New York State Offshore Wind Master Plan

Shipping and Navigation Study

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NYSERDA Report 17-25q
December 2017

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New York State Offshore Wind Master Plan Shipping and Navigation Study

Final Report

Prepared for:

New York State Energy Research and Development Authority

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The Renewables Consulting Group LLC

New York, New York

NYSERDA Report 17-25q

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Notice

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Acronyms and Abbreviations

ACPARS	Atlantic Coast Port Access Route Study
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
AoA	Area of Analysis
BMP	best management practice
BOEM	Bureau of Ocean Energy Management
COLREGS	International Regulations for Preventing Collisions at Sea
DOS	New York State Department of State
GIS	Geographic Information System
HSC	high-speed craft
IMO	International Maritime Organization
Master Plan	New York State Offshore Wind Master Plan
MCA	Maritime and Coastguard Agency (UK)
MGN	Marine Guidance Note
MMSI	Maritime Mobile Service Identity, Unique vessel ID used in AIS data
MPG	Marine Planning Guidelines
MW	megawatt
NEFSC	Northeast Fisheries Science Center
nm	nautical mile
NOAA	National Oceanic and Atmospheric Administration
NSRA	Navigation Safety Risk Assessment (USA)
NTSB	National Transportation Safety Board
OCS	Outer Continental Shelf
OCSLA	Outer Continental Shelf Lands Act
OREI	Offshore Renewable Energy Installation
OSA	Offshore Study Area
RCG	The Renewables Consulting Group LLC
Study	Shipping and Navigation Study
TSS	Traffic Separation Schemes
USCG	United States Coast Guard
UTM	Universal Transverse Mercator
WEA	Wind Energy Area
WIG	wing-in-ground

Executive Summary

This Shipping and Navigation Study (Study) explores the possible implications of locating potential new offshore Wind Energy Areas (WEAs) off the coast of New York to shipping and navigational safety, given current use of the region. New York State intends for this Study to provide the Bureau of Ocean Energy Management (BOEM), the maritime community, and other stakeholders with information useful for the identification of potential new offshore wind energy lease areas. Three heavily transited Traffic Separation Schemes (TSSs) are already in place to ensure safe passage for large commercial vessels and passenger ships heading to and from New York Harbor, but the TSSs do not fully extend through the Area of Analysis (AoA) and do not serve the needs of other users of the AoA, such as tugs and barges, fishing vessels, and other commercial and recreational craft. Therefore, shipping and navigation uses must be heavily considered in the offshore wind farm siting process.

To characterize current use of the region, vessel Automatic Identification System (AIS) data from the Marine Cadastre portal for 2011, 2013, and 2014 were processed and integrated in a geographic information system (GIS) model of the AoA. Using a density threshold of >21 vessels per year, seven main vessel routes were identified. “Gates” for each of the vessel routes were created to analyze the type, number, and size of vessels transiting these routes, which helped inform the location of areas for study that may be suitable for offshore wind development.

This Study also provides a recommendation for a suitable minimum distance between WEAs and shipping and navigation lanes—based on various navigation safety principles, guidance documents, and European case studies—that can be used for initial planning purposes and informing the preliminary identification of area for potential locating of WEAs. Regardless of the findings or recommendations of this Study, the developer of any future offshore wind farm would be required to conduct a Navigation Safety Risk Assessment (NSRA) to ensure that individual offshore wind farm components are located in a matter that is safe to shipping and navigational use in a specific area.

1 Introduction

This Shipping and Navigation Study (Study) is one of a collection of studies prepared on behalf of New York State in support of the New York State Offshore Wind Master Plan (Master Plan). These studies provide information on a variety of potential environmental, social, economic, regulatory, and infrastructure-related issues associated with the planning for future offshore wind energy development off the coast of the State. When the State embarked on these studies, it began by looking at a study area identified by the New York State Department of State (DOS) in its two-year Offshore Atlantic Ocean Study (DOS 2013). This study area, referred to as the "offshore study area (OSA)," is a 16,740-square-mile (43,356-square-kilometer) area of the Atlantic Ocean extending from New York City and the south shore of Long Island to beyond the continental shelf break and slope into oceanic waters to an approximate maximum depth of 2,500 meters. The OSA was a starting point for examining where turbines may best be located, and the area potentially impacted. Each of the State's individual studies ultimately focused on a geographic Area of Analysis (AoA) that was unique to that respective study. The AoA for this study is shown in Figure 2.

The State envisions that its collection of studies will form a knowledge base for the area off the coast of New York that will serve a number of purposes, including (1) informing the preliminary identification of an area for the potential locating of offshore wind energy areas (WEAs) that was submitted to the Bureau of Ocean Energy Management (BOEM) on October 2, 2017, for consideration and further analysis; (2) providing current information about potential environmental and social sensitivities, economic and practical considerations, and regulatory requirements associated with any future offshore wind energy development; (3) identifying measures that could be considered or implemented with offshore wind projects to avoid or mitigate potential risks involving other uses and/or resources; and (4) informing the preparation of a Master Plan to articulate New York State's vision of future offshore wind energy development. The Master Plan identifies the potential future WEAs that have been submitted for BOEM's consideration, discusses the State's goal of encouraging the development of 2,400 megawatts (MW) of wind energy off the New York coast by 2030, and sets forth suggested guidelines and best management practices (BMPs) that the State will encourage to be incorporated into future offshore wind energy development.

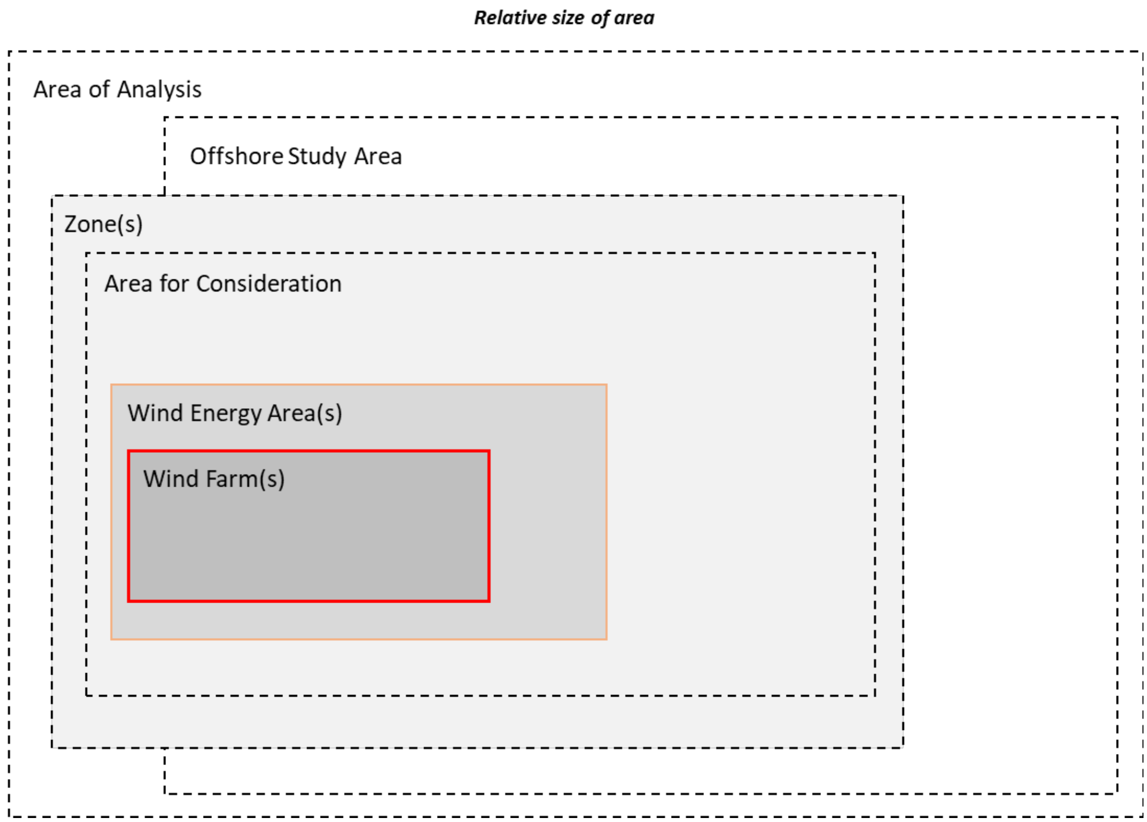
Each of the studies was prepared in support of the larger effort and was shared for comment with federal and State agencies, indigenous nations, and relevant stakeholders, including non-governmental organizations and commercial entities, as appropriate. The State addressed comments and incorporated feedback received into the studies. Feedback from these entities helped to strengthen the quality of the studies, and helped to ensure that these work products will be of assistance to developers of proposed offshore wind projects in the future. A summary of the comments and issues identified by these external parties is included in the Outreach Engagement Summary, which is appended to the Master Plan.

The Energy Policy Act of 2005 amended Section 8 of the Outer Continental Shelf Lands Act (OCSLA) to give BOEM the authority to identify offshore wind energy development sites within the Outer Continental Shelf (OCS) and to issue leases on the OCS for activities that are not otherwise authorized by the OCSLA, including wind farms. The State recognizes that all development in the OCS is subject to review processes and decision-making by BOEM and other federal and State agencies. Neither this collection of studies nor the State's Master Plan commit the State or any other agency or entity to any specific course of action with respect to offshore wind energy development. Rather, the State's intent is to facilitate the principled planning of future offshore development off the New York coast, provide a resource for the various stakeholders, and encourage the achievement of the State's offshore wind energy goals.

1.1 Terminology

This Study uses the following terminology for the physical, legal, and theoretical spatial boundaries used in the master planning process (Figure 1).

Figure 1. Terminology

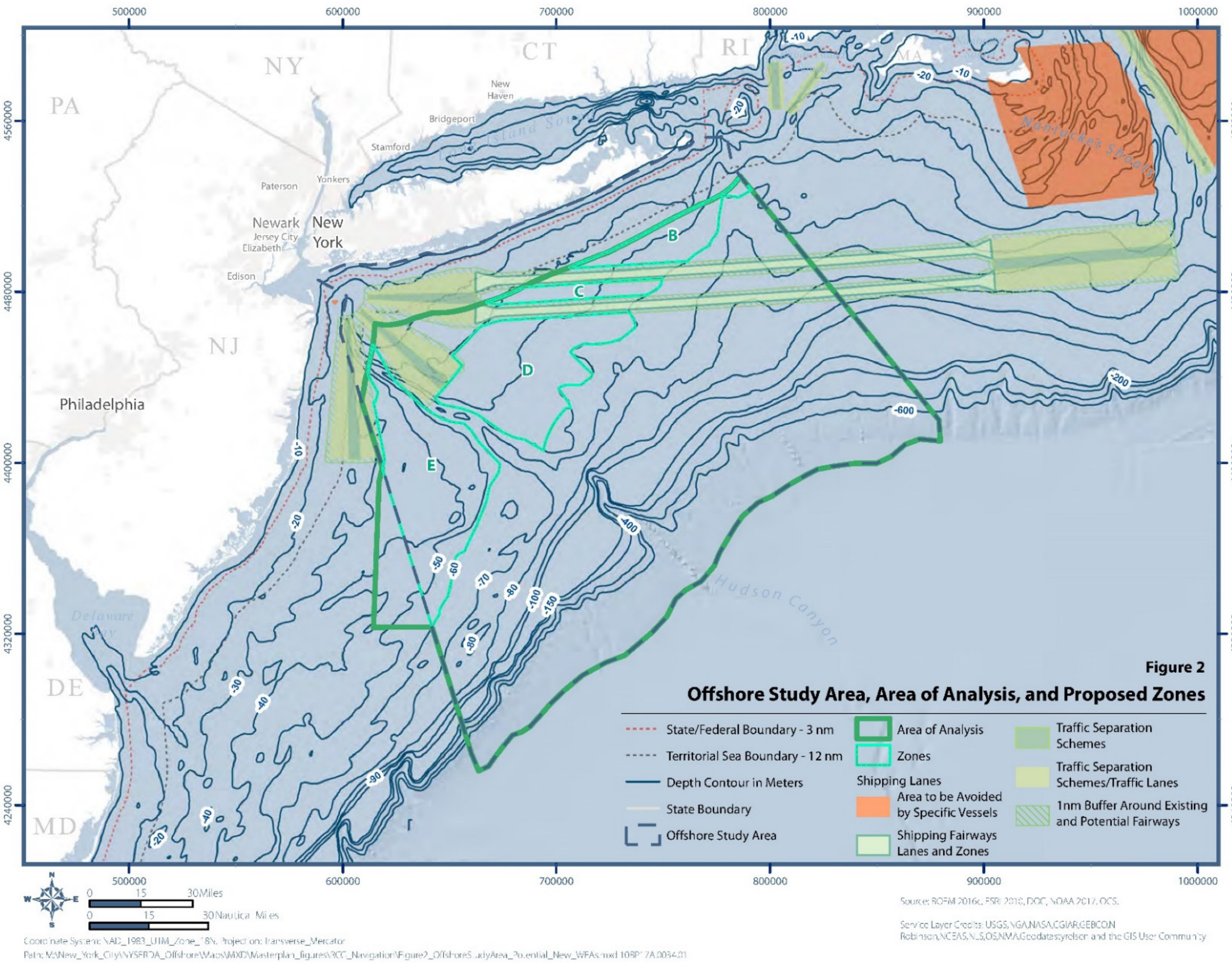


Term	Definition	Boundary Type
Area of Analysis (AoA)	The area analyzed for this Study	Theoretical
Offshore Study Area (OSA)	The original study area considered for master planning	Theoretical
Zone	An area within the AoA under consideration by New York State for offshore wind farm development	Theoretical
Area for Consideration	Area(s) proposed by New York State to BOEM for consideration for offshore wind farm leasing	Theoretical
Wind Energy Area	An area identified by BOEM for offshore wind leasing	Legal
Wind Farm (or Site)	An actual offshore wind farm site within a Wind Energy Area	Physical

The AoA consists of four Zones once constraints to water depth and distance to shore are applied and existing navigation corridors are excluded (Figure 2).

