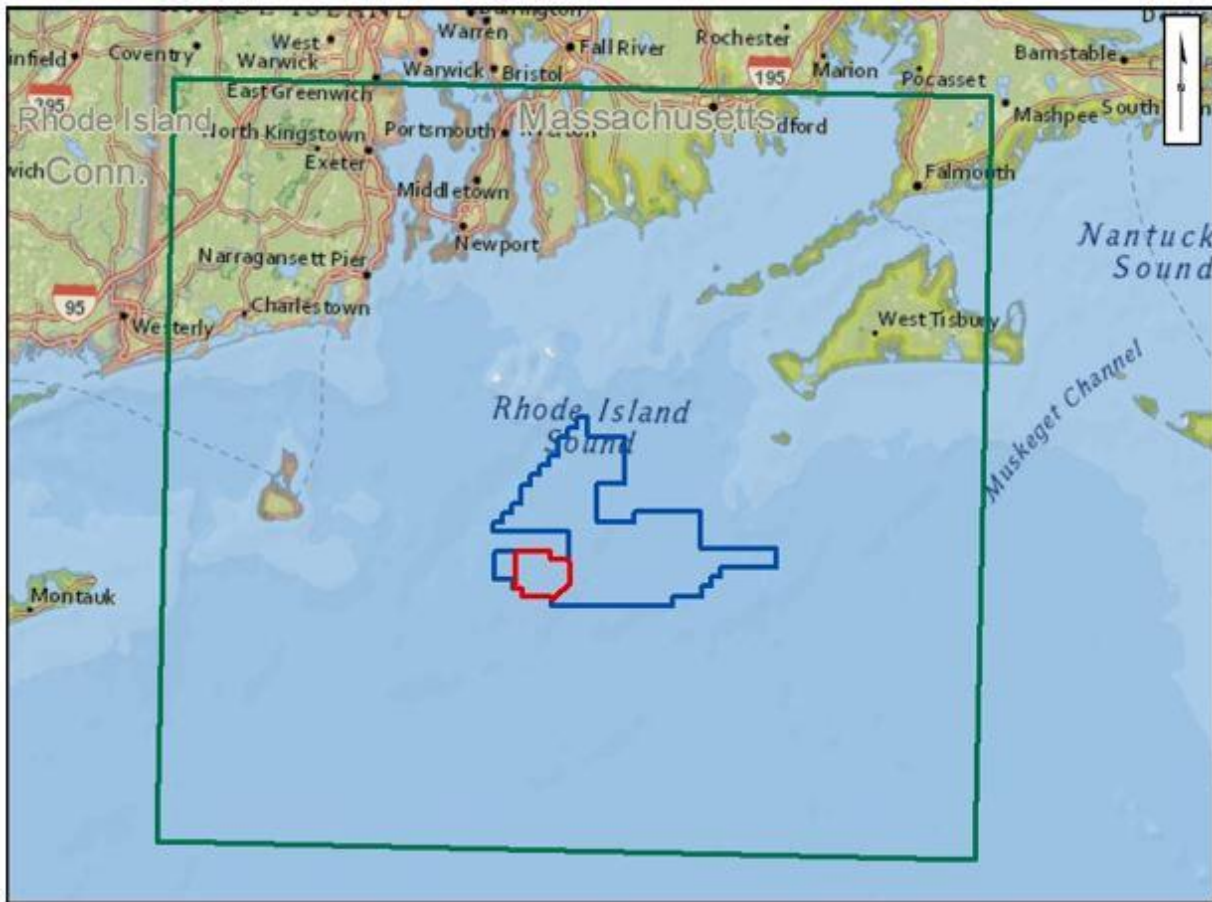
SFWF Navigational Safety Risk Assessment Study Area

The risk assessment built models to compare current marine traffic ("Base Case") and marine traffic conditions during operation of SFWF ("Future Case").

The potential marine casualties of primary concern in the quantified risk assessment are:

- Collision between two vessels

- Striking of a turbine by a vessel (sometimes called allision)

- Grounding of a vessel

Averaged over a long period of time, the model estimated an increase of 0.03 incidents per year (an average of 1 every 33 years) due to the presence of SFWF. For the study area, this represents an increase in marine incidents of 0.4%.

It is widely recognized that many smaller vessels do not carry AIS transponders, and are generally underrepresented in AIS data. For this study, fishing vessels are expected in the Study Area more often than the AIS data show. Therefore, an analysis of collision, striking, and grounding of commercial fishing vessels was undertaken. Commercial fishing vessels are expected to represent the majority of vessels transiting within the boundaries of the wind farm when it is operational.

Within the wind farm, the estimated probability of collision between two commercial fishing vessels sailing within 0.5 NM of each other is 4.7×10^{-9} in good visibility (greater than 2 NM) and 2.2×10^{-7} in bad visibility (less than 2 NM). The probability of striking a WTG while drifting is estimated to be 9.3×10^{-6} per fishing vessel transit within the project area. The probability of striking a WTG at speed is estimated to be 1.4×10^{-5} in good visibility and 4.0×10^{-5} in bad visibility.

Radar operations on smaller vessels will require vigilance in the form of notices and communication with mariners. Due to its location, outside of commercial shipping lanes, radar operations on commercial ships are not anticipated to be impacted by SFWF. Smaller vessels operating in or near SFWF may experience radar clutter and shadowing. Most instances of interference can be mitigated through the proper use of radar gain controls. Additional mitigation measures include vessel-to-vessel communication and safe transit speeds of vessels near/in SFWF.

SFWF is not anticipated to have any impact on USCG missions.

DNV GL understands that the project layout and turbine selection have yet to be finalized and larger turbines with greater spacing between turbines are being considered by Deepwater. DNV GL considers the project design considered herein to generally represent a worst-case scenario such that the aforementioned potential changes to the layout would not increase the level of risk to navigation. The possible exception to this is the impact on radar systems; in the event that the project selects a larger turbine (greater than 550 ft rotor diameter), the impact on navigational radar may change; however, currently, there is too much uncertainty in the turbine design to determine if the impact will increase or decrease. If and when the project layout and turbine selection are finalized, the project has advised that it will update this NSRA accordingly.

1 INTRODUCTION

Deepwater Wind South Fork, LLC ("DWSF") retained Garrad Hassan America, Inc. ("DNV GL") to perform a Navigational Safety Risk Assessment (NSRA) for the South Fork Wind Farm (SFWF). SFWF is an offshore wind farm located approximately 30 nautical miles (NM) east of Montauk that will consist of 15 wind turbine generators (WTG), an offshore substation, and a subsea transmission system[2]. The risk assessment was conducted for SFWF per the guidance of United States Coast Guard (USCG) *Navigation and Vessel Inspection Circular No. 02-07* ("NVIC 02-07")[1]. This report presents the results of DNV GL's analysis.

1.1 Objective

The objective of the assessment is to address items in NVIC 02-07 which are pertinent to the location and operation of SFWF. This document is intended to serve as an appendix and provide input to the SFWF Construction and Operations Plan (COP).

As defined in NVIC 02-07, this NSRA document intends to address the following key elements[1]:

- Assess navigation issues that could be reasonably foreseeable by which the siting, construction, establishment, operations, maintenance, and/or decommissioning of SFWF could:

    1. Cause or contribute to an obstruction of, or danger to, navigation

    2. Affect the traditional uses of the waterway

    3. Impact the USCG's missions.

- Assess potential navigational or communications impacts to any mariners or emergency services providers using the [wind farm] site area and its environment, including those impacts which could contribute to a marine casualty.

- Assess consequences of vessels deviating from normal routes or recreational craft entering shipping routes in order to avoid proposed [wind farm] sites.

DNV GL understands that the project layout and turbine selection have yet to be finalized and larger turbines with greater spacing between turbines are being considered by Deepwater. DNV GL considers the project design considered herein to generally represent a worst-case scenario such that the aforementioned potential changes to the layout would not increase the level of risk to navigation. The possible exception to this is the impact on radar systems; in the event that the project selects a larger turbine (greater than 550 ft rotor diameter), the impact on navigational radar may change; however, currently, there is too much uncertainty in the turbine design to determine if the impact will increase or decrease. If and when the project layout and turbine selection are finalized, the project has advised that it will update this NSRA accordingly.

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[2] Deepwater Wind. South Fork Wind Farm Information for Mariners. http://dwwind.com/wp-content/uploads/2017/05/2017-SFWF-Info-for-Mariners-web2.pdf.

1.2 Description of South Fork Wind Farm

Figure 1-1 shows the location of the SFWF.
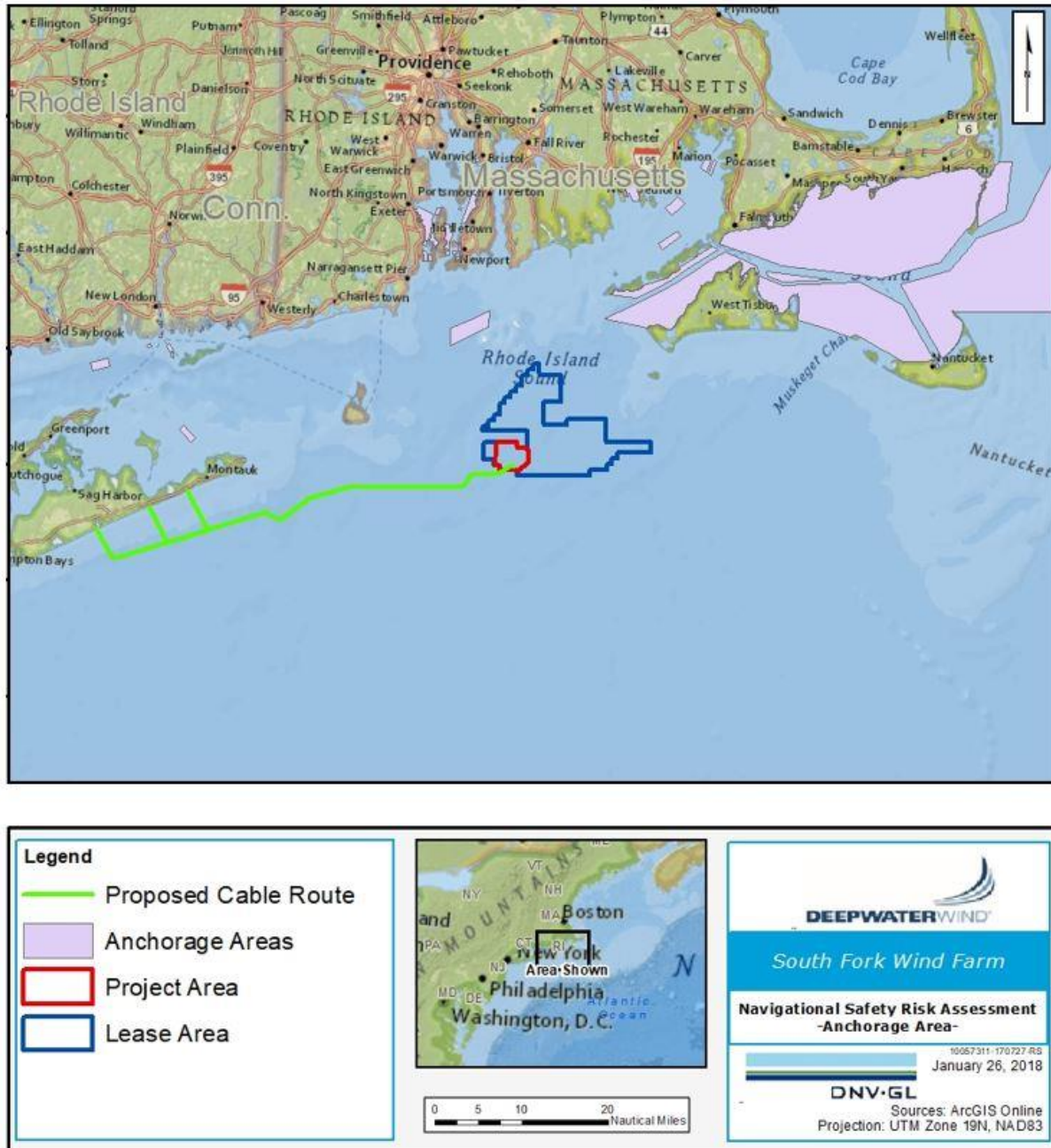
Figure 1-1 SFWF location

The wind farm will include up to 15 wind turbine generators (WTGs), which will have generating capacities from 6 MW to 12 MW each. A 138 kV or 230 kV export cable (SFEC) will be laid between the wind farm and shore.

On average, each WTG will be spaced 0.8 to 1.0 miles (1.3 to 1.6 km) apart, with more than 0.65 NM (0.75 miles) of sea room between the WTGs. For this purpose of this NSRA, the smallest spacing between any two WTGs is assumed to be 0.6 NM (1.1 km) to assure minor changes in layout do not affect the future validity of the study.

The model, size, and foundation type for the WTGs has not been selected at this time. For the purposes of the NSRA, the following indicative measurements are used:

- Foundation diameter: 65.6 ft (20 m)

- Hub height: 380 ft (116 m)

- Rotor diameter: 550 ft (167 m)

- Blade height above the waterline: 85.3 ft (26 m) to 105 ft (32 m)

Table 1-1 lists the project components.

Table 1-1 Project Components and Envelope

Project Component		Project Envelope Characteristic
SFWF	Foundations	Jacket, Monopile, or GBS
	WTGs	• Up to 15 WTGs • 6 to 12 MW each • Spaced approximately 0.8–1.0 miles (1.3–1.6 km) apart
	Inter-Array Cable	34.5 kV or 66 kV
	OSS	Mounted on a dedicated foundation or co-located with a WTG
	O&M Facility	Located in Montauk, New York, or Quonset Point, Rhode Island
SFEC	Export Cable (Offshore and Onshore)	• 138 kV or 230 kV • Offshore located within a surveyed corridor 590-feet (180-m) wide, target burial depth 4–6 feet (1.2–1.8 m) • Onshore duct bank located within existing paved road and railroad ROWs, target burial 8 feet (2.4 m)
	Sea-to-Shore Transition	• Landing site located at either Beach Lane or Hither Hills in East Hampton, New York • Installed using horizontal directional drilling between onshore underground cable transition vault and the offshore drilling exit location • Offshore sheet pile cofferdam, gravity cell cofferdam, or no cofferdam at the drilling exit location
	Interconnection Facility	Newly constructed, air-insulated facility located adjacent to existing East Hampton substation
SFWF and SFEC	Port Facilities	Located in New York, Rhode Island, Massachusetts, and/or Connecticut

Installation of the SFWF and SFEC is scheduled to take place over a 2-year period; however, installation could also be completed within a 1-year period. Construction will be completed in the following general sequence:

- Transportation of the foundations to the SFWF

- Installation of the foundations

- Installation of the OSS

- Installation of the cable systems

- Installation of the WTGs and OSS

The only ancillary facility that will be built as an operational component of the SFWF is the onshore Operations and Maintenance Facility. The facility will be in a port in Montauk in East Hampton, New York, or at Quonset Point in North Kingstown, Rhode Island. It will include a building and a berth for the crew transfer vessel at a nearby dock so that staff can prepare and mobilize from this location for offshore maintenance activities. The facility will also include office space where staff can monitor the wind farm. It also will have storage space for spare parts and other equipment to support maintenance activities.

2 WATERWAYS CHARACTERISTICS

The location of SFWF is shown in Figure 2-1. SFWF will be located in federal waters off the coast of Rhode Island. It will be approximately 15 NM (29 km) east-southeast of Block Island, Rhode Island, and approximately 30 NM (58 km) east of Montauk, New York. Table 2-1 provides a summary of the waterways characteristics.

Table 2-1 Summary of waterways characteristics

Site characteristic	Summary	Source
Tide height	3.0 ft (0.8 m) mean high water 3.2 ft (1.0 m) mean higher high water	OSU Tidal Inversion Software[3]; National Oceanic and Atmospheric Administration (NOAA) Block Island station 8459681[4]; NOAA Montauk station 8510560[5]; NOAA coastal chart 13218[6]
Tidal stream speed (surface)	0.6 knots (0.3 m/s) 1-year (tidal) 0.6 knots (0.3 m/s) 50-year (tidal)	DNV GL report on metocean design criteria[7]
Tidal stream direction (set)	NW (flood), SE (ebb)	DNV GL report on metocean design criteria[7]
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)	DNV GL report on metocean design criteria[7]
Current direction	NW-SE (tidal) W-E (residual)	DNV GL report on metocean design criteria[7]
Bathymetry	104-127 ft (32-39 m)	ArcGIS Online, New York State Geographic Information Gateway
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; DNV GL report on metocean design criteria[7]
Prevailing wind direction	WSW	DNV GL Virtual Met Data
Visibility	79.9% > 8 NM (4.3 km) visibility	Block Island State Airport (NOAA National Data Center [NNDC] station 94793) 2008-2017 data[8]
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[9]; RI SAMP[10]; correspondence with the USCG[11]; Merrill report[12]

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[3] Oregon State University, Tidal Inversion Software, http://volkov.oce.orst.edu/tides/.

[4] National Oceanic and Atmospheric Administration. Tides & Currents, Block Island, RI – Station ID: 8459681, https://tidesandcurrents.noaa.gov/stationhome.html?id=8459681.

[5] National Oceanic and Atmospheric Administration. Tides & Currents, Montauk, NY – Station ID: 8510560, https://tidesandcurrents.noaa.gov/stationhome.html?id=8510560.

[6] National Oceanic and Atmospheric Administration. Nautical Chart 13218 Martha's Vineyard to Block Island. http://www.charts.noaa.gov/PDFs/13218.pdf, Accessed November 2017.

[7] DNV GL, Metocean Design Criteria, South Fork, USA, Report number MS_10061220, Rev. 3, Dated 23 January 2018.

[8] NNDC Climate Data Online, Accessing data selection screen for Surface Data Hourly Global (DS3505), https://www7.ncdc.noaa.gov/CDO/cdopoemain.cmd?datasetabbv=DS3505&countryabbv=&georegionabbv=&resolution=40. Accessed September 2018.
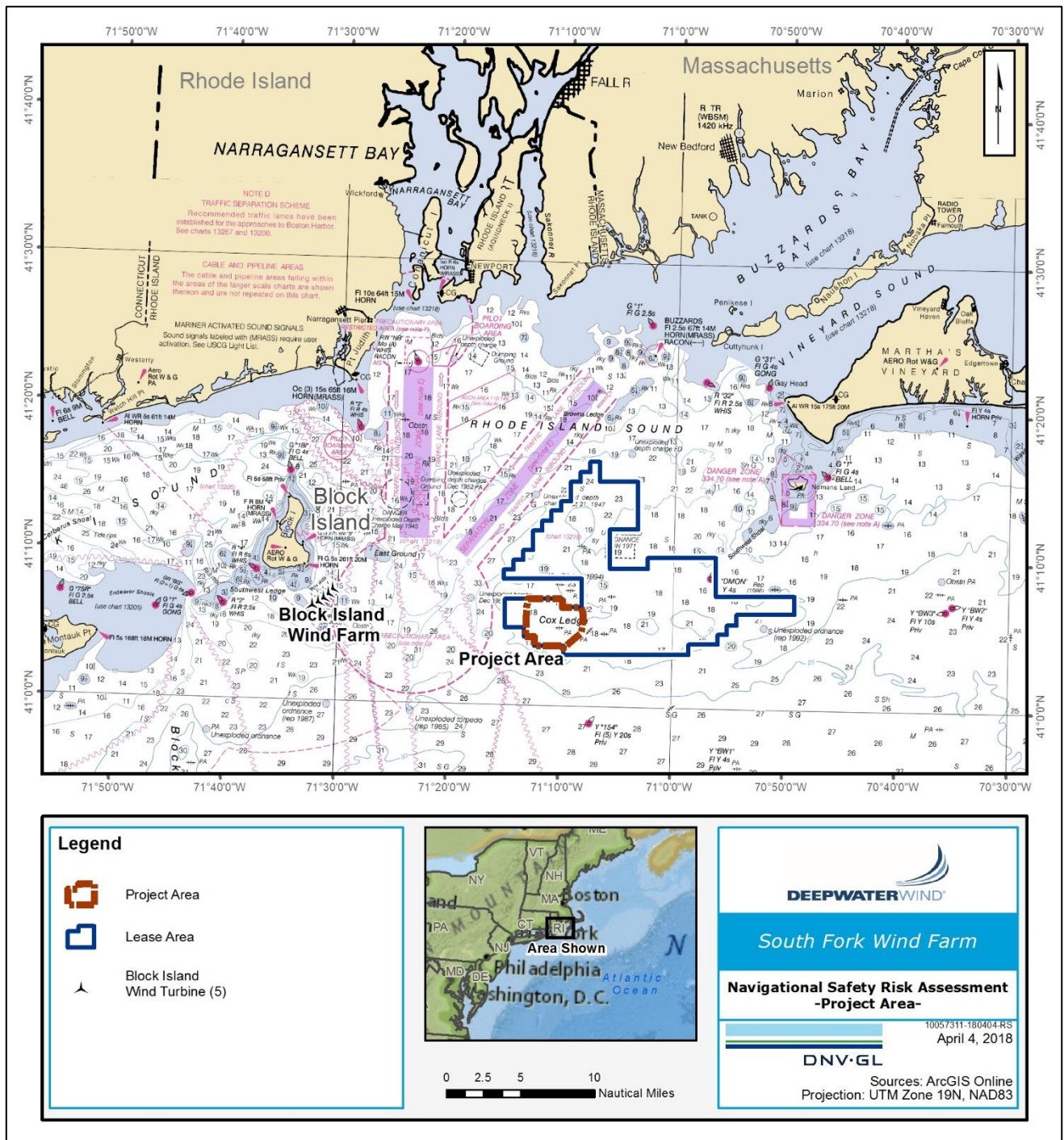
Figure 2-1 Location of the SFWF project area

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[9] NOAA, United States Coast Pilot 2, Atlantic Coast: Cape Cod, MA to Sandy Hook, NJ, 46th Edition, 2017.

[10] Rhode Island Ocean Special Area Management Plan. Ocean SAMP Volume 1. Oct 19, 2010.

[11] Email correspondence between Edward LeBlanc (USCG) and Chris Elkinton (DNV GL), "RE South Fork Wind Farm - ice conditions", dated 1 February 2018.

[12] Merrill, J., "Fog and Icing Occurrence, and Air Quality Factors for the Rhode Island Ocean Special Area Management Plan 2010", Dated 12 November 2010.

2.1 Effect of tides, tidal streams, and currents

Tides and currents are not measured at the SFWF project site and no measurement devices have been installed at the site, so alternative means of estimating tides and currents were used. The summary below is based on other sources of available data which were used to estimate tide heights, tidal currents, and residual currents at the wind farm. A summary of these data and the estimated results are provided in the sections below; further discussion is provided in the DNV GL report on metocean design criteria[7].

2.1.1 Tides, tidal streams, and currents

There is no tidal measurement at the SFWF project site, so tide heights were determined using two alternative methods:

- Analysis of tide height measurements from nearby NOAA stations

- Simulations using the Oregon State University (OSU) Tidal Inversion Software[3]

The closest NOAA stations to the project site that offer tide data are Block Island, RI (NOAA station 8459681) and Montauk Point, NY (NOAA station 8510560), which are 15 NM (28 km) WNW and 30 NM (58 km) west of the project site, respectively. The Block Island station was removed in July 2004, and usable data are available from 8 April 1998 to 31 October 2000[4]. The Montauk station is still in operation and data from 2010-2017 were analyzed[5]. These data are summarized in the Table 2-2.

Table 2-2 Summary of tides at Block Island

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

The East Coast of America 1/30° domain of the Oregon State University Tidal Inversion Software was used to estimate the tide heights at the SE and NW corners of the project site. This data set has a spatial resolution of 1/30°, simulating 8 tidal constituents and it assimilated 531 cycles of Topex/Poseidon, 114 cycles of Topex/Tandem and 108 cycles of ERS/Envisat satellites. This model also assimilated tide gauges along the coast of the domain. Further discussion of this data set is provided in the DNV GL report on metocean design criteria[7].

Table 2-3 Summary of modeled tide data for the SFWF project site

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

The tidal summaries above are generally consistent with the tide information provided on the NOAA coastal chart 13218[6], which shows a MHW level at Old Harbor, Block Island, of 3.0 ft (0.9 m) and a MHHW of 3.2 ft (1.0 m).

Estimates of tidal stream and residual current speeds were obtained using a combination of the Admiralty Total Tide software[13], the HYCOM model[14], the MIKE 21 simulation package[15,16], and the Oregon State University Tidal Inversion Software[3]. Additional discussion of these tools is provided in the DNV GL report on metocean design criteria[7].

Table 2-4 summarizes the tidal stream and residual current speeds based on analysis of the modeled results.

Table 2-4 Summary of tidal stream and residual current speeds at the SFWF project site

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 DNV GL met ocean report[7] also estimated the directional frequency of the tidal stream, residual current, and total current. The annual average directional frequency distributions are shown in Figure 2-2 below and follow an overall NW (flood) – SE (ebb) pattern[9].

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[13] Admiralty TotalTide, Admiralty TotalTide, version 6.5.0.16, Dated 2001.
[14] HYbrid Coordinate Ocean Model, HYCOM, http://www.hycom.org.
[15] DHI, MIKE 21/3 Flow Model FM Hydrodynamic and Transport Module - Scientific Documentation, Hørsholm, 2005.
[16] DHI, MIKE 21/3 Spectral Waves Model FM Module - Scientific Documentation, Hørsholm, 2005.
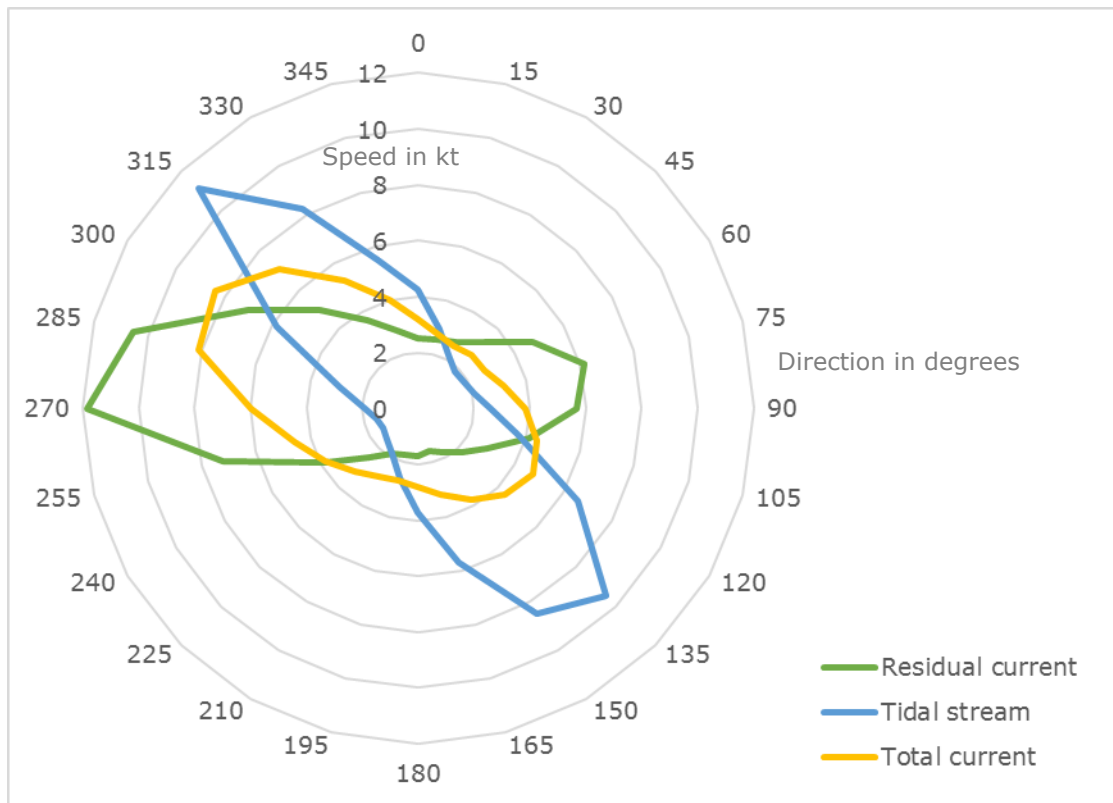
Figure 2-2 Tidal stream and current directional frequency (%) at the SFWF project site

2.1.2 Bathymetry

NOAA coastal chart 13218 ("Martha's Vineyard to Block Island")[17] was used to determine water depths across the project site. Water depths at the SFWF site range from 104 ft (32 m) to 127 ft (39 m).

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[17] ArcGIS Online, New York State Geographic Information Gateway, "Bathymetry - Atlantic Ocean, NY (bathy)", Published 1 March 2014.
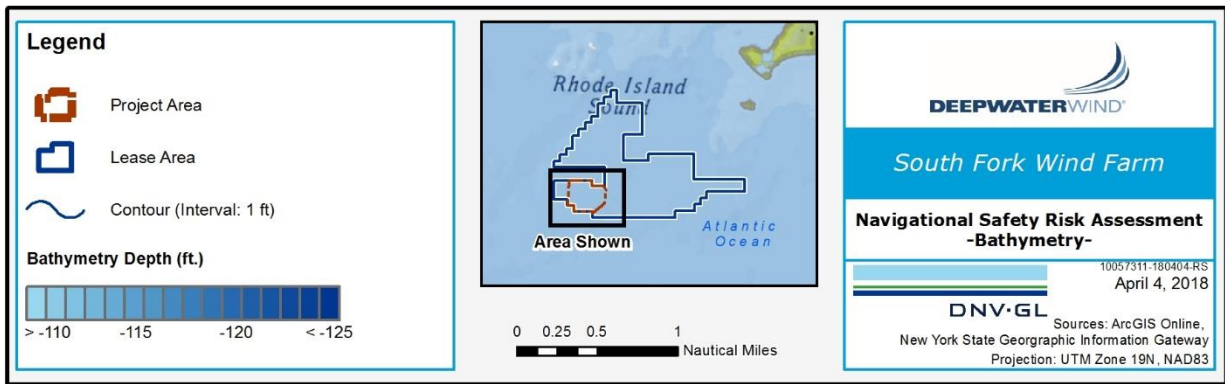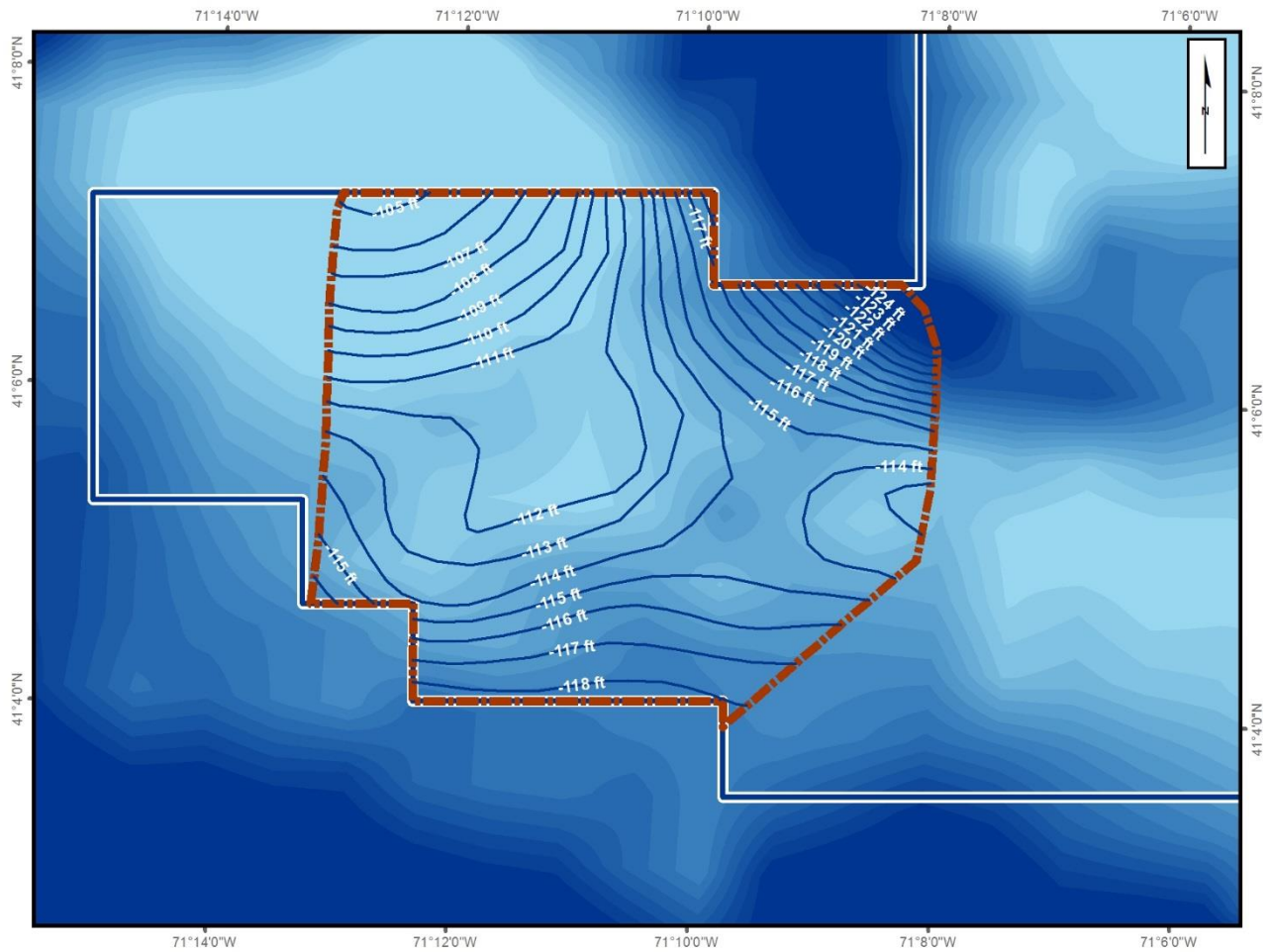
Figure 2-3 Bathymetry of the SFWF project area

2.2 Weather

2.2.1 Winds

No on-site wind speed measurements are available within or near the SFWF project area[18]. As such, DNV GL utilized its Virtual Met Data (VMD) system[19], 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). VMD is a mesoscale-model-based system for generating wind data for any point on the globe. VMD is founded upon two decades of research and development. At the heart of VMD is the Weather Research and Forecasting (WRF) Model, which employs a sophisticated land surface model, and high-resolution land- and sea-surface state data. VMD also incorporates Modern Era Retrospective-analysis for Research and Applications (MERRA-2) data and the European Centre for Medium-Range Weather Forecasts (ECMWF), Interim Reanalysis (ERA Interim) data. Summaries of these generated data at 33 ft (10 m) elevation are presented herein.

Figure 2-4 and Figure 2-5 present the average and maximum hourly wind speeds expected for each month of the year over this period, respectively. It can be observed that the highest wind speeds occur between November and February, while the lowest wind speeds occur between June and August. DNV GL finds this to be consistent with other wind speed datasets reviewed in this region.

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[18] NOAA buoy 44097, which is located near the project area, was also considered for this assessment; however, buoy 44097 was found not to have wind measurement equipment, so no current or historical wind data were available for use.