Figure 2. Offshore Study Area, Area of Analysis, and Proposed Zones

Source: BOEM 2016c; ESRI 2010; DOC; NOAA 2017; OCS



2 Study Overview

This Study identifies and evaluates the potential risks to navigation posed by siting offshore wind farms within the Zones shown on Figure 2 and recommends modifications to the Zone boundaries to identify of an appropriate Area for Consideration within which offshore wind energy development could potentially occur.

To characterize current use of the region, vessel Automatic Identification System (AIS) data from the Marine Cadastre portal for 2011, 2013, and 2014 were processed and integrated in a geographic information system (GIS) model to generate models of shipping densities and traffic patterns within the AoA. These models were used to identify and assess safety considerations relating to offshore wind farm component proximity to official vessel traffic routes (TSSs), fairway lanes, and other unofficial but regularly traveled routes.

For master planning purposes, potential navigation risks are evaluated at a high level, given that comprehensive, site-specific Navigation Safety Risk Assessments (NSRAs) would be undertaken if WEAs are identified and individual areas within them are proposed for development.[1]

Relevant spatial planning guidelines and benchmarks and existing best practices from Europe were reviewed to develop the recommendation for an appropriate minimum distance between offshore wind farms and the main vessel traffic routes identified in this Study.

1 An NSRA typically considers the potential impacts on navigational safety of each wind farm as well as potential cumulative impacts using up-to-date vessel traffic analysis, risk modeling, and IMO Formal Safety Assessment. The NSRA also considers the requirement established in the MOU between BOEM and the USCG for developers to undertake an NSRA guided by USCG NVIC 02-07. This knowledge is then used to make appropriate recommendations for any mitigation and risk control measures deemed necessary.

2.1 Data Sources

The following data sources were used in this Study:

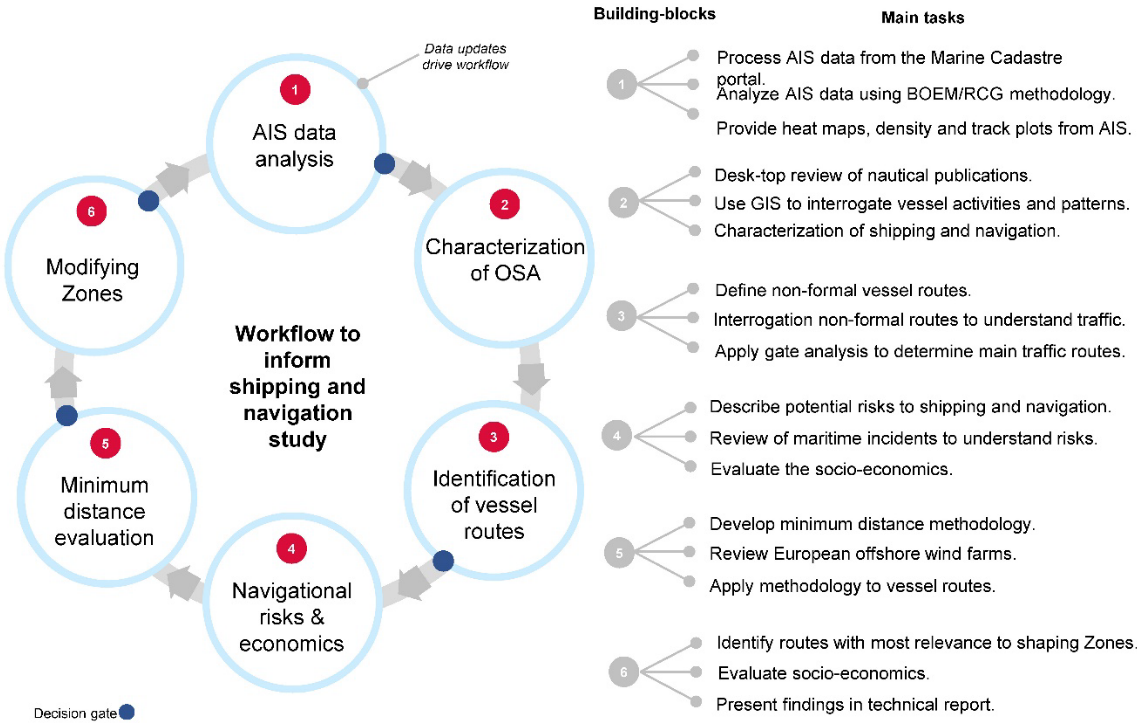
- **AIS Data:** BOEM and National Oceanic and Atmospheric Administration (NOAA).
- **Shipping Lanes**: NOAA Office of Coast Survey.
- **Fishing:** Vessel Monitoring System fisheries observation data obtained from NOAA's Northeast Fisheries Science Center (NEFSC).
- **Bathymetry:** NOAA National Geophysical Data Center.

2.2 Workflow and Methodology

The following workflow was used to develop the recommendations provided in this Study:

- **AIS data analysis:** GIS spatial analysis tools were used to ensure that data interpretation methods satisfy the objectives of this Study.
- **AoA characterization:** Reference guidelines for navigation safety and offshore wind siting were reviewed in the context of the AIS vessel data maps generated for the AoA.
- **Identification of vessel routes:** AIS data density plots that show relative vessel traffic were created to identify main vessel traffic routes by applying thresholds for vessel types and trip quantities and conducting a subsequent gate analysis of the main routes identified.
- **Navigational risk analysis:** The main potential risks to shipping and navigation that could be posed by offshore wind farms were evaluated. Historical incident data from the US National Transportation Safety Board (NTSB) was also mapped across the AoA to identify areas potentially sensitive to navigation safety issues.
- **Minimum distance evaluation:** International guidance, best practice, and distances currently applied to operational wind farms were evaluated to determine likely minimum acceptable distances between wind turbines and major shipping routes for initial planning purposes and informing the preliminary identification of area for potential locating of WEAs (Appendix A). The recommended minimum distance for planning purposes was also informed by examples of spatial planning tools from Europe (Appendix C).
- **Zone boundary modification:** Based on the findings of the earlier steps, recommendations for modifications to Zone boundaries are proposed.

Figure 3. Study Workflow[2]



2.2.1 AIS Data Analysis

AIS data provide information on vessel identity, type, position, course, speed, status, and other safety-related attributes. These data are automatically transmitted from vessels to receivers onshore, on other ships, and on aircraft. The United States Coast Guard (USCG) requires all vessels 65 feet or greater in length or towing vessels of at least 26 feet in length and all passenger ships to use AIS equipment to exchange information on vessel identify and location with other nearby ships (USCG 2017a). Some smaller vessels also use AIS equipment on a voluntary basis. The International Maritime Organization (IMO) International Convention for the Safety of Life at Sea requires AIS equipment to be carried on all passenger vessels and ships of 300 gross tons or greater that are engaged in international trade.

The AIS data analysis portion of this Study follows the methodologies developed by BOEM and NOAA to produce a series of GIS maps that show vessel track lines or spatial density using point data to characterize marine vessel traffic by type (e.g., cargo, tankers) (BOEM 2016a).

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2 A decision gate represents an opportunity to modify inputs.

The following process was used to create the aliquot vessel densities from the AIS point data:

- Each AIS data point provides information on the unique Maritime Mobile Service Identity (MMSI) vessel ID and the time and date of the recording.
- GIS tools were used to create vessel track lines from this AIS point data and then count the number of unique vessel tracks recorded within each 1,200-meter by 1-200-meter aliquot on an individual date (if the same vessel was present in an aliquot on two different dates, it was counted twice). The aliquots were then colored to show the number of vessels passing through the AoA in a series of maps.
- A separate GIS process was used to count the number of vessels where dates were disregarded, which avoided the situation of double-counting vessels traveling across the same aliquot on two separate dates (that is, if the same vessel was present in an aliquot on two different dates, it would be counted only once).

2.2.2 AoA Characterization

A GIS model was used to evaluate and map AIS data (e.g., vessel types, traffic patterns, voyage frequency, seasonality). In addition, factors that potentially constrain navigation, such as shipping lanes, water depths, submarine features, currents, existing structures, cables, pipelines, wrecks, hazardous areas (such as explosives dumping areas), and military use areas were mapped.

2.2.3 Main Vessel Traffic Route Identification

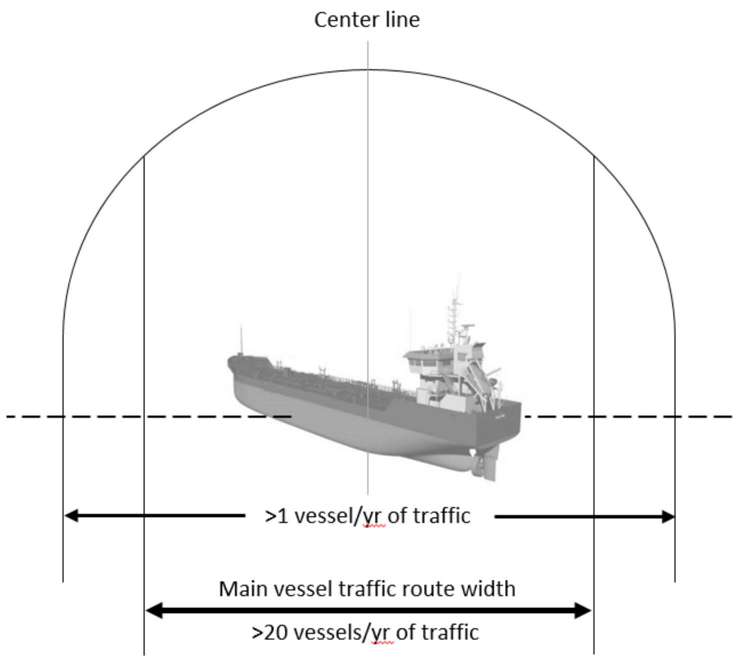
Main vessel traffic routes within the AoA were identified to gain an understanding of the use baseline and characterization of the area. To underpin the assessment of the recommended distances of wind farms from main vessel traffic routes, the assessment considered the following:

- The maneuvering capability of vessels, their turning circle (which is related to their length), and their crash stop (or emergency stop) distance
- The volume and frequency of traffic and the need to accommodate two-way traffic and overtaking
- Maps showing route plots and traffic density heat maps
- Statistical data on vessel distributions by type, size, direction, and speed
- Average traffic volume of vessels passing along key routes
- Key seasonal variations in traffic activity

The United Kingdom's Maritime and Coastguard Agency (MCA) has issued a guidance note on navigating offshore renewable energy installations (Marine Guidance Note [MGN] 543) that uses the principle of "interactive boundaries" and the 90th percentile to determine main vessel traffic routes for NSRA purposes (MCA 2016). However, it states that "the principle is not prescriptive." For initial planning purposes, it makes sense to identify main vessel traffic routes using heat maps, as they provide a broader view of vessel traffic in an area, rather than by defining the 90th percentile, which is more appropriate for NSRAs.

Figure 4 shows how the MCA's "interactive boundaries" principle was used to define a main vessel traffic route for this Study.

Figure 4. MGN 543 Criteria for a Main Vessel Traffic Route



Using the criteria described above and shown on Figure 4, vessel data were categorized to determine the number of individual vessels using each route, which is potentially indicative of their relative navigational importance.

2.2.4 Navigational Risks

The risks associated with offshore wind farms were reviewed to characterize the potential implications of wind farm development off the coast of New York to shipping and navigation use of the offshore region. This assessment of navigational risks included the following:

- Vessel movements (e.g., vessels transiting the area, fishing, minerals extraction)
- Wind farm structures (e.g., turbine and substation foundations, export cables)
- Conditions affecting navigation (e.g., weather, sea state, tides)

- Unplanned or unforeseen events (e.g., emergencies, unplanned vessel draft or maneuverability constraints, lack of command)
- Human actions (e.g., violations, mistakes)
- Incident statistics (e.g., historical accidents such as allisions, collisions, contacts, grounding, and stranding)[3]

The adoption of recognized navigation safety principles is a prudent way of managing wind farm siting risks. As Low As Reasonably Practical (ALARP) is a principle adopted by the MCA and the USCG, whereby best-practice risk controls are applied to reduce a given risk to an acceptable level (USCG 2016). However, since the primary objective of this Study is to identify appropriate Zones within which WEAs could potentially be sited, and not to establish the physical boundaries of individual wind farms, ALARP, which is a project-level consideration, would not be appropriate. Once a wind farm site has been proposed, the physical boundaries proposed by the developer can be assessed using appropriate risk-based tools (e.g., NSRA).

Risk-based models can assess potential navigational risk associated with offshore wind farms.[4] Such models can be used to assess the probability of vessel allision with a turbine in cases where vessels are transiting along, through, and between wind farms. These models, which combine probability coefficients of incidents with AIS data across a given area to identify potentially higher-probability locations for accidents, are typically used to inform the NSRA when the specific dimensions, location, and layout of a wind farm have been proposed.

For this Study, in line with MGN 543, the following factors have been considered (but not all modeled) in the development of recommendations for appropriate minimum distances (MCA 2016):

- Compliance with the best practices
- Vessel length
- Determining appropriate sea space for a vessel to maneuver safely
- Emergency stopping distance and anchoring
- Provisions for mechanical failure of a vessel

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3 Other types of accidents can occur that relate to safety risks, e.g., foundering, capsizing, fire and explosion, loss of hull integrity, flooding, machinery accidents, and cargo accidents. However, these types of accidents are generally not related to navigational conflicts.

4 EXAMPLES: Wawruch, R. and T. Stupak (2011). Modelling of Safety Distance Between Ships' Route and Wind Farm. The Archives of Transport Vol. XXIII. No 3; Chang, S-J., K-C. Tseng and S-M. Chang (2014). Assessing navigational risk of offshore wind farm development — with and without ships routing. IEEE; and Copping, A., Breithaupt, S., Whiting, S., Grear, M., Tagestad, J., and Shelton, G. (2015). Likelihood of a marine vessel accident from wind energy development in the Atlantic. Wind Energy Research article. John Wiley & Sons, Ltd.