[19] The DNV GL VMD system is a dynamical downscaling system developed to generate high-resolution mesoscale virtual time series for any part of the world. VMD incorporates MERRA-2 (~27 NM (~50 km) resolution), daily global 13.5 NM (25 km) analyses of resolution lake- and sea-surface temperatures, 3-hourly global 13.5 NM (25 km) analyses of soil temperature and soil moisture, and 3-hourly global 13.5 NM (25 km) analyses of snow cover and snow depth. In addition, global 13.5 NM (25 km) resolution 3-hourly and daily estimates of soil temperature and moisture, sea surface temperature, and snow depth, are used in conjunction with a sophisticated and proven land surface model (LSM), to accurately predict the land and ocean surface heat and moisture fluxes that drive the winds within the boundary layer. This is a significantly higher resolution than the land- and sea-surface states commonly used within the industry mesoscale downscaling systems. This leads to more accurate results because it enables the diurnal variation of processes in the planetary boundary layer (PBL), as well as the local forcing, to be well represented.
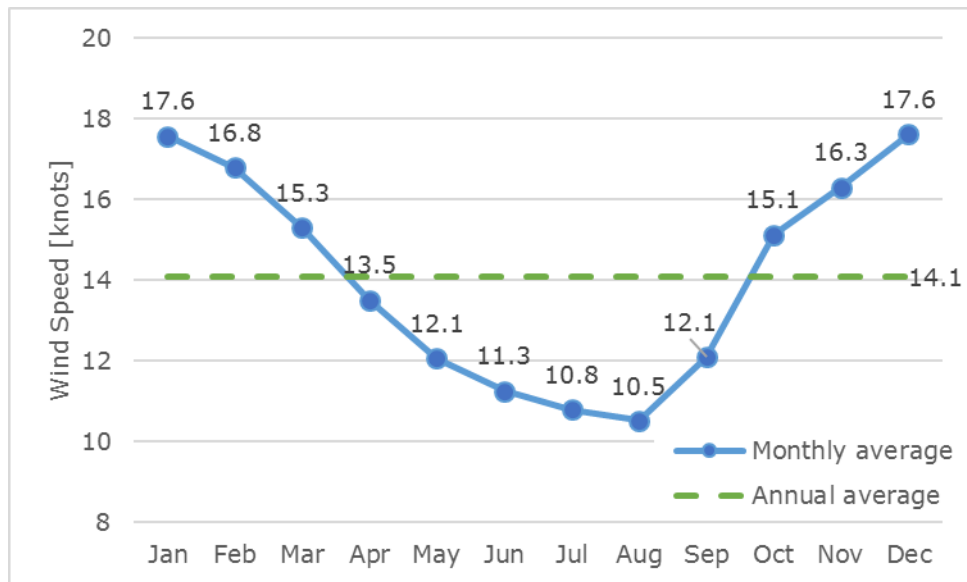
Figure 2-4 Average hourly wind speeds expected at the SFWF project site at 33 ft (10 m) height above MSL
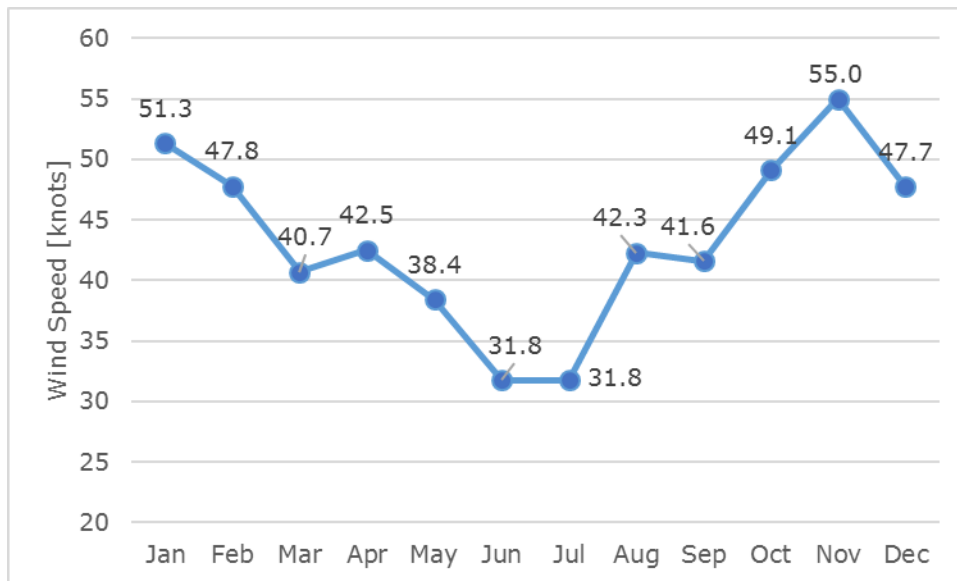
Figure 2-5 Maximum hourly winds speeds from 17.5-year VMD at the SFWF project site at 33 ft (10 m) height above MSL

The mean wind speed at 33 ft (10 m) elevation over the 17.5-year VMD data period is 14.1 knots (7.2 m/s). The distribution of wind speeds over this period is shown in Figure 2-6.
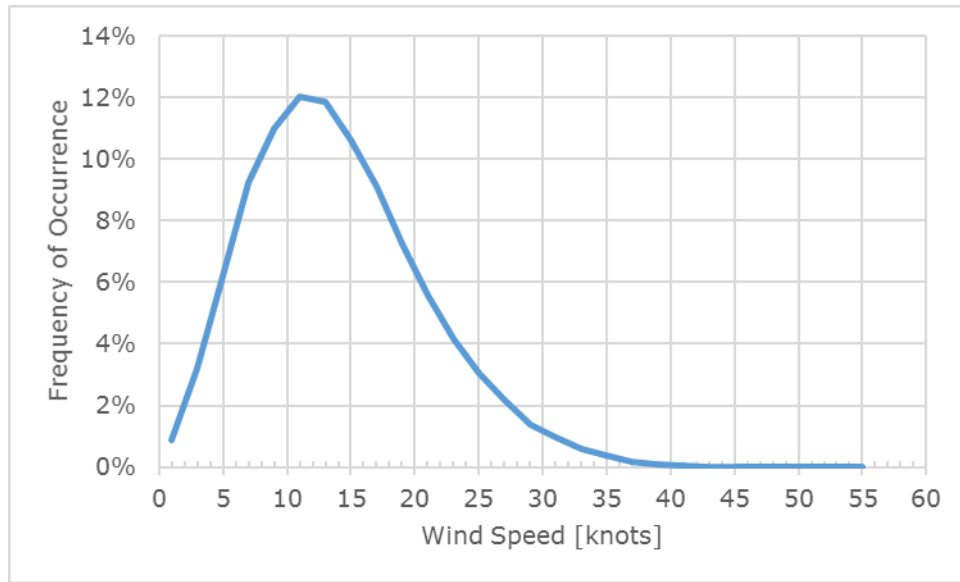
Figure 2-6 Distribution of wind speeds at the SFWF project site at 33 ft (10 m) height above MSL

Figure 2-7 presents the distribution of wind directions over this period. The distribution of wind directions (the wind rose) shows that winds come from almost all directions over the course of a year although the wind comes from the southwest to west the majority of the time. The prevailing wind direction is from the west-southwest.
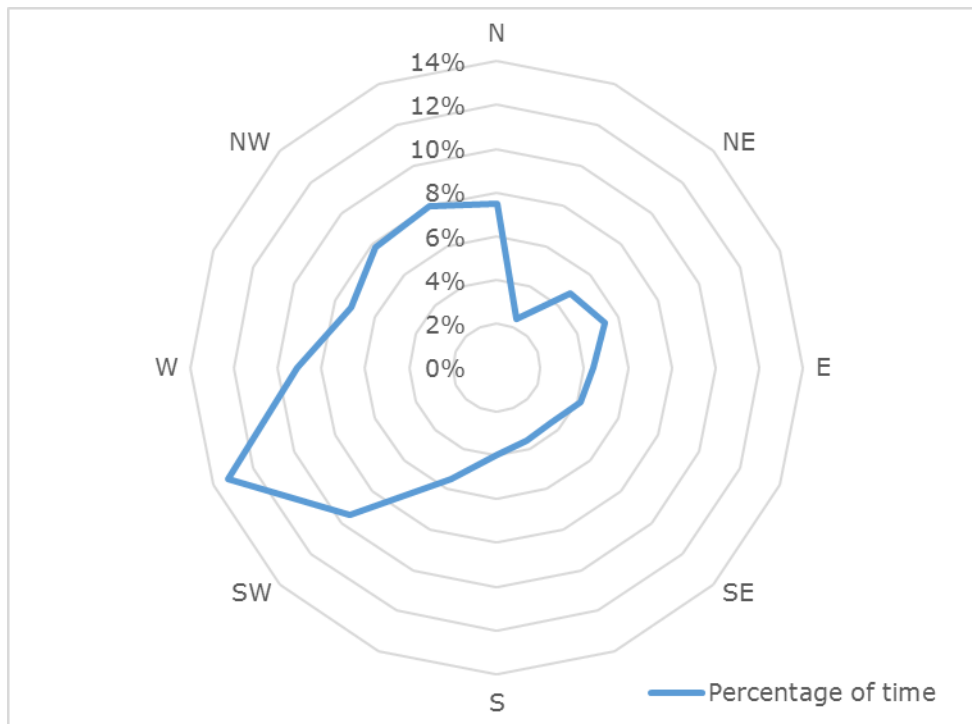
Figure 2-7 Wind direction distribution expected at the SFWF project site at 33 ft (10 m) height above MSL

Hurricanes are not common in the vicinity of the project site[10]. The International Best Tracks for Climate Stewardship (IBTrACS) database[20,21] has been utilized to obtain the track data for hurricanes that passed within 5 degrees of the SFWF site vicinity between 1971 and 2016. These are shown in Figure 2-8[7]. DNV GL conducted cyclone modeling in order to estimate extreme wind speeds at different return periods. Extreme storms were utilized in the modeling: Hurricanes Bob (1991) and Gloria (1985) were found to have the highest local wind speeds, and the Hurricane Sandy (2012) was included because of the path the storm took before coming ashore. Additional discussion of this data set and analysis methodology are provided in the DNV GL report on metocean design criteria[7].

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[20] Knapp KR, Kruk MC, Levinson DH, Diamond HJ, Newmann CJ. The International Best Track Archive for Climate Stewardship (IBTrACS): Unifying tropical cyclone best track data, March 2010.
[21] NOAA, National Climatic Data Center, "International Best Track Archive for Climate Stewardship (IBTrACS)", http://www.ncdc.noaa.gov/ibtracs/.

Cyclones that passed within 5deg. of the location from 1971 to 2016 - Nb cyc. = 92
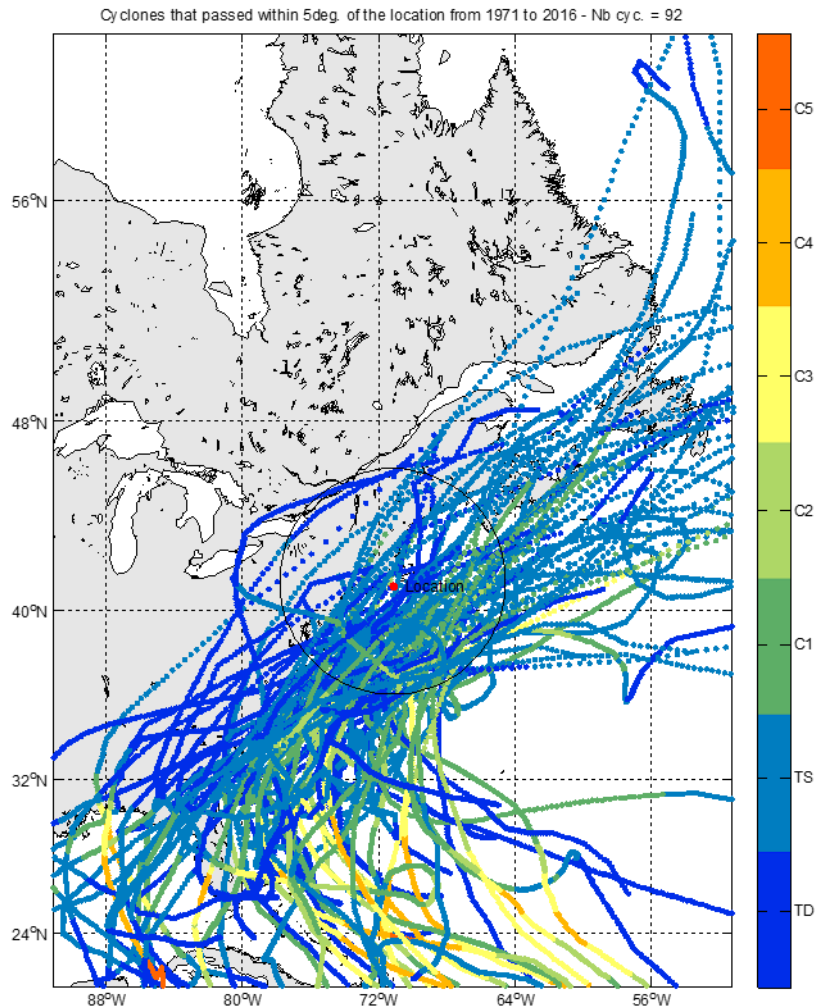
Figure 2-8 Tracks of cyclones that passed within 5 degrees of the SFWF project site (1971-2016)

DNV GL estimates the extreme wind speeds at the SFWF project site during hurricane conditions to be as follows[7]:

Table 2-5 Maximum hurricane wind speeds at the SFWF project site

Wind speed at 33 ft (10 m)	10-yr return	50-yr return
10-minute average wind speed	46.7 knots (24 m/s)	64.2 knots (33 m/s)
1-minute average wind speed	52.5 knots (27 m/s)	72.0 knots (37 m/s)
3-second gust wind speed	58.4 knots (30 m/s)	81.7 knots (42 m/s)

Hurricane conditions can also be expected to impact wave characteristics, water levels, and currents. Table 2-6 presents the 10- and 50-year return period extreme conditions taken from the DNV GL report on metocean design criteria[7].

Table 2-6 Hurricane metocean at the SFWF project site

	10-yr return	50-yr return
SEA STATE		
Maximum individual wave height	32.2 ft (9.8 m)	44.9 ft (13.7 m)
Associated period	9.4 sec	11.0 sec
Associated wave length	452.8 ft (138 m)	600.4 ft (183 m)
Significant wave height	18.4 ft (5.6 m)	25.6 ft (7.8 m)
Zero-crossing period	7.7 sec	9.0 sec
Peak energy period	10.2 sec	12.0 sec
WATER LEVELS		
Tidal rise	4.6 ft (1.4 m)	4.6 ft (1.4 m)
Storm surge	1.3 ft (0.4 m)	3.0 ft (0.9 m)
CURRENT		
Total surface current	2.1 knots (1.1 m/s)	2.5 knots (1.3 m/s)

2.2.2 Visibility

Visibility data were obtained from the NNDC Climate Data Online for Block Island State Airport, station 94793[8]. This station is the closest station with visibility data to the site and is assumed therefore to be most representative of visibility conditions at the site.

DNV GL obtained 10 years of visibility data from the Block Island State Airport station and observed the distribution of visibility measurements shown in Figure 2-9.
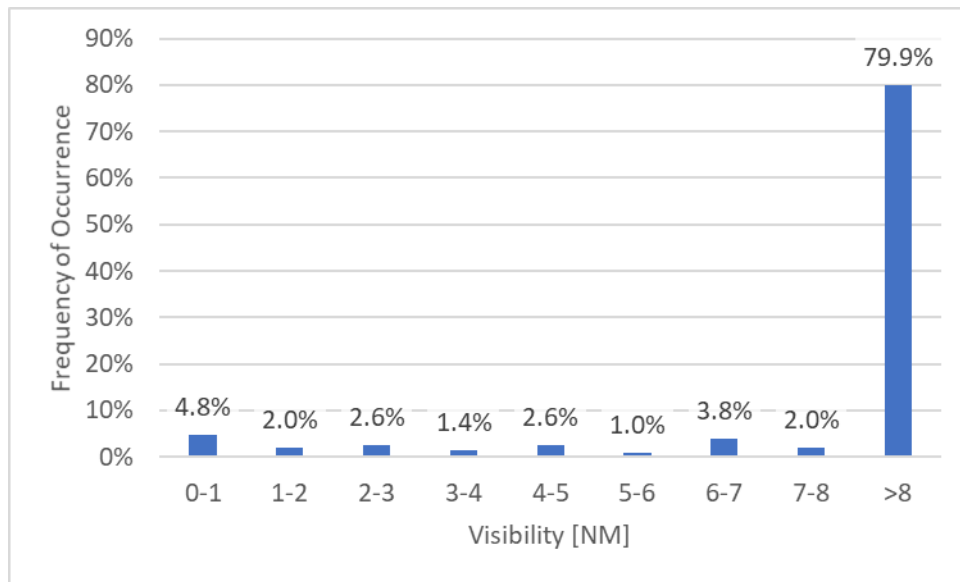
Figure 2-9 Summary of visibility measurements at Block Island State Airport, 2008-2017

A discussion of fog conditions is provided in the Rhode Island Ocean Special Area Management Plan ("RI SAMP")[10], which references analysis from Merrill[12]. Merrill found that fog conditions are most frequent between June and August with 6-10 days of fog per month, and less frequent between March to May and October to December when 3-4 days per month of fog are typical.

2.3 Ice

Ice can impact navigation around offshore WTGs in two ways: floating ice can cause treacherous conditions for vessels, and ice can accumulate on the WTG structures causing potentially hazardous conditions for people and vessels beneath when it melts and falls from a WTG.

2.3.1 Floating ice

The Coast Pilot 2 report[9] discusses pack ice that forms within Narragansett Bay and its tributaries, and advises that accumulated ice can restrict vessel access to certain parts of the bay, especially during severe winter conditions. There is, however, no discussion of ice accumulation near the SFWF project site in the Coast Pilot 2 report or the RI SAMP[10] and DNV GL has found no other information to suggest that floating ice is present or poses a risk to navigation near the project site. In discussion with a representative of the U.S. Coast Guard familiar with the area, DNV GL was advised that floating ice has not been observed in the project site and that the closest sea ice was observed near Cuttyhunk Island, more than 20 NM (37 km) from the project site[11].

2.3.2 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. For a WTG, ice drop occurs when ice falls from a WTG that is not rotating.

The term "ice throw", on the other hand, is used to describe ice being flung from rotating WTG blades such that pieces of ice land some distance from the base of the tower.

When ice builds up on WTG blades, the weight and center of mass of the blades changes, causing an imbalance in the rotor. If the rotor continues 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 wide-spread use of this control strategy, very little ice throw occurs on modern WTGs; most ice drops to the base of the WTG. Therefore, the greatest risk from ice shedding off a WTG is to vessels and personnel in the immediate vicinity of the WTG. This includes maintenance vessels, fishing vessels, and recreational vessels. Risk to recreational vessels is expected to be low, however, given that recreational boating activity is typically reduced during the winter months.

Merrill[12] analyzed meteorological data from the BUZM3 station in Buzzard's Bay and found that the conditions needed for light ice accretion occur between November and March, with nine or fewer icing days per month in the RI SAMP area, which includes the SFWF project site. Icing days with moderate ice accretion occur less than one day month. The findings of that study are shown in Figure 2-10.
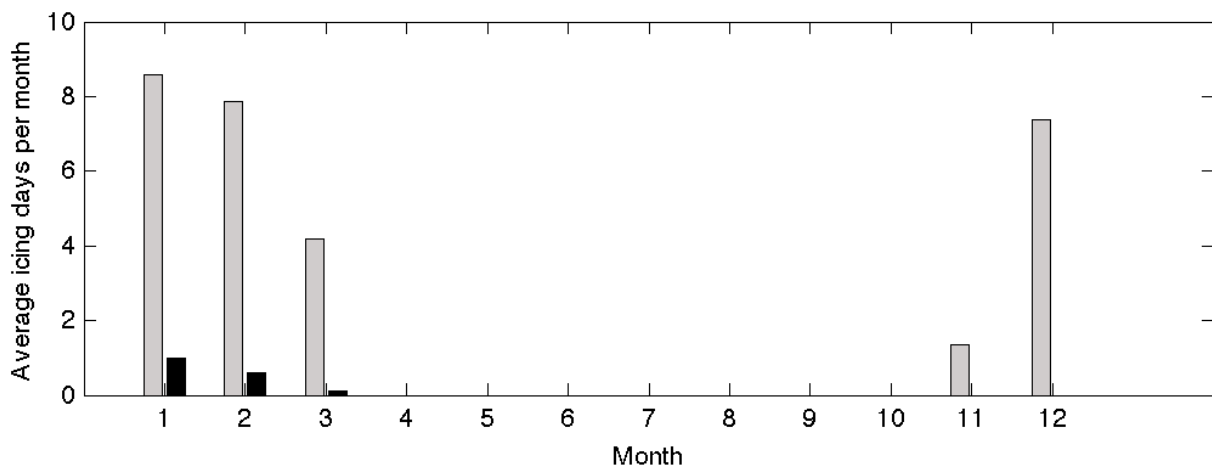
Figure 2-10 Annual distribution of light (light) and moderate (dark) icing days at BUZM3[12]

Ice accumulation can occur during periods of high relative humidity and near freezing temperatures or high convective cooling rates, such as in cold damp windy weather or in frost, snow and freezing rain. It can generally be assumed that ice accumulation on a structure will occur when the temperature is below 37°F (3°C) and when the relative humidity is higher than 95%[22]. It is noted, however, that ice accumulation on a wind turbine blade is also dependent on the temperature of the blade surface, the wind speed, and other atmospheric conditions[23].

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[22] DNV GL, Recommended Practice: Icing of Wind Turbines, December 2017.
[23] "Phases of icing on wind turbine blades characterized by ice accumulation", Renewable Energy, Andrea G. Kraj,Eric L. Bibeau. May 2010.

Confirmation of ice conditions and the extent of the build-up can generally be made using binoculars from a safe distance. A conservative (worst case) estimate for ice throw distance that is generally adopted in the wind industry is:

Maximum ice throw distance = (Hub height + rotor diameter) × 1.5

Assuming a hub height of approximately 380 ft (116 m) and a rotor diameter of approximately 550 ft (167 m), the worst case ice throw distance for the SFWF turbines would therefore be approximately:

Maximum ice throw distance = [(380 ft) + (550 ft)] x 1.5 = 1,300 ft (425 m).

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, or when ice build-up is observed.

3 MARITIME TRAFFIC AND VESSEL CHARACTERISTICS

To accurately survey traffic in the study area (Figure 3-1), a combination of local traffic data sources is used. For the quantitative collision, striking, and grounding assessment (Section 4), Automatic Identification System (AIS) data is the best available comprehensive source for traffic input to the model. It is supplemented by data from the Northeast Ocean Data portal, Vessel Monitoring System (VMS) data provided by National Marine Fisheries Services (NMFS). Its primary purpose is to be used for ocean planning throughout the northeastern United States. It provides a robust source of local information and data to fill in gaps identified in the AIS dataset[24].

As discussed in Section 3.1.1.2, the commercial fishing traffic is not well represented in the AIS data. So, commercial fishing activity is based on density maps from the Northeast Ocean Data portal (VMS and recreational survey data).

The following subsections describe the following aspects of local marine traffic:

- Traffic patterns, structure, and vessel density (Section 3.1.1)

- Statistical summaries (Section 3.1.2)

- Vessel size (Section 3.1.3)

- Vessel speed (Section 3.1.4)

In addition to analyzing data, this assessment also engaged with local pilots to capture their views on the impact of SFWF on navigation. A summary of these discussions is included in Section 3.3.

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[24] "Data Explorer." Northeast Ocean Data Portal, www.northeastoceandata.org/.
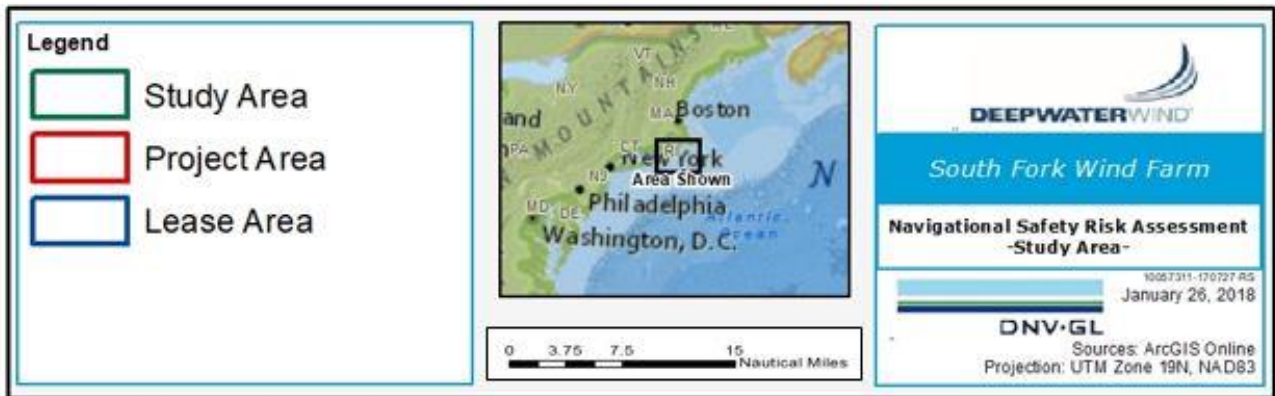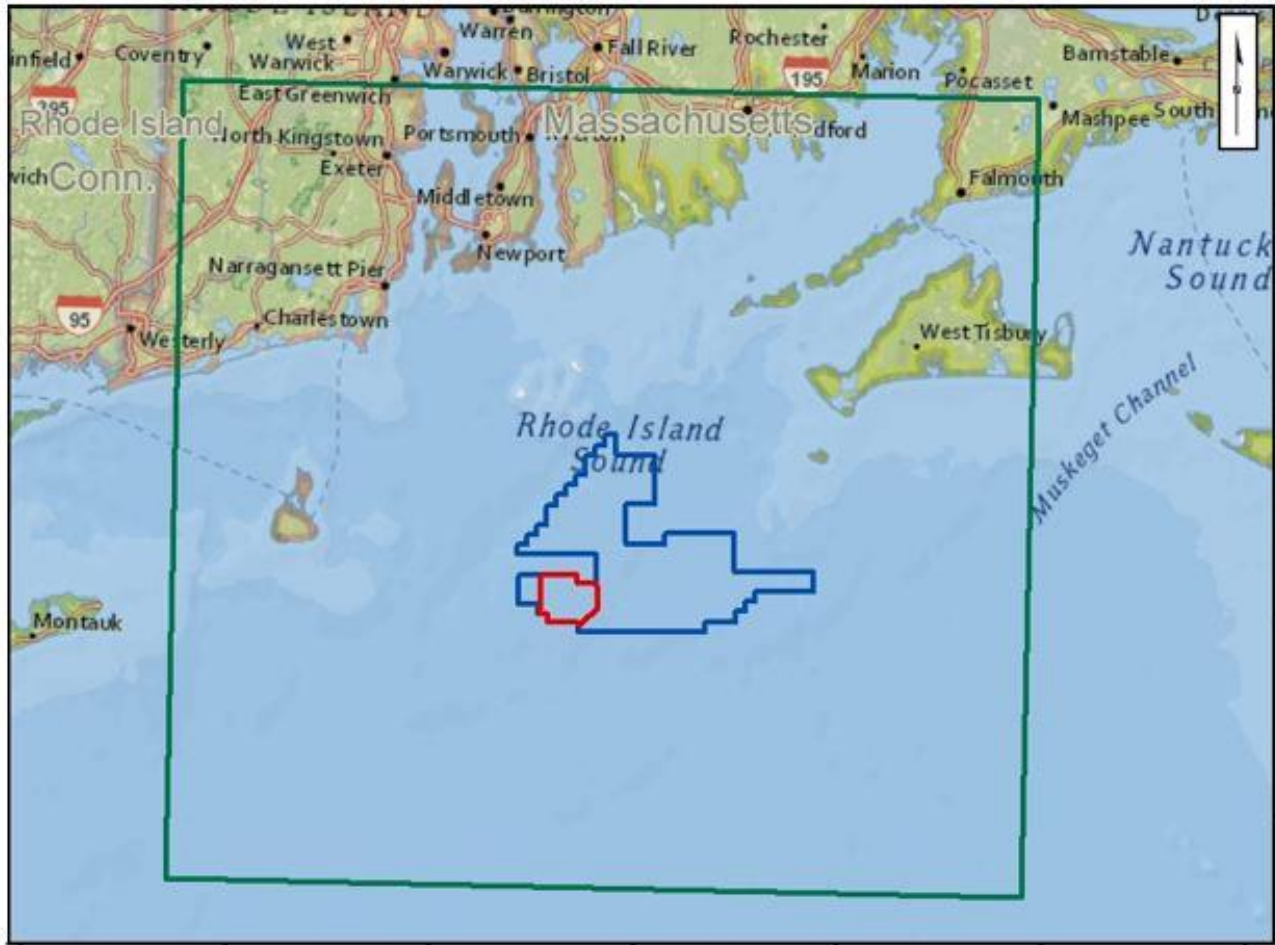
Figure 3-1 Study Area for SFWF NSRA

3.1 Data review and traffic survey

The general marine patterns and traffic statistics described in this section are based on AIS data. AIS data provides a quantifiable and reliable method to determine the primary traffic patterns and analyze the size, speed, and movements of vessels in the region. AIS data was purchased from MarineTraffic for the most recent available full-year period[25]. The data includes all AIS entries with a timestamp from "2016-07-18 00:00" through "2017-07-18 13:00" UTC.

AIS carriage requirements published by USCG were updated on 2 March 2015. All self-propelled vessels of more than 1,600 gross tons are now required to carry AIS, with certain exceptions made for foreign vessels[26]. The new regulations were in force for the time period covered in the data for this assessment (July 2016 – July 2017)[27].

The AIS points were converted into vessel for the quantitative analysis described in Section 4. The AIS treatment methodology is schematically represented in Figure 3-2.
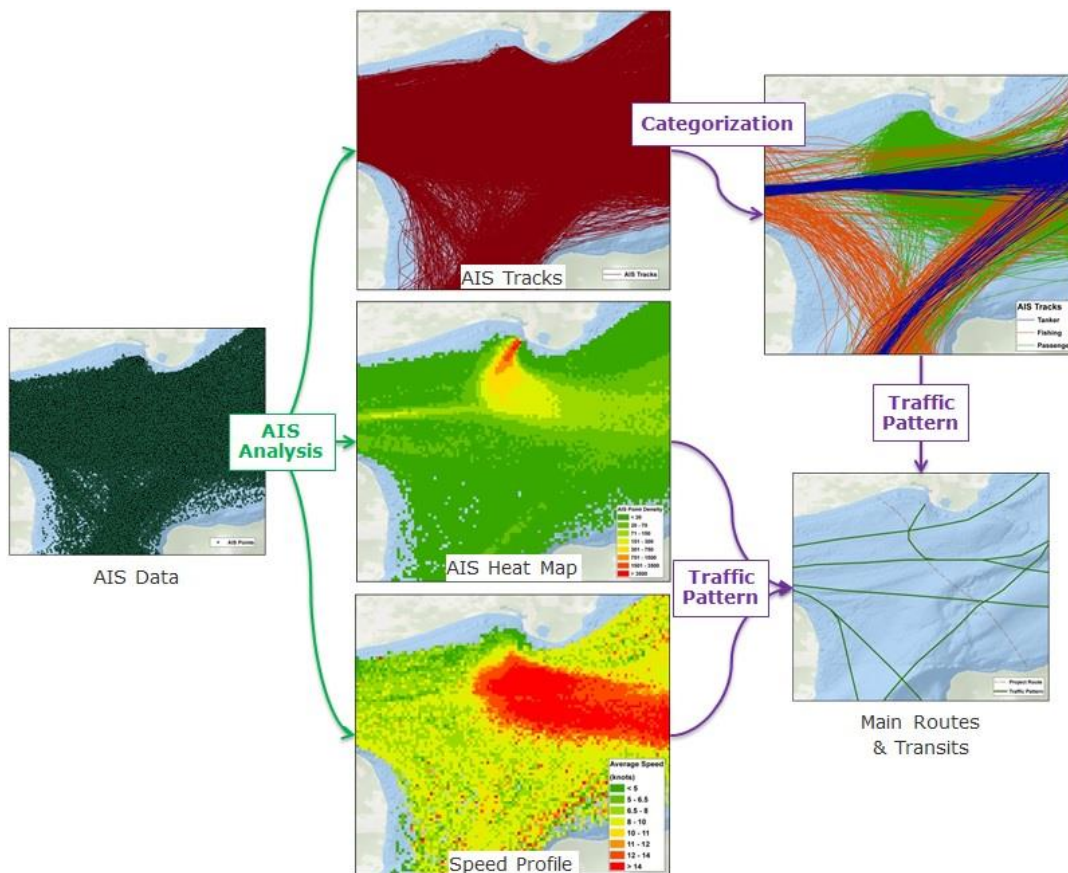
Figure 3-2 AIS treatment methodology

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[25] Automatic Identification System data acquired from MarineTraffic. Obtained July 31, 2017.
[26] United States Coast Guard. Navigation Center of Excellence. *AIS Requirements.*
https://www.navcen.uscg.gov/?pageName=AISRequirementsRev.
[27] United States Coast Guard. Navigation Center of Excellence. *AIS requirements. [superseded]*
https://www.navcen.uscg.gov/?pageName=AISCarriageReqmts.

3.1.1 Traffic patterns, structure, and traffic density

This section presents vessel traffic patterns for each vessel type. DNV GL processed AIS data points, connecting them based on timestamp and location to create vessel tracks. Each vessel track represents a movement of a single vessel. Tracks were grouped into the following vessel types for the analysis:

- Cargo/Carrier

- Tanker – Not carrying oil products

- Fishing

- Tanker – Possibly carrying oil products

- Passenger

- Tug

- Pleasure/Recreation

- Other

- Service

- Unspecified

For each vessel category, a map was created utilizing AIS to view the traffic patterns in relation to SFWF. A complete set of maps of AIS tracks, density, and speed are included in Appendix A. For instances where the AIS data did not appear to provide sufficient information to fully depict the traffic patterns, the AIS maps were supplemented with data obtained from the Northeast Ocean Data portal, Vessel Monitoring System (VMS) data provided by National Marine Fisheries Services (NMFS).

In addition, DNV GL reviewed other data sources to supplement the most recent year of AIS data. This achieves two objectives; it addresses any gaps in the AIS data, and is recommended in the UK Maritime and Coastguard Agency guidance document *Safety of Navigation: Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency***Error! Bookmark not defined.**. This is not an explicit requirement in the United States, but is considered best practice.

Figure 3-3 presents the AIS tracks for all vessels that are equipped with AIS transponders in the study area.
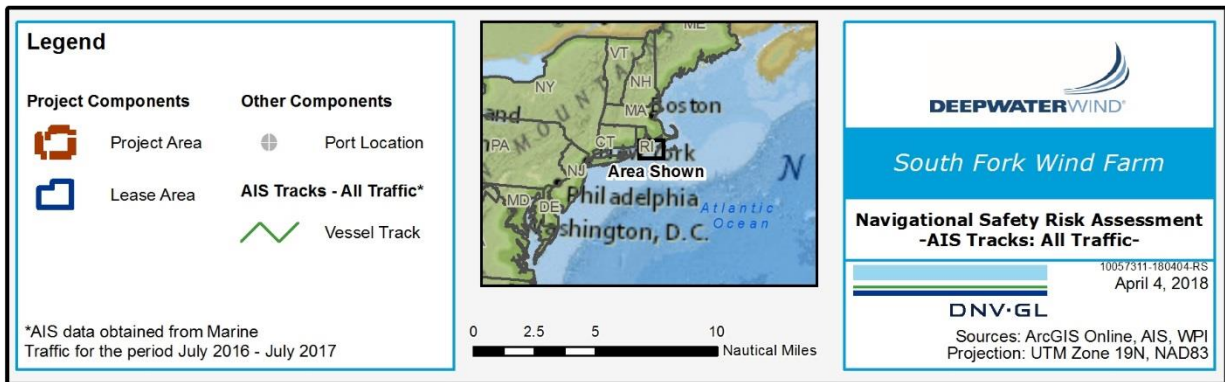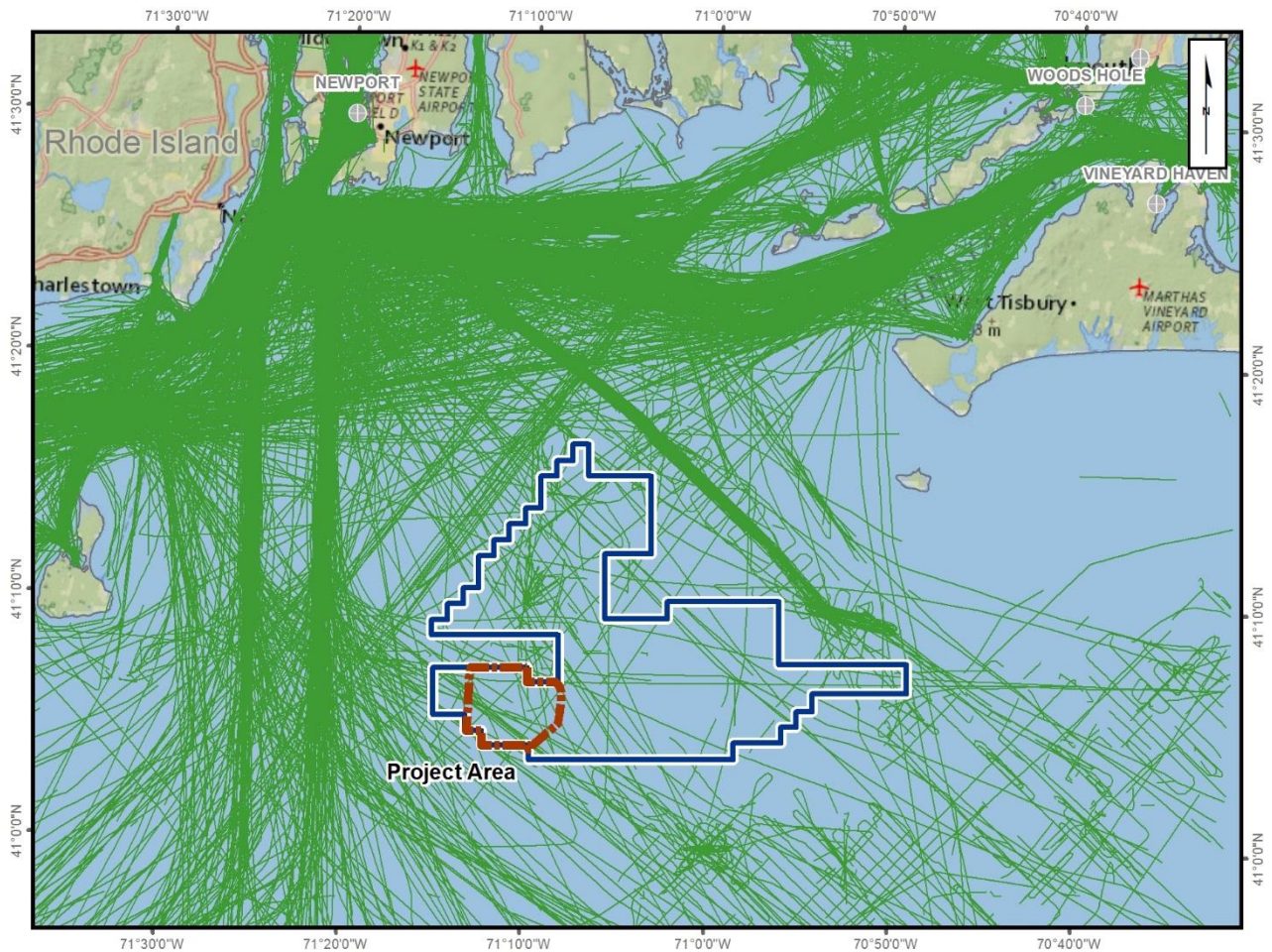
Figure 3-3 AIS tracks for all vessel categories

Figure 3-4 presents the same data on a nautical chart. Traffic separation zones are illustrated as the purple rectangles. From the figure, it is apparent that tracks are most frequent through Rhode Island Sound and along the traffic separation zones. The Narragansett Bay traffic separation zone is located over 7 NM to the northwest of the project area (commercial traffic transiting north-south). Traffic continues transiting from the Narragansett Bay traffic separation zone in a north-south direction past the project area through the

precautionary zone. To the north of the project area, the Buzzards Bay traffic separation zone is located more than 4 NM from the project area and over 1.5 NM from the northwestern edge of the lease area.
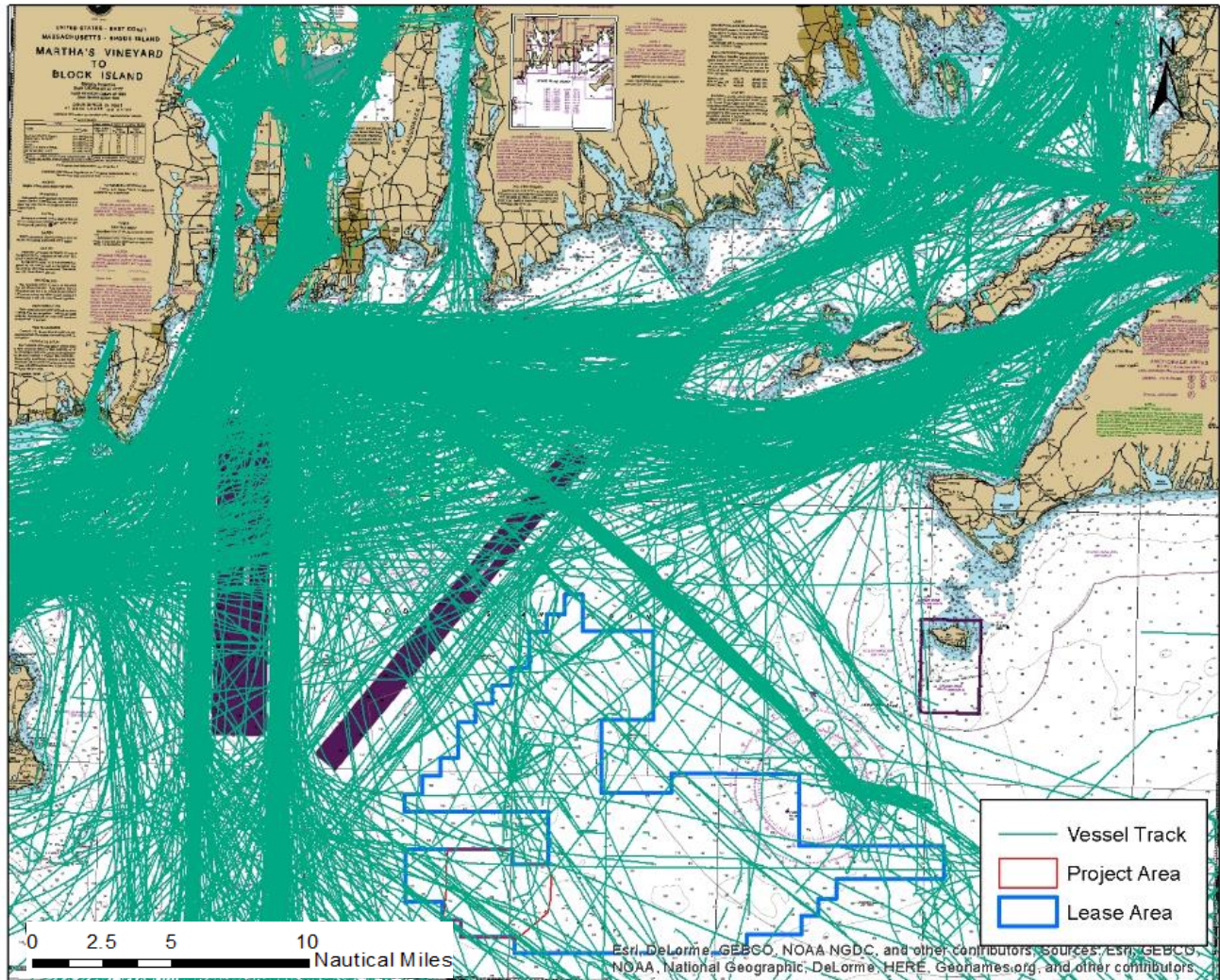
Figure 3-4 All AIS tracks on Nautical Chart 13218[6]

Another way to view AIS data is in a density heat map. Figure 3-5 presents a density heat map for all AIS points in the study area. The density is calculated by determining the number of AIS data points within each 1x1 km grid cell. This is interpreted as the traffic density. It is worth noting that since the AIS dataset is terrestrial (from land-based AIS receivers), the data quality has the highest resolution close to the coast. This is more apparent for the point density maps than it is with tracks because the density relies only on the number of AIS points while the tracks connect points that may be spaced farther apart.