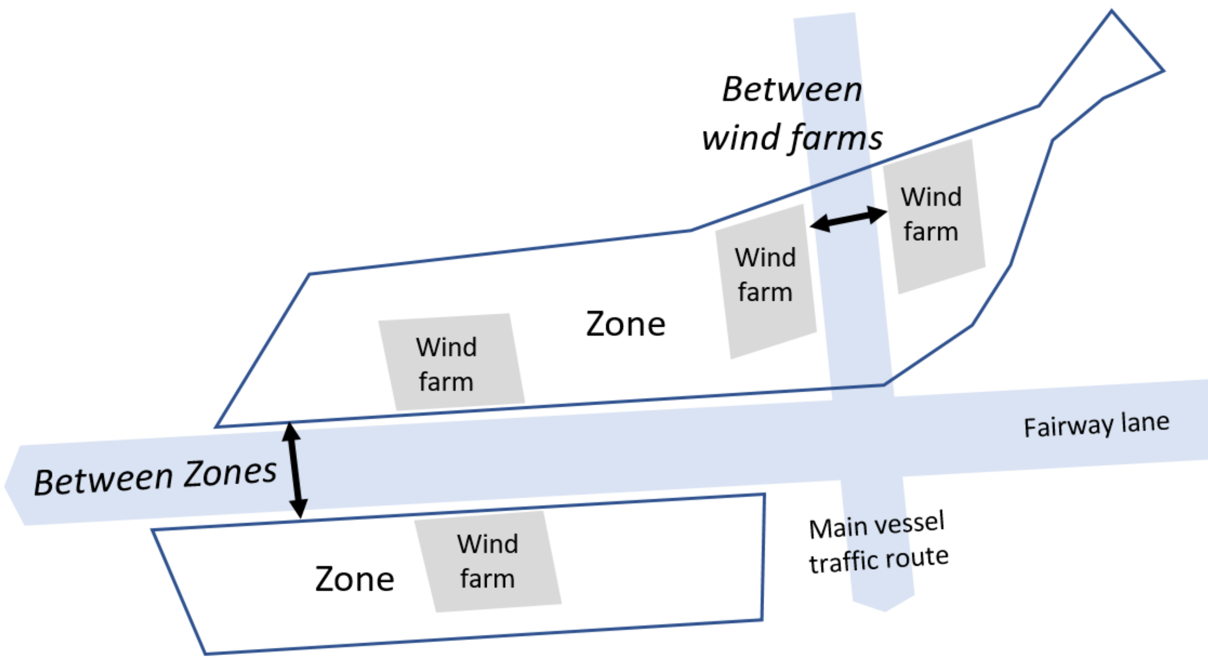
- Visibility, wind, sea and tidal stream, and proximity of navigational hazards.
- Traffic density, including that of fishing vessels.
- Draught in relation to the available depth of water, submarine cables, and obstructions.

2.2.5 Minimum Distance Evaluation

To determine an appropriate minimum distance between vessel traffic routes and offshore wind farm structures for initial planning purposes and informing the preliminary identification of area for potential locating of WEAs, routes identified through the AIS analysis were classified as either official routes (such as TSS and fairway lanes), or unofficial routes (such as regular runner/operator routes).

It was conservatively assumed that turbines could be sited up to the boundary of a WEA (although BOEM prohibits turbine blades to extend beyond WEAs, and in Europe the typical set-back distance is 500 meters) and, in some cases, on both sides of a vessel traffic route.

Figure 5. Conceptual Illustration of Distances Between Zones and Distances Between Potential Wind Farms



The following documents were reviewed to develop a minimum distance recommendation for initial planning purposes that ensures safe navigational passage between Zones and between wind farms (see Appendix A and B):

- MGN 543 (2016): Safety of Navigation: Offshore Renewable Energy Installations (OREIs) – Guidance on UK Navigational Practice, Safety and Emergency Response.[5]
- USCG (2016): Atlantic Coast Port Access Route Study (ACPARS).[6]
- Netherlands Guidance (2015): Shipping Advisory Board North Sea and Ministry of Transport for the Netherlands.[7]
- Nautical Institute (2013): The Shipping Industry and Marine Spatial Planning – A Professional Approach.
- Pacific Northwest National Laboratory (2013): Risk Assessment for Marine Vessel Traffic and Wind Energy Development in the Atlantic.
- Steamship Mutual (2009): Navigation in the Vicinity of Offshore Renewable Energy Installations.
- Swedish guidance (2009).
- Baltic SCOPE Project (2015). Swedish shipping guidelines referenced in Baltic SCOPE topic – Shipping (paper 2.0 Stockholm June 2015).
- WSV (2009) German guidelines for the Design, Marking and Operation of Wind Generators in the Area of Responsibility of the Federal Waterways and Shipping Directorates North-West and North to Guarantee the Safety and Efficiency of Vessel Traffic – Requirements for Spatial Planning.
- DTI (2005) Guidance on the Assessment of the Impact of Offshore Wind Farms: Methodology for Assessing the Marine Navigational Safety Risks of Offshore Wind Farms.
- BMT Cordah (2003) Offshore Wind Energy Generation: Phase 1 Proposals and Environmental Report.
- IMO (2002) Resolution ANNEX 6 - MSC.137(76): Standards for Ship Maneuverability.
- IMO International Regulations for Preventing Collisions at Sea 1972 (COLREGS).[8] COLREGS 8: calculation for a round turn to starboard in a shipping lane.

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5 This notice replaces the previous MCA guidance note MGN 371.

6 The USCG report noted that the Confederation of European Shipmasters' Associations (CESMA) and the Shipping Advisory Board North Sea recommend that minimum distances for wind farms should comply with the COLREGs.

7 Guidance supports the principle that siting of a wind farm and its associated safety zone is based on allowing sufficient space for a round turn of the largest vessel using existing shipping lanes – see DNV-GL (2015). Summary report on North Sea regulation and standards: Review of maritime and offshore regulations and standards for offshore wind.

8 The International Regulations for Preventing Collisions at Sea 1972 (COLREGs) are published by the International Maritime Organization (IMO) and set out, among other things, the "rules of the road," or navigation rules to be followed by ships and other vessels at sea to prevent collisions between two or more vessels.

Operating European offshore wind farms and the maritime spatial planning that has allowed them were also studied to provide benchmark distances between existing offshore wind farms and nearby shipping and navigation lanes (Figure 30) and between existing offshore wind farms themselves (Figure 32).

2.2.6 Zone Boundary Modification

Once the AoA was characterized by the identification of TSS lanes and the types of vessels and quantity and seasonality of voyages along key official and unofficial routes were analyzed, recommendations to modify Zone boundaries were made to ensure that areas considered for the potential siting of WEAs takes shipping and navigation conflicts into account.

3 Study Findings: AIS Analysis

The 2013 and 2014 one-minute interval AIS data for Universal Transverse Mercator (UTM) zones 18 and 19 were downloaded from the Marine Cadastre data portal, and the file sizes of the datasets were compared. Gaps for UTM zones 18 and 19 were identified from August onwards in the 2014 data; therefore, the 2013 data were used for this Study.[9] A 2011 vessel density grid created from AIS point data was also downloaded from Marine Cadastre for comparison, as shown on Figure 9.

Figure 6 shows the AIS point data for one month, January 2013. This point data was then merged with other monthly datasets for 2013 and processed to create vessel track lines and vessel density grids (heat maps).

Figure 7 shows the AIS 2013 dataset created by following the instructions provided by BOEM and NOAA to show high- to low-densities of vessels. Figure 7 provides an overview of where AIS-enabled vessels transit through the AoA, but it does not effectively identify main vessel traffic routes other than TSSs, fairway lanes, and coastal traffic. Therefore, heat maps were created by dividing AIS data into categories by vessel type and spatial density to provide better visualizations of the information (see Section 4).

The 2013 vessel traffic patterns (Figure 8) were compared with those from 2011 (Figure 9) and showed similar patterns in vessel use of the AoA, confirming the representative accuracy of the 2013 dataset.[10]

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[9] Omissions in the data were due to a change in methodology by the USCG in identifying and recording of the raw data (personal communication with the Marine Cadastre Team). Marine Cadastre was not aware of any similar omissions or discrepancies in the 2013 datasets.

[10] The use of any AIS dataset cannot account for future use, which may change due to external drivers such as economics, port development plans, and trends in global trade markets.