The traffic density shows that there is relatively low AIS point density in the SFWF project area. In line with the calculated vessel tracks, there are areas of higher density north of the lease area. East Passage has areas of high density that continue through the pilot boarding area and the north-south Narraganset Bay Traffic Separation Zone.
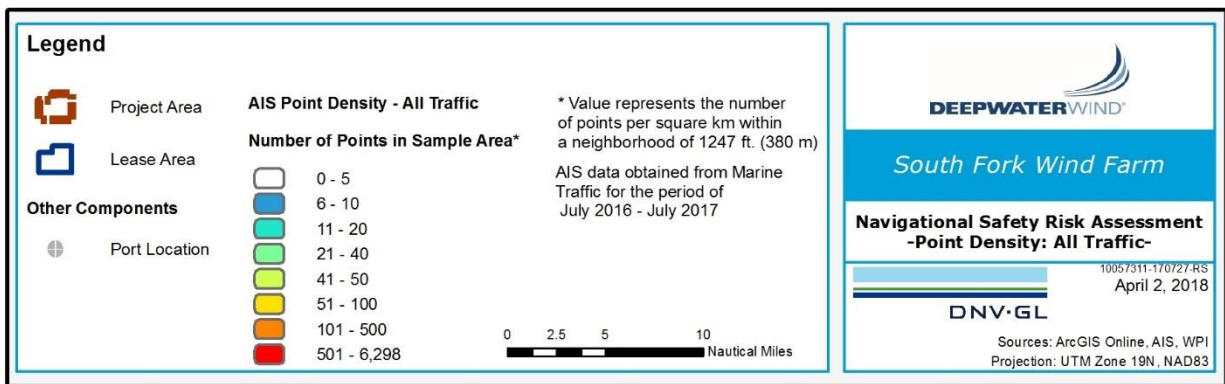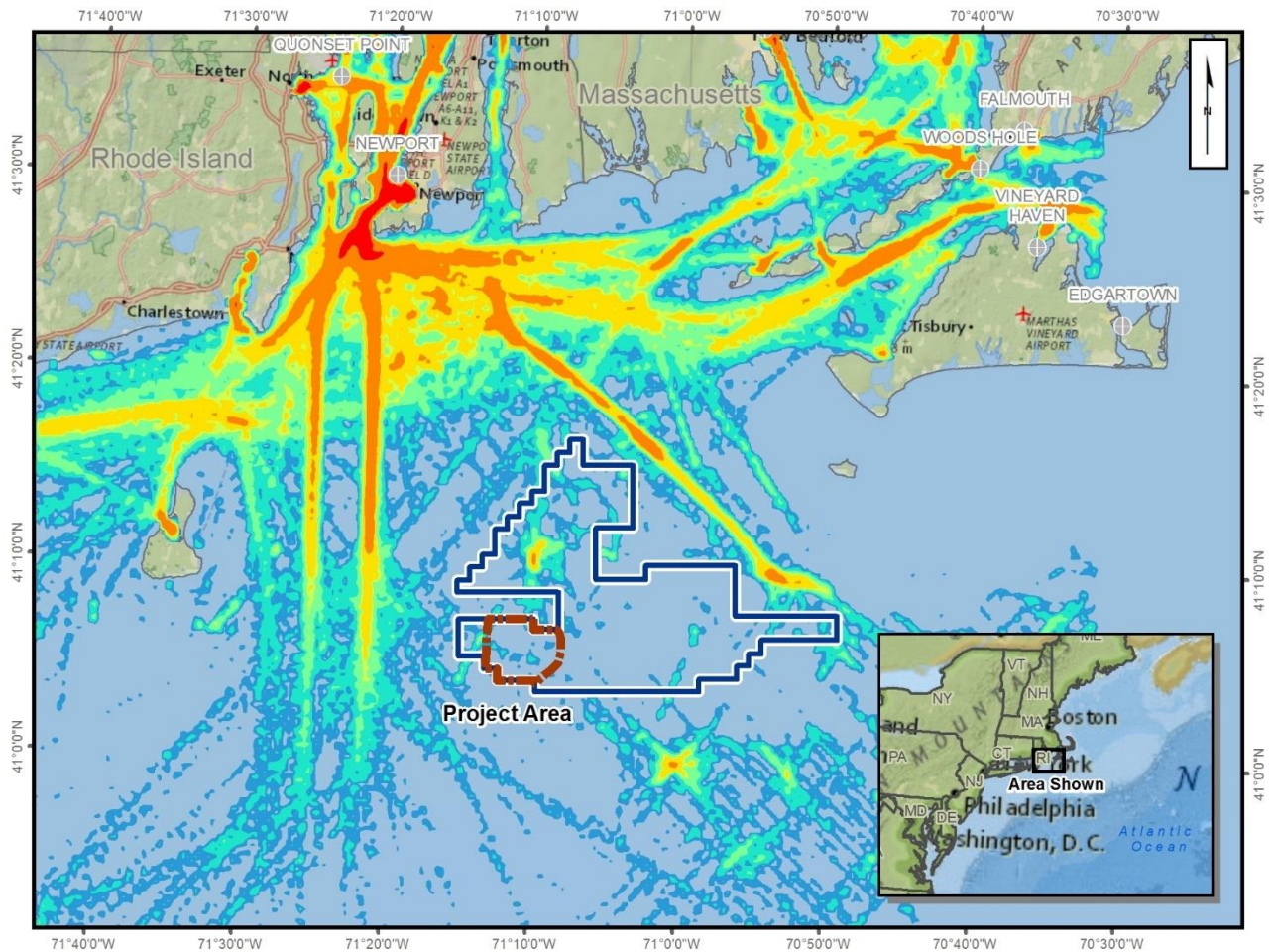
Figure 3-5 Traffic AIS point density for all AIS data

3.1.1.1 Deep draft commercial vessel traffic

Deep draft commercial vessels (cargo/carriers and tankers) transit the main shipping routes following the designated traffic separation zones as expected. Deep draft vessels predominantly transit three main courses through the study area as follows:

- North-south via the Narragansett Bay inbound and outbound lanes to/from East Passage. This route transits to the west of the project area and diverges south of the study area after the defined precautionary area. Mariners are advised to exercise extreme care in navigating within the precautionary area[6].

- Southwest-northeast along the recommended vessel route through Buzzards Bay. This route is recommended for all deep draft vessels entering and departing Buzzards Bay. Although the defined route is not mandatory, deep draft vessels are recommended to follow the designated routes at the master's discretion[6].

- East-west along the recommended vessel route to/from Block Sound. Near the pilot boarding station, deep draft commercial vessels merge in to/from the Narragansett Bay traffic lanes.

Figure 3-6 presents the tracks for cargo/carriers and tankers (both carrying hydrocarbon cargo and non-hydrocarbon cargo). The AIS track maps for each individual vessel type are in Appendix A to this NSRA. From the figure, the three main courses described above are clearly defined by the traffic pattern.
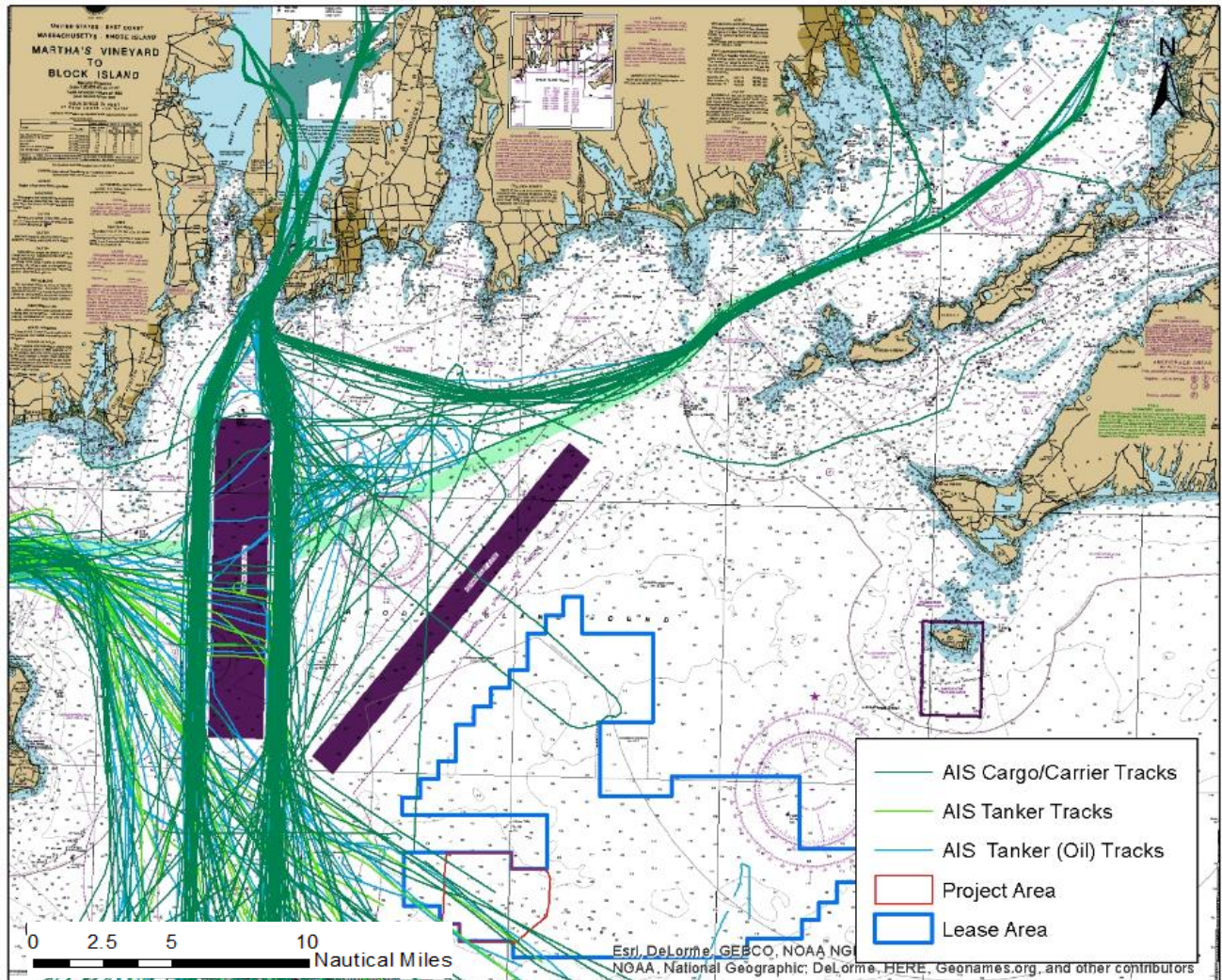
Figure 3-6 AIS Tracks for Tankers and Cargo Carriers[6]

3.1.1.2 Fishing vessel traffic

Commercial and recreational fishing vessels are underrepresented in the AIS data based on a review of USCG AIS carriage requirements and a general knowledge of local fishing practices**Error! Bookmark not defined.**. A significant portion of these vessels do not fall under the AIS carriage requirements and are not likely to be equipped with AIS. Certain "industry fishing vessels" are required to carry Class B AIS equipment, in which they have the capacity to receive messages, but cannot transmit them to be included in the dataset**Error! Bookmark not defined.**.

Figure 3-7 presents the AIS tracks for fishing vessels, which does not align with an expectation of a significant number of vessels transiting throughout the area. It is apparent that a large majority of commercial and recreational fishing vessels are not captured in the AIS data set.

A useful source of fishing data is the Northeast Ocean Data portal. Density maps based on Vessel Monitoring System (VMS) data provided by National Marine Fisheries Services (NMFS)[24] were used to assess fishing

vessel traffic, described below. Section 4.4 describes how fishing vessel movements within SFWF were included in the quantitative analysis.
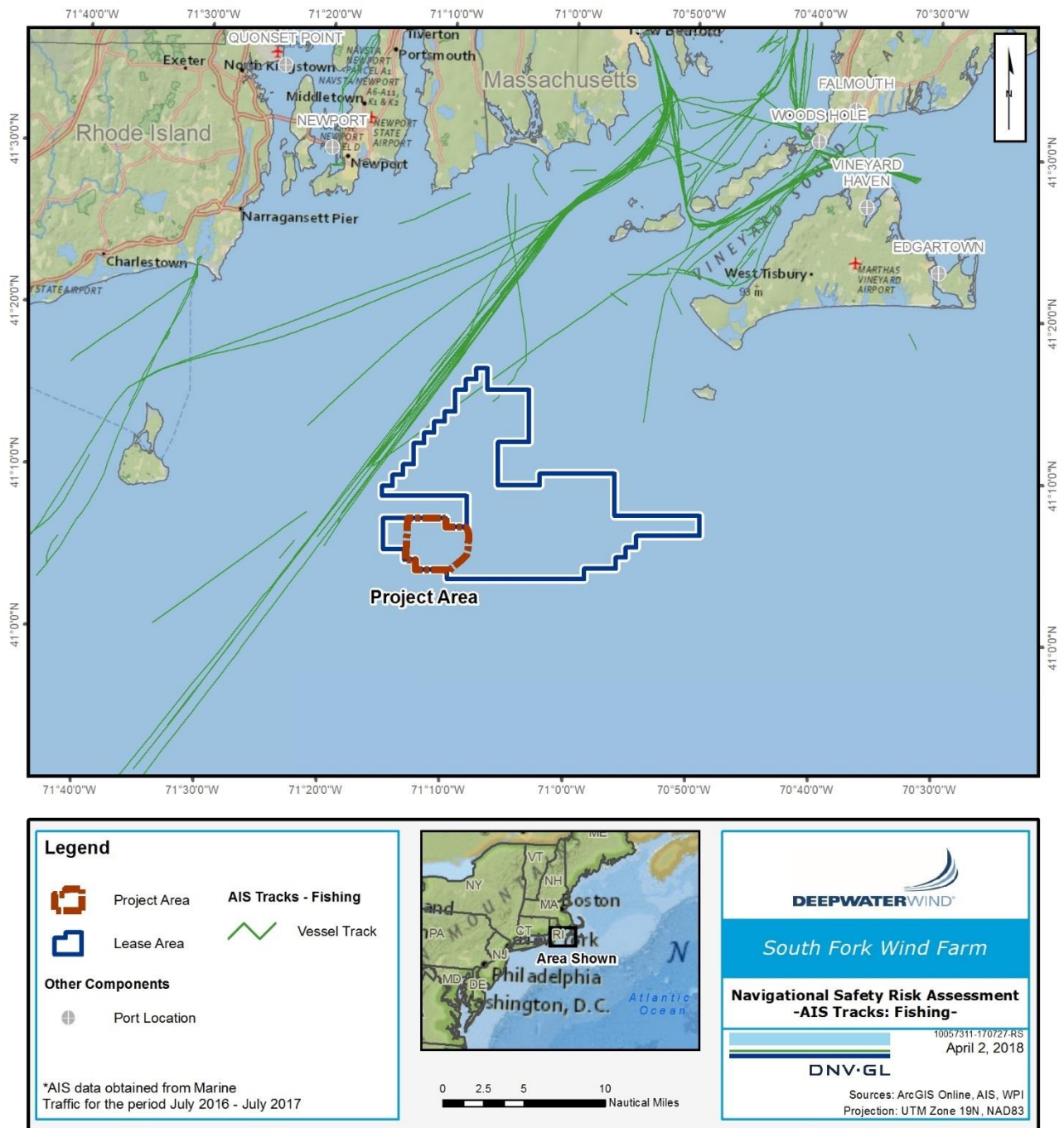
Figure 3-7 AIS Tracks for fishing vessels

Commercial fishing vessel density

The Northeast Ocean Data portal presents various views of commercial fishing activity in the study area, but detailed data is not available from download. It is subject to strict confidentiality restrictions that do not allow for individual vessel tracks or positions to be identifiable[24]. The figures in this section are based on images from the Northeast Ocean Data portal, Vessel Monitoring System (VMS) data provided by National Marine Fisheries Services (NMFS).

Figure 3-8 and Figure 3-9 show multispecies commercial fishing vessel activity. The SFWF site is categorized as "Med-Low" and "Med-Hi" fishing activity in 2011-2014 and "Low" to "High" fishing activity in 2015-2016, indicating an increase in activity over time. Commercial fishing vessels do not travel within prescribed vessel routes as other commercial vessel types. Instead, the data exhibit more erratic density patterns related to fishing activity and their speeds vary widely.

Figure 3-10 and Figure 3-11 present multispecies commercial fishing vessel activity under 4 knots. The SFWF site is categorized as "Low" or "Med-Low" in 2011-2014, and "Low" to "High" in 2015-2016, indicating a similar increase over time.

A comparison of the densities for all traffic versus vessel transiting under 4 knots implies that fishing vessels transit though the SFWF area more often than they fish there.

It is noteworthy that DWSF has been working closely with local fishing groups and has adjusted project area boundaries to be considerate of local fishing interests. Section 4.4 describes the method in which fishing vessel movements within SFWF are captured in the quantitative analysis.
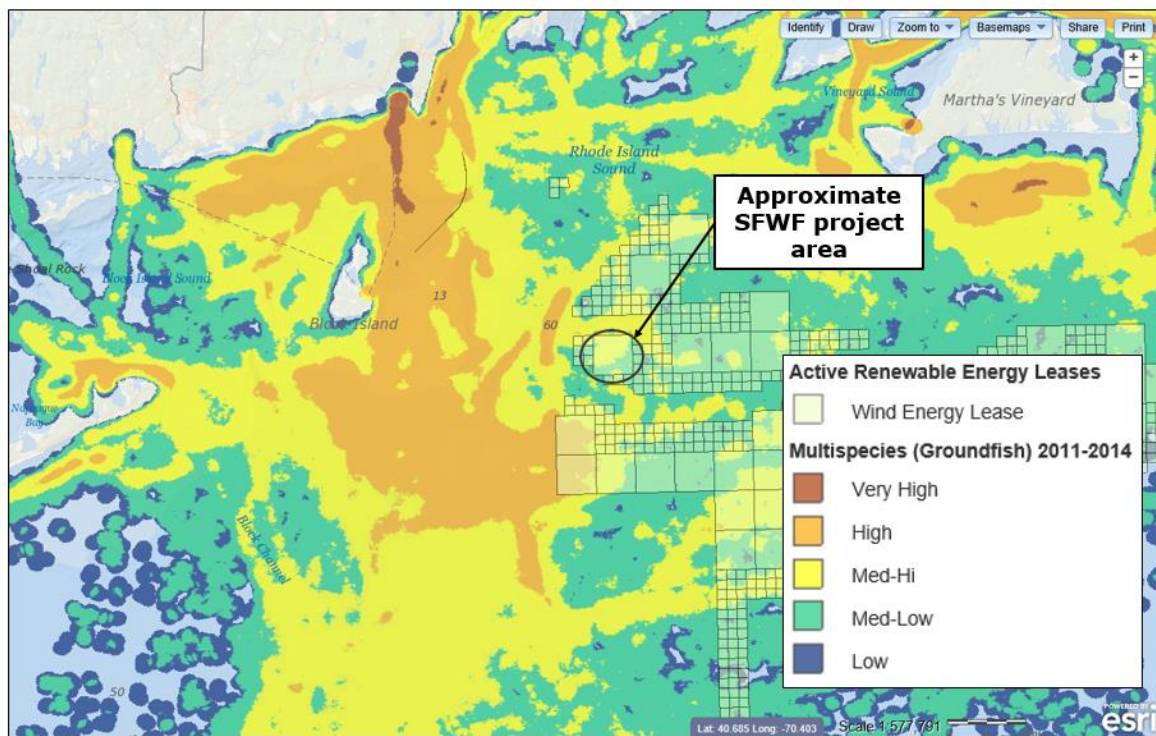
Figure 3-8 Commercial Fishing Traffic (Multispecies 2011 – 2014) Density[24] (overlay added)
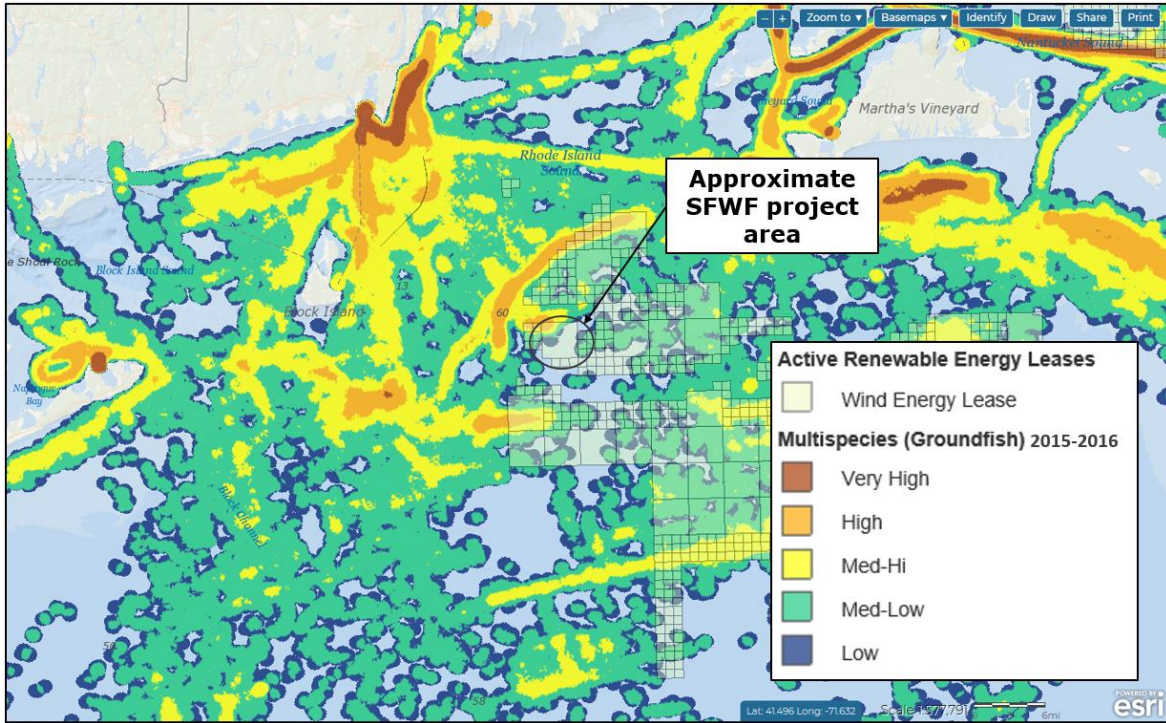
Figure 3-9 Commercial Fishing Traffic Density (Multispecies 2015 – 2016)[24] (overlay added)
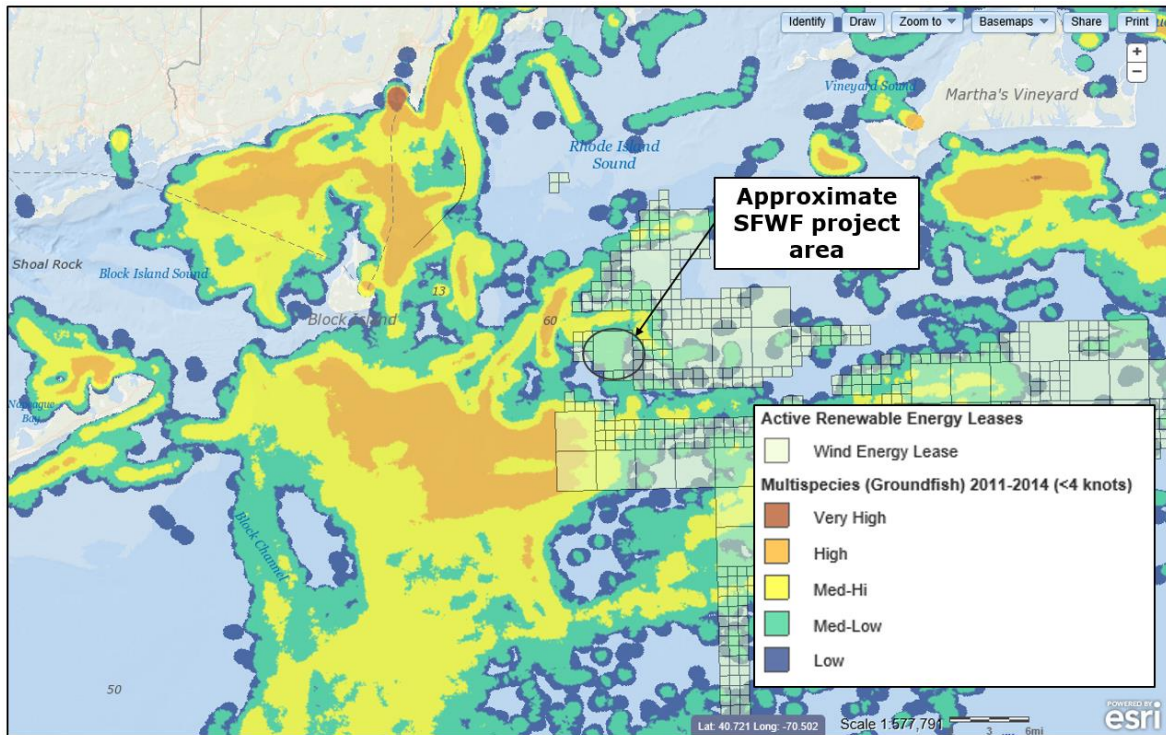
Figure 3-10 Commercial Fishing Traffic Density (Multispecies 2011-2014) for Vessels travelling under 4 knots[24] (overlay added)
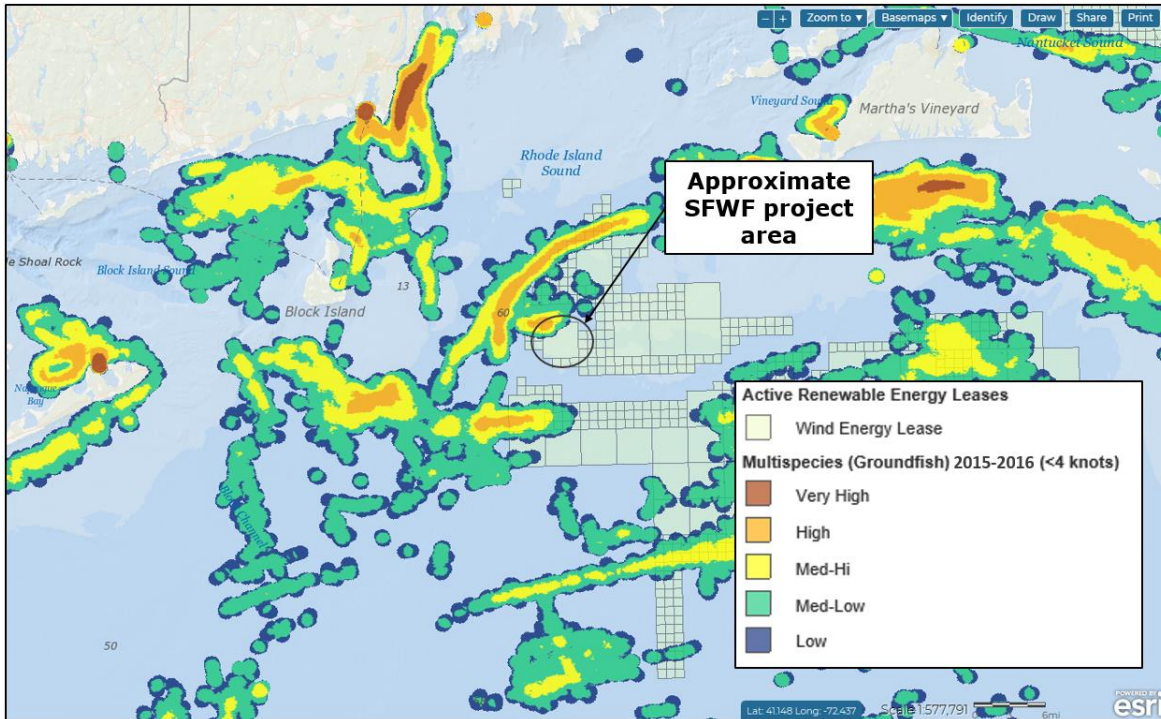
Figure 3-11 Commercial Fishing Traffic Density (Multispecies 2015-2016) for Vessels travelling under 4 knots[24] (overlay added)

Fishing vessel traffic patterns

There are several major commercial fishing ports in the region that berth the majority of vessels that fish the areas near and within SFWF. The main ports include Point Judith and New Bedford.

In Rhode Island, Port Judith is the main commercial fishing port[10]. In addition to commercial fishing vessels, Point Judith is home to recreational fishing vessels[10]. Based on commercial fishing landings, vessels based in Point Judith yield the highest amount of commercial fishery landings for the state of Rhode Island, thus it is expected that most commercial fishing vessels licensed to Rhode Island will transit the project area from/to Point Judith[24]. Of the 179 vessels home ported to Point Judith in 2009, the majority of commercial fishing vessels are bottom trawlers between 45 ft length overall (LOA) and 75 ft LOA[10].

In Rhode Island, recreational fishing vessels, including charter boats, are mainly docked at Point Judith or in the Port of Galilee[10]. Based on a 5-year period between 2001 and 2005, there were a total of 7,709 charter boat trips out of Point Judith[10]. More recent comparable data was not readily available; however, this analysis assumes a steady number of charters since then.

Additional data on fishing trends is available from the Rhode Island Department of Environmental Management Division of Marine Fisheries, who published a Spatiotemporal and Economic Analysis of VMS Data covering the years 2011 through 2016. The data shows relatively constant fishing activity for the 2011-2016 period; however, there is an increase in the non-confidential total landings coming from the Deepwater

Wind lease. This data shows that this increase is due to the scallops caught by dredge and bottom fish caught by otter trawl. It is unknown how this recent trend relates to the number of fishing vessels in 2009.
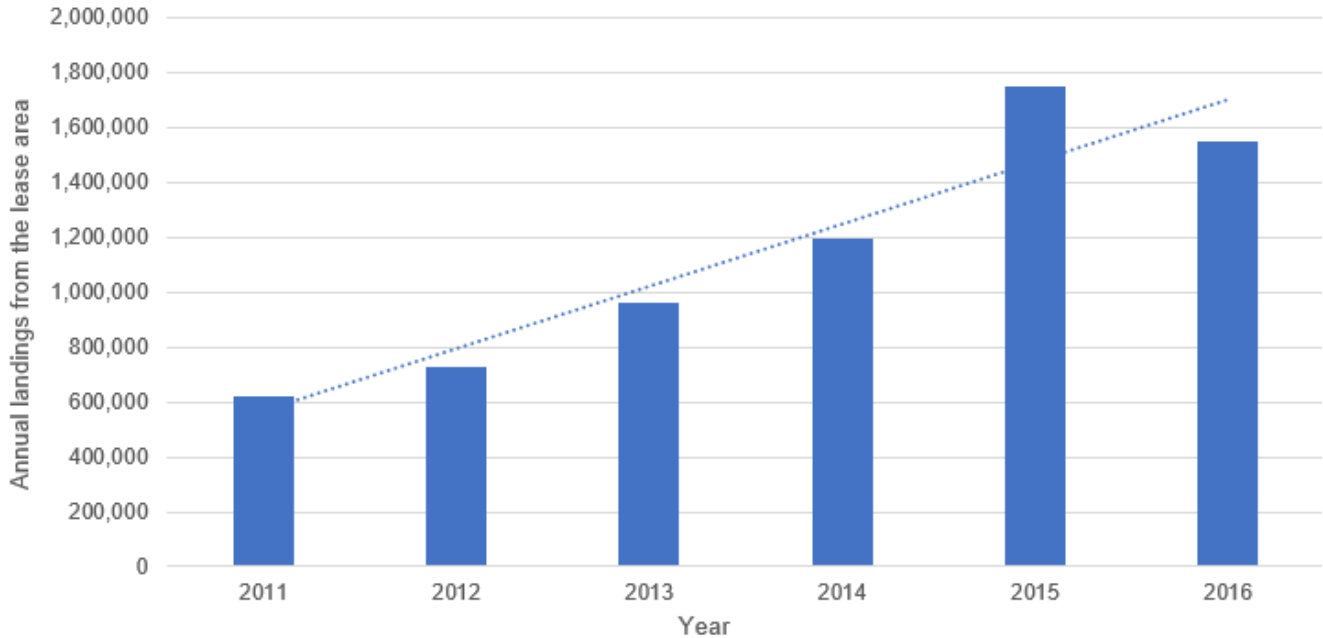
Figure 3-12 Annual landings coming from the Deepwater Wind lease area[28]

In Massachusetts, New Bedford is the primary home port of commercial fishing vessels and yields the largest amount of commercial fishing landings in the region[24]. It is expected that most commercial fishing vessels in the region are docked at New Bedford and travel to/from the project area.

3.1.1.3 Passenger vessel traffic

Passenger vessels are typically very well represented in AIS datasets. As shown in Figure 3-13, passenger vessels (including ferries and cruise ships) tend to strictly follow Narragansett Bay inbound and outbound lanes to/from East Passage. As previously described, this route transits to the west of the project area and diverges south of the study area after the defined precautionary area which consists of vessels operating between Narragansett Bay or Buzzards Bay and an established traffic lane. A smaller percentage of the passenger traffic transits southwest-northeast along the recommended vessel route through Buzzards Bay. Passenger vessels in the study area are typically large vessels (Section 3.1.3), therefore it is expected that most passenger vessels transit routes similar to other deep draft vessels.