Figure 6. AIS Point Data Obtained within the Area of Analysis in January 2013

Source: BOEM 2016c; ESRI 2010; NOAA 2013

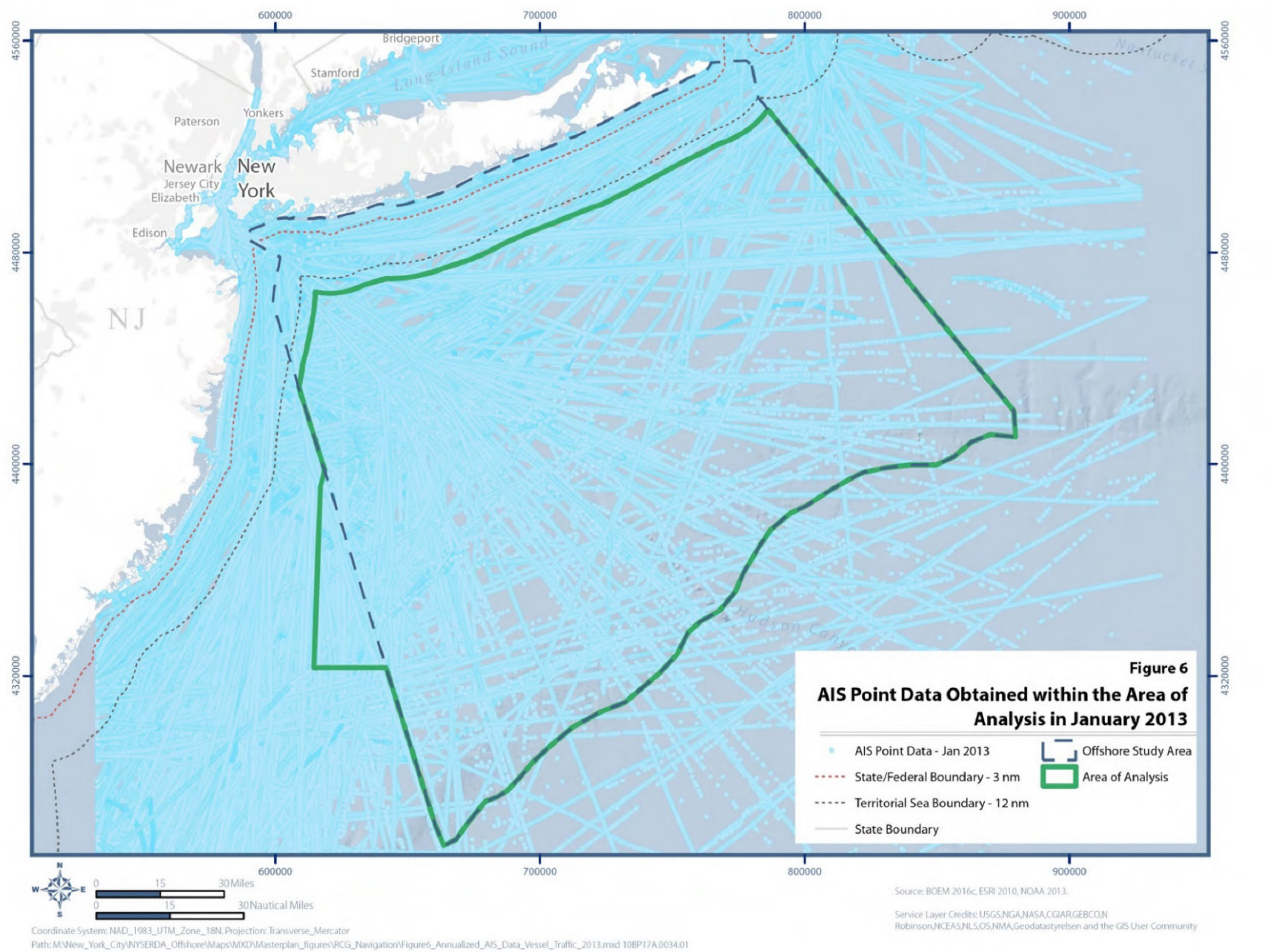


Figure 7. Annualized AIS Data Produced Following BOEM and NOAA Guidelines, 2013

Source: ESRI 2010; BOEM 2016c; NOAA 2013

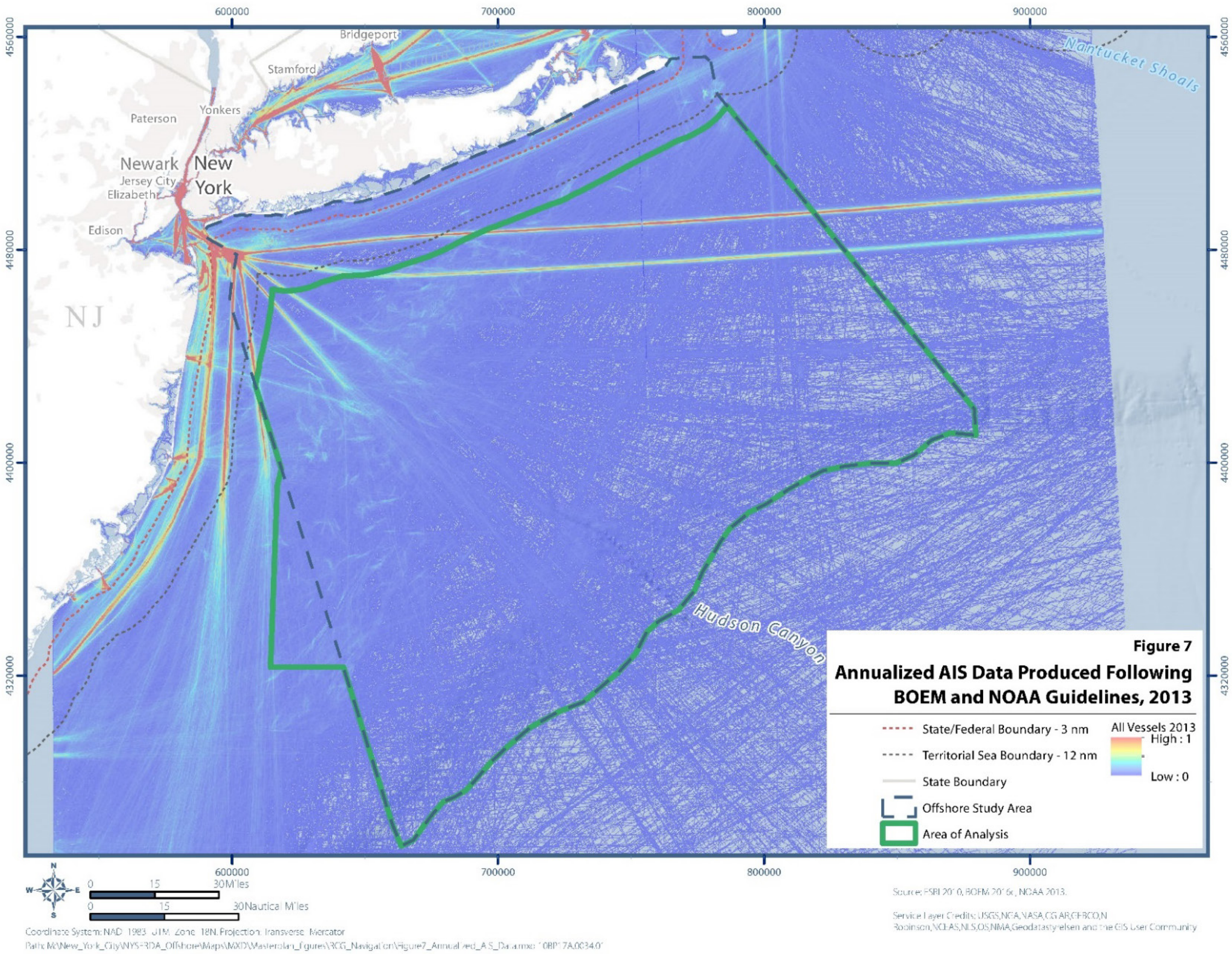


Figure 8. AIS Heat Map of All Vessels Within the Area of Analysis in 2013

Source: ESRI 2010; BOEM 2016c; DOC; NOAA 2013; OCS

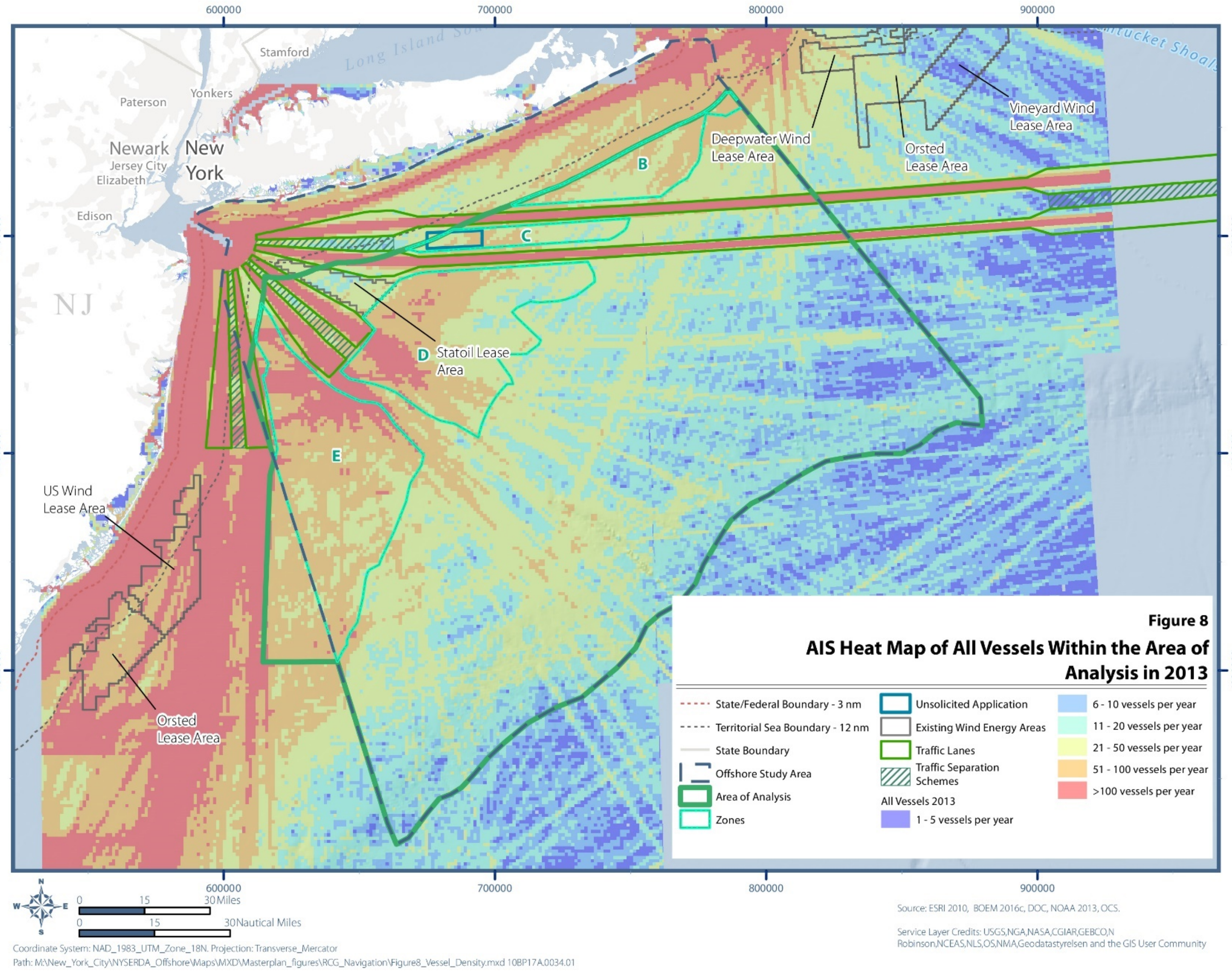
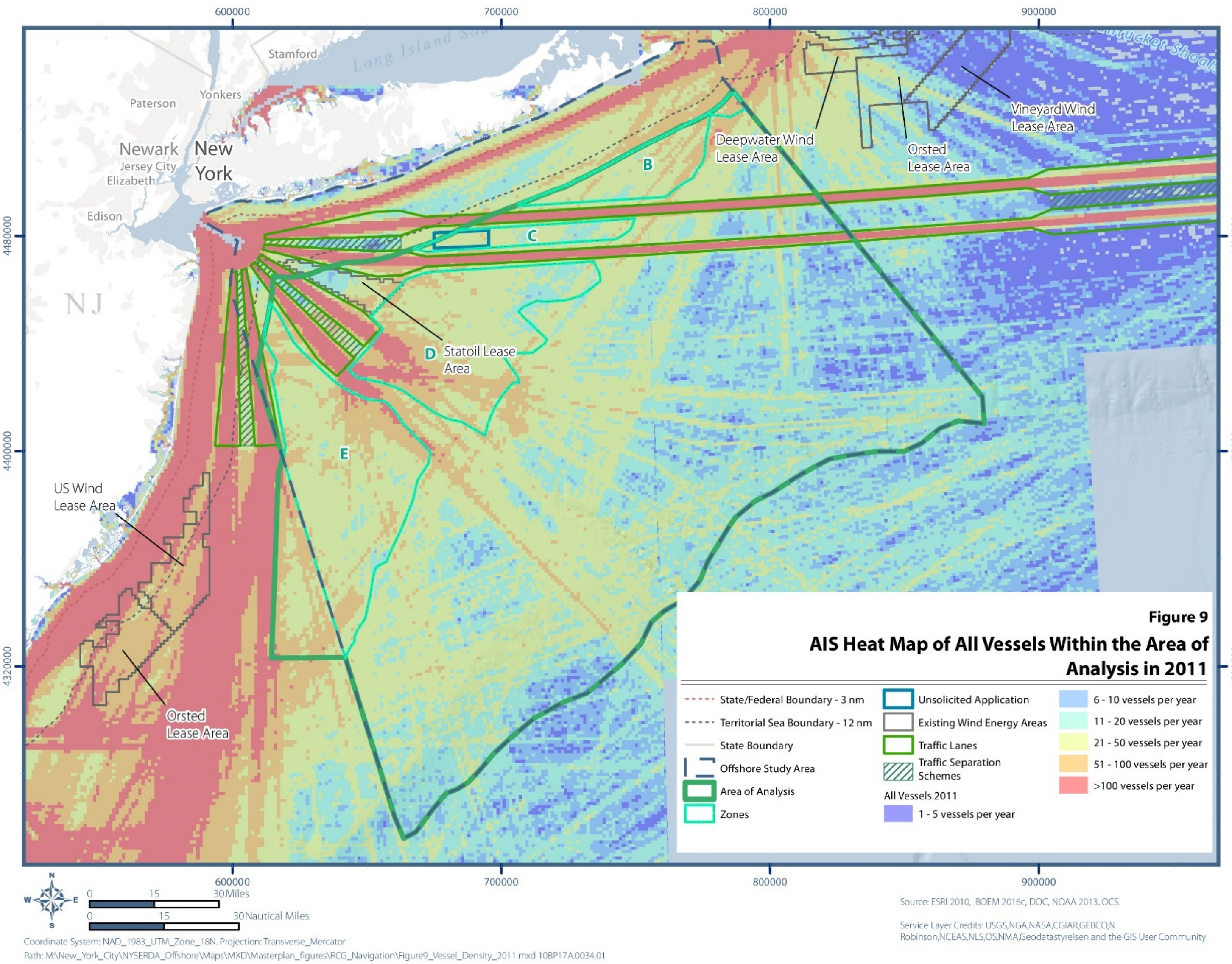


Figure 9. AIS Heat Map of All Vessels in the Area of Analysis in 2011

Source: ESRI 2010; BOEM 2016c; DOC; NOAA 2013; OCS



Although this heat-map approach was more effective than showing high- to low-densities, there were still limitations to clearly identifying main vessel traffic routes. According to AIS data, cargo, tanker, tug and towing, passenger, and fishing vessels are the main users of the AoA as they account for the greatest number of voyages within the region. However, the AIS data indicates that other vessel types such as military, USCG, wing-in-ground (WIG), high-speed craft, and recreational (sailing and pleasure) also use the AoA.[11]

To help visualize the routes for all vessel types, maps were created for each vessel category using vessel density classifications of 5-20 vessels, 21-50 vessels, 51-100 vessels, and greater than 100 vessels per year. These heat maps by vessel type are presented in Section 4.1, which discusses use of the AoA by each vessel type.

11 The New York Harbor Ops committee indicated that no WIG vessels operate on the East Coast, and given the traffic patterns of WIGs according to AIS data, they may be tug and barge vessels. This issue is addressed in Section 4.4.

4 Study Findings: AoA Characterization

New York's waters are economically important for commercial shipping. In 2013, over 2,928 AIS-enabled vessels (i.e., number of unique MMSIs) transited the AoA.[12] The Port of New York and New Jersey is the largest port on the East Coast and the third largest port in the U.S., and it processed over $188 billion in cargo in 2016 (Port Authority of New York and New Jersey 2016).

Three TSSs are in place to ensure the safe passage of large commercial shipping vessels inbound or outbound from New York and New Jersey, as shown in Figure 10 (Abercrombie, Debra and Karen Chytalo 2016).[13, 14] There are also two safety fairways within the AoA that serve as extensions to two TSSs (Ambrose-to-Nantucket Safety Fairway and Nantucket-to-Ambrose Safety Fairway).[15] According to the AIS data, the main vessels using the TSSs and fairways are large commercial vessels (>70 meters in length) such as cargo, tankers, and large passenger ships. The other types of vessels within the AoA exhibit different patterns of use, which must also be evaluated in the determination of appropriate locations for potential offshore wind energy development.

4.1 Overview of Vessel Use of the AoA

The main types of AIS-enabled vessels that transited the AoA in 2013 are provided on Figure 11. A full list of vessel types is provided on the Marine Traffic website (Marine Traffic 2017).

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12 This figure includes AIS records where vessel type is listed as null, which were not counted on Figure 11.

13 TSSs, which are established by the IMO and USCG in busy shipping areas where a lack of traffic regulation may result in accidents, typically consist of at least one traffic lane in each direction, turning points, deep-water lanes, and separation zones (IMO 2015).

14 According to Rule 10 of the COLREGS, vessels may enter or leave the TSS at any position and not just at the start or end.

15 A safety fairway is a lane or corridor in which no artificial island or fixed structure, whether temporary or permanent, will be permitted, and a fairway anchorage is an area contiguous to and associated with a fairway.

Figure 10. Designated Shipping Lanes Within and Adjacent to the Area of Analysis

SOURCE: BOEM 2016c; ESRI 2010; DOS; NOAA 2017; OCS

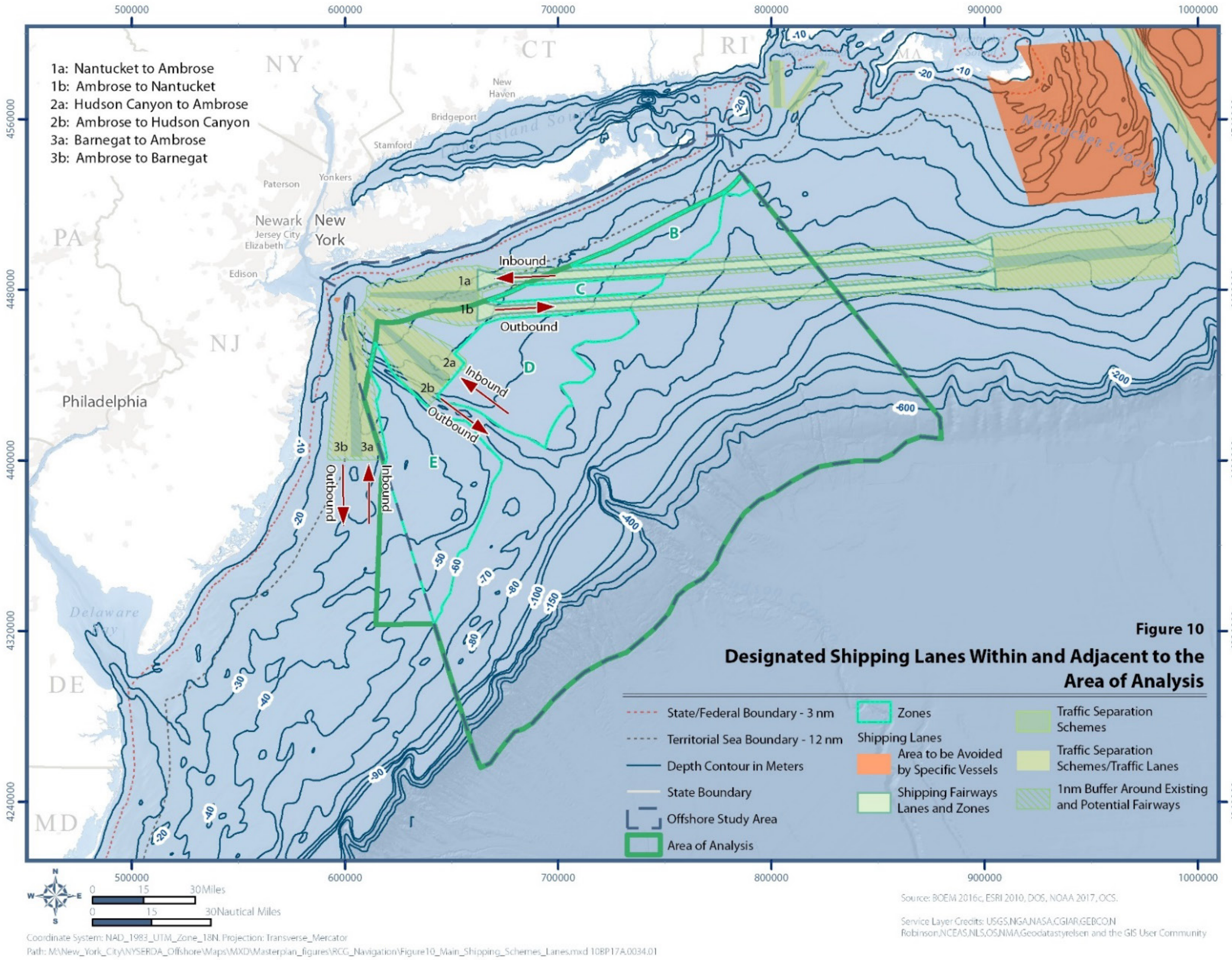


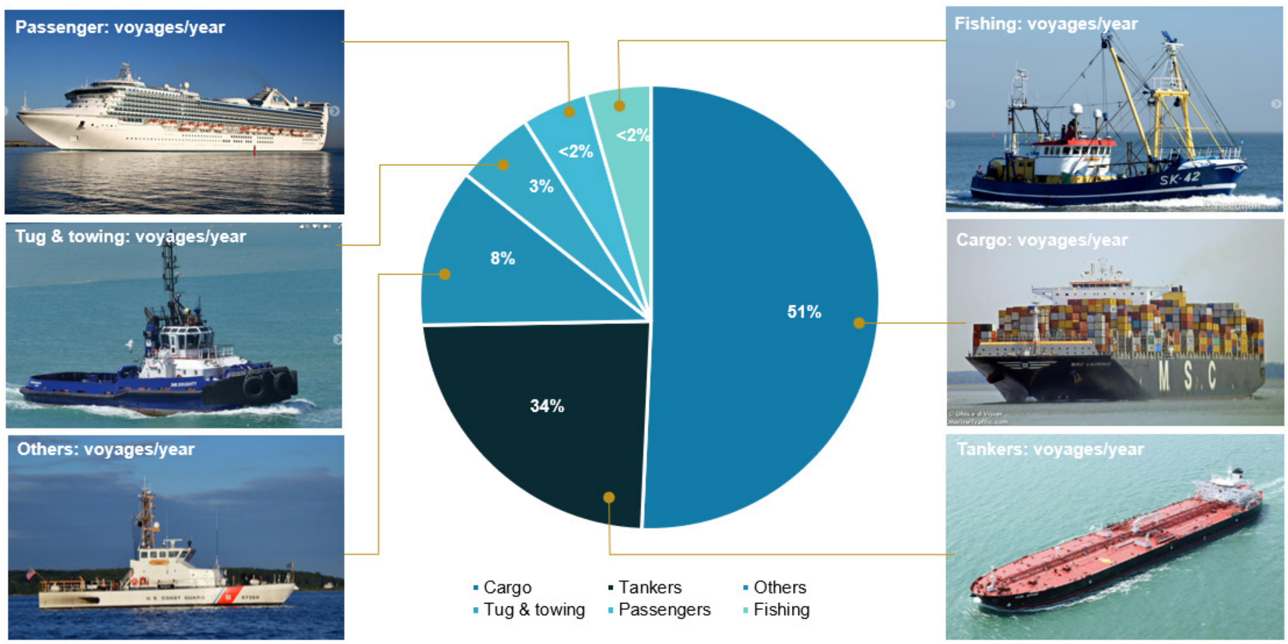
Figure 11. List of AIS-enabled Vessel Types and Unique Vessels within the Area of Analysis in 2013

Vessel type		Description	Unique vessels per year	Length (m)
Cargo		Bulk carriers, container vessels, general cargo	1220	36-337
Tanker		Bulk/oil carriers, chemical tankers, liquefied gas, oil tankers	825	100-277
Tug and towing		Barges, tugs, towing	78	10-196
Passenger		Cruise Vessels, ferries, high speed ferries	40	30-359
Fishing		Fishing vessels, fish processing	34	9-62
Recreational		Sailing and pleasure craft	150	13-60
Other	WIG	Wing-in-ground	8	33-159[a]
	HSC	High-speed craft	1	17
	Military	Engaged in military operations, patrol ships, navy vessels	28	7-289
	Port and pilot	Pilot boats and port tenders	2	35-220
	Law enforcement	Police launches	4	38-69
	Dredging	Engaged in dredging or underwater operations	4	65-116
	Search and rescue	USCG and fire-fighting vessels	2	14-68
	Diving	Engaged in diving operations	1	14

[a] The New York and New Jersey Harbor Safety and Operations Steering Committee suggested that no WIGs exist on the East Coast and that AIS datasets may include mischaracterized vessel types.

Of these vessel types, cargo ships comprised about 51% of overall voyages in the AoA, and tankers comprised 34% (Figure 12). Other vessel types, such as tugs and towing vessels comprised 3%, passenger vessels 1.6%, and fishing vessels 1.4%. Collectively, the remainder of vessels (e.g., diving, military, pilots, dredging, and USCG vessels) accounted for about 8%.

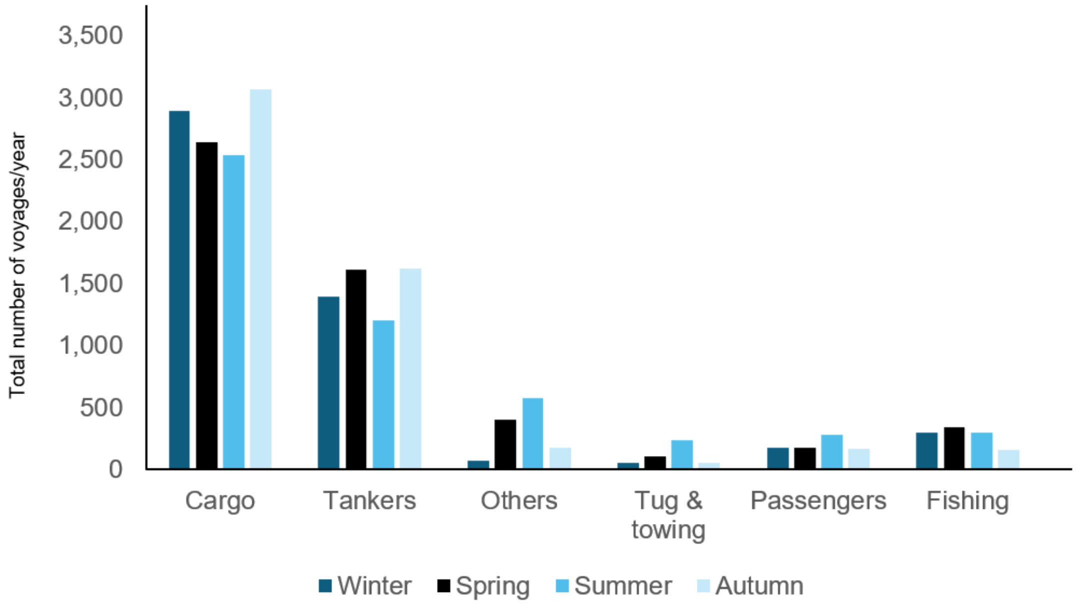
Figure 12. Percentage of Vessel Trips by Each Type of AIS-enabled vessel within the Area of Analysis in 2013



Vessel traffic patterns within the AoA are somewhat seasonal (Figure 13). This is expected as many vessels seek to take advantage of good-weather windows, fishing seasons, and other seasonal conditions. The principal observations on the seasonality of vessel use are

- The routes taken by commercial cargo vessels do not seem to change by season (Field, P, 2015)
- “Other” vessels show increased activity during spring and summer
- Tugs and towing vessels also show increased activity in summer

Figure 13. 2013 Seasonality of the Area of Analysis Use by Vessel Type



4.2 Cargo Vessel Patterns

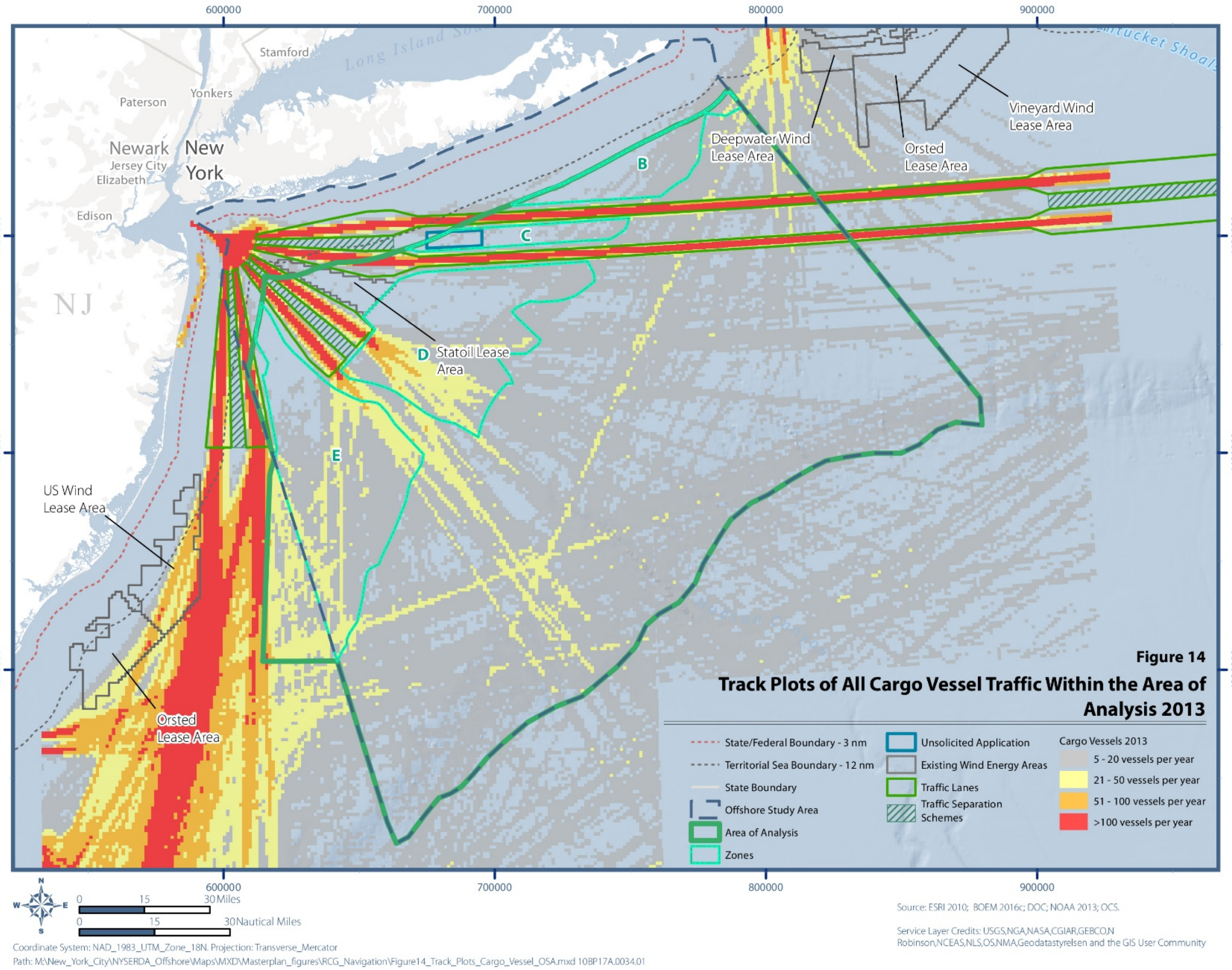
Figure 14 shows that cargo vessels predominantly follow fairways and TSSs, as shown on the heat map where vessel numbers >100 per year are represented in red. Both Nantucket-to-Ambrose and Ambrose-to-Nantucket TSSs are heavily used. Inbound traffic converging on the Hudson Canyon-to-Ambrose TSS come from a wide spread of traffic to converge on the TSS in a funnel shaped pattern. Conversely, outbound traffic from Ambrose-to-Hudson Canyon show a dispersing 'reverse funnel' pattern as vessels head to open sea.