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[28] Rhode Island Department of Environmental Management Division of Marine Fisheries, Spatiotemporal and Economic Analysis of Vessel Monitoring System Data within Wind Energy Areas in the Greater North Atlantic. 2017. http://www.dem.ri.gov/programs/bnatres/fishwild/pdf/RIDEM_VMS_Report_2017.pdf
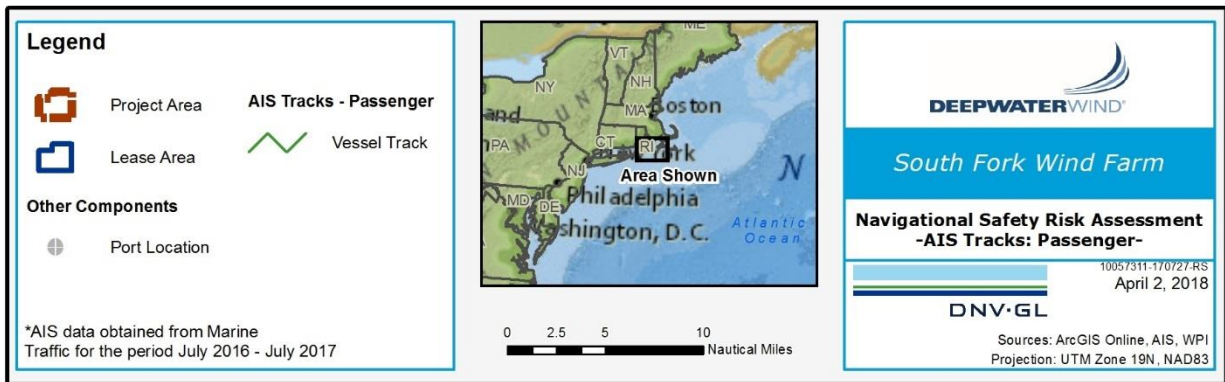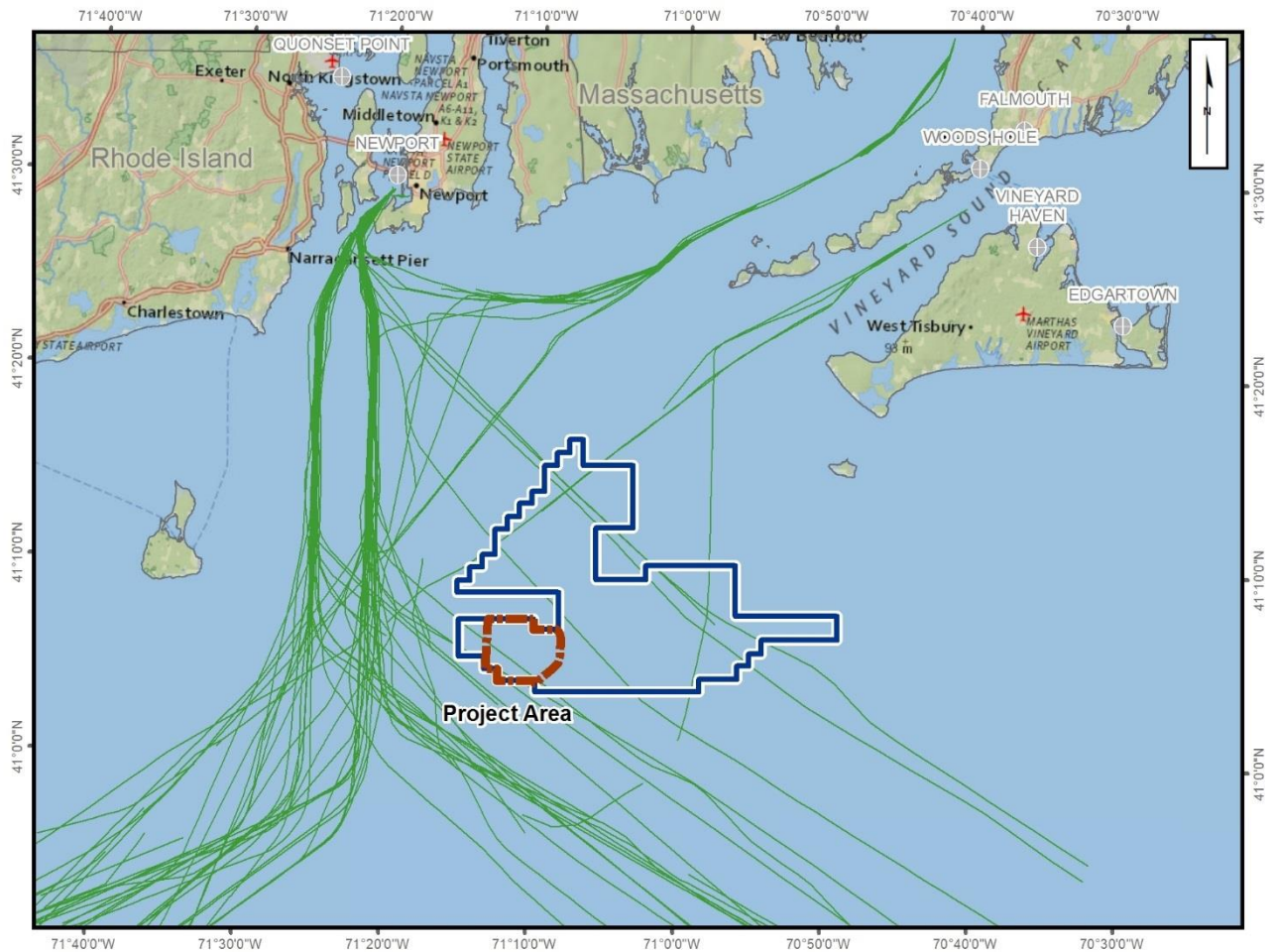
Figure 3-13 AIS tracks for passenger vessels

3.1.1.4 Pleasure and recreation traffic

Pleasure vessels and recreation traffic are mainly concentrated in the northern portion of Rhode Island Sound (Figure 3-14). The AIS data indicates that a small amount of recreation/pleasure traffic transits the project area. To verify and critique the AIS dataset used in this project, DNV GL compared the AIS data to the recreational boating density data from the Northeast Ocean Data Portal.

The data from the Northeast Ocean Data Portal was collected from the 2012 Northeast Recreational Boater Survey, conducted by SeaPlan and the Northeast Regional Ocean Council (NROC)[24]. The density maps from this survey (Figure 3-15) validate the traffic pattern in the AIS dataset and the inference that recreational traffic is low within the SFWF project area. However, it is likely that many of the vessels captured in this survey are not captured in the AIS dataset.

To assure that the most realistic traffic is used in the MARCS model, the survey data to the AIS dataset in the model. The MARCS model is a set of risk parameters and calculation tools that have been developed by DNV GL to help quantify marine risk (see Section 4.1). The method used for calculating the amount of recreational vessel activity is described in Section 4.2.4.1.
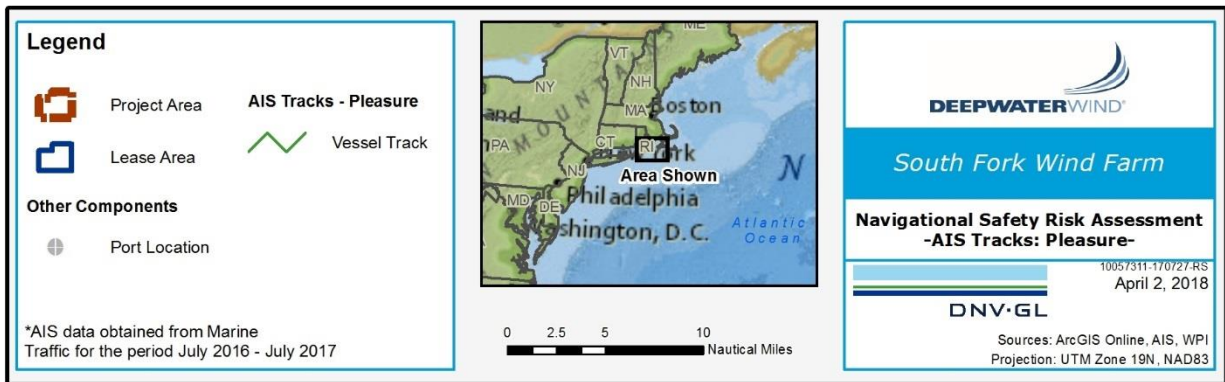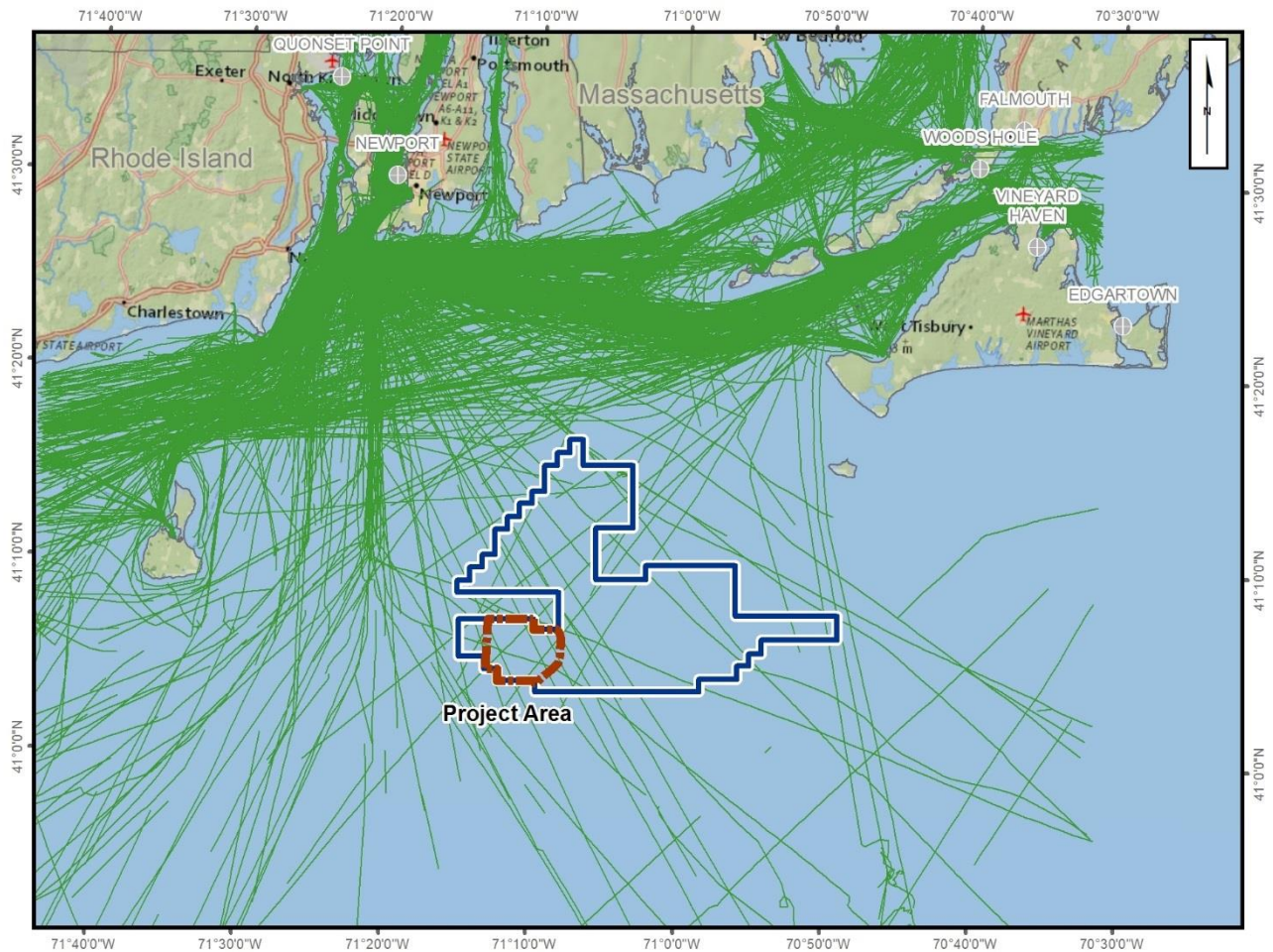
Figure 3-14 AIS tracks for pleasure/recreation vessels
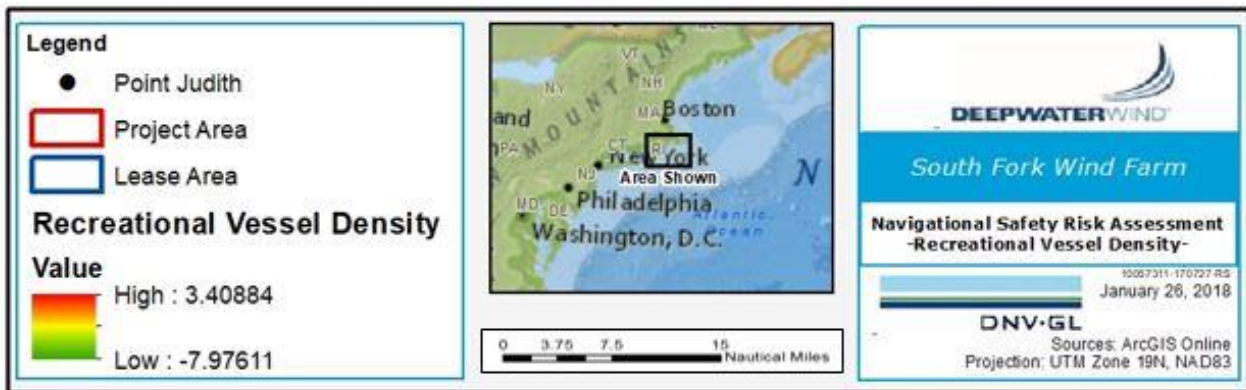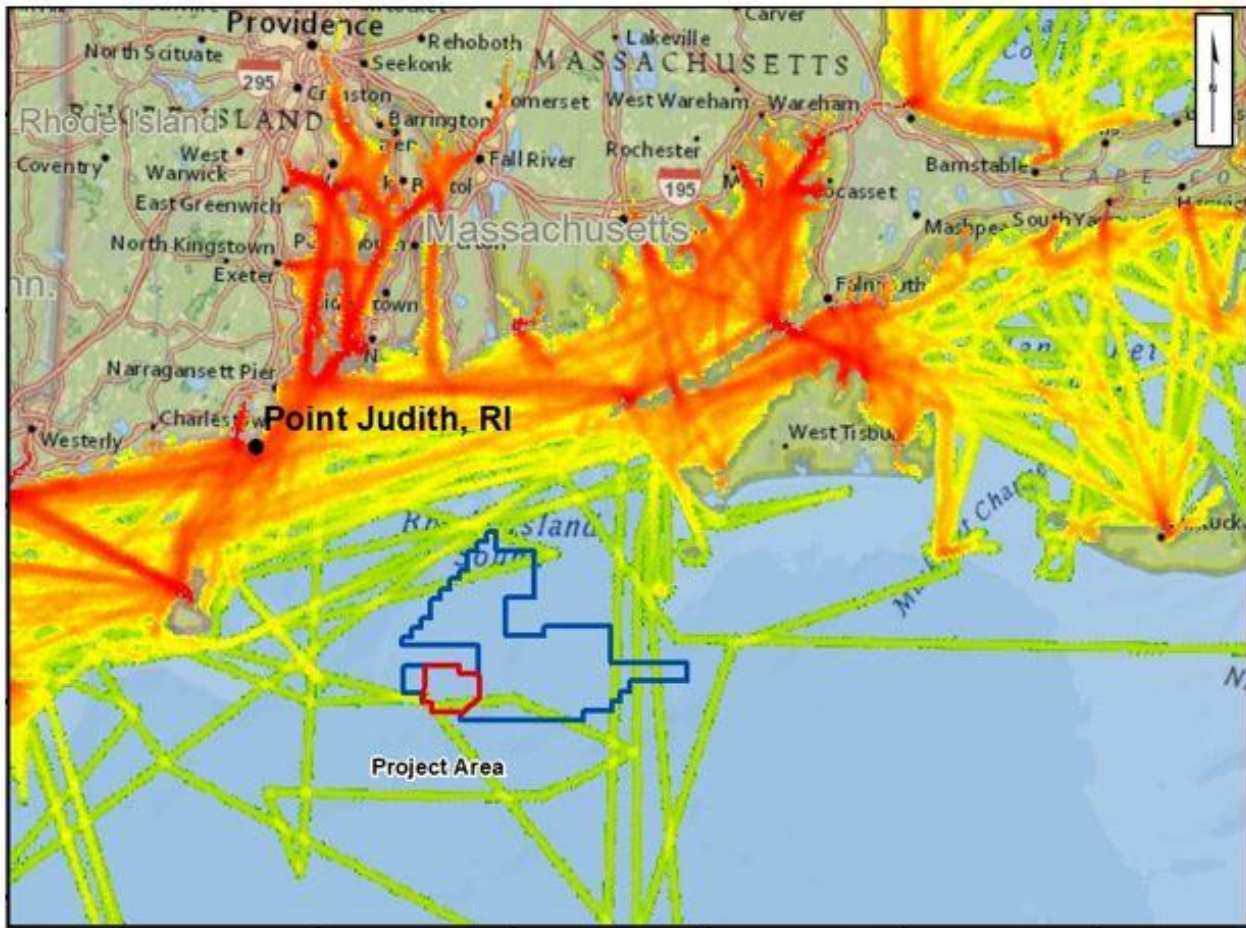
Figure 3-15 Recreational boating density[24]

3.1.1.5 Tug traffic

The AIS tracks for tugs are primarily to the northwest of the lease area, as shown in Figure 3-16. Tugs transit to/from various port locations; the southernmost location is New Harbor in Great Salt Pond on Block Island; other locations are generally north of Point Judith, Rhode Island.
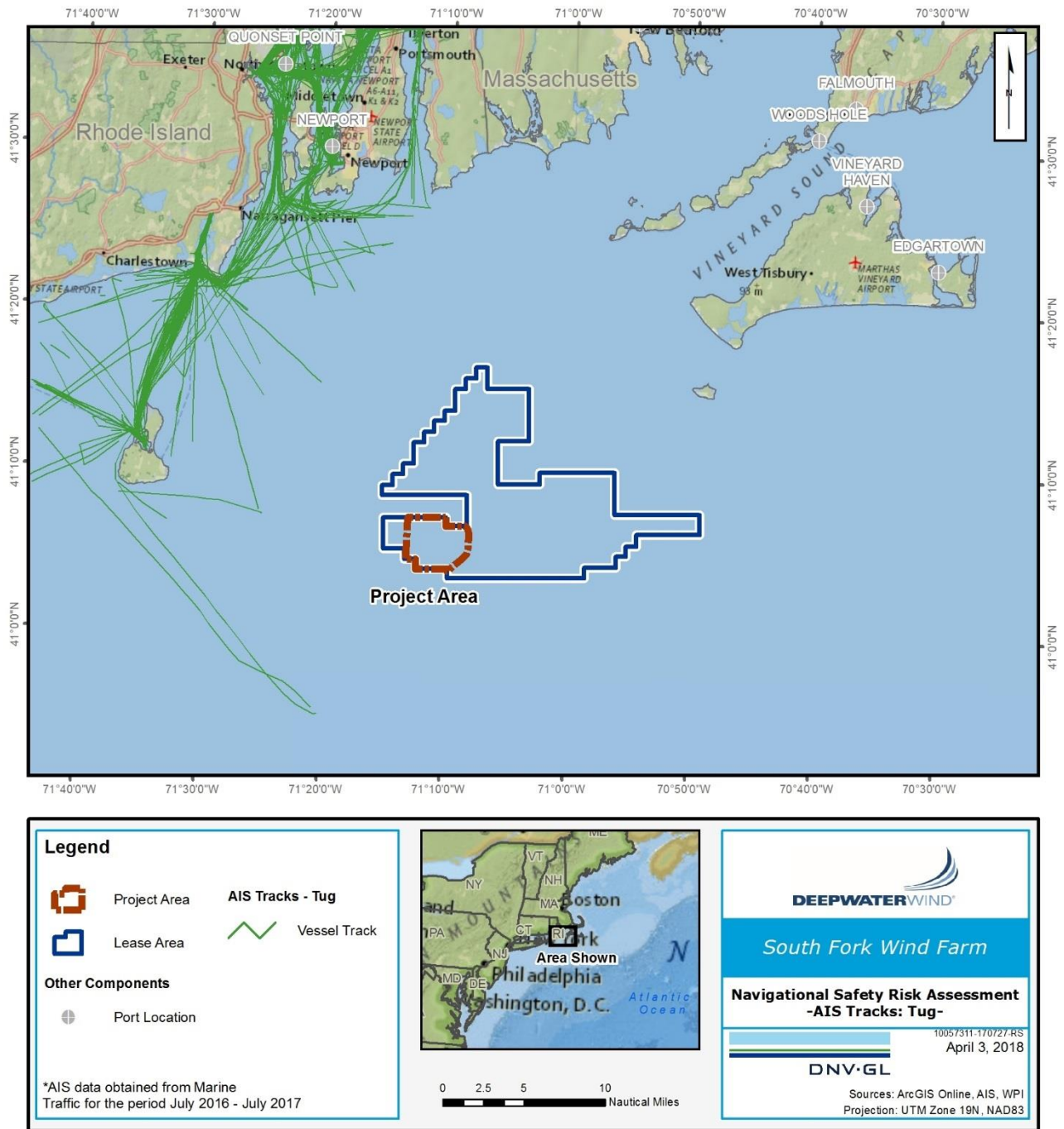
Figure 3-16 AIS tracks for tugs

3.1.1.6 Other vessel traffic

AIS tracks for "Other" vessel types are presented in Figure 3-17. Other vessel types include AIS vessel sub-categories that do not fit well into the defined categories and include research vessels, "special vessels" and drill ships. From the dataset, these vessels appear to rely less on defined shipping channels, but occasionally

transit Narragansett Bay inbound and outbound lanes to the west of the SFWF project area. Areas of tracks are present that indicate systematic vessel movements, which are typical of research vessels.
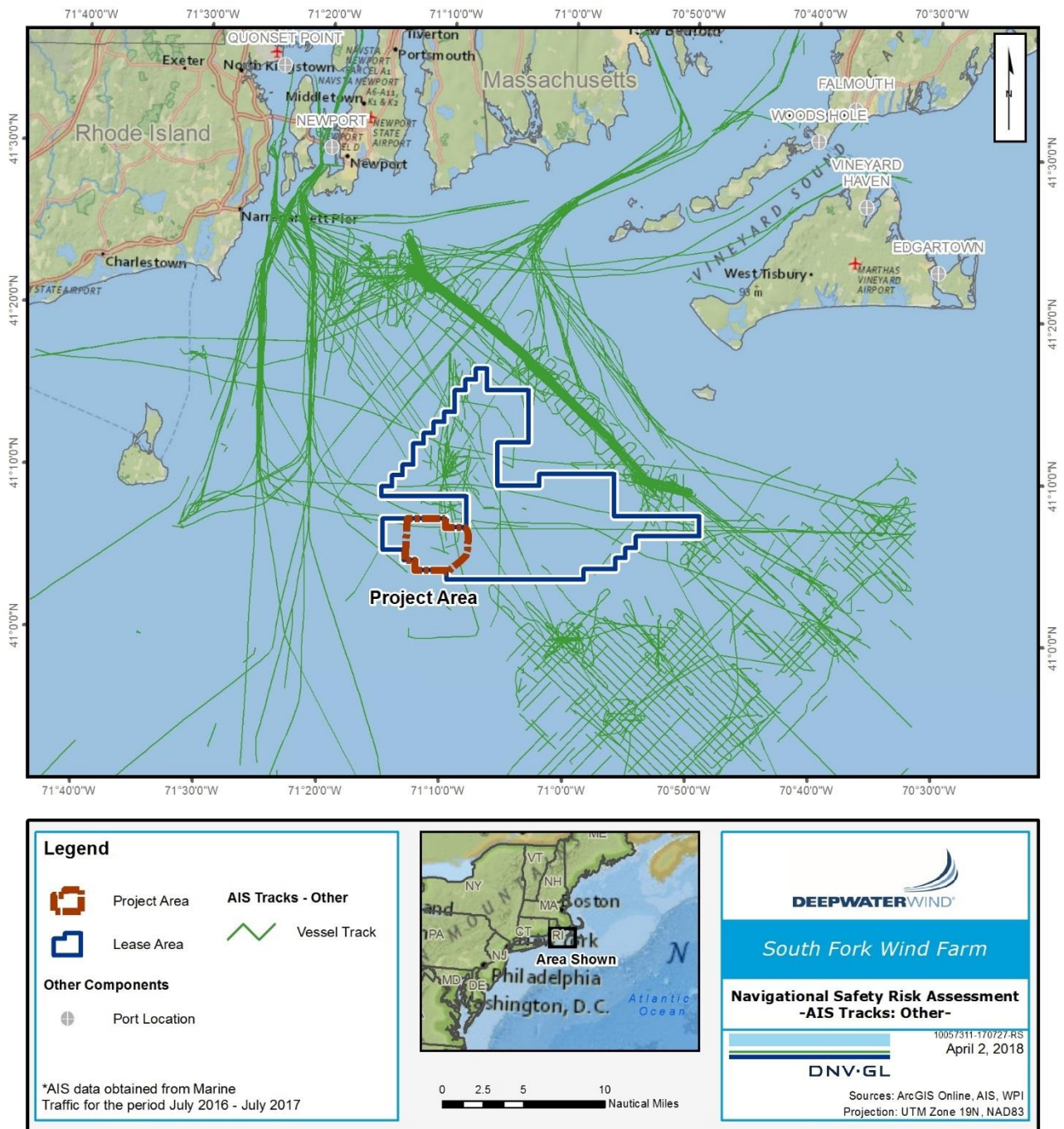
Figure 3-17 AIS tracks for other vessels

The complete set of maps for all vessel tracks in AIS are presented in Appendix A to this NSRA.

3.1.2 Traffic statistics

This section presents the traffic statistics of the study area. The traffic statistics provide insight into where which vessel types are present in the study area. The distribution of vessel types that frequently transit near the lease area were then estimated.

Figure 3-18 defines the cross-sections (transects) used to develop the statistics for the major marine routes. The number of vessels crossing each transect was analyzed per vessel type. Traffic that either passes through or passes near the project area is captured in transects 13, 16, 17, and 18. Transects 2, 3, 5 and 6 may see temporary increases in traffic during SFWF construction.
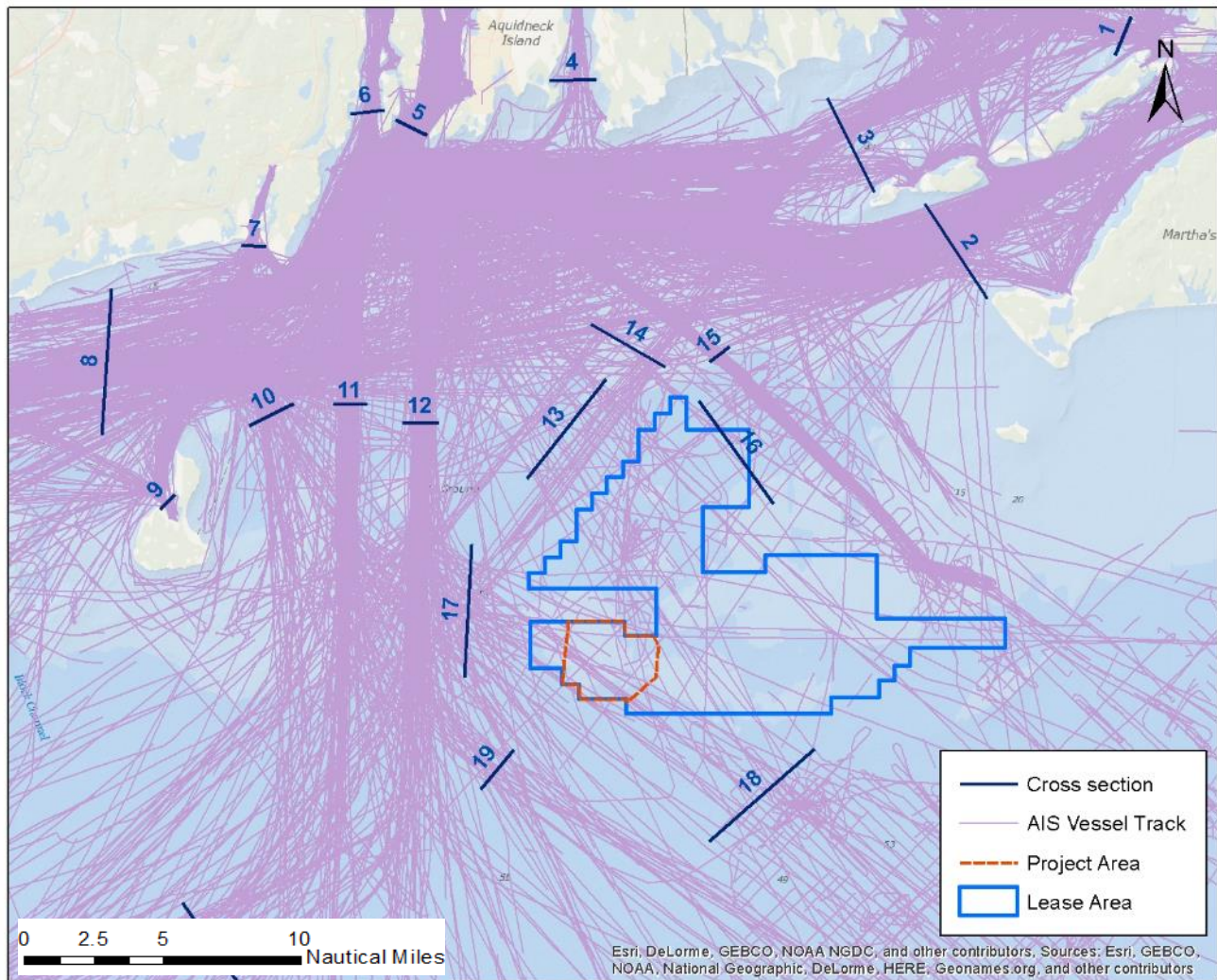
Figure 3-18 Transects used for statistical analysis of traffic

Figure 3-19 lists the total number of vessels crossing each transect (see map in Figure 3-18). Generally low annual traffic counts are seen near the lease area (Cross-Sections 13, 16 and 18), with less than 30 crossings per year. Transect17 has a slightly higher annual traffic count with 60 transits per year. Based on transect 17, many of the vessels headed into the Buzzards Bay inbound traffic lane do not cross through the SFWF lease area.
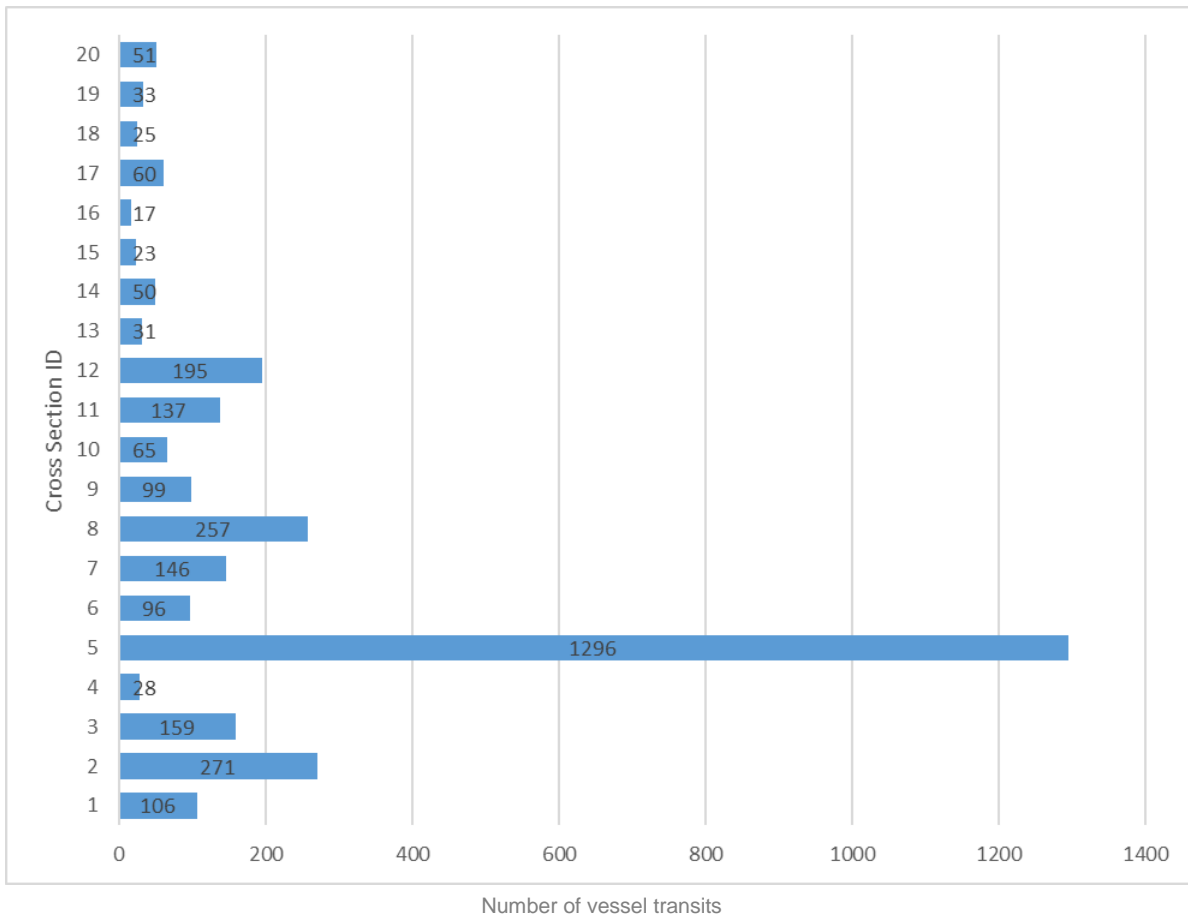
Figure 3-19 Annual number of transits per cross-section (as defined in Figure 3-18)

Figure 3-20 presents the vessel type distribution per cross-section in percentages. Half of the traffic captured by Cross-Sections 13 and 16 is from pleasure/recreation vessels with "other" vessels being the next largest contributor. This is consistent with the traffic patterns shown in the AIS dataset which do not follow defined channels and have slightly erratic tracks. Cross-Section 17, which captures vessels merging in and out of the traffic separation zones, shows 55% of the tracks captured are from deep draft vessels (cargo/carrier and tankers) as expected. Most transits (76%) captured in Cross-Section 18 are from other, passenger, or pleasure vessels. Recreational fishing vessels are likely represented in the "pleasure" category or underrepresented in the AIS dataset. Commercial fishing vessels are underrepresented in the AIS dataset. A full description of the quantitative assessment utilized for commercial fishing vessels is described in Section 4.4.
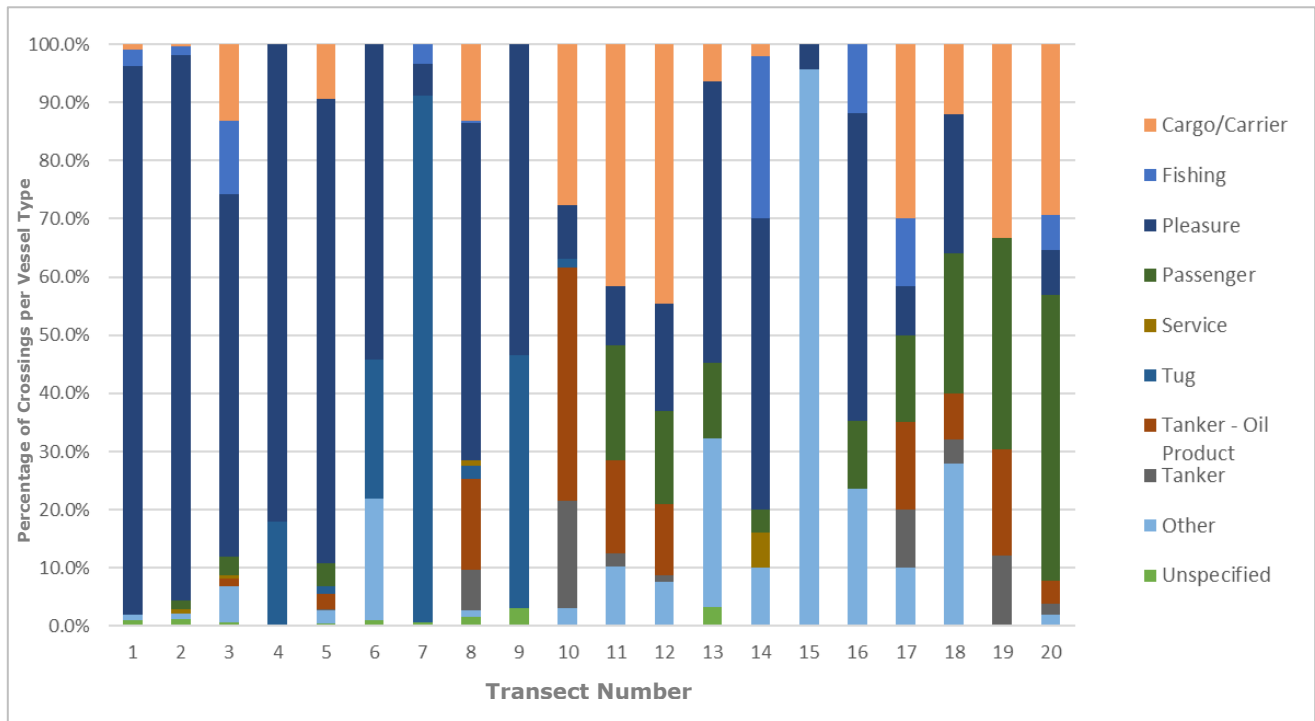
Figure 3-20 Traffic distribution at defined cross sections

3.1.3 Vessel size

This section describes the average vessel size, viewed by vessel type and location: in the study area and within 4.3 NM (5 miles) of the SFWF. For deep draft vessels, the vessel size in the AIS data is likely reasonably accurate. It should be noted that for smaller vessels, the AIS averages may overestimate vessel size since typically only the largest vessels are equipped with AIS transponders.

Table 3-1 presents the average dead-weight tonnage (DWT), length overall (LOA), and beam for vessel types in the study area. Blank cells, indicated by "-", are values for which AIS data for the vessel type did not include that parameter. The data has been color coded for DWT, LOA, and beam, with red indicating the largest value and green indicating the smallest value. As expected, tankers (both with hydrocarbon cargo and non-hydrocarbon cargo) are the largest in terms of DWT, as well as being one of the largest vessel types in terms of LOA. Cargo/carrier, tankers and passenger vessels are the largest in terms of LOA and beam.

Table 3-1 Average DWT, LOA, and Beam for vessel types in study area

Vessel Type	Average DWT	Average LOA	Average Beam
Cargo/Carrier	26,255 metric tons	593.8 ft (181 m)	91.9 ft (28 m)
Fishing	-	75.5 ft (23 m)	23 ft (7 m)
Other	2,113 metric tons	213.3 ft (65 m)	45.9 ft (14 m)
Passenger	6,649 metric tons	613.5 ft (187 m)	88.6 ft (27 m)
Pleasure	183 metric tons	82 ft (25 m)	19.7 ft (6 m)
Service	-	128 ft (39 m)	23 ft (7 m)
Tanker	46,314 metric tons	587.3 ft (179 m)	98.4 ft (30 m)
Tanker - Oil Product	52,732 metric tons	620.1 ft (189 m)	105 ft (32 m)
Tug	-	-	-
Unspecified	-	95.1 ft (29 m)	26.2 ft (8 m)

Geospatial analysis was used to identify the average size of vessels near SFWF. Table 3-2 presents the average DWT, LOA, and beam for vessels within 4.3 NM (8.0 km) of SFWF. Again, tankers (regardless of cargo type) are the largest in terms DWT, while passenger vessels are largest in terms of LOA and beam.

A review of the data showed that all passenger vessels within 4.3 NM (8.0 km) of SFWF are cruise ships. Smaller passenger vessels and ferries travel closer to shore; only the large cruise vessels travel in open water near SFWF project area. Therefore, the average size of passenger vessels is larger near the project area than for the entire study area.