In general, commercial ships take the most direct passage between waypoints, provided there are no other constraints, to reduce transit time and fuel costs (Toke, 2011). In both inbound and outbound cases, traffic also merges and crosses over these routes.

Southwards, inbound and outbound cargo traffic using the Barnegat-to-Ambrose and Ambrose-to-Barnegat TSSs merge with other coastal bound vessel routes to create a high concentration of vessel traffic. This is just outside the most southerly proposed Zone and the AoA.

Figure 14. Track Plots of All Cargo Vessel Traffic Within the Area of Analysis in 2013

Source: ESRI 2010; BOEM 2016; DOC, NOAA 2013; OCS



Other cargo vessels cross the AoA from the north and southwest corners and, in several locations, relatively high concentrations of cargo vessel traffic crosses other routes, but this generally occurs outside of the AoA Zones.

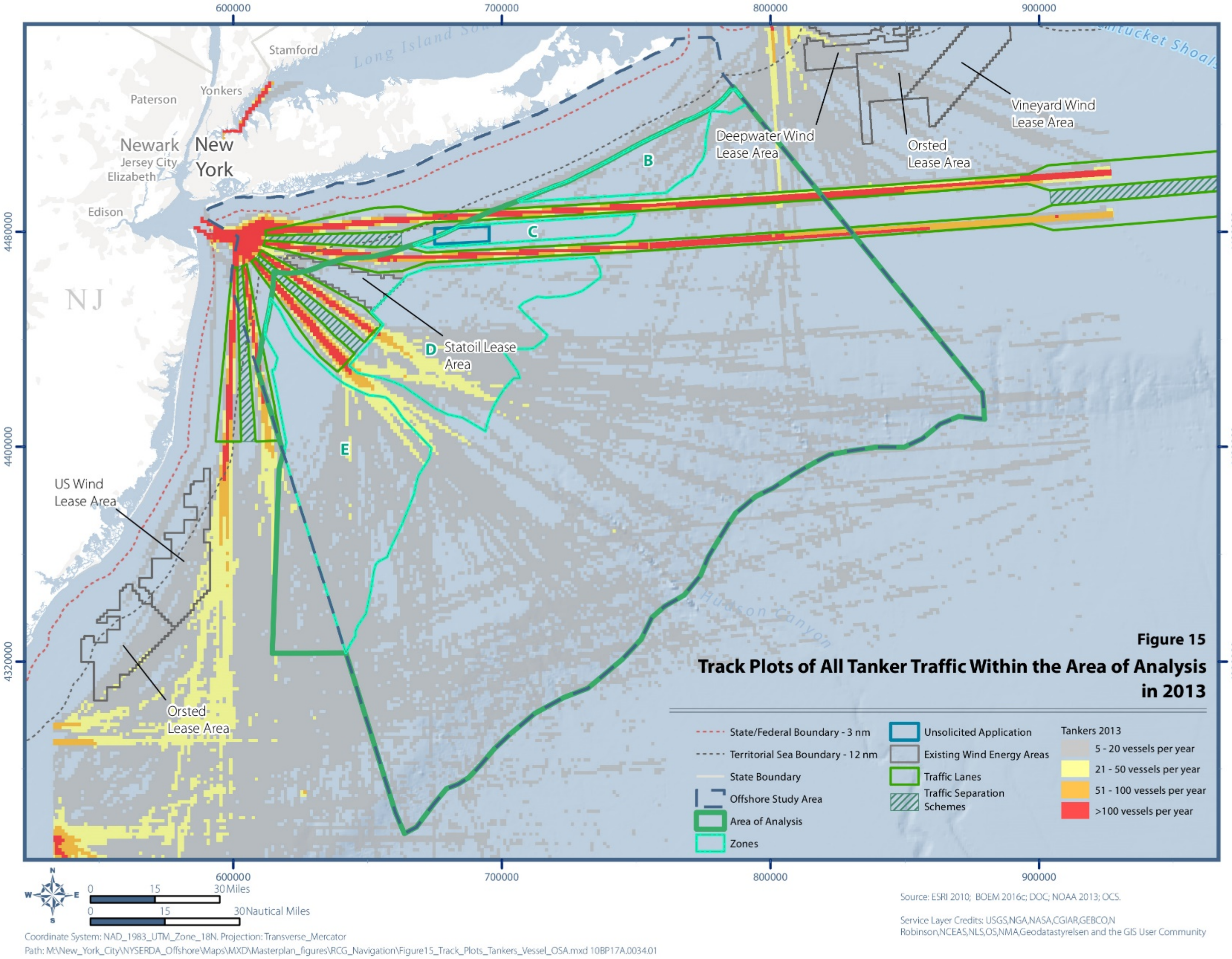
4.3 Tanker Vessel Patterns

Tankers cross the AoA in a similar pattern to cargo ships, with traffic predominantly following fairways and TSSs (Figure 15). Both the Nantucket-to-Ambrose and Ambrose-to-Nantucket TSSs are heavily used by tankers. Inbound tankers using the Hudson Canyon-to-Ambrose TSS en route to New York converge from a wide spread of traffic. By contrast, outbound traffic disperses from the Ambrose-to-Hudson Canyon TSS, heading to open sea and taking the most direct passage to their destination, creating a “reverse funnel” pattern.

Inbound and outbound tankers using the Barnegat-to-Ambrose and Ambrose-to-Barnegat TSSs also merge with other coastal traffic routes, whereby the inbound routes join the same high concentration of cargo traffic (see Figure 15), although this traffic is less dense and still outside the proposed Zones and AoA. Tanker transit routes also merge from the north and southwest corners of the AoA to follow a similar crisscrossing pattern as cargo vessels.

Figure 15. Track Plots of All Tanker Traffic Within the Area of Analysis in 2013

Source: ESRI 2010; BOEM 2016; DOC, NOAA 2013; OCS



4.4 Tug and Towing Vessel Patterns

Tug and towing vessel traffic predominantly follows coastal routes, with the highest concentration of traffic south from New York and outside the Ambrose-to-Barnegat TSS. A small number of tug and towing vessels use the fairways inbound to the Nantucket-to-Ambrose TSS and outbound from Ambrose-to-Nantucket TSS (Figure 16). Very few, if any, tug and towing vessels use the Hudson Canyon-to-Ambrose and Ambrose-to-Hudson Canyon TSSs, or the Barnegat-to-Ambrose and Ambrose-to-Barnegat TSSs. While the majority of tug and towing vessels transit outside the proposed Zones, some of these vessels use routes that enter the AoA from the north and southwestern corners, presumably to take the most direct route possible.

Although the AIS data do show WIGs and high-speed crafts (HSCs) as distinct vessel types present within the AoA, the New York and New Jersey Harbor Safety and Operations Steering Committee indicated that there are no WIGs on the East Coast and few, if any, HSCs, so it is possible that the data shown on Figure 16 understates the amount of tug and towing vessel activity within the AoA.

To address this concern, HSC and WIG vessels were analyzed independently to determine whether traffic patterns were similar to that of correctly marked tug and barges. Given that WIG vessel tracks were very similar to tug and barge tracks, Figure 17 was created to show the density and resulting tracks of both tug and towing and WIG vessels combined. Note that HSC vessel tracks did not match tug and towing vessel patterns whatsoever.

Given the low quantity of WIGs identified within the AoA (per Figure 11) and the minimal change in vessel density shown on Figure 17 from that on Figure 16, the misclassification of WIGs does not materially affect the findings of the route identification or gate analysis described in Section 5.

Figure 16. Track Plots of All Tug and Towing Vessel Traffic Within the Area of Analysis in 2013

Source: ESRI 2010; BOEM 2016; DOC, NOAA 2013; OCS

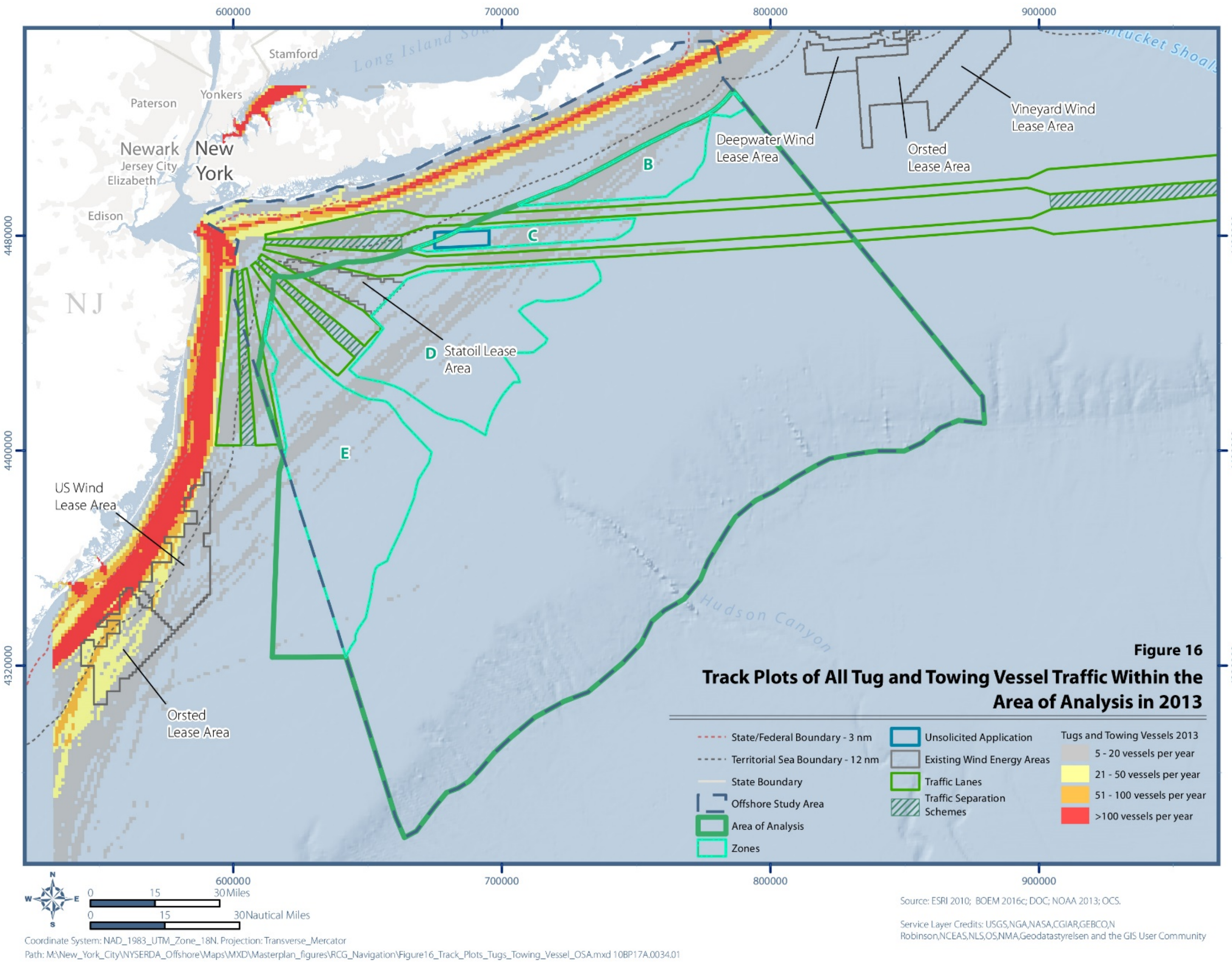
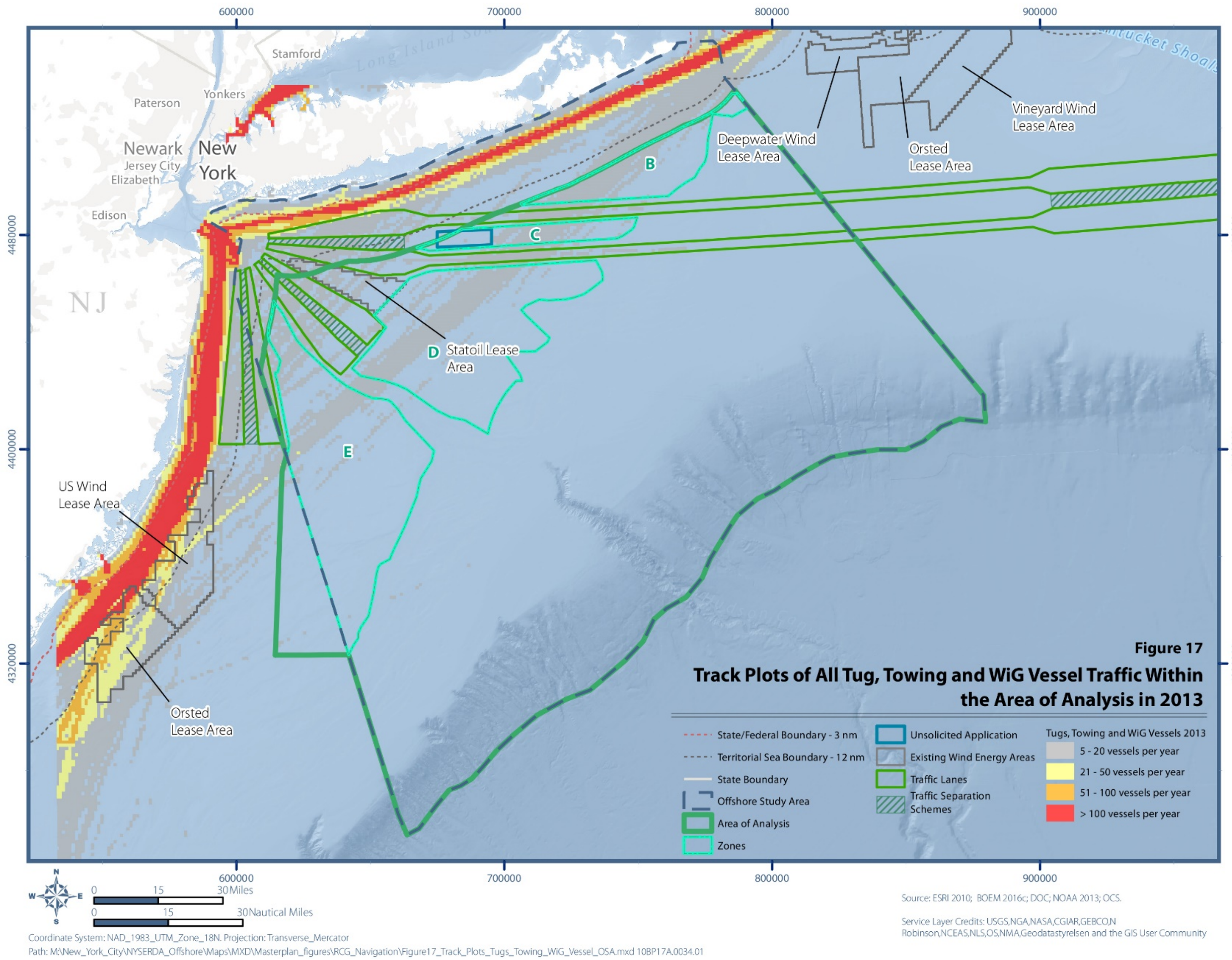


Figure 17. Track Plots of All Tug, Towing and "WIG" Vessel Traffic Within the Area of Analysis in 2013

Source: ESRI 2010; BOEM 2016; DOC, NOAA 2013; OCS



4.5 Passenger Vessel Patterns

Figure 18 shows that passenger vessels tend to follow fairways and TSSs. Outbound passenger vessel traffic from the Ambrose-to-Hudson Canyon TSS does not disperse as cargo and tanker traffic does, rather it takes a more direct route heading southeast to the open sea.