Table 3-2 Average DWT, LOA, and Beam for Vessel Types within 4.3 NM (5 miles) of SFWF

Vessel Type	Average DWT	Average LOA	Average Beam
Cargo/Carrier	30,382 metric tons	597.1 ft (182 m)	95.1 ft (29 m)
Fishing	-	85.3 ft (26 m)	26.2 ft (8 m)
Other	1,561 metric tons	210 ft (64 m)	42.7 ft (13 m)
Passenger	8,779 metric tons	889.1 ft (271 m)	118.1 ft (36 m)
Pleasure	86 metric tons	118.1 ft (36 m)	23 ft (7 m)
Tanker	47,802 metric tons	600.4 ft (183 m)	98.4 ft (30 m)
Tanker - Oil Product	57,429 metric tons	633.2 ft (193 m)	108.3 ft (33 m)
Unspecified	-	-	-

3.1.4 Traffic speed

This section characterizes vessel speeds in the study area. Figure 3-21 presents the speed profile based on the AIS data. The speed is calculated by looking at the time and distance between successive AIS points to calculate the speed. In the study area, the majority of vessels sail between 8 and 12 knots (between 4 and 6 m/s). Appendix A to this NSRA includes the traffic speed profiles for each vessel type.
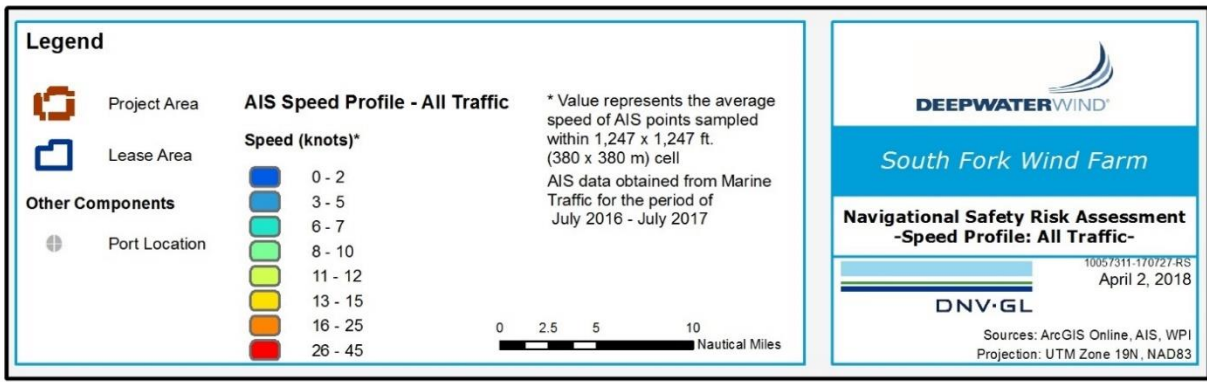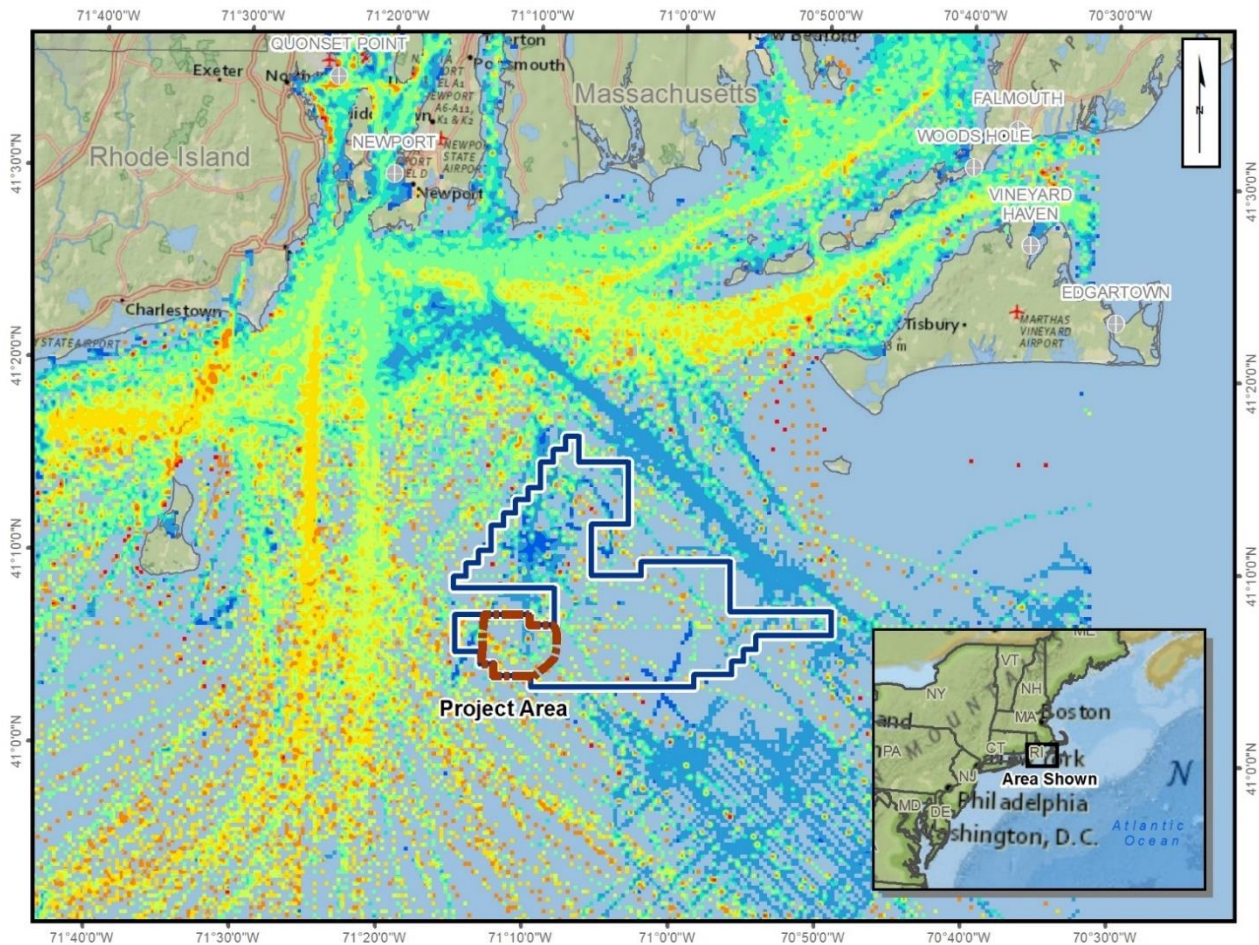
Figure 3-21 Speed profile of entire AIS dataset

3.2 Potential disruption of traditional waterway uses

Given the project location relative to major commercial shipping lanes (not including commercial fishing), no significant disruption of the normal traffic patterns is expected during construction, operation, or

decommissioning of SFWF. The number of vessels that operate for SFWF construction and decommissioning phases is expected to be a negligible risk addition to current traffic patterns described in this section.

Most construction vessels are expected to transit from local ports SFWF construction is anticipated to take place in work windows for specific construction activities that will limit the number of vessels introduced to the local traffic at one time. Potential tasks to be completed individually in a work window include WTG jacket foundation installation, offshore cable line installation and final WTG installation.

The vessels that are anticipated to be present during construction of SFWF include construction barges, support tugs, jack-up rigs, supply/crew vessels and cable laying vessels. These vessels will also be present in the region during decommissioning of SFWF. The highest navigation risk during construction will be smaller vessels operating in close proximity to construction and work vessels during construction. This risk is mitigated by a safety zone that is anticipated to be implemented by USCG during construction operations. This precedent was set during construction of Block Island Wind Farm (BIWF) and successfully protected mariners during the construction phase. Based on this precedent, it is expected that 500-yard safety zones will be established during construction around each location where the SFWF WTG towers, nacelles, blades and subsea cables will be installed in navigable waters[29]. The intention of establishing safety zones is to safeguard mariners from the hazards associated with construction of SFWF[29].

The safety zone is expected to prohibit the following action on precedent:

> This regulation prohibits vessels from entering into, transiting through, mooring, or anchoring within safety zones which construction vessels and associated equipment are working on site at one or more of the SFWF WTG sites, unless authorized by the Captain of the Port (COTP), Southeastern New England or the COTP's designated representative[29].

The dates in which the safety zones are likely to be implemented are pending and will be dependent on SFWF project schedule and duration of the expected construction phase.

3.3 Pilots perspective of SFWF impact on commercial navigation

In addition to reviewing and analyzing data sources, DNV GL reached out to the Northeast Marine Pilots Association to informally capture their view on the potential impact of SFWF to commercial traffic[30]. SFWF is not located in pilotage waters, however, the opinion of experienced pilots is important to capture a realistic view of traffic in the area.

The opinion shared with DNV GL is that SFWF is not expected to have a significant impact on commercial traffic in the region, during construction, operation, or decommissioning. SFWF is located far enough from commercial traffic lanes that with proper navigational marking, it is not expected to pose any negative effects on commercial traffic.

The Pilots do not anticipate any issues or impacts on navigation regarding the proposed SFWF cable route[30].

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[29] Federal Register: Safety Zone, Block Island Wind Farm; Rhode Island Sound, RI. 81 FR 31862
[30] Personal communication. DNV GL and Northeast Marine Pilots. October 18, 2017.

4 COLLISION, STRIKING, AND GROUNDING ASSESSMENT

This section presents the assessment of collision, striking, and grounding in the study area. Per NVIC 02-07, the risk of collision, striking (allision), or grounding due to SFWF structures should be conducted. The risk assessment includes a frequency of each event and a 'what if' consequence analysis. The frequency assessment is a method to determine how often an event is estimated to happen. The consequence analysis will discuss how severe an event could be if it happens.

To accurately describe the impact of SFWF on navigation, two cases are modeled for comparison. The Base Case presents the current conditions of the study area. The Base Case estimates the collision and grounding frequencies of vessels following normal traffic patterns. Striking scenarios cannot occur in the Base Case as SFWF WTGs and structures are not present. The second case, the Future Case with SFWF, estimates the anticipated future conditions of the study area. The Future Case incorporates the SFWF WTGs and structures, traffic redistribution due to SFWF, and any anticipated increases in traffic due to SFWF. The Future Case estimates the frequency of a collision, grounding, and striking SFWF structures. Per NVIC 02-07 recommendations, a 'what if' consequence analysis was conducted for the Future Case.

Table 4-1 Summary of Cases

Case	Considerations
Base Case	- 2016-2017 AIS dataset - Traffic adjustments to recreational/pleasure vessels
Future Case with SFWF	- 2016-2017 AIS dataset - Traffic adjustments to recreational/pleasure vessels - Traffic adjustments to excursion traffic - Re-distribution of traffic lanes for deep draft vessels - Implementation of SFWF structures

The Base Case and Future Case are modelled in DNV GL's proprietary Marine Accident Risk Calculation System (MARCS) software. The MARCS model is described in Section 4.1 and detailed further in Appendix B to this NSRA. The MARCS model has been utilized globally by DNV GL to determine the navigation risk of more than 15 wind farms.

All fishing vessels captured in the AIS dataset are included in the MARCS modelling. As previously described, a separate analysis was conducted to fully capture the effect of SFWF on fishing vessels that are not included in the AIS dataset, both commercial and recreational, transiting through the project area. The probability of collision between commercial fishing vessels and striking SFWF WTGs was estimated. Several scenarios and the methodology used are described in Section 4.4.

4.1 MARCS description

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 incidents 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 striking, where a ship strikes a man-made structure (i.e., WTG) due to human error (steering and propulsion not impaired).

- Drift striking, where a ship strikes a man-made structure (i.e., WTG) due to mechanical failure (steering and/ or propulsion failure).

The frequency of each incident type is calculated for the grid cells of study area for each incident type and each ship type.

The data flow through the model is shown in Figure 4-1.
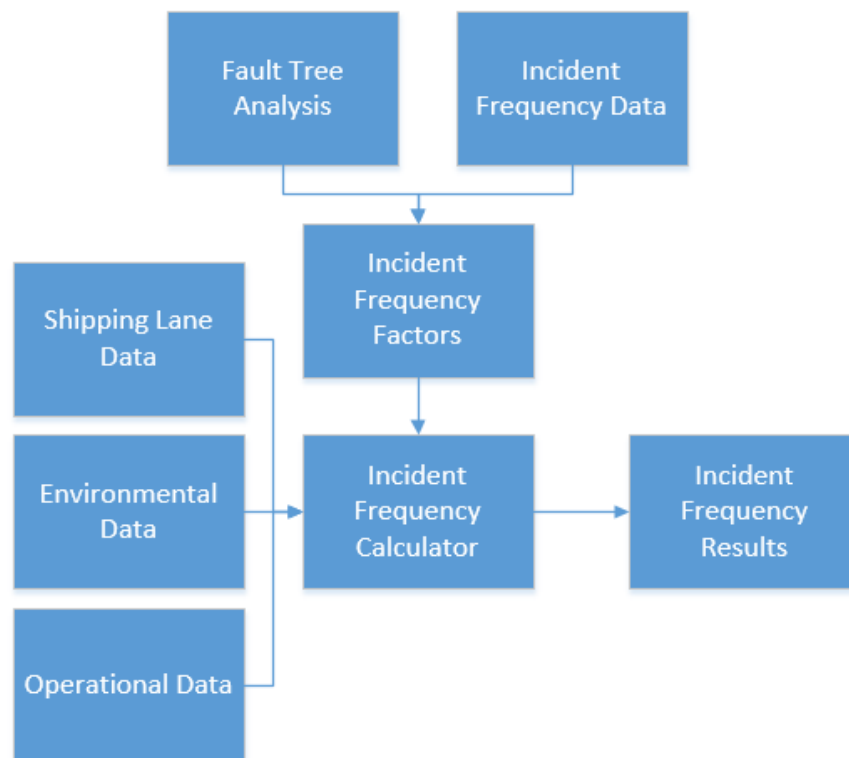
Figure 4-1 Summary of data flow through MARCS

Three general types of data are input to represent local conditions in the model:

- Shipping data to represent which ships, of which size and type trade.

- Environmental data to represent the environment in which the ships trade. This includes coastline data, man-made object data (e.g., offshore platforms, WTG), visibility data, wind data, etc.

- Operational data to represent how shipping operations are performed. This includes ship speed data, use of pilots, use of Vessel Traffic Services, etc.

The calculations are performed for a specific study area. The study area is determined using expert judgement to capture marine events that may affect the area of interest.

MARCS calculates the frequency of collision, grounding, and striking for each cell defined by a grid covering the study area. The average annual frequency of occurrence is calculated separately for each incident type. A detailed description of the collision, grounding (drift and powered) and striking (drift and powered) models is included in Appendix B to this NSRA.

For the scope of this work, the MARCS model estimated the average annual rate describing how often a collision, grounding or collision might occur. The incident rates with and without the SFWF are compared to estimate the incremental increase in risk from the SFWF.

4.2 MARCS inputs

4.2.1 Study area

In alignment with NVIC 02-07 guidance, it is critical to choose a large enough study area to capture any variations in grounding frequencies due to implementation of SFWF. Since, SFWF is located in open water, a large study area is required for this assessment. The study area utilized in the MARCS model is presented in Figure 4-2.
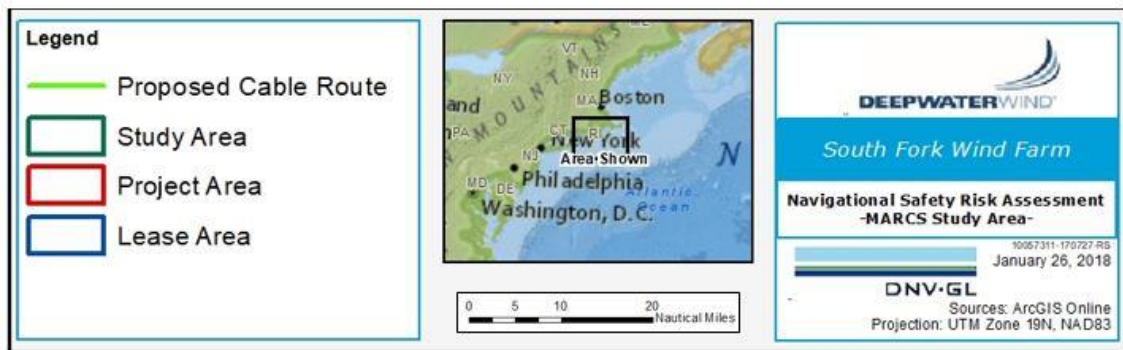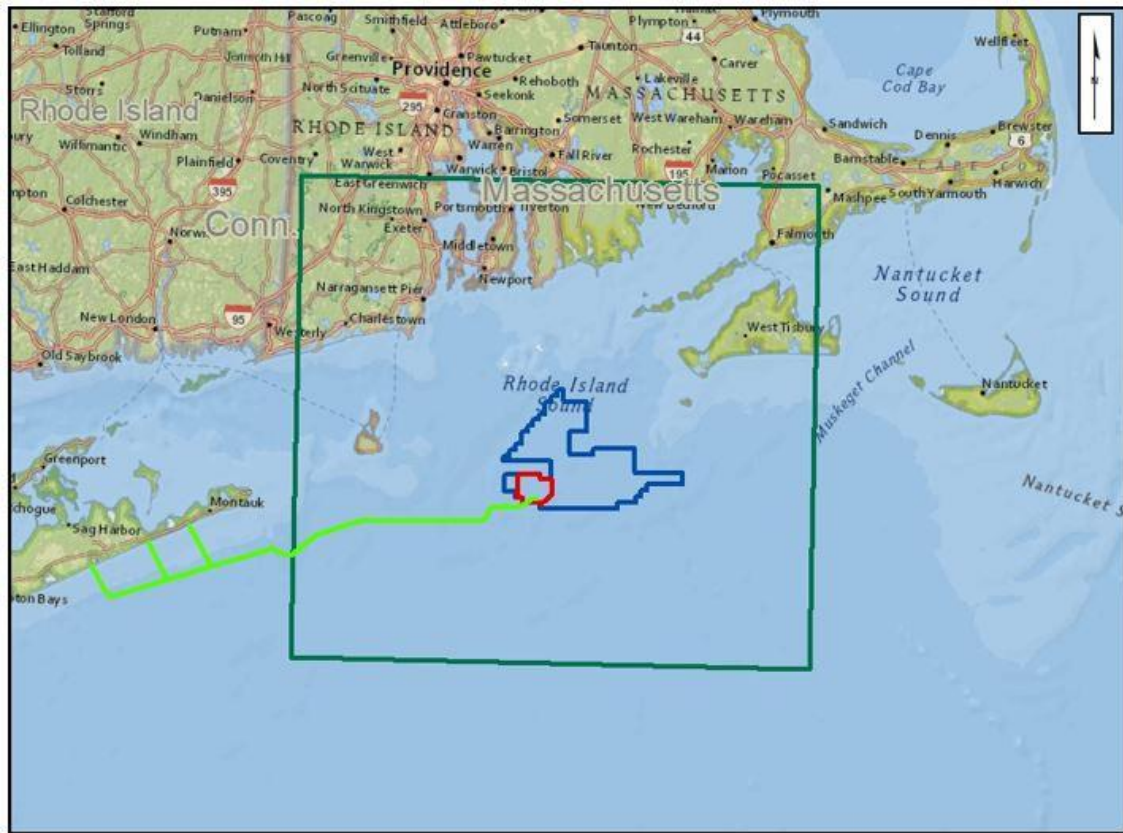
Figure 4-2 Quantified risk study area

4.2.2 Metocean inputs

The metocean inputs utilized in MARCS are consistent with the weather described in Section 2, and are described in greater detail below.

4.2.2.1 Wind

MARCS uses the wind speed and direction as a modelling input. Table 4-2 shows the wind data formatted for MARCS: eight directions (North, Northeast, East, Southeast, South, Southwest, West and Northwest) and four speed categories (Calm, Fresh, Gale and Storm). Additional discussion of wind conditions at the site is give in Section 2.2.1 herein).

Table 4-2 Annual Wind Probabilities used in MARCS

Wind Speed in knots	N	NE	E	SE	S	SW	W	NW	Total
< 20 (Calm)	0.07	0.08	0.07	0.06	0.10	0.21	0.12	0.10	0.81
20 – 30 (Fresh)	0.02	0.02	0.01	0.01	0.01	0.02	0.03	0.05	0.16
30 – 45 (Gale)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
> 45 (Storm)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	0.09	0.10	0.08	0.07	0.12	0.24	0.15	0.15	1.00

4.2.2.2 Visibility

The Journal of Navigation's information regarding marine traffic studies[31] defines poor visibility as beginning at 2.2 NM (4.0 km). Visibility was therefore assesses as either poor , less than 2 NM (3.7 km) or good, greater than 2 NM. Table 4-3 presents the visibility data assessed for use in the MARCS model (see additional discussion of visibility in previous Section 2.2.2).

Table 4-3 Visibility data inputs for MARCS modelling

Visibility in NM	Frequency	Modeled Visibility
< 1	4.8%	Bad visibility = 6.8% of an average year
1 - 2	2.0%	
2 - 3	2.6%	Good visibility = 93.2% of an average year
3 - 4	1.4%	
4 - 5	2.6%	
5 - 6	1.0%	
6 - 7	3.8%	
7 - 8	2.0%	
> 8	79.9%	
Total	**100.0%**	

4.2.2.3 Sea state

A designation of "open water" in MARCS allows a higher speed transfer from the wind to the waves than "semi-sheltered" or "sheltered" waters. 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 lease area is located far from the shoreline: 15 NM (28 km) from Block Island and almost 19 NM (35 km) from the main land.

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

4.2.2.4 Shoreline

Figure 4-3 illustrates the shoreline used in MARCS. The defined shoreline identifies possible grounding locations for the model.
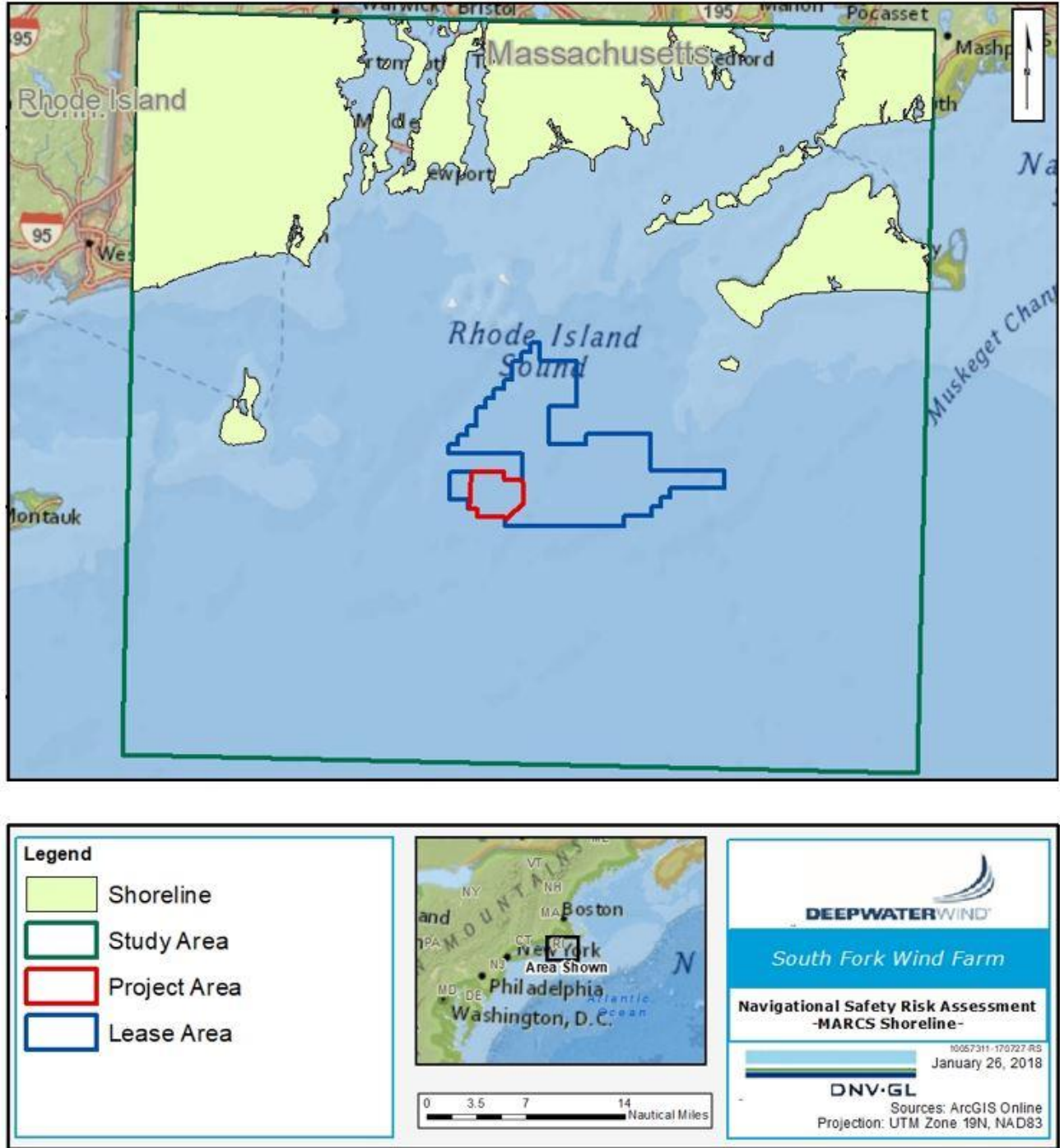
Figure 4-3 Shoreline utilized in MARCS

4.2.3 Operational Inputs

The MARCS model can apply different risk reduction options to a specific type of traffic and/or area. The risk controls applied to vessels transiting are described in Table 4-4. This table show which risk controls are applied based on vessel types and areas.

Table 4-4 Risk controls applied in MARCS modelling for the study area

Risk Reduction Option	Cargo/Carrier, Tanker and Passenger Vessels		All Other Traffic
	Study Area except Rhode Island Sound / Block Island Sound	Rhode Island Sound/ Block Island Sound	
Vessel Traffic Services	Yes	Yes	Yes
Pilotage	No	Yes	No
Portable Pilotage Unit	No	Yes	No
Differential Global Positioning Systems	Yes	Yes	No
Conventional Aids to Navigation	Yes	Yes	Yes
Electronic Chart Display and Information System	Yes	Yes	No
Port State Control	Yes	Yes	No
Underkeel Clearance Management	No	Yes	No

Figure 4-4 below presents the areas where specific risk reductions different from the study area were used in the MARCS model. No risk reductions different than the ones in the study area were identified in Buzzards Bay.
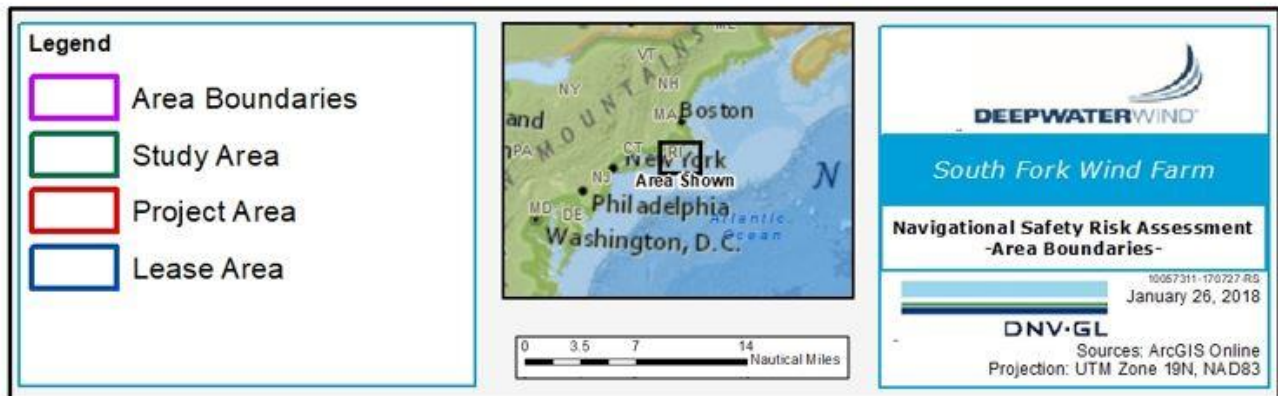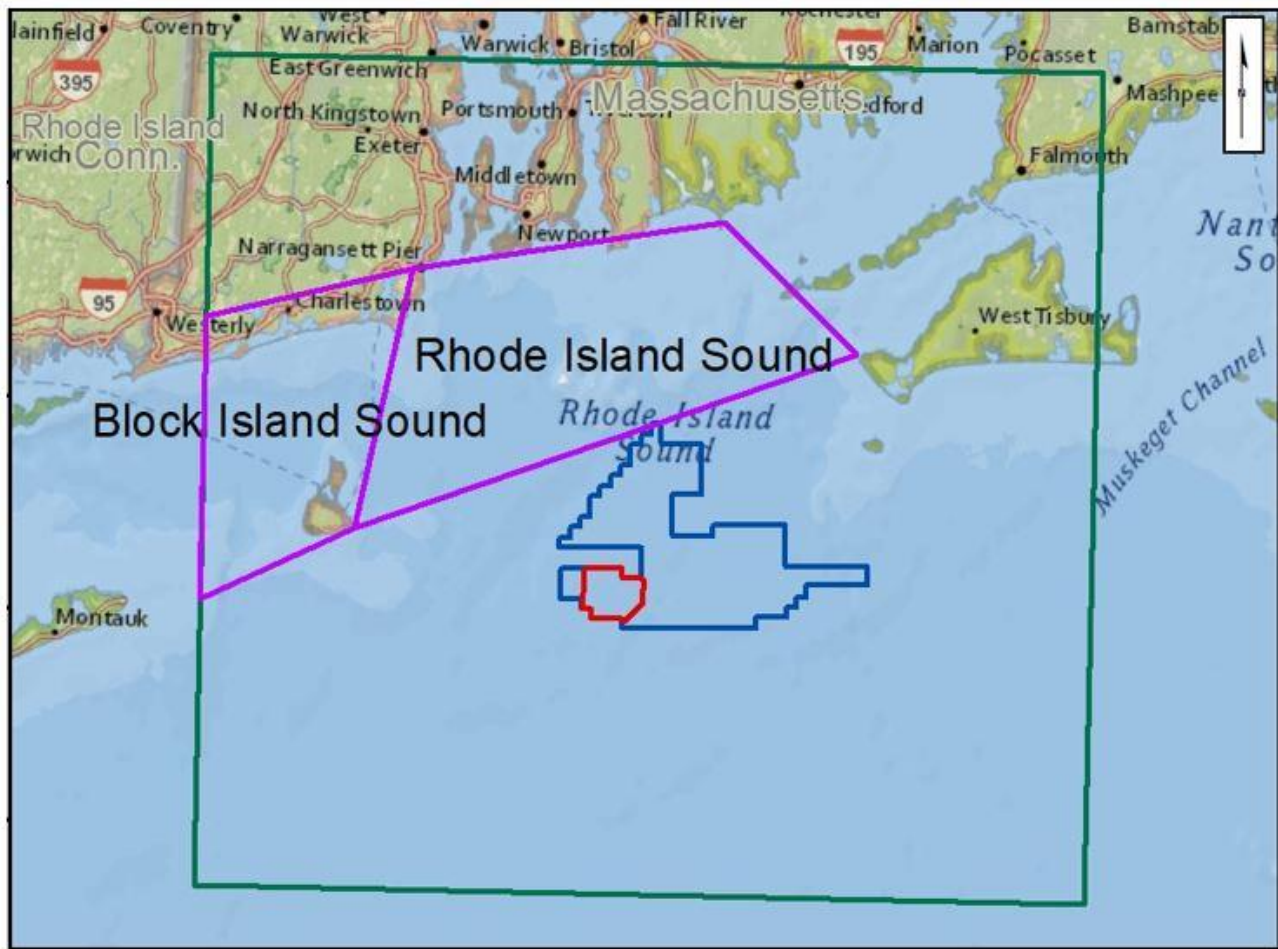
Figure 4-4 Risk Reduction Area Boundaries

Per Rhode Island Code § 46-9-2 and § 46-9.1-5, DNV GL applied pilotage to vessels in the method most appropriate for modelling purposes. Pilots have been applied and quantified in MARCS for deep draft and passenger vessels in Rhode Island Sound and Block Island Sound.

4.2.4 Traffic adjustments

To achieve the most realistic results possible, adjustments to the AIS traffic were made for recreational, pleasure and passenger vessels.

4.2.4.1 Recreational fishing and pleasure craft

The adjustments for recreational fishing and pleasure craft were implemented into both the Base Case MARCS model and Future Case MARCS model with SFWF.

The AIS dataset is a reliable resource for capturing the main traffic patterns and vessels equipped with AIS transmitters. However, based on USCG regulation, not all vessels are required to have AIS on board. To achieve the most realistic results for the study area, special care was placed on estimated recreational and fishing vessel traffic that may not have been captured in the AIS dataset.

Figure 4-5 presents the Northeast Recreation Boater Activities downloaded from the Northeast Ocean Data portal. The activities presented in the figure are from participants in the 2012 Northeast Recreational Boater survey, conducted by SeaPlan, the Northeast Regional Ocean Council (NROC), states' coastal agencies, marine trade association of industry representatives, and the First Coast Guard District[32]. The data is from a randomly selected survey of registered boaters in the 2012 boating season[32].

For each of the 941 registered activities in the data, a transit to and from the stated location was added to the traffic data in the model. The activities labelled "Recreational Fishing Activities" in the dataset were added to the *Fishing* ship type and all non-fishing activities were added to the *Pleasure* ship type. Within the study area, about half of the activities were recreational *fishing* activities and the other half were from *other* recreational activities.

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[32] SeaPlan, "Recreational Boater Activities"
http://www.northeastoceandata.org/files/metadata/Themes/Recreation/RecreationalBoaterActivities.pdf.
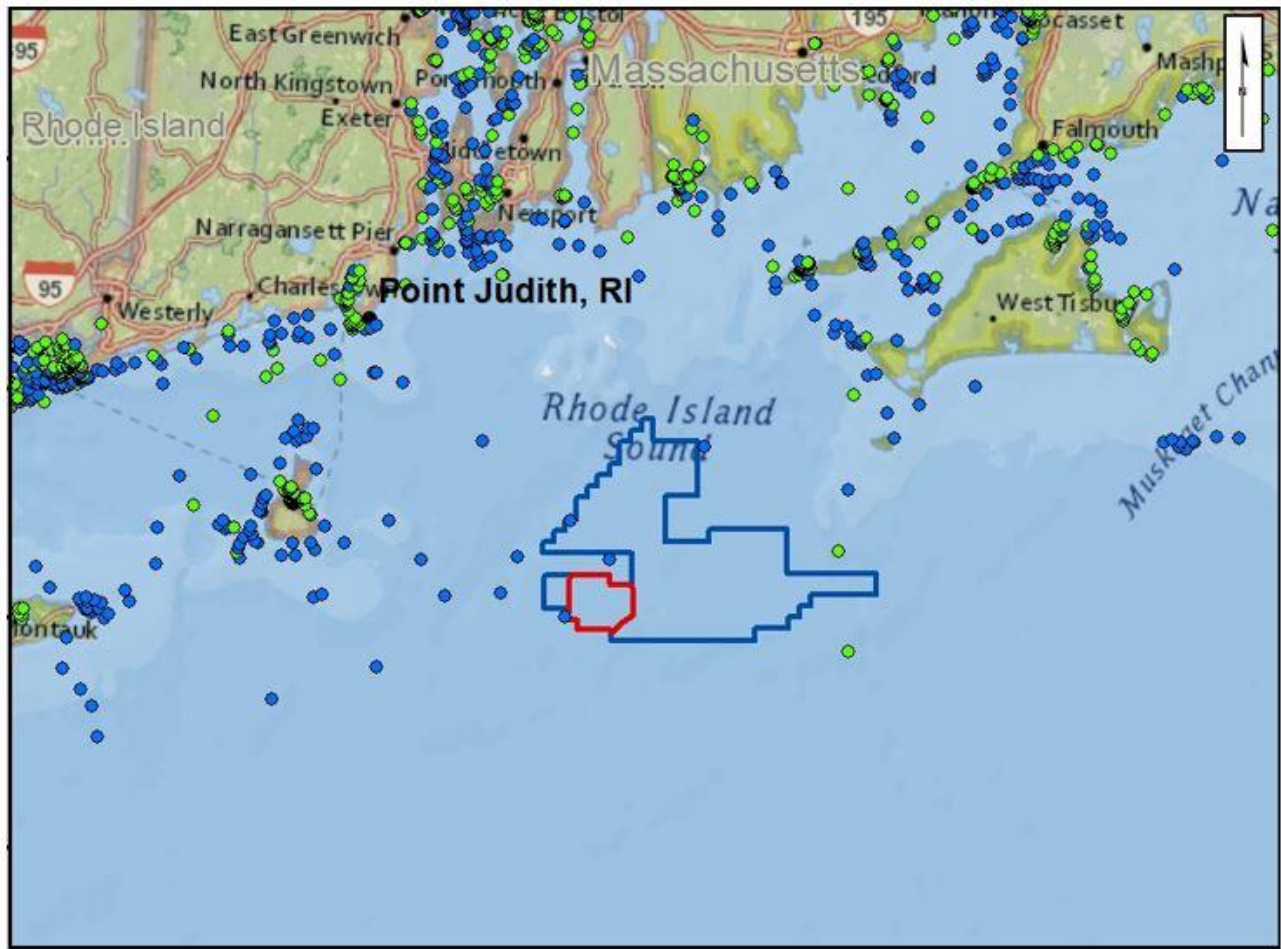
Figure 4-5 Northeast recreational boater activities[24]

4.2.4.2 Future Passenger and Recreational vessels

The adjustments described in this section are to the Future Case MARCS model, with SFWF.

It is anticipated that there will be public interest in SFWF that could potentially lead to ferry 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 SFWF, it is assumed that there will be 100 vessels per year. This is a conservative estimate for the first operational year of SFWF. It is anticipated that as time passes, there will be less traffic due to wind tours and the increase in vessels may diminish. This study aims to present the conservative case with the most possible traffic, as opposed to an average traffic scheme over a longer period. This increase is included in the Passenger vessel category.

4.3 MARCS marine incident frequency results

This section presents the MARCS model frequencies for the Base Case and the Future Case with the addition of SFWF.

Per NVIC 02-07 recommendations, the NSRA should address the difference in collision and grounding due to the implementation of SFWF, in addition to the risk of striking a WTG. The approach used in this assessment was to model a Base Case without SFWF and a Future Case with SFWF and compare the two. The difference between the Base Case and the Future Case represents the estimated effect of SFWF on how often collision, grounding and striking events might occur.

4.3.1 Base case

The Base Case results are the baseline of annual frequencies of marine incidents. The Base Case year is based on July 2016 – July 2017 AIS data with corrected (additional) recreational fishing and pleasure vessels.

Note that the "Fishing" vessel type includes:

- All recreational and commercial fishing vessels in the AIS dataset described in Section 3.1.1.2, and

- The recreational fishing vessels captured by the method described in Section 4.2.4.1.

For those commercial fishing vessels not captured in the AIS dataset, a separate analysis is presented in Section 4.4.

Table 4-5 presents the incident frequencies for each ship type and for each incident type. Table 4-6 shows the same results, but in terms of return periods. For example, a fishing vessel collision incident has an annual frequency of 0.001 from Table 4-5. This is equivalent to a collision happening 1 in every 1,800 years (Table 4-6). The higher the return period, the less frequently an event is estimated to occur. A higher average return period indicates an expectation that a longer period of time will pass between events.

Table 4-5 Annual incident frequencies for all traffic in the study area

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Striking	Drift Striking	Total
Cargo/Carrier	<0.0005	0.022	0.009	-	-	0.031
Fishing	0.001	0.063	0.033	-	-	0.097
Other & Undefined	0.050	4.970	1.780	-	-	6.810
Passenger	<0.0005	0.012	0.003	-	-	0.015
Pleasure	0.002	0.346	0.105	-	-	0.454
Tanker	<0.0005	0.001	0.001	-	-	0.002
Tanker – Oil	<0.0005	0.005	0.003	-	-	0.008
Tug & Service	<0.0005	0.010	0.001	-	-	0.011
Total	**0.053**	**5.43**	**1.94**	**-**	**-**	**7.42**

Table 4-6 Incident return periods (1 incident every X years) for all traffic in the study area

Base Case	Collision	Powered Grounding	Drift Grounding	Powered Striking	Drift Striking	Total
Cargo/Carrier		47	110			**32**
Fishing	1,000	16	31			**10**
Other & Undefined	20	0.2	1			**0.15**
Passenger		85	340			**68**
Pleasure	500	3	10			**2.2**
Tanker		1,100	1,300			**620**
Tanker – Oil		210	340			**130**
Tug & Service		100	740			**91**
Total	**19**	**0.2**	**0.5**			**0.13**

There are no striking results in the Base Case because no SFWF WTGs are present. The average incident frequency is 7.4 marine incidents per year in the study area. In addition, this frequency includes any incident, independent of its severity. This analysis includes incidents ranging from minor groundings on soft seabed to major collisions between vessels. It includes incidents that will not result in cargo/oil spilled and incidents with the potential of a cargo/oil spill due to collision or grounding.

Powered grounding is the incident with the highest frequency, followed by drift grounding, since most vessels in the study area are transiting close to the shoreline. The ship type involved most often in an event is the "Other & Undefined" ship type, involved in 92% of the incidents. This vessel type typically does not have risk controls to help avoid collision and do not move with a steady course in the AIS data.

4.3.2 Future case with SFWF

Table 4-7 lists the incident frequency results assuming SFWF is in operation. Striking events are possible in this case, a as the WTGs are assumed to be in operation.

Table 4-8 shows the same results, but in return periods. The higher the return period, the less frequently an event is estimated to occur. A higher return period indicates a longer time between estimated events.

Table 4-7 Annual incident frequencies for the entire traffic in the study area

Future Case with SFWF	Collision	Powered Grounding	Drift Grounding	Powered Striking	Drift Striking	Total	Percentage Increase compared to Base Case
Cargo/Carrier	0.00021	0.02150	0.00911	<0.000005	0.00043	**0.0312**	**1.5%**
Fishing	0.00054	0.06340	0.03270	0.00001	0.00004	**0.097**	**0.0%**
Other & Undefined	0.00500	4.98000	1.78000	0.00001	0.00394	**6.81**	**0.1%**
Passenger	0.00013	0.02040	0.00981	0.00109	0.00194	**0.0334**	**127.9%**
Pleasure	0.00241	0.34600	0.10500	0.00007	0.00017	**0.454**	**0.1%**
Tanker	0.00001	0.00086	0.00074	<0.000005	0.00006	**0.00167**	**4.1%**
Tanker – Oil	0.00005	0.00460	0.00292	<0.000005	0.00017	**0.00775**	**2.5%**
Tug & Service	0.00002	0.00962	0.00133	-	<0.000005	**0.0110**	**0.2%**
Total	**0.0532**	**5.44**	**1.94**	**0.00119**	**0.00675**	**7.45**	**0.4%**
Percentage Increase compared to Base Case	**0.3%**	**0.2%**	**0.3%**	**-**	**-**	**0.4%**	**-**

Table 4-8 Incident return periods (1 in every X years) for the entire traffic in the study area

Future Case with SFWF	Collision	Powered Grounding	Drift Grounding	Powered Striking	Drift Striking	Total	Percentage Increase compared to Base Case
Cargo/Carrier	4,700	47	110	350,000	2,300	**32**	**1.5%**
Fishing	1,800	16	31	140,000	25,000	**10**	**0.0%**
Other & Undefined	20	0.2	0.6	69,000	250	**0.1**	**0.1%**
Passenger	7,800	49	100	910	510	**30**	**127.9%**
Pleasure	410	3	10	14,000	6,000	**2**	**0.1%**
Tanker	96,000	1,100	1,300	1,000,000	16,000	**590**	**4.1%**
Tanker – Oil	20,000	210	340	590,000	5,900	**120**	**2.5%**
Tug & Service	49,000	100	750	-	430,000	**91**	**0.2%**
Total	**19**	**0.2**	**0.5**	**840**	**148**	**0.1**	**0.4%**
Percentage Increase compared to Base Case	**0.3%**	**0.2%**	**0.3%**	**-**	**-**	**0.4%**	**-**

There is a small increase of 0.1 incidents per year from SFWF, which is the result of:

- Most of the traffic in the study area is transiting near shore, relatively far from the wind farm, and therefore, the incident rates for most of the vessels remain unchanged in the Future Case.

- Some traffic was routed around SFWF in the Future Case. It was assumed that most deep draft vessels will choose to avoid the project area. Re-routing the vessels increases the incident frequencies.

- Per input from Northeast Marine Pilots Association, passenger and cruise vessels were assumed to transit around rather than through SFWF in the Future Case. This increased the miles sailed by passenger vessels and routed them slightly closer to the shoreline, which increased the likelihood of a grounding event.

- One hundred passenger transits per year were added in the Future Case to represent possible tours of SFWF. This is the primary reason why incident frequencies increase for passenger vessels. One hundred vessels per year was a conservative estimate, perhaps most relevant to the first year of operation. After the first year of operation, it is likely that the number of tours will decrease.

- Striking a WTG, both powered and drift are included in the Future Case. These incident frequencies are the lowest of the incidents, with an average of 1 striking every 126 years (return period). Only ships sailing relatively close to the SFWF would be subject to this potential hazard. About 0.1% of all incidents in the Future Case are due to striking a WTG.

The overall incident frequency increases by 0.03 incidents per year, from 7.42 in the Base Case to 7.45 in the Future Case. This represents a frequency increase due to the project of 0.4%.

4.3.3 Potential consequences

There are several potential consequences should a striking occur. The least severe consequence is that a drifting vessel grazes a WTG. In this event, there may be minor damage to both the vessel and the WTG. It is likely that all personnel and passengers and structures would not experience any injury or damage. The severity of an striking increases with the speed of impact and size of the vessel (further described in Section 6).

A powered striking (i.e., occurring at speed) would likely result in the most severe consequences for both the vessel and the WTG. Worst-case scenario of a powered striking could result in the following:

- Personnel / passenger injury or fatality

- Major damages to the vessel. Damages could potentially be so severe that vessel foundering is possible. Damages could also result in a release of cargo.

- Major damages to the WTG. The severity of damages to the WTG is dependent on the design specifications.

Section 6 describes the potential consequences of a powered striking, including an impact analysis of a vessel with a WTG. Although potential consequences have the possibility of being severe, it is important to consider the frequency of powered striking when considering the consequence. Not all vessel types could cause severe consequences. The vessel types that have the potential to cause severe consequences are cargo/carrier and tankers (regardless of product). When combining the frequency of these vessel types, the

resulting frequency of any powered striking is 0.0000054. This event has a return period of 1 in every 180,000 years - a very unlikely event.

The consequences of a collision or grounding event are the same regardless of SFWF operation, with the exception of commercial fishing, described below. Very minor increases in the frequency were estimated with the modelling of SFWF, but no meaningful changes in collision or grounding consequences are expected.

In a collision, the consequence can range from minimal (almost no consequence) to severe. The consequence of a collision is dependent on collision angle, collision location, the size of vessels involved and the speed of the vessels. The worst-case scenario of a collision could result in a fatality. The consequences of a grounding are highly dependent on grounding location. A rocky seabed or shoreline results in much more severe consequences than a grounding on a soft/sandy seabed or shoreline. A grounding has the potential to result in damage to the vessel, loss of cargo and personnel injury or fatality.

4.4 Commercial fishing quantitative analysis

It is assumed that commercial fishing vessels will continue to transit and fish in the SFWF project area during wind farm operation. This section quantifies marine risks to commercial fishing vessels operating within the boundaries of SFWF. As most commercial fishing vessels are not present in the AIS dataset, an engineering approach was used to estimate the probability of generic scenarios occurring for commercial fishing collision and striking in the project area. The approach uses underlying failure data and similar principles as the MARCS model.

Because first principles of engineering and physics are described in this section, the paragraphs describing the methodology are necessarily technical. However, summary descriptions of the general approach and how the results can be interpreted are provided at the beginning and end of each section.

The analysis is taken one incident type at a time:

- Collision (Section 4.4.1)

- Drift striking (Section 4.4.2)

- Powered striking (Section 4.4.3)

- Fishing operations (Section 4.4.4). This includes any risks posed to the SFWF submarine power cables during fishing operations.

4.4.1 Probability of collision

This section evaluates the likelihood of two commercial fishing vessels colliding when in the SFWF. The calculation estimates the probability of collision between two commercial fishing vessels operating within the SFWF.

In the model and for the purpose of this assessment, a critical situation is formally defined as two vessels sailing in the proximity of each other which could result in a collision under certain circumstances. For collision, this is defined as two vessels sailing within 0.5 NM of each other. The implication is that within the SFWF project area, two fishing vessels are always in a critical situation if they are transiting between the

same two WTGs. This is a conservative assumption, intended to assure than any error from uncertainty is on the side of protecting life, property, and the environment.

Just because a critical situation occurs does not mean that an incident *will* occur, it only means that it *could* occur. If there are zero critical situations, there are zero potential incidents.

The probability of a collision given a critical situation is the result of several factors: the conditional probability of human error (from MARCS), the conditional probability of equipment malfunction (from MARCS), and the conditional probability of good vs. poor visibility. Note that good visibility is 2 NM or more, and occurs during 93.2% of an average year, described further in Section 4.2.2.2.

The estimated probability of collision between two commercial fishing vessels transiting within 0.5 NM of each other is about 1 in 200 million (4.7×10^{-9} per year) in conditions of good visibility and 1 in 4 million (2.2×10^{-7} per year) in conditions of poor visibility (less than 2 NM). These probabilities are a measure of how likely it is for two commercial fishing vessels sailing near each other in the SFWF to collide with each other.

To provide some context, if every day of the year, 100 fishing vessels passed each other between two WTGs in good visibility, the risk of a collision would be 0.00017 per year, or an average of 1 collision every 5,800 years.

It is worth discussing whether any additional risk of collision is posed by SFWF WTGs because they might force vessels to be in closer proximity to each other than they may otherwise choose to be. However, because of the significant spacing between WTGs. The distance between any two adjacent WTGs is estimated to vary from a minimum of 0.6 NM and a maximum of 0.9 NM (1.1 and 1.7 km). This risk is mitigated by the amount of sea room between the WTGs. This risk is also mitigated by vessels complying with general "rules of the road" and following the COLREGs during both active working activities and transit activities.

4.4.2 Probability of drift striking

This section presents a quantified probability of a commercial fishing vessel drifting and striking a WTG. For the analysis, probabilities and methods are extracted from the MARCS model and utilized for the specific scenario presented. For estimating the probability of drift striking, several assumptions are made:

- Commercial fishing vessels have an equal probability of drifting in any direction.

- The vessel is drifting at a perpendicular angle toward a WTG, hence it will collide with the foundation on either starboard or port side.

- The calculation is made for the nearest set of WTGs (distance rank 1) and the second nearest set of WTGs (distance rank 2). Rankings are assigned based on distance from the theoretical commercial fishing vessel. WTGs at the same distance have the same ranking, see Figure 4-6).

- The vessel is initially assumed to be sailing in the middle of the available water at a speed of 6 knots.

- The distance between any two neighboring WTGs is taken as the distance between the two closest WTGs in the SFWF layout, which is 0.6 NM.

- The beam of the fishing vessel is not considered in the calculation because of the relative difference of the distances involved (average AIS beam of 27.2 ft (8.3 m) compared to 0.6 NM (1,110 m)).

Figure 4-6 presents the two scenarios expected to result in the highest estimate for the probability of a fishing vessel to strike a WTG.
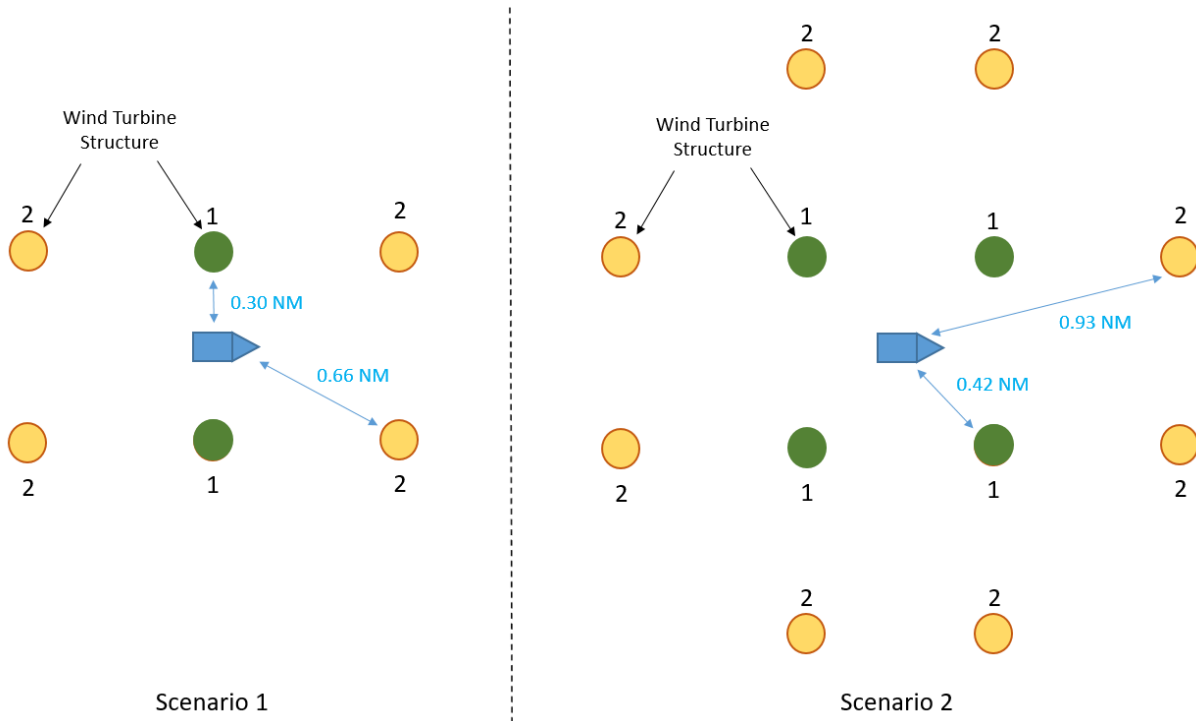
Figure 4-6 Drift striking scenarios for commercial fishing traffic (Not to scale)

Scenario 1 has two WTGs of rank 1 and four WTGs of rank 2. Scenario 2 has four WTGs of rank 1, and eight WTGs of rank 2. The calculation accounts for the actual distance; the rank 1 WTGs in scenario 1 are closer to the vessel than rank 1 WTGs in scenario 2.

The frequency of drift striking is estimated by the equation:

$$F_{allision\ by\ drift} = F_{failure} \cdot time \cdot P_{direction}$$

Where:

- $F_{failure}$ is the generic mechanical failure rate used in MARCS and is equal to 2.5×10^{-4} / hour.

- *time* is the time the vessel is sailing in the project area. This parameter differs depending on whether the vessel is fishing or just sailing through the wind farm. For a vessel that is fishing, time average time spent in the SFWF is assumed to be 12 hours per day. For a vessel that is transiting the wind farm, the maximum possible time sailing SFWF is 0.51 hours based on the longest path through the wind farm, a diagonal (maximum) distance of 3.04 NM (5.6 km). Both are considered conservative assumptions.

- $P_{direction}$ is the probability of the fishing vessel to drift towards a WTG structure. $P_{direction}$ for one WTG of rank n is the ratio between:

$$P_{direction\ (one\ turbine\ of\ rank\ n)} = \frac{turbine\ structure\ width\ +\ vessel\ length}{circle\ rank\ n\ perimeter}$$

Where:

- The average length of the fishing vessels is taken as the average reported in the AIS data, which is 87.6 ft (26.7 m). This value is considered conservative because the average from the AIS dataset is likely in the high end of the range. The WTG structures are taken as 65.6 ft (20 m) in diameter.

Figure 4-7 illustrates the variables for calculating $P_{direction}$.
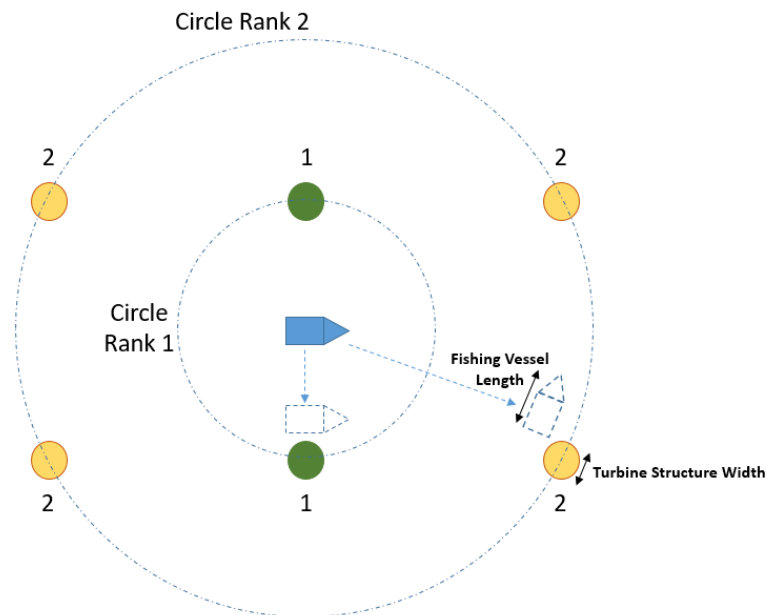
Figure 4-7 Illustration of $P_{direction}$ calculation for one WTG structure (Not to scale)

Table 4-9 presents the probability of having a fishing vessel striking a WTG by drift impact.

Table 4-9 Probability of Striking by Drift Impact for Commercial Fishing Vessels

Scenario	Actively fishing	Transiting the SFWF
Scenario 1	0.00015 (0.015%)	0.0007%
Scenario 2	0.022%	0.0009%

Given that a vessel is drifting, the conditional probability of the vessel to drift toward a rank 1 or 2 WTG structure is 5.2% for scenario 1 and 7.3% for scenario 2.

Therefore, the probability of striking by drift impact is estimated to be 0.000009, equivalent to one event per 100,000 fishing vessel visits to the SFWF. When a fishing vessel is actively fishing in the SFWF, the probability of striking at WTG by drift impact is estimated to be 0.0002, equivalent to one event per 4,500 fishing days in the SFWF.

These estimates are conservative for reasons discussed above, and because no additional risk mitigation measures were considered such as crew actions to avoid or minimize contact and not sailing in the SFWF when visibility is low.

4.4.3 Probability of powered striking

This section presents a quantified probability of a commercial fishing vessel striking a WTG at full speed. For the analysis, probabilities and methods are extracted from the MARCS model and utilized for the specific scenario presented. For estimating the probability of powered striking, several assumptions are made:

- When on dangerous course, the commercial fishing vessel is sailing directly towards a WTG structure. The collision occurs between the bow of the vessel and the tower.

- Only the three closest ranks of WTGs and the WTGs directly next to the vessel's course are considered for a fishing vessel transiting the SFWF. A rank is defined as all the WTGs located at the same distance from the vessel.

- For a fishing vessel actively fishing in the SFWF, it is assumed that the vessel will have a reduced speed; and therefore, only the two closest ranks of WTGs and the WTGs directly next to the vessel's course are considered.

- As the ship is powered, the vessel can collide only with the structures in front of it: any structure present within an angle of ±90° from the vessel's course.

- The vessel is assumed to sail in the middle of the waterway.

- The distance between two neighboring WTGs is assumed to be constant between the WTGs and is taken as the actual distance between the two closest WTGs, which is 0.6 NM.

Figure 4-8 presents the scenarios for an striking between the fishing vessel and a WTG structure to happen.
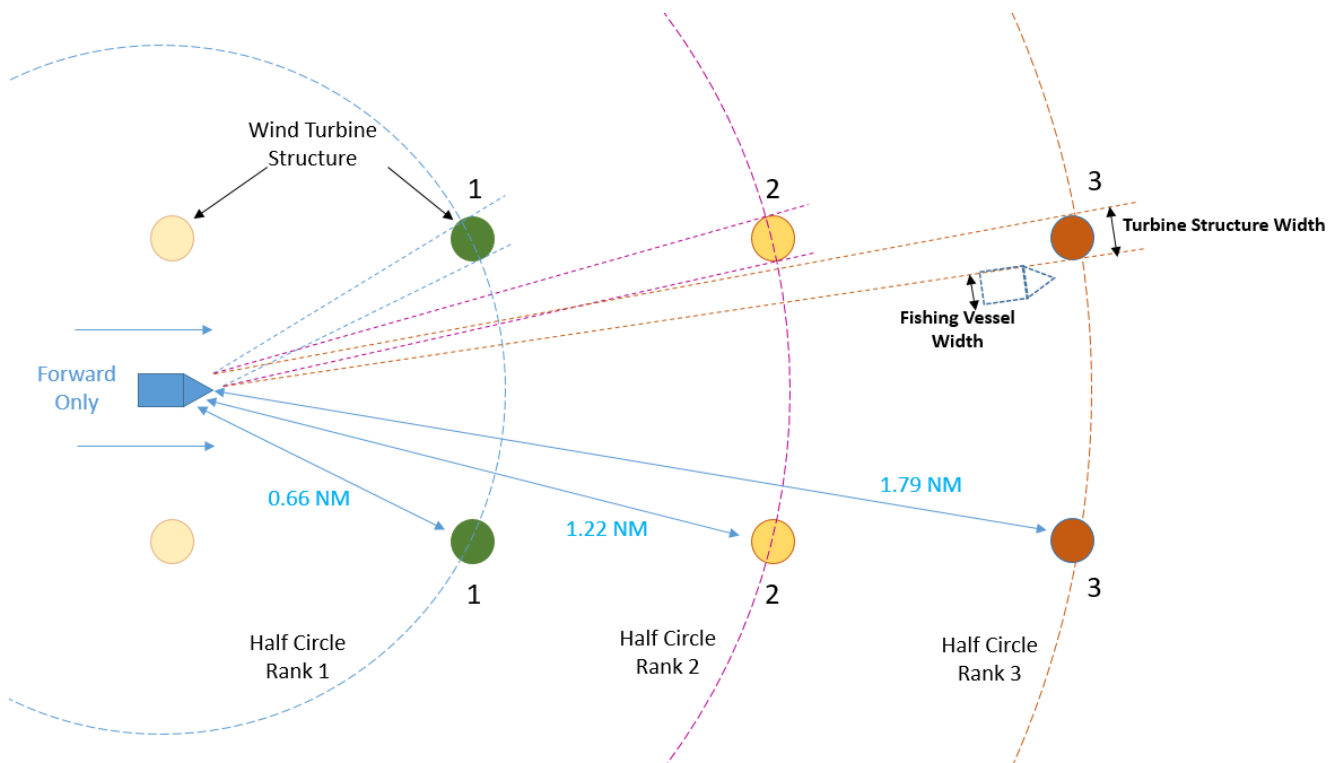
Figure 4-8 Powered Striking Scenarios for Commercial Fishing Traffic (Not to scale)

The probability of striking is estimated by the equation:

$$P_{allision\ by\ powered} = P_{grounding} \cdot P_{direction}$$

With:

- $P_{grounding}$ is the probability of a powered striking (if on a dangerous course) (based on MARCS model data) for fishing vessels are 2.33×10^{-4} in good visibility and 6.47×10^{-4} in bad visibility. Note that good visibility is 2 NM or more, and occurs during 93.2% of an average year, described further in Section 4.2.2.2.

- $P_{direction}$ is the probability of the fishing vessel being on a dangerous course, or in this case on a WTG structure course.

$P_{direction}$ for one WTG of rank n is the ratio between:

$$P_{direction\ (one\ turbine\ of\ rank\ n)} = \frac{turbine\ structure\ width\ +\ vessel\ beam}{half\ circle\ rank\ n\ perimeter}$$

The average beam of the fishing vessels present in the AIS is 27.2 ft (8.3 m). This value is estimated to be conservative to represent the fishing vessels not present in the AIS data. The WTGs' structures are assumed to be 65.6 ft (20 m) in diameter.

Table 4-10 presents the probability of having a fishing vessel powered striking a WTG.

Table 4-10 Probability of Powered Striking for Commercial Fishing Vessels

Scenario	Actively fishing	Transiting the SFWF
Bad visibility	0.000036	0.000040
Good visibility	0.000013	0.000014
Total	**0.000015**	**0.000016**

Transiting the SFWF Area

A fishing vessel transiting the SFWF has a probability of being on a WTG structure course of 6.1%. The resulting probability of powered striking is estimated to be 0.000014 in good visibility and 0.00004 in bad visibility. This could be viewed as a per-vessel risk of a powered striking 1 in every 70,000 times it transits the SFWF in good visibility. For bad visibility, the per vessel risk is about 1 in every 25,000 times it transits the SFWF.

Actively Fishing in the SFWF Area

The probability of being on course to strike a WTG structure is 5.6% for a vessel actively fishing in the SFWF. Therefore, the probability of a powered striking is estimated to be 0.000013 in good visibility and 0.000036 in bad visibility. This could be viewed as a per-vessel risk of a powered striking 1 in every 77,000 times it transits the SFWF in good visibility. For bad visibility, the per vessel risk is 1 in every 27,500 times it transits the SFWF.

To provide some context, if every day of the year, 100 fishing vessels are sailing the SFWF while fishing in good visibility, the risk of a powered striking would be 0.47 per year, or an average of 1 powered striking every 2 years.

4.4.4 Operational risks of fishing activities

As described in Section 3.1.1.2, mobile gear fishing techniques are frequently employed near and within the boundaries of SFWF. These techniques present an additional hazard from mobile fishing gear and operations potentially damaging SFWF submarine power cables by penetrating the sea bed.

The fishing activities that pose a threat include bottom trawling and shellfish dredging. Both activities are expected to happen near the project area and export cable[10]. To prevent damage from fishing vessel activities, the recommended burial depth is 3.28 ft (1 m) and at least a single armor layer[33].

This risk will be mitigated by DWSF's commitment to a four to six foot (1.83 m) cable burial depth when possible. Any disturbance of the seabed from fishing gear was found to be less than 1.6 ft (0.49 m) below the surface of the seabed in recent studies conducted in the region[34].

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[33] Bureau of Ocean Energy Management, Regulation & Enforcement – Department of the Interior. Offshore Electrical Cable Burial for Wind Farms: State of the Art, Standards and Guidance & Acceptable Burial Depths, Separation Distances and Sand Wave Effect. November 2011. https://www.bsee.gov/sites/bsee.gov/files/tap-technical-assessment-program//final-report-offshore-electrical-cable-burial-for-wind-farms.pdf

[34] Deepwater Wind prepared for TetraTech. Block Island Wind Farm & Block Island Transmission System. Navigational Risk Assessment. May 2012.

Table 4-11 Penetration depth of fishing gear[33]

Gear	Penetration Depth in Fine Sand	Penetration Depth in Fine Clay	Penetration Depth in Course Sand
Trawl boards, Beam trawls and Scallop dredges	< 1.3 ft (< 0.4 m)	< 1.3 ft (< 0.4 m)	1.6 ft (0.5 m)

4.4.5 Conclusions of commercial fishing risk analysis

Commercial fishing vessels transit to/from the region's main ports, including Point Judith and New Bedford, and operate in close proximity and within the boundaries of SFWF, as described in Section 3.1.1. Public interest in SFWF could potentially lead a potential increase of recreational fishing traffic. Some traffic adjustments have been made in the future case modeling (see Section 4.2.4.2).

Based on the analysis conducted in this section, there is minimal additional risk posed to fishing operations due to SFWF. Adherence to COLREGs and general safe navigation and operational practices are important risk control measures.

This generic analysis of fishing vessel interaction with other vessels and WTGs did not account for any additional risk reduction measures and operational risk mitigations that might be used. For instance, there are fishing operation best-practices (e.g. "requirements for the approval of technical specifications for the production (and importation) of safety equipment, machinery and services facilities, and the identification of approved manufacturers and suppliers within the country")[35] that would likely reduce risk for commercial fishing vessels.

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[35] Food and Agriculture Organization of the United Nations, ISSN 1020-5292, FAO Technical Guidelines for Responsible Fisheries, Volume 1 Suppl. 3, 2015. http://www.fao.org/3/a-i4740e.pdf.

5 NAVIGATION CONSIDERATIONS

5.1 Navigation within, or close to, the SFWF

5.1.1.1 Construction phase

During construction, it is anticipated that USCG will choose to implement safety zones to protect mariners from potential hazards during construction activities. The specifications of the anticipated safety zone are previously discussed in Section 3.2.

As with all marine navigation, it is assumed that all vessels, including construction and service vessels, follow International Regulations for Preventing Collisions at Sea (COLREGs)[36]. Vessels have the obligation to use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt, the vessel operator will assume that there is a risk of collision[36]. This would apply to vessels taking special precautions when travelling directly around or behind a single WTG, with possible limited visibility. COLREGs also state that every vessel shall proceed at a safe speed so that she can take proper and effective action to avoid collision and be stopped within a distance appropriate for the prevailing circumstances and conditions. To determine a safe speed as defined in COLREGs, the elements a vessel will consider include but are not limited to the following[36]:

- The state of visibility,

- The traffic density (including fishing vessels and other vessels),

- The maneuverability of the vessel with reference to stopping distance and turning ability under prevailing conditions,

- The state of wind, sea and current, and the proximity of navigational hazards.

5.1.2 Operations phase

Based on discussions with USCG Sector Southeastern New England, it is confirmed that safety or exclusion zones are not anticipated during operation of SFWF. Therefore, vessels will be free to navigate close to and within SFWF.

Navigation through the SFWF project area is not limited by shallow water; therefore, there is no grounding risk within the borders of the project or lease areas. The project area lays on charted depths of over 100 ft (30 m). Due to the depth, there are no draft restrictions in place to prevent vessels from transiting through the project area.

The remaining risks to consider are collisions between vessels and strikings of WTGs.

The WTG layout at SFWF provides sufficient sea room for most vessels to transit between WTGs if the risks have been considered and a vessel is transiting at a safe speed per COLREGs.

The layout of SFWF is designed to provide at least 0.7 NM (1.3 km) of sea room between WTG (with two exceptions where the distance between WTGs approximately 0.6 NM (1.1 km). This design is a navigation

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[36] "Convention on the International Regulations for Preventing Collisions at Sea", 1972 (COLREGs). Adoption: 20 October 1972; Entry into force: 15 July 1977.

risk mitigation measure in itself and provides sufficient room for most vessels to transit through and safely maneuver within SFWF.

It is expected that most deep draft and commercial vessels (not commercial fishing vessels) will choose not to transit through or near the wind farm. The SFWF is more than 4 NM from major commercial shipping lanes (excluding areas frequented by commercial fishing vessels) and directly east of the precautionary zone outside the traffic separation zones. It is likely that deep draft vessels will continue to transit north-south past the traffic separation zones and will sail to the south of SFWF if they are transiting toward the southeast.

UK Maritime and Coastguard Agency guidance document *Safety of Navigation: Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response* categorizes safe distances between a commercial shipping lane and a wind farm**Error! Bookmark not defined.**. This guidance is used throughout the North Sea and European locations with significant experience in the assessment and installation of wind farms.

The categorization of "safe" distances defined are based on navigation safety buffers of the vessels and the potential impacts of WTGs on radar[37]. The risk classification of WTG distances are defined in Table 5-1.

Considering the distance of SFWF from shipping lanes, SFWF's location falls into the "BROADLY ACCEPTABLE" range.

Table 5-1 Tolerability of Distances from Shipping Lane to WTG Error! Bookmark not defined.

Distance of turbine boundary from shipping route (90% of traffic, as per Distance C)	Factors for consideration	Tolerability
<0.5nm (<926m)	X-Band radar interference Vessels may generate multiple echoes on shore based radars	**INTOLERABLE**
0.5nm – 3.5nm (926m – 6482m)	Mariners' Ship Domain (vessel size and manoeuvrability) Distance to parallel boundary of a TSS S Band radar interference Effects on ARPA (or other automatic target tracking means) Compliance with COLREG	**TOLERABLE IF ALARP** **Additional risk assessment and proposed mitigation measures required**
>3.5nm (>6482m)	Minimum separation distance between turbines opposite sides of a route	**BROADLY ACCEPTABLE**

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[37] Scientific Journals of the Maritime University of Szczecin. *Assessing the impacts to vessel traffic from offshore wind farms in the Thames Estuary.* file:///C:/Users/mmatu/Downloads/16-zn-am-43-115-rawson-rogers-org044%20(1).pdf .

5.1.2.1 Vessel sizes transiting near/through SFWF

To estimate the size distribution of vessels transiting the project area vicinity, vessels were identified within 4.3 NM (8.0 km) from the SFWF (Figure 5-1) using AIS data. The purpose was to create a reasonably realistic view of vessels that may transit though the project area. The AIS data inside this buffer area were used to analyze the vessel size distribution. Summary statistics for vessel length, beam and deadweight tonnage (DWT) are shown in Table 5-2, Table 5-3, and Table 5-4.
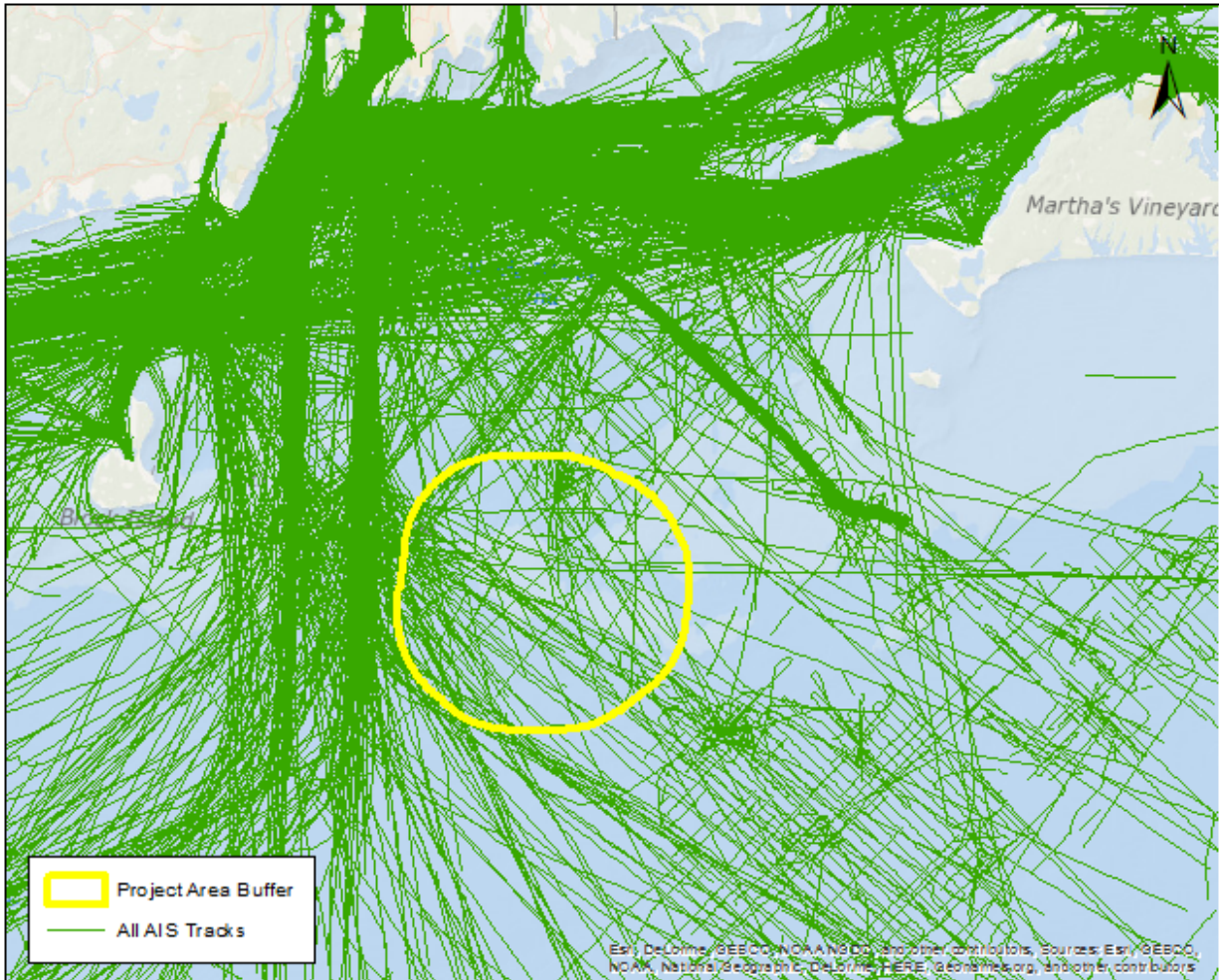
Figure 5-1 AIS traffic and Buffer of 4.3 NM (8.0 km)) around Project Area

Table 5-2 LOA distribution within 4.3-NM (8.0-km) of SFWF

LOA Categories	Size Distribution
< 65.6 ft (< 20 m)	5%
65.6 - 164 ft (20 - 50 m)	16%
164 - 246 ft (50 - 75 m)	37%
246 - 328 ft (75 - 100 m)	0%
328 - 574 ft (100 - 175 m)	11%
574 - 820 ft (175 - 250 m)	24%
> 820 ft (> 250 m)	7%
Total	**100%**

Table 5-3 Beam distribution within 4.3-NM (8.0-km) of SFWF

Beam Categories	Size Distribution
< 16.4 ft (< 5 m)	5%
16.4 - 32.8 ft (5 - 10 m)	35%
32.8 - 49.2 ft (10 - 15 m)	19%
49.2 - 82.0 ft (15 - 25 m)	7%
82.0 - 98.4 ft (25 - 30 m)	7%
98.4 - 115 ft (30 - 35 m)	20%
> 115 ft (> 35 m)	7%
Total	**100%**

Table 5-4 DWT distribution within 4.3-NM (8.0-km) of SFWF

DWT (metric tons) Categories	Size Distribution
< 500	28%
500 - 3,500	22%
3,500 - 7,500	8%
7,500 - 25,000	23%
25,000 - 50,000	5%
50,000 - 75,000	13%
> 75,000	1%
Total	100%

Table 5-5 provides summaries per vessel type. The average vessel information for the "fishing" vessel category likely over-estimates the size of fishing vessels near the project area. This is because the AIS dataset typically only captures the largest vessels in this category, while smaller fishing vessels are not required to be equipped with AIS. As reference, the majority of fishing vessels that are docked at Point Judith are 45 ft to 75 ft LOA[10]. The average LOA estimated by the AIS dataset near the project area is 85 ft.