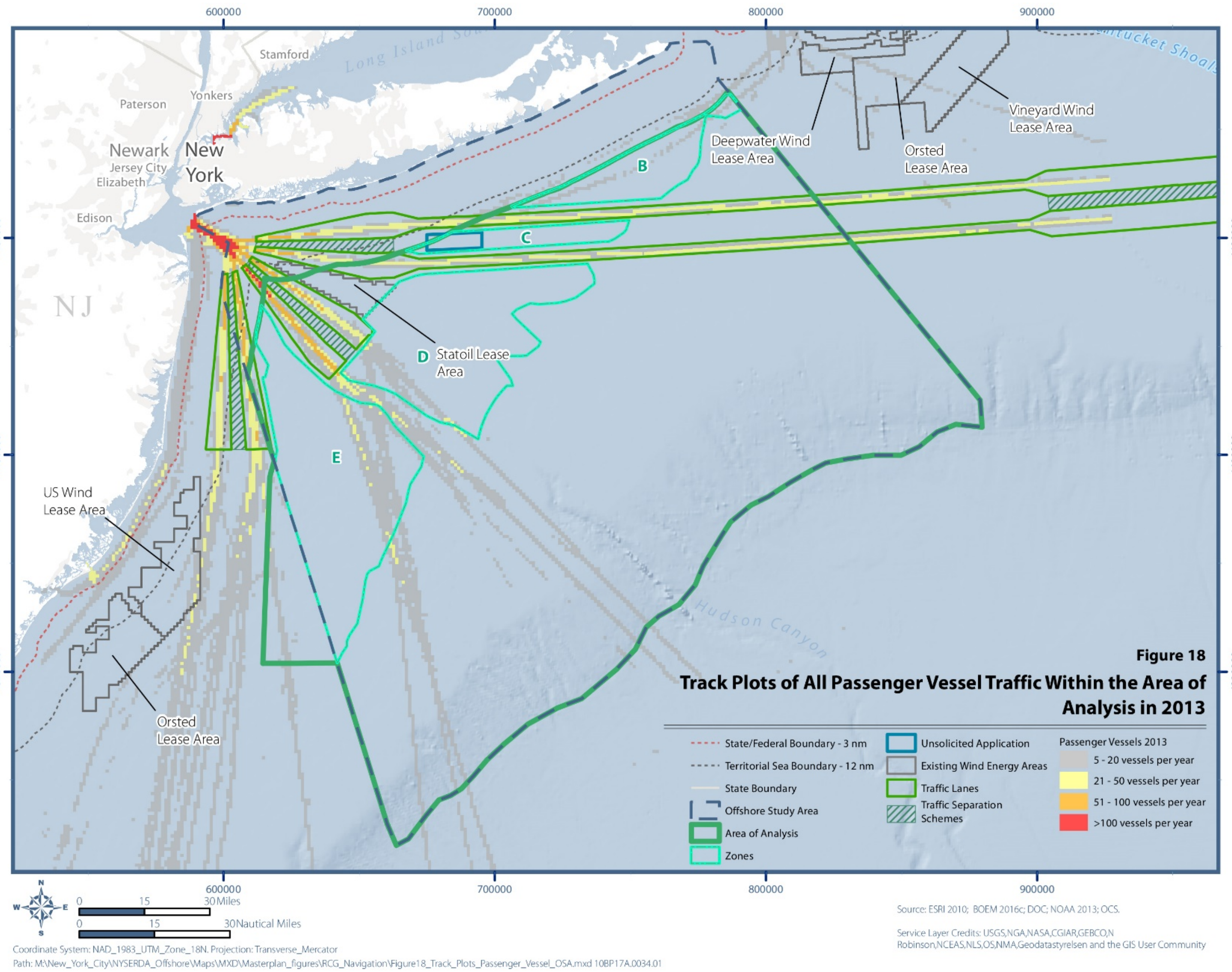
Inbound passenger vessel traffic at the Hudson Canyon-to-Ambrose TSS shows a similar pattern, but with traffic emerging from the south. In general, passenger traffic follows similar routes to some cargo and tanker vessels. Southwards, passenger traffic from the Barnegat-to-Ambrose and Ambrose-to-Barnegat TSSs also passes through the high concentration of traffic that includes cargo and tanker traffic. Again, these movements are outside the proposed Zones and AoA.

4.6 Fishing Vessel Patterns

Fishing vessel traffic patterns were analyzed to distinguish those transiting to and from fishing grounds from with those undertaking fishing activities. The results were used to identify potential fishing grounds in and around the proposed Zones, as characterized by high concentrations of fishing vessels. Mobile fishing gear types show a strong relationship with vessel speed (Hu et al. 2016). The 2013 AIS data show that a 5-knot speed threshold can be used to differentiate between mobile and stationary fishing activities (Battista and Cleaver 2013). However, this approach does not capture variances between different fishing activities or all fishers; rather, it was used as a high-level proxy to help meet the objectives of master planning.

Figure 18. Track Plots of All Passenger Vessel Traffic Within the Area of Analysis in 2013

Source: ESRI 2010; BOEM 2016; DOC, NOAA 2013; OCS



The analysis demonstrates that fishing vessels do not use fairways and TSSs other than to cross them on route to or returning from fishing grounds (Figure 19).[16] Relatively high vessel counts were recorded at ports and harbor entrances, but vessels appear to rapidly disperse or converge (depending on inbound or outbound direction) along coastal routes and harbors of origin and/or at fish landing sites. Three prominent transit routes emerge from inlets along the New Jersey coast (e.g., Barnegat Inlet and Manasquan Inlet) that cross the Barnegat-to-Ambrose and Ambrose-to-Barnegat TSSs. Some fishing vessels traverse the southwestern area of the AoA, with a noticeably higher presence in the proposed Zone located between the Ambrose-to-Hudson Canyon and Barnegat-to-Ambrose TSSs, although traffic movements also occur to a lesser extent in the other Zones.

A more comprehensive analysis of commercial fishing activities, by gear type, between the years 2011 and 2017 is provided in the *Fish and Fisheries Study*, which is appended to the Master Plan. Data obtained from NOAA and the NEFSC were mapped in a 10-minute-square grid to show fishing activity (number of trips observed in each grid square) for mobile gear types (e.g., trawls, dredges, and purse seines) and stationary gear types (e.g., gillnets, hand lines, longlines, pots and traps). These maps (Figures 20 and 21) were overlaid with AIS data on fishing vessel speeds using a threshold of <5 knots to show stationary fishing (Hu et al. 2016).[17] The AIS data for fishing vessels coincided well with the fisheries spatial patterns for mobile gear types, compared with that for stationary gear types.

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[16] Fishing industry representatives have reported that the spaces between TSSs and fairways are "safe harbors" for smaller vessel to avoid large cargo vessels.

[17] Recommendation from BOEM, pers. coms. September 1, 2017.

Figure 19. Track Plots of All Fishing Vessel Traffic Within the Area of Analysis in 2013

Source: ESRI 2010; BOEM 2016c; DOC; NOAA 2013, OCS

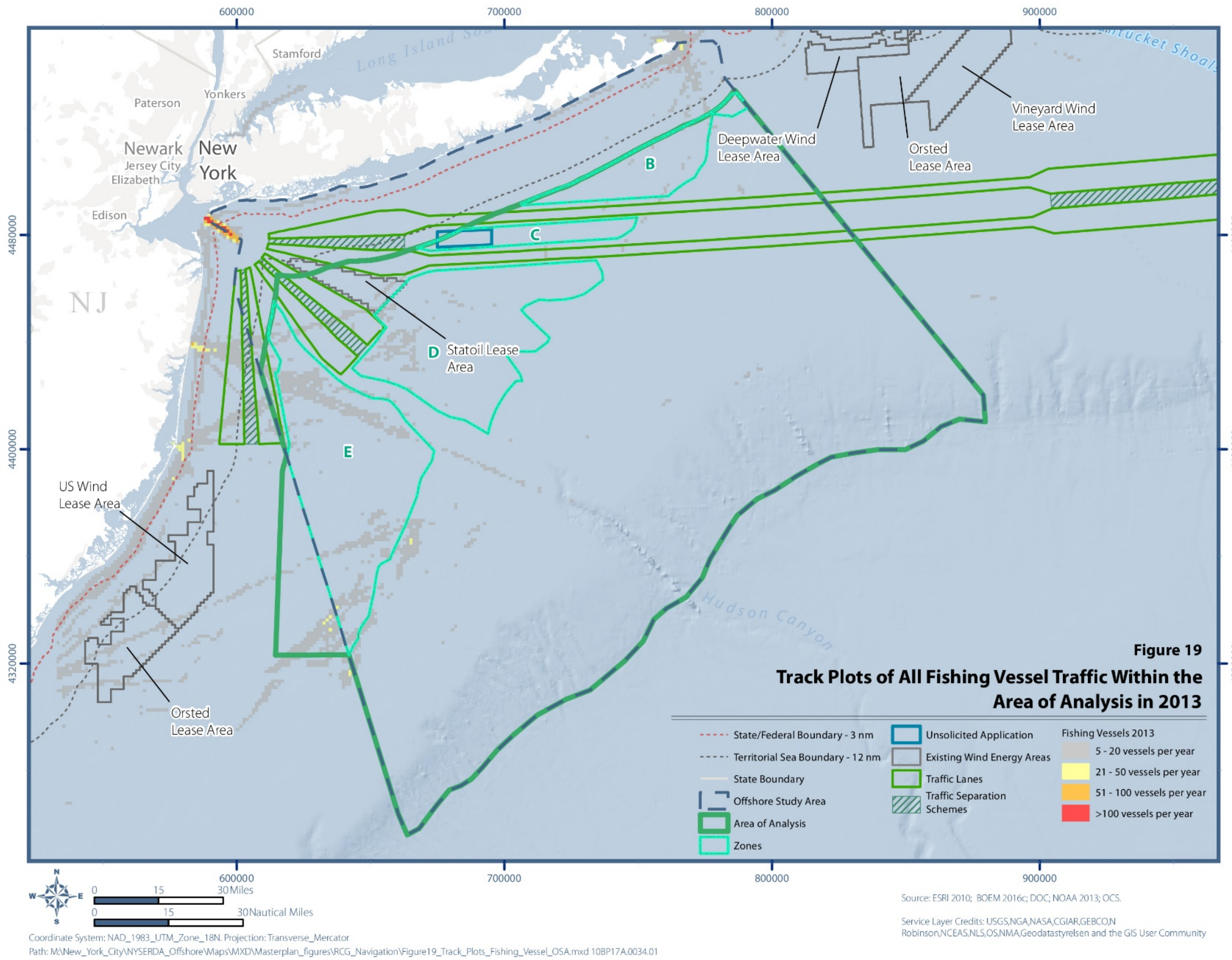


Figure 20. Track Plots of Fishing Vessels Traveling at Less Than 5 Knots Within the Area of Analysis in 2013 Overlaid with NOAA Mobile Gear Fishing Observations from 2011–2017