Table 5-5 Average Vessel Length and Beam within 4.3-NM (5-mile) Project Buffer

Vessel Type	Average LOA within Buffer	Average Beam within Buffer	Average DWT within Buffer	Expected to transit within SFWF Project Area
Cargo/Carrier	597.1 ft (182 m)	95.1 ft (29 m)	30,382 metric tons	No
Fishing	85.3 ft (26 m)	26.2 ft (8 m)	**	Yes
Other	210.0 ft (64 m)	42.7 ft (13 m)	1,561 metric tons	Yes
Passenger	889.1 ft (271 m)	118.1 ft (36 m)	8,779 metric tons	No*
Pleasure	118.1 ft (36 m)	23.0 ft (7 m)	86 metric tons	Yes
Tanker	600.4 ft (183 m)	98.4 ft (30 m)	47,802 metric tons	No
Tanker – Oil Product	633.2 ft (193 m)	108.3 ft (33 m)	57,429 metric tons	No

* All passenger vessels transiting within 5 miles of the project area are large cruise ships. Per discussions with Northeast Marine Pilots association[30], any large passenger vessels that might request to transit through the project area will be advised to follow traffic separation lanes. It is very unlikely that cruise ships will pass through the project area.

** The AIS dataset did not contain any data for this parameter.

The only vessel types expected to transit within SFWF are:

- fishing vessels
- "other" vessels
- pleasure/recreation vessels.

All other vessel types will likely re-route and not travel directly through SFWF.

The vessel types expected to frequently transit through SFWF (fishing, other, pleasure/recreation) have plenty of navigable sea room to transit between structures (0.6 NM [1.1 km] for the few closest WTGs).

The vessel types that are not expected to transit through SFWF (cargo/carrier, passenger/cruise ships, and tankers) are likely to able to safety transit directly between WTGs. However, due to vessel maneuverability and preference, these vessel types are anticipated to transit to the south/southwest of SFWF.

Blade Tip Clearance

The exact model of WTG has not been selected at this time. The estimated envelope of blade tip will be between 85 ft (26 m) and 105 ft (32 m) above the waterline. Within the AIS dataset, sailing vessels have been identified as the only vessel type that might be exposed to a hazard from blade tips when transiting through SFWF. All foundations will be marked with Highest Astronomical Tide, indicating an 85ft air gap.

5.2 Visual navigation and collision avoidance

This section will describe the effect of SFWF on visual navigation and any potential effect on collision avoidance. During a workshop with USCG, DNV GL was informed that the largest concern for the study area was the ability for mariners to see though the project area to the traffic on the other side.

DNV GL utilized a geometric approach to determine potential visual obstruction from SFWF, particularly concerning a mariner's ability to see a vessel on the other side of the project area.

The red dots in Figure 5-2 represents WTG foundation widths, each with an additional 32.8-ft (10.0-m) buffer. The dots are 65.6 ft (20.0 m) in diameter, and represent the WTGs potential for visual obstruction. This is a conservative size based on typical WTG dimensions plus the buffer.

It is noteworthy that the red 65.6-ft (20.0-m) dots presented on the are very difficult to see; therefore additional black markings were added around them. This illustrates the minimal visual obstruction that is expected to be experienced by mariners when transiting through or past SFWF. The grid size is 1,640 ft x 1,640 ft (500 m x 500 m).

From the figure, it can be seen that the proposed layout minimizes visual impedance of mariners caused by SFWF WTGs. A grid-like layout, as opposed to a staggered layout, maximizes visual distances and allows more opportunities for mariners to have an uninterrupted line of sight when passing near and through SFWF.
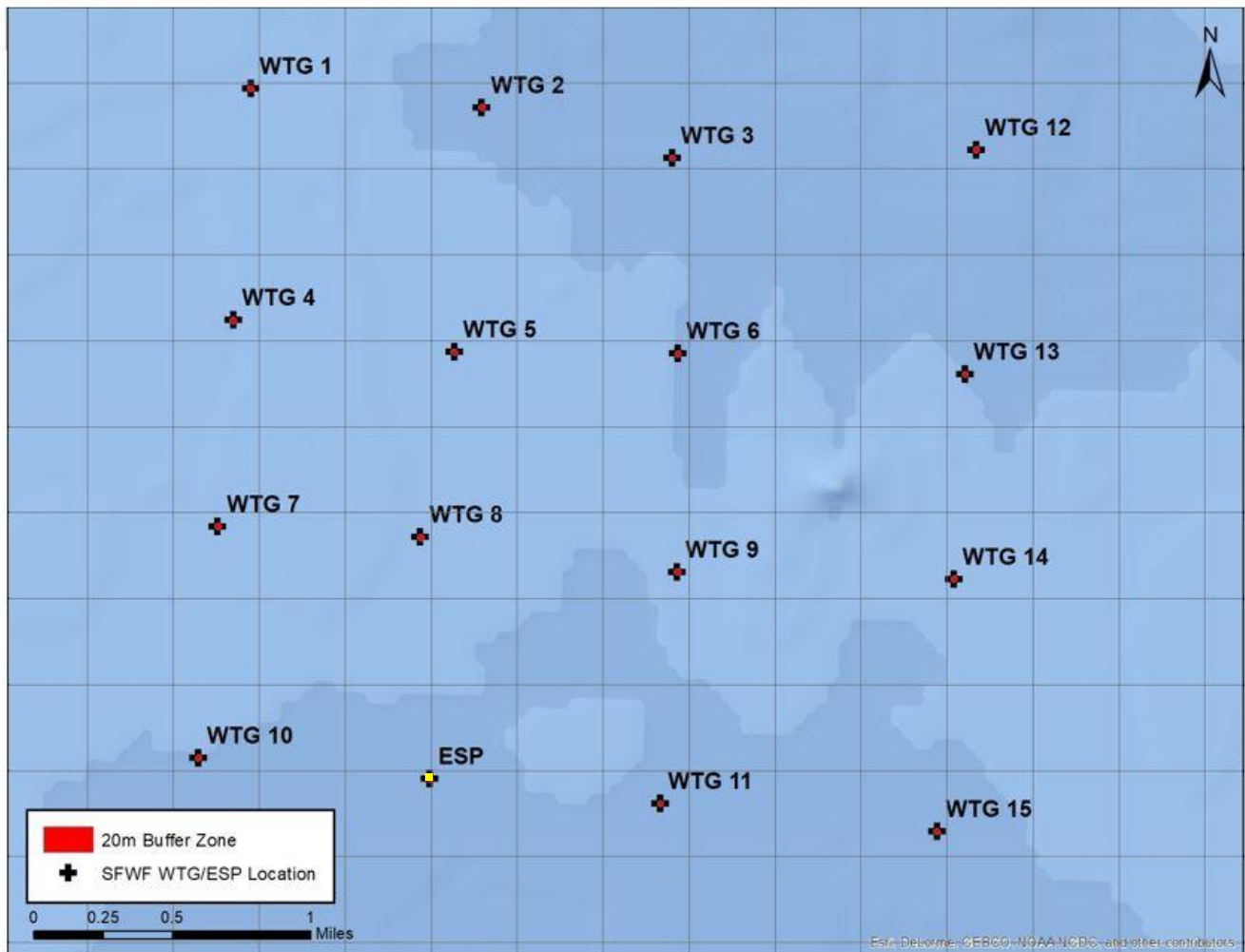

Figure 5-2 Indicative WTG layout on 1,640 ft x 1,640 ft grid

For a vessel travelling at 5 knots, the maximum amount of time that a WTG could potentially limit visibility directly opposite the WTG is 7.8 seconds. This calculation in based on the assumption that a single tower could obstruct visibility to a fixed location for a maximum of 65.6 ft (20 m). This is a conservative approach since the WTG spacing is so far apart, vessels would need to be transiting on very specific route to lose sight in the direction of transit or of a vessel transiting in the vessel's general direction. The following table summarizes the potential time of limited visibility for vessels transiting at various speeds.

Table 5-6 Time (in seconds) of Potential Visual Obstruction based on Vessel Speed

Speed of Vessel (knots)	Maximum Time of Potentially Obstructed Visibility (seconds)
5	7.8
10	3.9
15	2.6

Within the study area, a concern identified by the USCG was a potential increase in collisions between fishing vessels based on visual obstruction of the WTGs. For this scenario, the time calculated in Table 5-6 is very conservative because it calculates the time where a vessel cannot see a location, not the time where two moving vessels are not visible to/by each other. Additionally, a diameter of 65.6 ft (20.0 m) that could limit visibility is very conservative when a vessel is in close proximity to the tower. For two fishing vessels in motion within the boundaries of SFWF, it is overwhelmingly likely the vessels will not have limited visibility of each other at the same time. A more detailed view of navigation within the boundaries of SFWF is included in Section 5.1.

SFWF will not have any effect on a mariner's ability to use marked Aids to Navigation (AtoNs) or the coastline as reference for navigation due to the project area's relative location to marked aids and the coastline. To visually verify SFWF will not impact the ability of mariners to utilize AtoNs for navigation, Figure 5-3 plotted current AtoNs (including WTGs of Block Island Wind Farm), the coastline and SFWF geospatially. During operation, each WTG foundation will serve as an AtoN for mariners as they are large structures with lights. SFWF WTGs, electric service platform (ESP), and submarine transmission line will be clearly marked on applicable National Oceanic and Atmospheric Administration (NOAA) nautical charts, including:

- No. 31218 Martha's Vineyard to Block Island

- No. 12300 Approaches to New York, Nantucket Shoals to Five Fathom Bank.

Deepwater Wind intends to work closely with USCG and NOAA to chart all elements of SFWF.
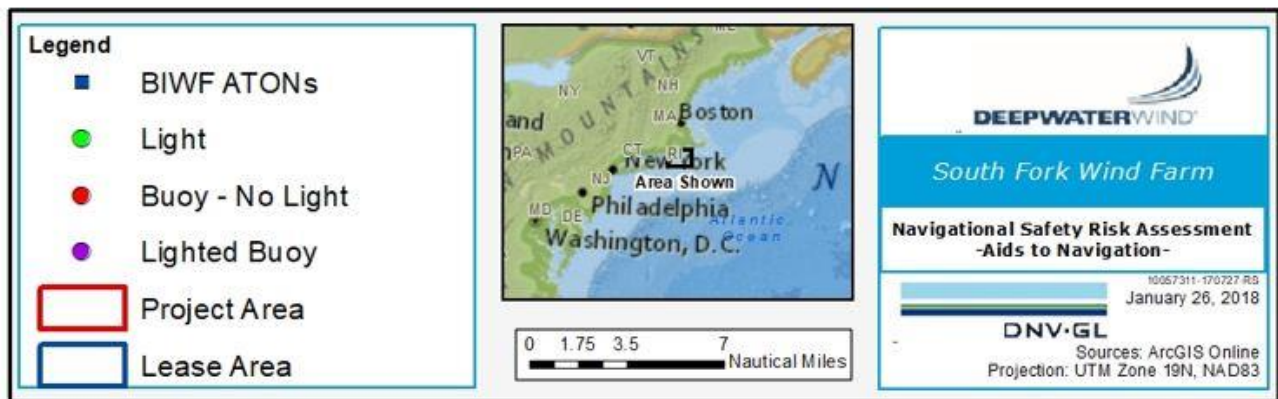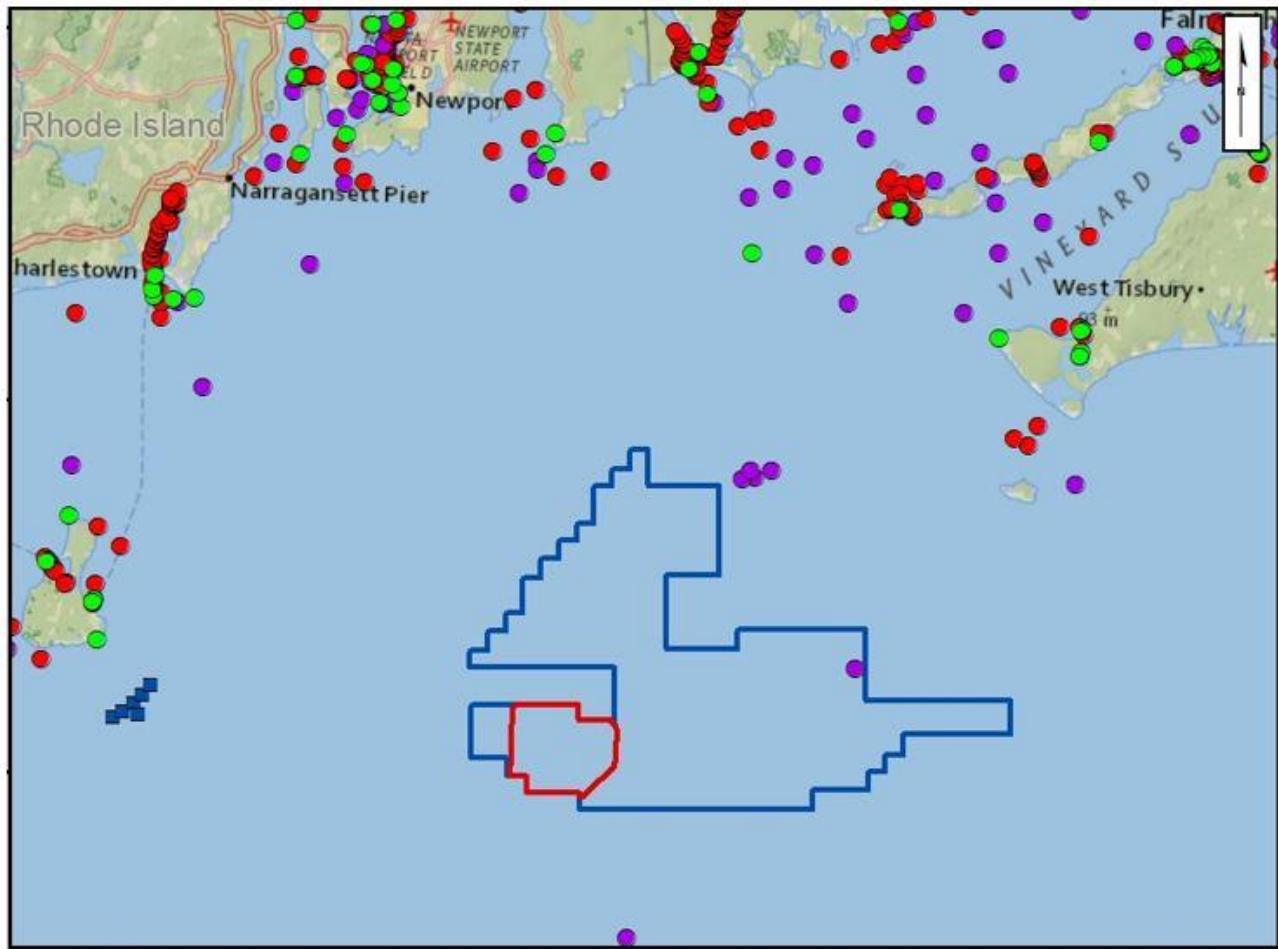
Figure 5-3 Plotted AtoNs and SFWF [24]

The marking scheme that will be put in place for SFWF is described in Section 7.

5.3 Noise impact on navigation

NVIC 02-07 states that any noise or vibration should be assessed that could potentially impact USCG missions. During a workshop with USCG, their opinion was captured that the noise and vibration of the project will not have any impact on their missions (Section 9.2).

COLREGs Annex III describes the required sound signal intensity and range of audibility for vessels by length. Table 5-7 summarizes the requirement[36]. This requirement assumes an average background noise level of a vessel to be 68 dB[36].

Table 5-7 Intensity requirements of whistle[36]

Length of Vessel (meters)	1/3-octave band level at 1 meter (decibels)	Audibility Range (nautical miles)
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 SFWF is not anticipated to pose any negative effects on navigation in the region. This conclusion is drawn because the background noise level is already more than any noise level that will be added by SFWF.

5.4 Project impact on anchorage areas

NVIC 02-07 guides the applicant to consider the effect SFWF will have on normal operations, including anchorage areas. Figure 5-4 presents the anchorage areas available for vessels in the study area. The nearest anchorage area is Brenton Point in Narragansett Bay and is located over 12 NM (22 km) from SFWF. As the project is in open water, there are no anchorage areas to the south of SFWF. The SFWF is not expected to have any effect on vessel anchorage operations.
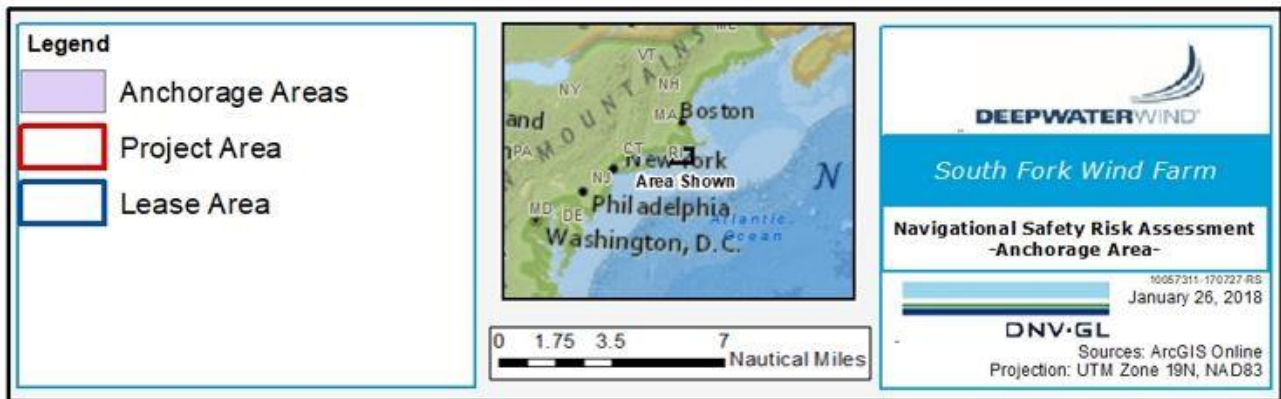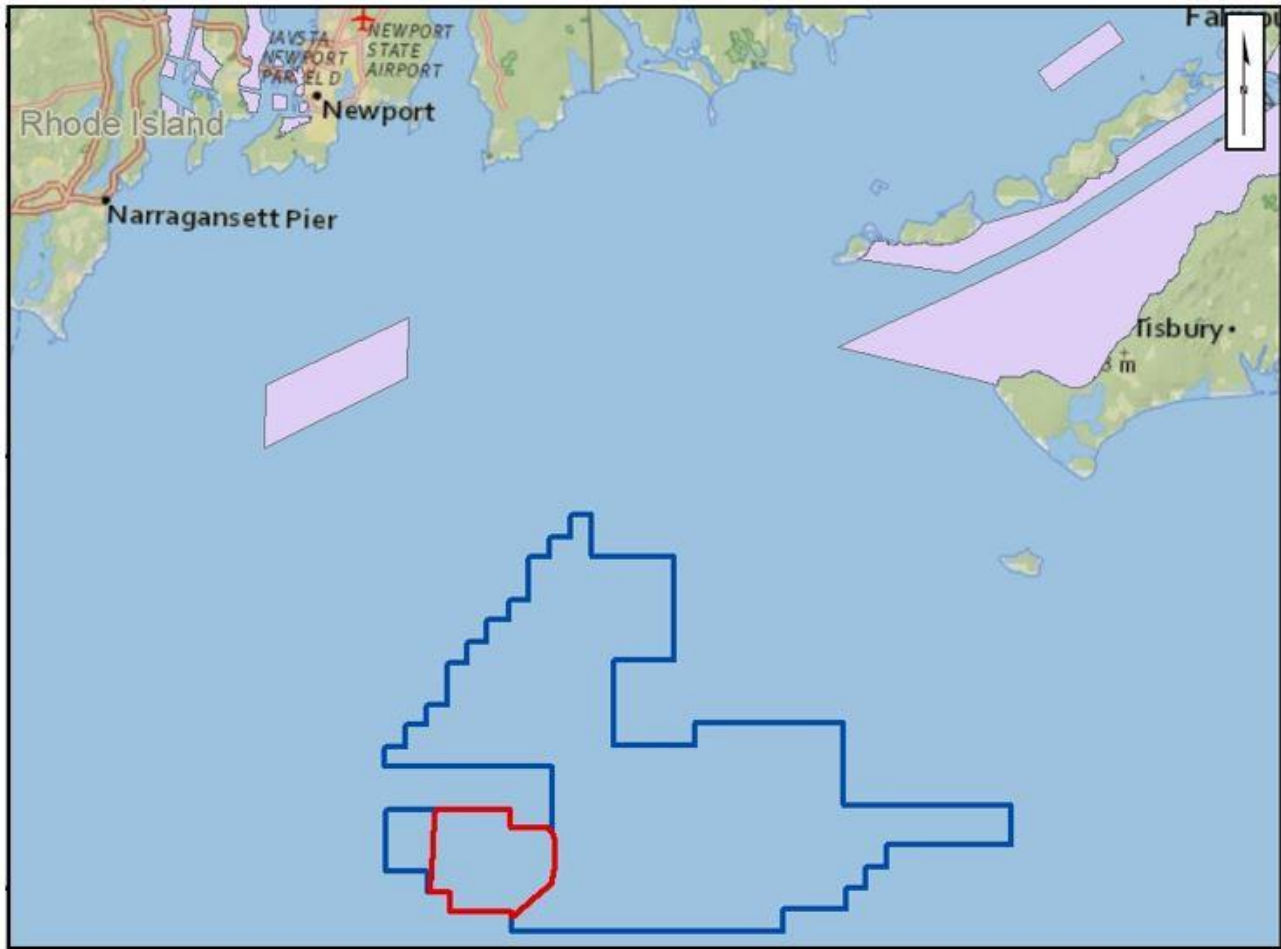
Figure 5-4 Designated anchorage areas in study area[24]

The preliminary cable route is presented in Figure 5-5. There are not any designated anchorage areas within the vicinity of the cable route. The cable route will not interfere with normal vessel anchorage activities.
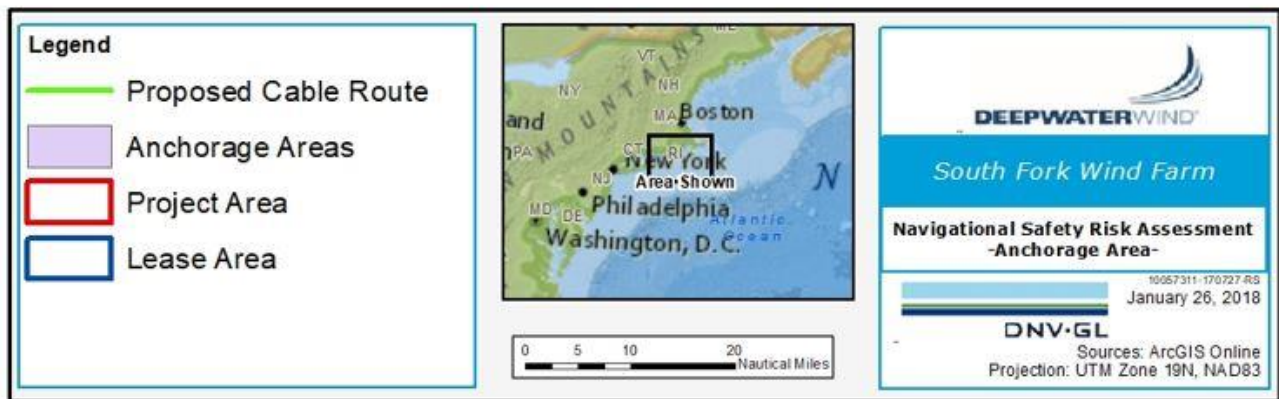
Figure 5-5 Anchorage areas in study area and cable route[24]

Deviations from "normal" anchorage activities may pose a hazard to the South Fork cable, and have the potential to introduce an additional risk of damage. Ships rarely drop anchors, even more unlikely outside of normal operations, but can damage the cable if they are dropped directly on top of the cable or dragged across the cable line[33]. Emergency situations are the only credible situation that could cause damage to the

cable line, as most ocean vessels secure their anchor during transit[33]. (Note that fishing activities discussed in Section 4.4.4 may also pose a hazard.)

Emergency anchorage has the potential to damage the cable in the event that the anchor can penetrate the seabed to the approximate 6 ft (1.8 m) burial depth proposed for SFWF. Based on quantitative studies conducted for other projects in the region, estimate that the emergency anchoring of a large vessel >50,000 DWT with an anchor weighing more than 12 tons has the potential to penetrate the seabed to burial depth[34].

Based on the average DWT of vessels in the study area, only tankers carrying oil products have an average tonnage greater than 50,000 DWT. All other vessels in the study area are generally smaller and less likely to cause damage to the cable even in an emergency anchorage situation. Fishing activities that may pose a threat to the cable line are discussed in Section 4.4.4.

Based on historic analysis, construction vessels are the most likely to inadvertently damage a cable during normal operations if unaware of the location[33]. However, proper marking of the cable on applicable navigation charts will reduce this risk. DWSF has also committed to publishing frequent notices to mariners in the area that will make all non-SFWF construction vessels aware of all locations where damage is possible.

6 PROJECT STRUCTURE IMPACT ANALYSIS

This section describes the potential damage to a WTG from a marine incident. The damage from a powered striking is more severe than from a drift striking, and therefore present the most conservative damage case.

The goal of the impact analysis is to estimate the consequences or damages in the case of a powered striking of a WTG by a ship transiting within the boundaries of SFWF. 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.

Table 6-1 presents the ship types and sizes based on the AIS data within a 5-mile radius from the project area (as displayed in Figure 5-1). Recreational fishing vessels are categorized in the "pleasure" category, as the AIS category typically will capture many recreational fishing vessels.

Table 6-1 Details of the vessels sailing within 4.3 NM (5 mile) of project area

Ship Type	Average DWT (tons)	Min. DWT (tons)	Max. DWT (tons)	Average LOA (ft)	Average Breadth (ft)
Cargo & Carrier	30,382	10,520	56,015	597.1 (182 m)	95.1 (29 m)
Passenger	8,779	635	11,788	889.1 (271 m)	118.1 (36 m)
Commercial Fishing*	500	-	-	85.3 (26 m)	26.2 (8 m)
Pleasure/Recreational Fishing	86	26	228	118.1 (36 m)	23.0 (7 m)
Tanker	47,802	13,085	74,896	600.4 (183 m)	98.4 (30 m)
Tanker – Oil Product	57,429	16,909	115,691	633.2 (193 m)	108.3 (33 m)
Other & Unspecified	1,561	50	4,400	210.0 (64 m)	42.7 (13 m)

*DWT for commercial fishing vessels is an assumption since there is limited data in the AIS dataset. 500 is based on a very conservative estimate of fishing vessel tonnage in the region.

Table 6-2 shows the speed ranges assumed to estimate the average kinetic energy for each ship type. The speeds are based on the AIS data speed profiles (Appendix A) with distributions used in the MARCS model. The maximum speeds are obtained by adding 20% to the MARCS speeds. The minimum speeds are half of the MARCS speeds. This analysis analyzes vessels at cruising speed in direct impact with a WTG, as this is the most conservative case and will result in the most potential damage.

Table 6-2 Vessel speed when striking occurs

Ship Type	Min. Speed (knots)	Speed used in MARCS (knots)	Max. Speed (knots)
Cargo & Carrier	6	12	14.4
Passenger	7	14	16.8
Commercial Fishing*	5	10	12
Pleasure / Recreational fishing	5	10	12
Tanker	6	12	14.4
Tanker – Oil Product	6	12	14.4
Other & Unspecified	4	8	9.6

*Commercial fishing speeds are assumed to be the same as pleasure vessels

The kinetic energy (in joules) is then calculated with the following formula from DWT (in kilograms) and speed in (meters per second):

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

Figure 6-1 gives the range of kinetic energy obtained with the previous formula for every ship type present within a 5-mile radius from the project area.
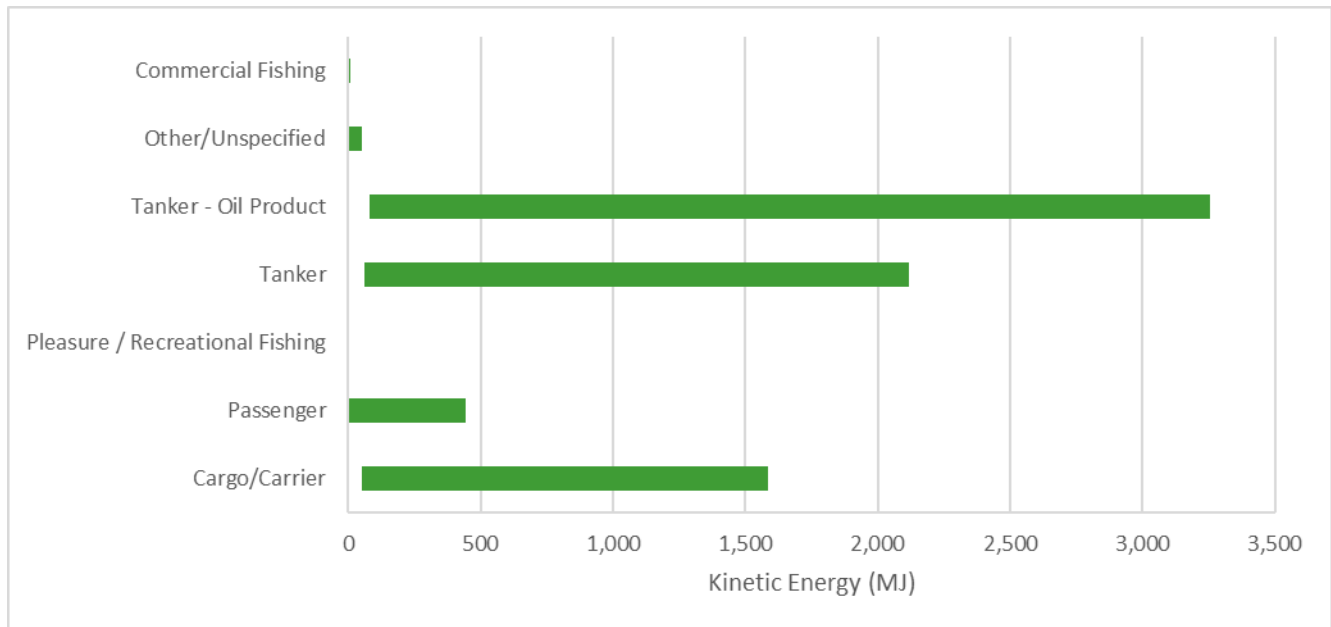

Figure 6-1 Ranges of kinetic energy per ship type

The estimated energy ranges are conservative for the following reasons:

- The kinetic energy is assumed by be received by the WTG. However, the energy received by the WTG structure will be lower than kinetic energy, as some of the energy will be dispersed during the collision (e.g., vessel hull plastic deformation, vessel movement/rotation).

- The 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.

A study published in Ocean Engineering journal, discusses ship impact consequences to monopile and to jacket fixed-bottom foundations when struck by a 4,000-ton class vessel[38].

Should a vessel strike a monopile foundation, the three main factors identified that influence the location and extent of the damage to the foundation are the collision energy, the height of the vessel, and the area of impact. Vessels with a lower profile typically will result in less extensive damage to the monopile due to the stiffness of a generic foundation design[38]. 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[38]. At high striking energies, the monopile foundation is likely to deform nearer to the seabed and will likely not collapse.

Should a vessel strike a jacket, the main factors affecting the resulting damage include the vessel speed and impact area. When a vessel strikes a WTG at a low velocity, the damage to the jacket foundation is not extensive. For a 4,000-ton vessel at about 7.8 knots, the forces generated are enough to cause multiple failures to joints and/or rupture of elements of the jacket foundation. At lower velocity strikes, the damage to the jacket is not extensive and may not even require repairs [38].

Due to the range of sizes and speeds of vessels in this study, it can be concluded that pleasure, fishing, and "other" vessel categories are unlikely to cause extensive damage to a jacket because of their tonnage and average speeds. Exceptions would be unusually high speeds or unusually large vessels in these categories. Passenger and large commercial fishing vessels have a greater potential to cause damage to the jacket, depending on their speed and size. It is noteworthy that within a 4.3-NM (5-mile) buffer of the project area, all passenger vessels are identified as cruise vessels.

The highest postulated consequences would be from striking by a non-oil tanker, followed by striking by an oil tanker, and striking by a cargo/carrier. The damage caused by a large vessel at average cruising speed is expected to cause enough damage to any foundation that there is a potential for WTG collapse. When these vessels travel at lower speeds, the likelihood of severe damage is reduced.

As previously stated, it is not anticipated that tankers of any kind or cargo/carrier vessel types will transit within or near the wind farm boundary. Based on the powered striking results of the MARCS model during operation, there is a 0.0000054 annual frequency of a tanker (carrying oil products or not) or cargo/carrier striking a WTG; a one in 180,000-year event.

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[38] Moulas, D., et al. "Damage Analysis of Ship Collisions with Offshore Wind Turbine Foundations." Ocean Engineering, vol. 143, 2017, pp. 149–162., doi:10.1016/j.oceaneng.2017.04.050.

Although the consequence of this event would likely be severe damage to the vessel and WTG, the infrequent nature of the event reduces the risk of this event to one that does not require mitigation beyond appropriate marking of SFWF on nautical charts and prudent seamanship of mariners.

With the anticipated construction safety zones, it is very unlikely that passing vessels strike a WTG during the construction phase. Any commercial or recreational vessels that enter the construction area while work is ongoing would be in violation of the anticipated USCG regulation[29].

During construction, the primary risk is an on-site construction vessel could strike a WTG while transiting through the wind farm. However, construction vessels are anticipated to be travelling at very low speeds through the construction zone and are unlikely to cause significant damage in the event of a striking. Based on the low speeds that are expected in a construction zone, a drifting or direct strike from a construction or work vessel is unlikely to cause extensive enough damage to a monopile or jacket based on the WTG strength analysis discussed earlier in this section[39].

In terms of damage to the WTG, neither pleasure vessels nor recreational fishing vessels should be able to cause significant damage, regardless of tower design. Specific consequences of a striking on a WTG are highly dependent the inherent design strength of the structure.

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[39] Moulas, D., et al. "Damage Analysis of Ship Collisions with Offshore Wind Turbine Foundations." Ocean Engineering, vol. 143, 2017, pp. 149–162., doi:10.1016/j.oceaneng. 2017.04.050.

7 MARINE NAVIGATIONAL MARKING

7.1.1 Summary of requirements

Marine Navigation Lighting (MNL) is regulated by the US Coast Guard (USCG) through Federal Regulation 33 CFR Part 67[40]. Structures will be fitted with lights for nighttime periods. No daytime lighting is required.

The lighting requirements depend on the class (A, B, or C) of the offshore structure as determined by the District Commander of the USCG. The term "Class A, B, or C structures" refers to the classification assigned to structures erected in areas in which corresponding requirements for marking are prescribed. The lighting requirements are determined based on, but not limited to, the dimensions of the structure and the depth of water in which it is located, the proximity of the structure to vessel routes, the nature and amount of vessel traffic, and the effect of background lighting.

- Class A structures must be fitted with white lights visible to at least 5 NM (9.3 km) 90 percent of the nights of the year. Lights must be positioned at least 20 ft (6.1 m) above mean high water, with a maximum height that allows at least one light to be visible until within 164 ft (50 m) of the structure. Class A structures must be equipped with a sensor-operated sound signal that has a rated range of at least 2 miles (1.7 NM).

- Class B structures must be fitted with white lights visible to at least 3 NM (5.6 km) 90 percent of the nights of the year. Lights must be positioned at least 20 ft (6.1 m) above mean high water, with a maximum height that allows at least one light to be visible until within 164 ft (50 m) of the structure. For structures that require only one light, the light must be placed at least 10 ft (3 m) above mean high water if the structural features preclude mounting the light within the range of heights otherwise specified in this section. Class B structures must be equipped with a censor-operated sound signal that has a rated range of at least 0.5 miles (0.4 NM). The District Commander may waive or increase the requirements for obstruction lights and sound signals depending on the potential hazard to navigation.

- Class C structures must be fitted with white or red lights visible to at least 1 NM (1.9 km) 90 percent of the nights of the year. The lights must be displayed at a height above mean high water prescribed by the District Commander. If red lights are authorized, the color must conform to military specification. Structures located near each other may be lit at the perimeter structures only, if not deemed a hazard to navigation by the District Commander. Unless advised to the contrary by the District Commander, obstruction lights shall be required on structures erected in water with a depth of 3 ft (0.9 m) or more at mean low water. The District Commander may waive or increase the requirements for obstruction lights and sound signals depending on the potential hazard to navigation.

Structures with a horizontal diameter of 30 ft (9.1 m) or less will be fitted with an obstruction light visible from all approach directions. Structures with a horizontal dimension of more than 30 m, but no more than 50 ft (15.2 m) on any side, will be fitted with two obstruction lights, on opposite corners, each visible from all approach directions. Structures with a horizontal diameter of more than 50 ft (15.2 m) on any side will be

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[40] Code of Federal Regulations. Title 33 – Navigation and Navigable Waters. Part 67 - Aids To Navigation on Artificial Islands and Fixed Structures [33 CRF 67]. [On line] https://www.gpo.gov/fdsys/pkg/CFR-2009-title33-vol1/pdf/CFR-2009-title33-vol1-part67.pdf.

fitted with an obstruction light on each corner, in a manner that at least one light must be visible to approaching vessels within 50 ft (15.2 m). All flashing obstruction lights will be synchronized.

All WTG unique identifiers/labels will be visible at a distance of at least 150 yards (137.2 m) using lighting or phosphorescence[41]. The District Commander may also require the use of Private AtoNs (PAtoN). The SFWF will follow the IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) Buoyage System.

7.1.2 Aids to Navigation for SFWF

Aids to navigation (ATON) are structures intended to assist a navigator in determining position or safe course, or to warn of dangers or obstructions to navigation. This data set includes lights, signals, buoys, day beacons, and other ATONs. The ATON in the region and near the SFWF is USACE Block Island Lighted Research Buoy 154, located 5.4 miles (10 km) southeast of SFWF (Figure 7-1).

In addition, AIS will be installed at the SFWF marking the corners of the wind farm to assist in safe navigation.

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[41] United States Coast Guard, "Navigation and Vessel Inspection Circular No. 02-07", Guidance on the Coast Guard's Roles and Responsibilities for Offshore Renewable Energy Installations (OREI). Dated 9 March 2007.
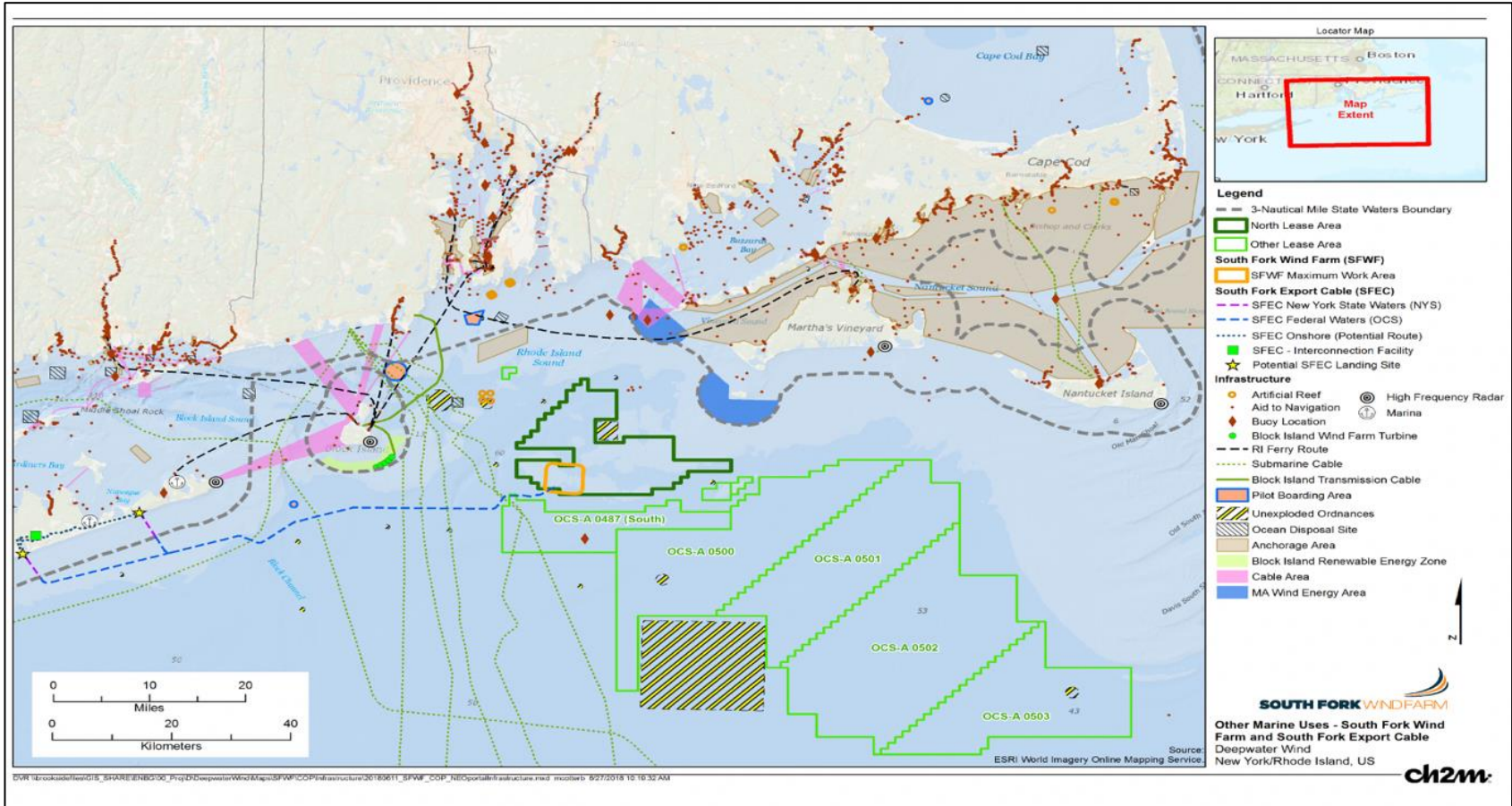
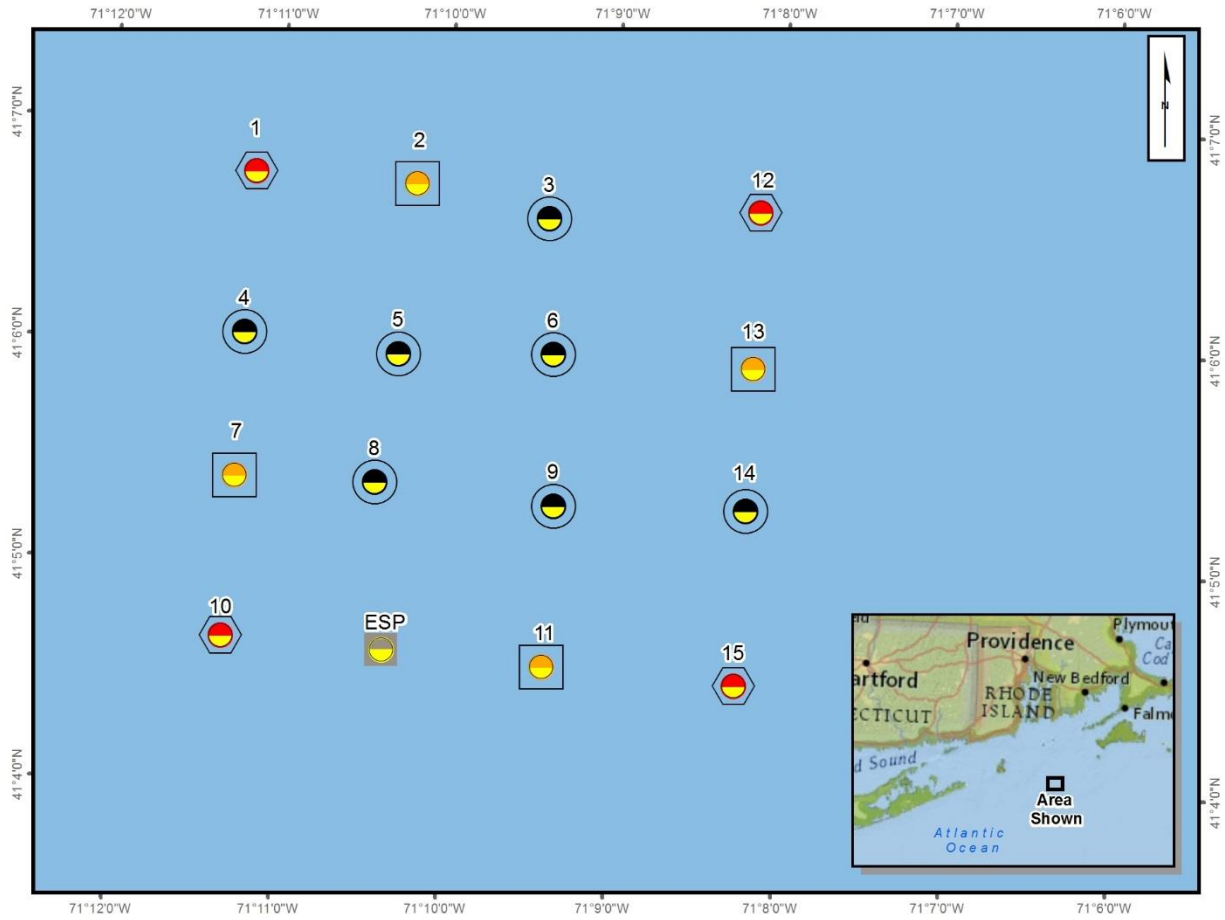**Figure 7-1 Aids to navigation near SFWF**

7.1.3 Project marking and lighting scheme

Based on the requirements mentioned above, DNV GL has prepared a conceptual lighting scheme the SFWF project; see Figure 7-2. Each WTG will be marked and lit with both USCG and FAA compliant aviation lighting.

While the Regulations[40] require the use of white lights for Class A and B structures and white or red lights for Class C structures, it is possible that other colors be requested or permitted by the Coast Guard. Key points from the conceptual lighting scheme are as follows:

- WTGs 1, 10, 12, and 15 are considered Class A structures (Special Peripheral WTGs). As such, they will be equipped with a flashing white light visible to 5 NM.

- WTGs 2, 7, 11, and 13 are considered Class B structures (Intermediate Peripheral WTGs). These will be equipped with a flashing white light visible to 3 NM.

- WTGs 3, 4, 5, 6, 8, 9, and 14 are Class C structures (Internal WTGs). These must be fitted with white or red lights visible to at least 1 NM.

- All WTG unique identifiers/labels must be visible at a distance of at least 150 yards (137.2 m) using lighting of phosphorescence[41].

- The Electric Service Platform must be equipped with one or more lights. The number and arrangement of the lights will depend on the horizontal length of the platform.

- In addition to MNL, foundations and/or towers must be painted yellow up to 50 ft (15 m) above the maximum water level[42]. BOEM recommends turbines (above the foundation) be painted no lighter than RAL 9010 Pure White and no darker than RAL 7035 Light Grey. Corner WTGs must be equipped with sensor-operated foghorns which must be audible at 2 NM. The Coast Guard District commander may prescribe that some or all class 2 structures be equipped with sensor-operated foghorns which must be audible at 0.5 NM, or to a greater range but not exceeding to 2 NM.

- Finally, marine navigation buoys may be required around the SFWF project (not included in Figure 7-2). The Coast Guard District Commander has final approval on the need for buoys and their location and specification. Location and specifications depend on multiple factors, including the presence of shipping route, navigation activities, etc.).

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[42] United States Coast Guard, "Aids to Navigation Manual Administration, Short Range Aids to Navigation", COMDTINST M16500.7A. Dated 2 March 2005, updated 23 Feb 2015.

Figure 7-2 Conceptual lighting scheme for the South Fork Wind Project

8 COMMUNICATIONS, RADAR, AND POSITIONING SYSTEMS

WTGs and the movement of the blades can potentially interfere with communications signals from radio and radio transmitters. The WTGs can interfere with radio and radar transmissions by either blocking or reflecting the signals. DNV GL researched a selection of studies performed to assess the impacts of offshore WTGs on shipboard communications and navigation systems. This is a summary of technical research conducted by multiple sources. The technical information in this report is limited to that which is necessary to understand its contents.

8.1 Effect of wind farms on radar

8.1.1 Block Island Wind Farm

In 2015, QinetiQ performed an assessment of the Block Island Wind Farm, modelling two different radar types that are typical for the vessels transiting in the vicinity[43]. Due to the location of the Block Island Wind Farm, the vessel types operating in the area are similar in nature to those operating near the SFWF project area. Hence, the Block Island Wind Farm study is the most relevant to the proposed SFWF.

QinetiQ modelled 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 GHz to 4.0 GHz and are generally installed on large vessels[40].

The study evaluated four different scenarios with each of the radar types, for a total of eight scenarios. Three separate assessments were performed; radar clutter assessment, saturation assessment, and shadowing assessment[40].

Radar Clutter Assessment

The clutter assessment found that radar clutter could be reduced by the operator's use of the gain control. It also found that as the distance from the wind farm increased, the clutter caused by the wind farm appeared larger on the radar screen. This increases the possibility that a vessel within the wind farm may not be detected. However, the increased distance creates a reduction in the risk of collision with vessels in the wind farm[40].

Saturation Assessment

The QinetiQ study found that within approximately 0.5 NM (0.9 km), radar saturation was possible. However, for both radar types (S-band and X-band) gain control adjustments by the operator can reduce saturation. The study compared this to the effects of buildings and other structures on radar display when a vessel is in port or close ashore[40].

Shadowing Assessment

For both radar types at longer ranges, shadowing effects may be up to 328 ft (100 m) wide behind the WTGs. This means that smaller vessels situated behind the WTG towers may not be visible on radars of

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[43] Assessment of the Impact of the Proposed Block Island Wind Farm on Vessel Radar Systems, QINETIQ/15/01675/2.0, August 25, 2015.

nearby transiting vessels. However, the movement of each vessel will likely limit the amount of time a vessel is not detectable due to shadowing, either by movement of the target vessel out of the shadow or by movement of the shadow as the vessel with the transmitting radar unit moves. Also, as with radar clutter, shadowing effects increase as distance from the WTGs increases. The increased distance could reduce the risk of vessel collision[40].

8.1.2 Horns Rev Wind Farm

The Horns Rev 1 Wind Farm is an 80-WTG wind farm located in the North Sea off the coast of Denmark[44]. Observations of radio interference were made during construction and during operations of the wind farm. No shadowing was observed and vessels operating within the wind farm were able to detect all of the 80 WTG towers on radar[45].

8.1.3 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, United Kingdom. The wind farm consists of 30 WTGs, with a combined capacity of 90 MW[46].

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 (VTS) and small recreational craft.

The MARICO findings concluded that trained mariners can identify the effects of wind farms on radar display 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 and near 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 WTG. 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 aids to navigation, 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 "relative unconcerned" with the presence of the wind farm and its impact on shipboard radar. They did

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[44] Horns Rev 1. http://powerplants.vattenfall.com/horns-rev, Accessed October 17, 2017.

[45] "Report on Horns-Rev VHF radio and marine radar," Elsam Engineering, DK report to Cap Wind Associates, Doc. No. 186829, Mar. 2004.

[46] https://corporate.vattenfall.co.uk/projects/operational-wind-farms/kentish-flats/, accessed October 16, 2017.

express that if wind farms were situated closer to shipping lanes, it could be cause of some concern and require further evaluation[47].

DNV GL conducted interviews with the Northeast Marine Pilots, who expressed similar sentiment as the pilots in the MARICO Kentish Flats study. The SFWF does not create a risk to navigation due to radar or communications interference[30].

8.1.4 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 in an area of approximately 3 NM^2 (10 km^2) [48]. QinetiQ partnered with the Maritime and Coastal Agency (UK) to evaluate the impacts of the North Hoyle Wind Farm on shipboard radar systems. The study evaluated shipboard and shore-based radar systems[50].

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.

8.2 Effect of wind farms on communications

The scope of this section includes marine communications system, including ship-to-ship and ship-to-shore communications systems. The research included evaluations of High Frequency (HF), Very High Frequency (VHF) and Ultra High Frequency (UHF) radio systems. The effects of offshore WTGs on marine communications is not discernable. The following sections summarize the relevant studies.

8.2.1 US Department of Energy

The US 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[49]. 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"[49].

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[47] "Investigation of Technical and Operational Effects on Marine Radar Close to Kentish Flats Offshore Wind Farm" MARICO Marine, April, 2007.
[48] http://coastalenergyandenvironment.web.unc.edu/ocean-energy-generating-technologies/offshore-wind-energy/offshore-wind-farm-case-studies/case-study-north-hoyle-offshore-wind-farm/. Accessed October 17, 2017.
[49] United States Department of Energy Final Report DE-EE0005380, Assessment of Offshore Wind Farm Effects of Sea Surface, Subsurface and Airborne Electronic Systems, September 30, 2013.

8.2.2 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 Maritime and Coastguard Agency (MCA)[45]. The studies showed that the effect of wind farms on communications and positioning systems are minor.

8.2.3 North Hoyle Wind Farm

The effects of the North Hoyle Wind Farm in the UK on shipboard communications was studied in 2004[50]. 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.

8.3 Potential mitigation measures

Mitigation measures can be used to reduce the impacts of the wind farm on radar and communications. Consideration should be given to each measure, taking into account its relative cost and risk reduction value. These are general mitigation measures and are not specific to SFWF.

- Wind Farm Layout: It may be possible to design the wind farm to reduce the impacts on radar. Increasing the spacing between WTGs generally decreases its effects on radar. However, the viability of the wind farm to produce sufficient energy should be measured against the reduction in risk due to radar interference. This measure generally does not offer sufficient risk reduction to warrant redesign of a wind farm.

8.4 Conclusions of the effects of SFWF on radar and communications

It is not likely that offshore WTGs will have a measurable impact on radar and communications. The impacts on marine radar are variable, with some degree of signal degradation in most instances. Proximity to the WTGs is the leading factor in the degree of radar signal degradation.

Due to its location, outside of commercial shipping lanes, radar operations on commercial ships is not anticipated to be impacted by SFWF. Smaller vessels operating in or near the SFWF project area may experience radar clutter and shadowing.

Vessels operating in or near the wind farm should be made aware of potential radar interference from wind farms. 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 or near wind farms.

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[50] "Electromagnetic Investigations and Assessments of Marine Radar, Communications and Positioning Systems undertaken at the North Hoyle Wind Farm," QinetiQ and the UK Maritime and Coastguard Agency, MCA MNA 53/10/366 or QINETIQ/03/00297/1. November 1, 2004.

9 COAST GUARD MISSION CONSIDERATIONS

DNV GL facilitated a workshop with representatives from USCG Sector Southeastern New England on 12 September 2017 to discuss how the project could potentially effect USCG missions. A workshop participant list is in the Appendix C to this NSRA.

9.1 USCG mission data

USCG provided DNV GL with data of the missions that have occurred near the project area from 2006-2016. Over that period, a total of 26 USCG missions have taken place. The missions are plotted in GIS and overlaid with the AIS tracks and SFWF lease area in Figure 9-1. A cluster of missions occurs to the west of the project area.
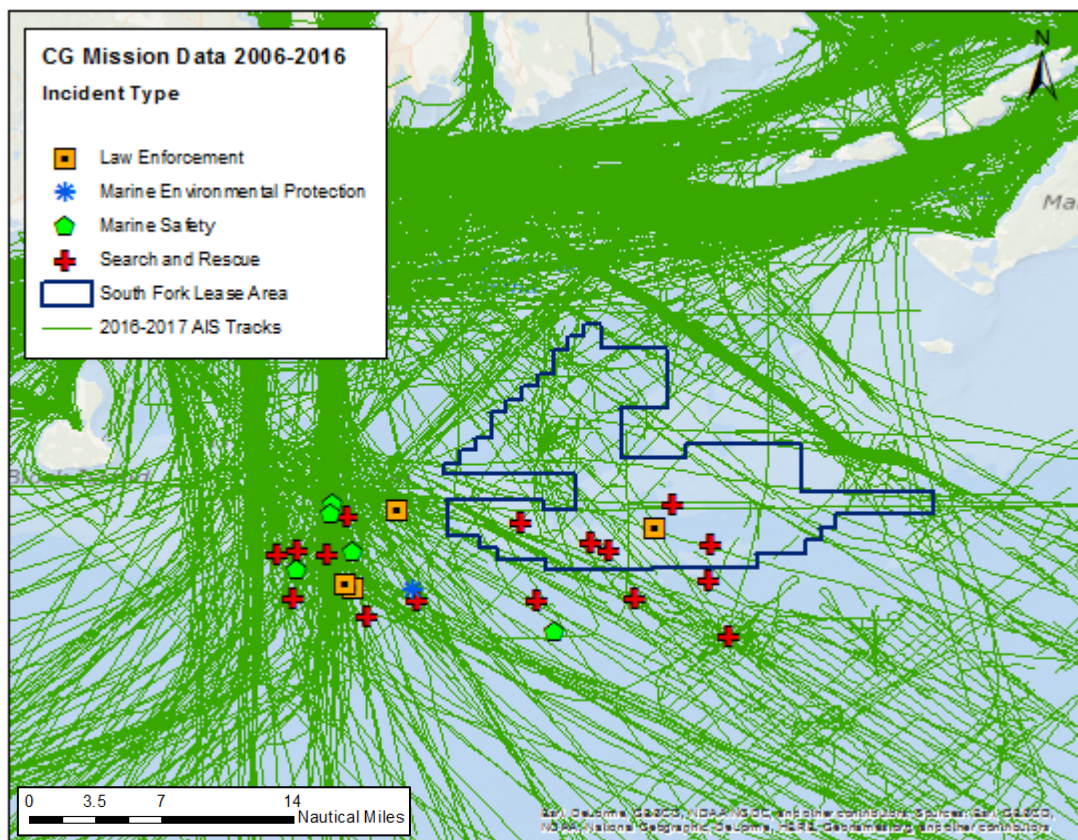
Figure 9-1 USCG mission data from 2006 to 2016 plotted by incident type

Of all the missions, Search and Rescue (SAR) missions made up 62% the missions near the project area. SAR missions are followed by Marine Safety missions (19%), Law Enforcement missions (15%) and Marine Environmental Protection Missions (4%). Figure 9-2 presents the breakdown of mission incident types from 2006 to 2016.

Figure 9-2 USCG missions from 2006 to 2016 by incident type

The maximum number of missions that occurred annually is five (in 2009 and 2014). Figure 9-3 presents the breakdown of missions per year from 2006 to 2016.

Figure 9-3 USCG missions per year from 2006 to 2016 near the project area

9.2 Effect of project / project structures on USCG missions

During the workshop, DNV GL posed the following questions to USCG representatives:
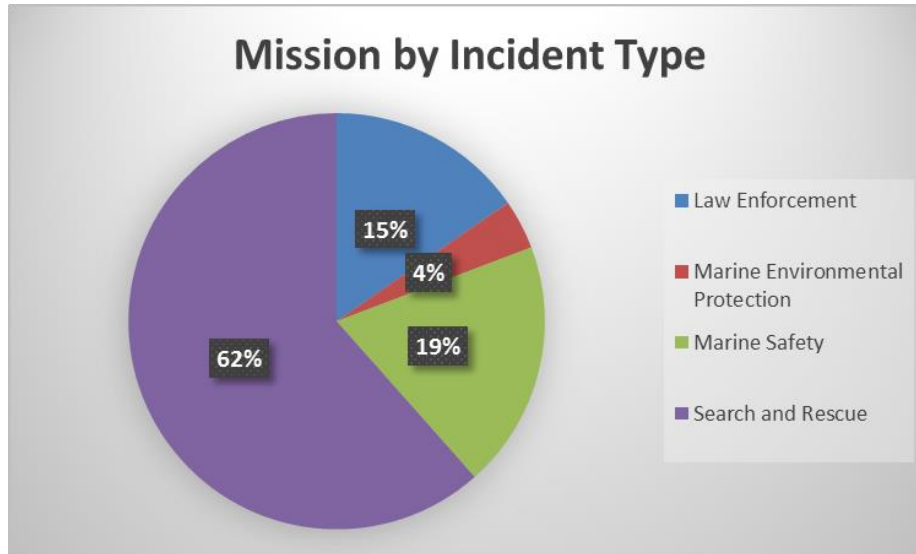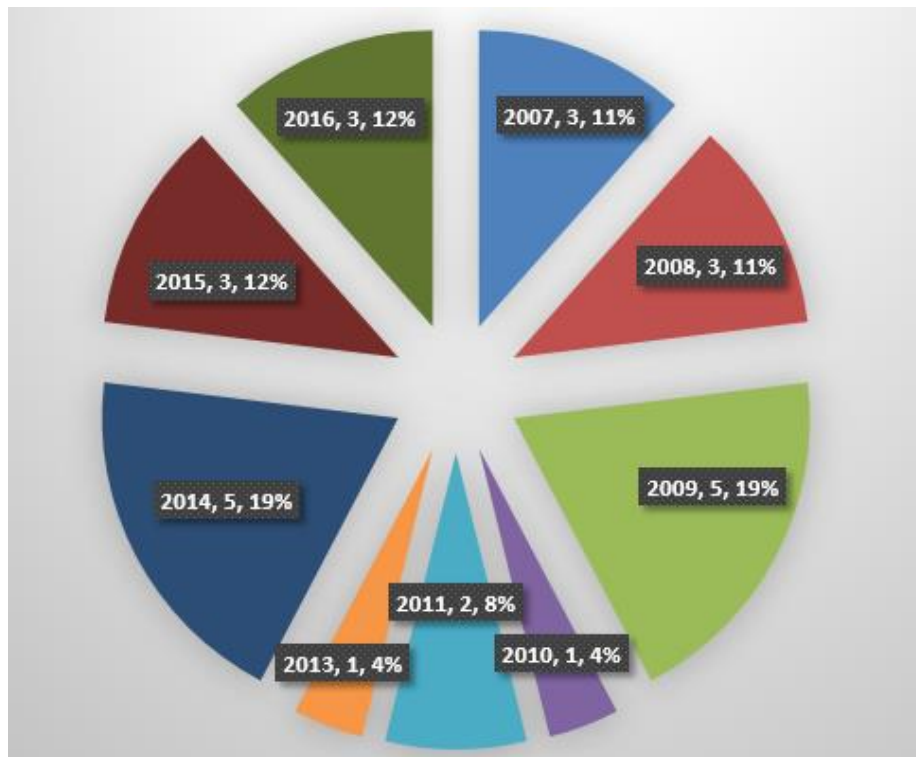
- What (if any) are the potential effects of SFWF on USCG missions?

- How can the effects be mitigated?

USCG believes that, overall, the project will not have negative effects on the missions in the region. This is primarily due to the low frequency of missions in the project area. A single mission has occurred in the project area over a 10-year period.

SAR incidents are the primary incident that occurs near the project area. Based on the USCG SAR Standard, SAR operations proceed through five stages: awareness, initial action, planning (iterative), operations (iterative), and conclusion[51]. To determine which Rescue Coordination Center (RCC) will respond to a specific SAR event, the flow chart in Figure 9-4 is utilized by USCG[51]. For Coast Guard First District, the SAR Coordinator Command / Joint Rescue Coordination Centers (JRCCs) are located in Boston, Massachusetts[51].

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[51] United States Coast Guard. *U.S. Coast Guard Addendum to the United States National Search and Rescue Supplement (NSS) to the International Aeronautical and Maritime Search and Rescue Manual (IAMSAR)*. COMDTINST M16130.2F. January 2013.
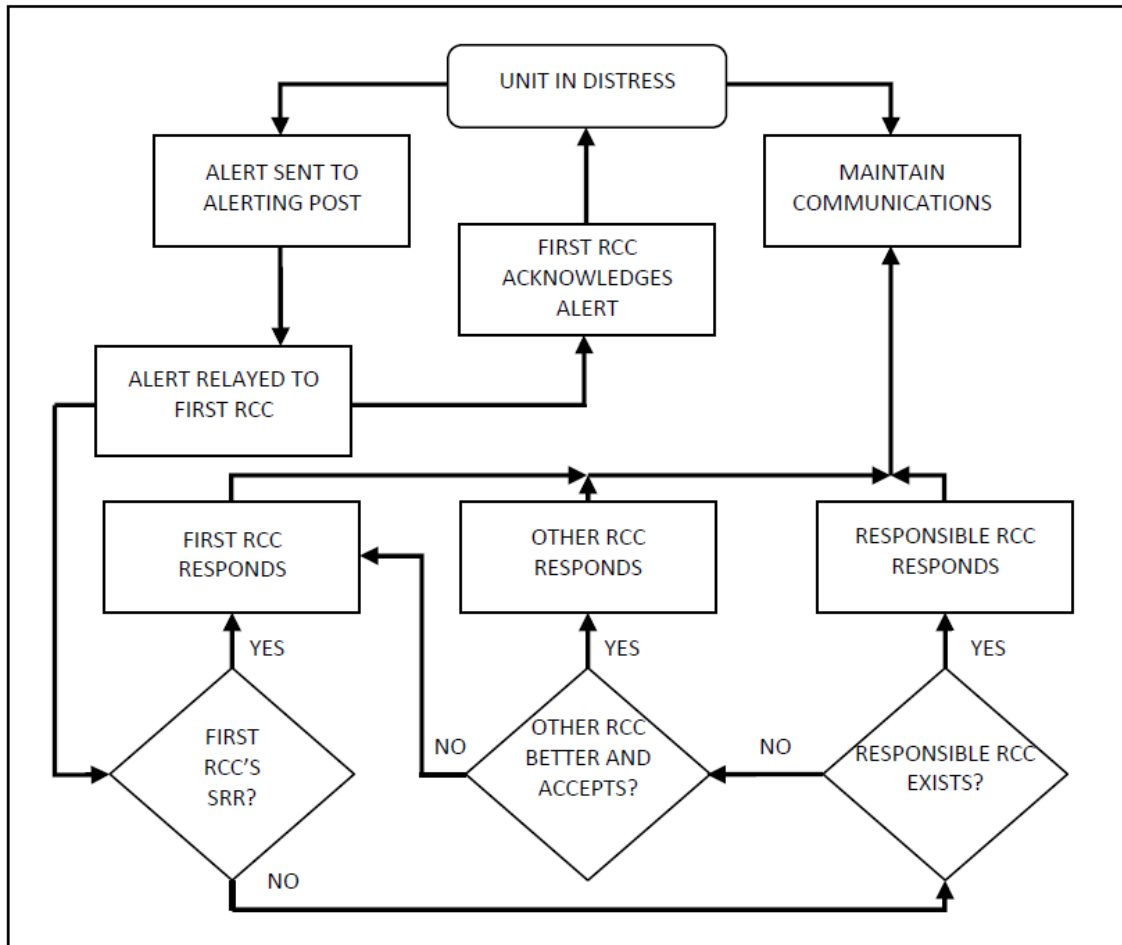
Figure 9-4 Determination of RCC to respond[51]

Per USCG SAR mission response standards, the siting, basing or staging of search and rescue units should provide a maximum of two-hour total response time for any one surface search and rescue unit. This includes 30 minutes' preparation time and a maximum of 90 minutes' travel time from underway to on scene. USCG does not anticipate that SFWF will affect the ability to be on-scene per the requirements of USCG standards or affect abilities once on scene[51].

USCG confirmed that they could continue to meet the SAR standard at the location of the SFWF.

10 CONCLUSIONS AND RECOMMENDATIONS

This NSRA did not identify any major areas of concern regarding SFWF impact on marine navigation. SFWF is located in open water more than 4 NM from high-vessel density deep draft commercial shipping lanes. It is approximately 15 NM from the closest land mass (Block Island), and nearly 19 NM from the main land.

Due to the large distance between WTGs and the grid-like WTG placement, the structures are not anticipated to significantly increase risk to vessels operating within the boundaries of SFWF. The calculated risk increase is considered negligible and did not take credit for additional mitigation measures that DWSF is planning to employ.

The three general types of marine incidents were evaluated: assessment of collision, striking, and grounding. The frequency of these events was estimated for current traffic conditions and for traffic conditions during operation of SFWF. Figure 10-1 presents a summary of the collision, striking, and grounding annual frequency results in the study area. The annual frequency is a measure of how likely it is that a collision, grounding or striking occurs in a year. An overall percent increase of 0.4% of marine incidents in the study area is estimated due to the presence of SFWF.

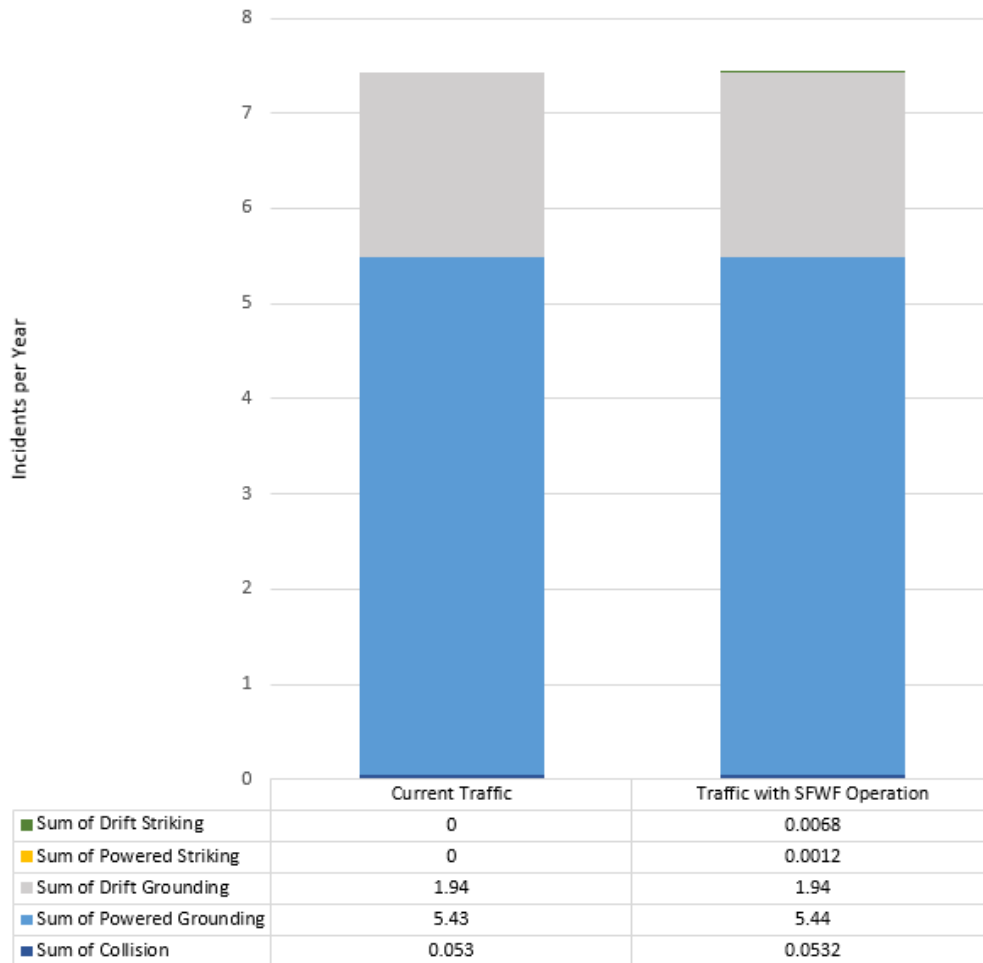|	Current Traffic	Traffic with SFWF Operation
■ Sum of Drift Striking	0	0.0068
■ Sum of Powered Striking	0	0.0012
■ Sum of Drift Grounding	1.94	1.94
■ Sum of Powered Grounding	5.43	5.44
■ Sum of Collision	0.053	0.0532

Figure 10-1 Marine annual incident frequency results

Table 10-1 presents the same values in terms of average return period in years. The return period indicates the period of time in which one event is estimated to occur. The larger the return period, the less likely the event is. For example, a powered striking is expected to occur once every 840 years, which is much less likely than a collision, which is expected to occur once every 18 years.

Table 10-1 Marine annual incident return period results (1 incident every X years)

Future Case with SFWF	Powered Grounding	Drift Grounding	Collision	Powered Striking	Drift Striking	Total
Base Case	5.43	1.94	0.053	-	-	0.1
Future Case	5.44	1.94	0.0532	0.0012	0.0068	0.1
Percent Increase [%]	0.2	0.3	0.3	-	-	0.4

The collision probability and striking probability of commercial fishing vessels transiting within SFWF is very low compared to the estimated frequencies for collisions and groundings and other strikings. The assessment of risk to commercial fishing provides additional detail concerning this vessel type.

A single commercial fishing vessel *transiting* the SFWF has a probability of striking a WTG at up to full speed equivalent to 1 in every 70,000 times it transits, or visits, the SFWF in good visibility (greater than 2 NM). For visibility less than 2 NM, the per vessel risk is about three times higher: 1 in every 25,000 times it transits the SFWF.

A single commercial fishing vessel *actively fishing* the SFWF has a slightly greater probability of striking a WTG at up to full speed: equivalent to 1 in every 77,000 times it transits, or visits, the SFWF in good visibility. In bad visibility, the per vessel risk is about 1 in every 27,500 times it transits the SFWF.

Collision risk for commercial fishing vessels is low. It was estimated as how likely it is for two commercial fishing vessels sailing near each other in the SFWF to collide. The probability of a collision occurring in the SFWF when two commercial fishing vessels are between the same WTGs is 1 in 200 million in conditions of good visibility and 1 in 4 million in conditions of poor visibility. To put this in context, suppose if every day of the year, 100 fishing vessels transiting the SFWF passed each other between two WTGs in good visibility, then the risk of a collision would be 0.00017 per year, or an average of 1 collision every 5,800 years.

Due to its location, outside of major deep-draft commercial shipping lanes, radar operations on commercial ships is not anticipated to be impacted by the SFWF structures. Smaller vessels operating in or near the SFWF project area may experience radar clutter and shadowing.

SFWF is not anticipated to have any impact on USCG missions.

10.1 Potential mitigation measures

Table 10-2 summarizes the planned mitigation measures. It is important to note that the project is still in planning / design phases, and these mitigation measures may be adjusted based on finalization of design and the development of the COP.

Table 10-2 Summary of SFWF mitigation measures

Phase	Category	Mitigation
Pre-Construction	Design	SFWF WTG layout was designed to have over 0.65 NM (0.75 miles) of sea room between most WTGs (with a minimum distance between WTGs of 0.6 NM [0.68 miles]) to minimize impacts on navigation, including the reduction of potential radar impacts. SFWF WTG layout follows a grid-like layout to promote safe navigation.
Pre-Construction	Design	The distance of SFWF from deep-draft commercial shipping lanes minimizes the risk of large deep-draft vessels striking a WTG or having navigational challenges due to the construction/operation of SFWF.
Construction	Stakeholder Outreach and Communication	DWSF will provide frequent and thorough notices to mariners during construction, operation, and decommissining to mitigate any impact SFWF activities may have on traditional waterway uses. This will include construction activities within the boundaries of the lease area and for all cable laying operations. The notices will be frequently published on and broadcasted though regular radio communications, online information for mariners and notices to mariner updates from USCG.
Construction	Procedure	DWSF will abide by all USCG defined procedures to preserve mariner and construction safety during construction activities. This includes the implementation of safety zones during construction.
Construction	Procedure	DWSF will define weather constraints under which they will stop relevant construction activities. DWSF will monitor current and future weather conditions to proactively plan construction activities during the safest weather conditions.
Operation	Design	DWSF will instal best available AIS technology to assist in safe navigation near and within SFWF based on input and frequent communication with USCG.
Operation	Design	SFWF will implement all appropriate lighting and marking schemes based on current regulations.
Operation	Procedure	SFWF will have a 24-hour operational monitoring center to verify safe conditions of SFWF are being maintained. The monitoring center will have the ability to remotely operate and shut down WTGs if required.
Operation	Stakeholder Outreach and Communication	SFWF WTGs, electric service platform (ESP), and transmission line will be clearly marked on applicable National Oceanic and Atmospheric Administration (NOAA) nautical charts, including but not limited to No. 31218 Martha's Vineyard to Block Island and No. 12300 Approaches to New York, Nantucket Shoals to Five Fathom Bank. Deepwater Wind intends to work closely with USCG and NOAA to chart all elements of SFWF and have frequent communication with local mariners on location and status of infrastructure.

About DNV GL

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