Source: ESRI 2010; BOEM 2016c; DOC; NOAA 2013, OCS

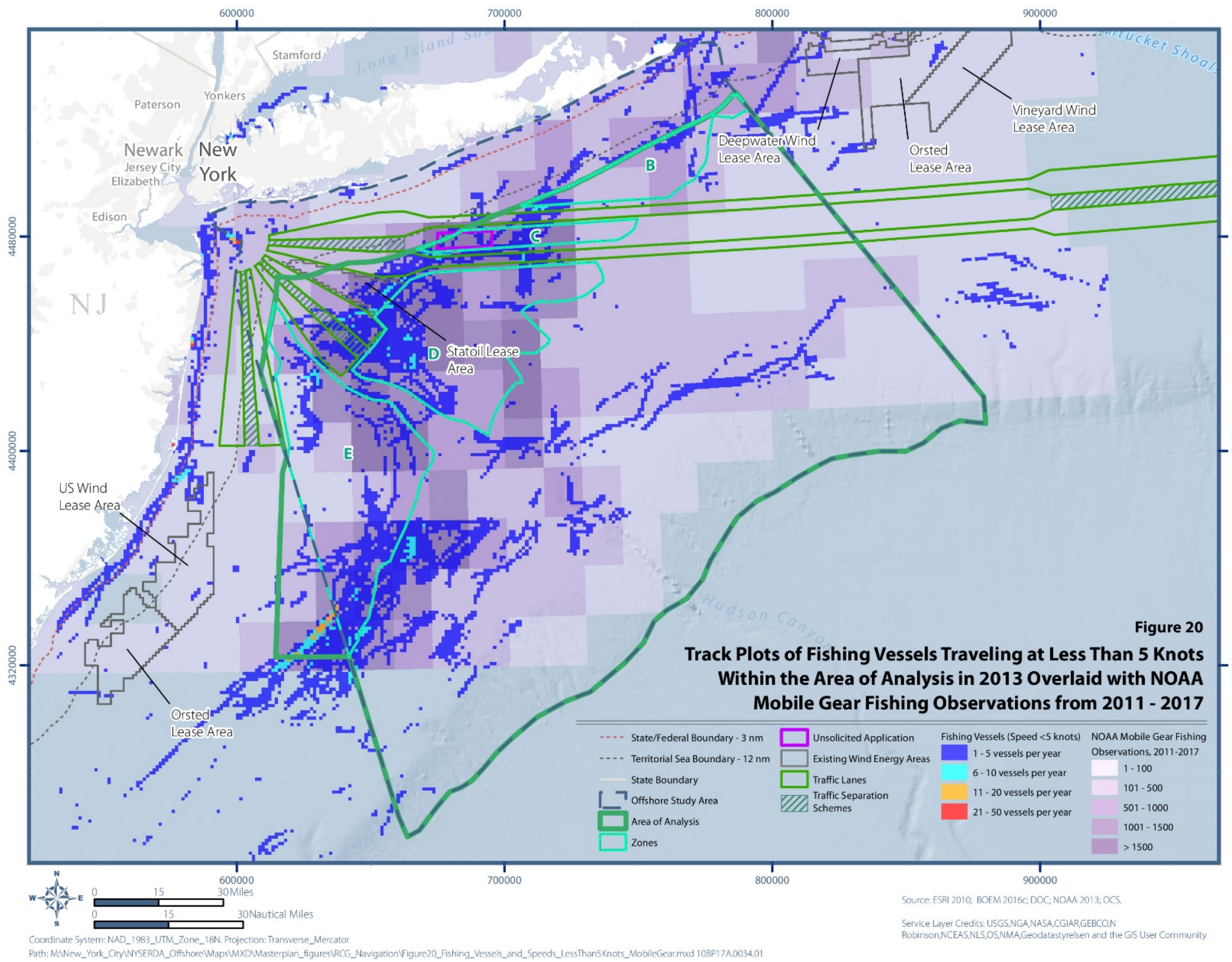
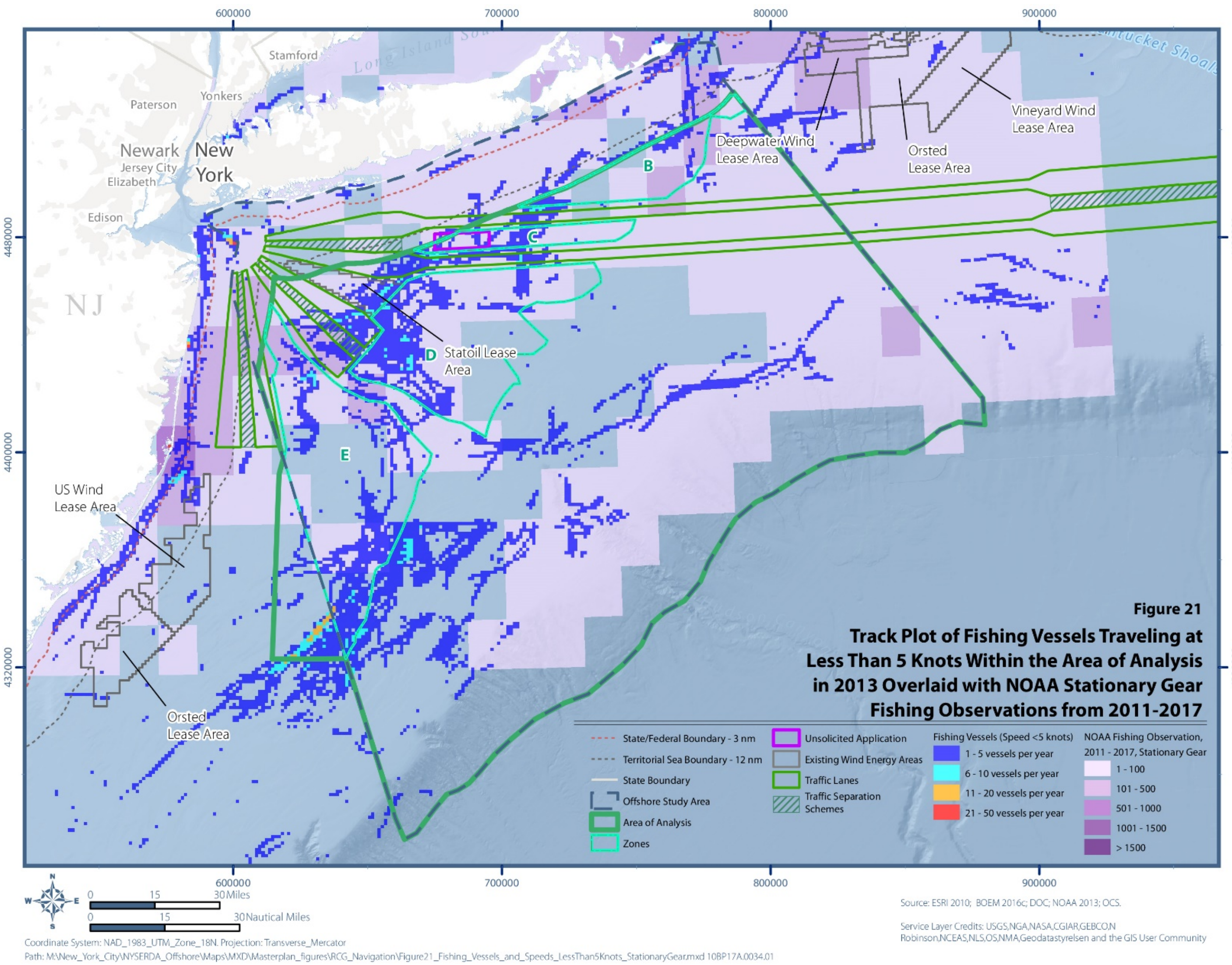


Figure 21. Track Plot of Fishing Vessels Traveling at Less Than 5 Knots Within the Area of Analysis in 2013 Overlaid with NOAA Stationary Gear Fishing Observations from 2011–2017

Source: ESRI 2010; BOEM 2016c; DOC; NOAA 2013, OCS



4.7 Other Vessel Patterns

As shown on Figure 11, a variety of vessel types with limited use of the AoA (such as WIGs, HSCs, military, port and pilot, law enforcement, dredging, search and rescue, diving) have been grouped into the vessel category "other" for this Study.

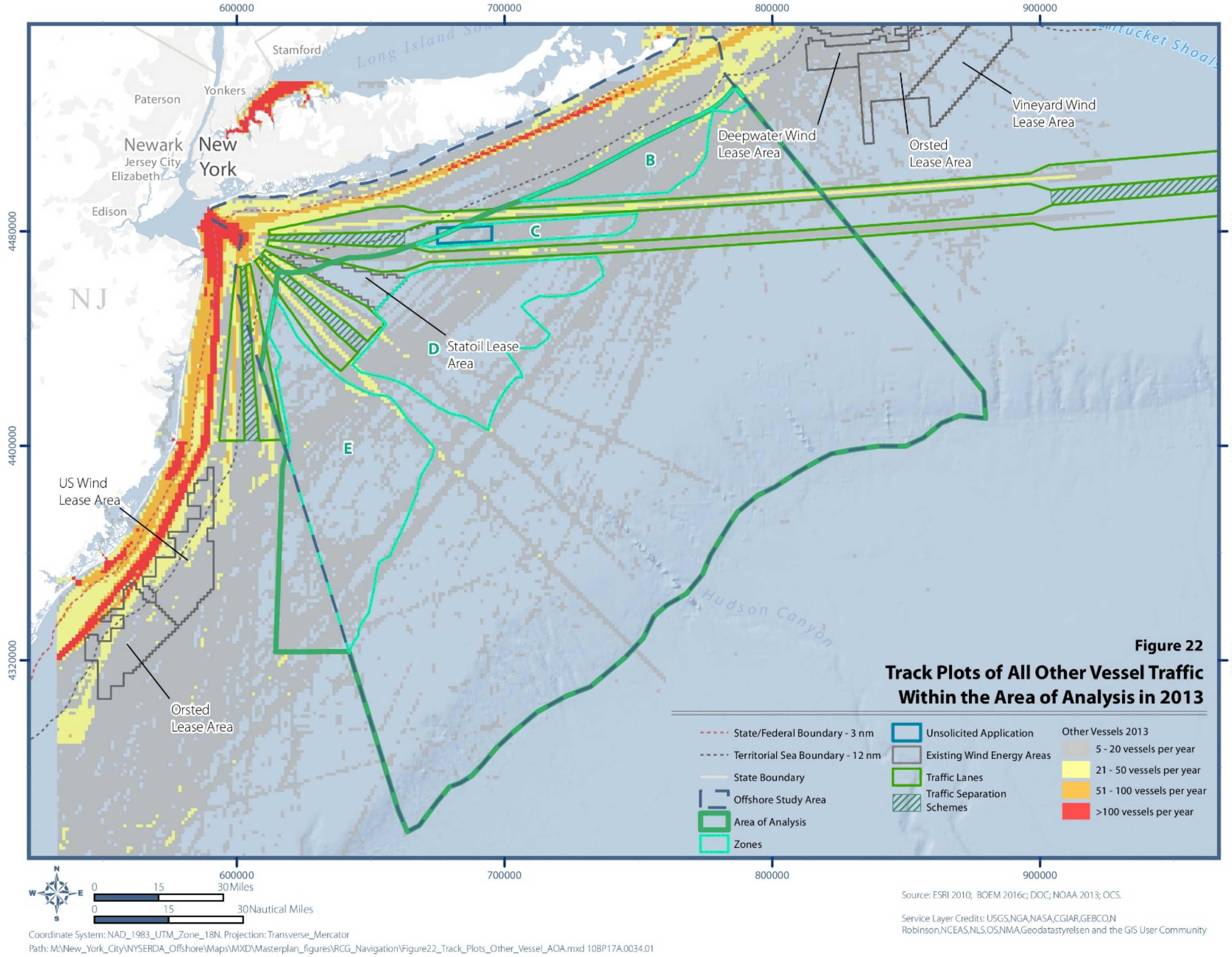
Although the AIS data did show WIGs and HSCs as individual vessel types present, the New York Harbor Ops Committee indicated that there are no WIGs on the East Coast and few, if any, HSCs, so it is possible that some of the vessel tracks shown on Figure 22 should be attributed to vessel types already analyzed.

The voyage patterns of "other" vessels show that most traffic is along coastal routes, although many vessels use the fairways inbound to Nantucket-to-Ambrose and, to a lesser extent, the outbound Ambrose-to-Nantucket TSSs (Figure 22). Other vessels also use both the Hudson Canyon-to-Ambrose and Ambrose-to-Hudson Canyon TSSs, and the Barnegat-to-Ambrose and Ambrose-to-Barnegat TSSs.

As seen with cargo and tankers, "other" vessels also merge with coastal traffic routes in roughly the same high concentration areas shown on Figure 15 and Figure 16. The other vessels also merge from the north and southwest corners of the AoA and traverse the region, although to a lesser extent.

Figure 22. Track Plots of All Other Vessel Traffic Within the Area of Analysis in 2013

ESRI 2010; BOEM 2016c; DOC; NOAA 2013, OCS



5 Study Findings: Main Vessel Traffic Routes

Following the main vessel route identification methodology described in Section 2.2.3, seven main unofficial routes through the AoA were identified by creating a heat map of all vessel types at a density threshold of >21 vessels per year (Figure 23).

Large cargo vessels traveling east-west typically use the safety fairways and are likely to follow the Nantucket-to-Ambrose and Ambrose-to-Nantucket TSSs. Although most of the traffic in these lanes consists of cargo ships and tankers carrying bulk cargoes from northern ports in the US, Europe, or the Middle East (e.g., crude oil and petroleum products, liquefied natural gas, dry cargo), other vessels, tugs and towing vessels, and passenger vessels also use these lanes.

There is a high concentration of vessels entering and exiting the inbound and outbound Hudson Canyon-to-Ambrose and Ambrose-to-Hudson Canyon TSSs (associated with routes 3, 4, and 5).

Two other main routes were identified emerging from the southwestern corner of the AoA heading east (routes 1 and 2), with route 2 crossing the southern corner of one of the proposed Zones. In addition, two other main routes also transit the AoA in the northern corner (routes 6 and 7), with route 6 crossing the northern corner of a Zone heading south and eventually crossing route 2, but outside the Zones.

To understand the relative importance of the seven main vessel traffic routes, gate analysis was used to determine the types, numbers, and sizes of vessels transiting these routes (Figure 24). Gate 6 was used as a reference to allow a comparison with one of the busiest routes in the AoA (outbound Ambrose-to-Nantucket Safety Fairway).

Routes 5, 4, and 8 have high concentrations of vessel traffic compared to the others, but not as high as reference gate 6. By contrast, gates 1, 2, 3, and 7 have noticeably low concentrations of vessel traffic compared to reference gate 6. The gate analysis showed that all routes are used primarily by large commercial cargo and tanker vessels.

Figure 23. Main Vessel Traffic Routes Identified Within the Area of Analysis

Source: ESRI 2010; BOEM 2016c; DOC; NOAA 2012, NSACA 2012; NOAA NAFS 2013; OCS

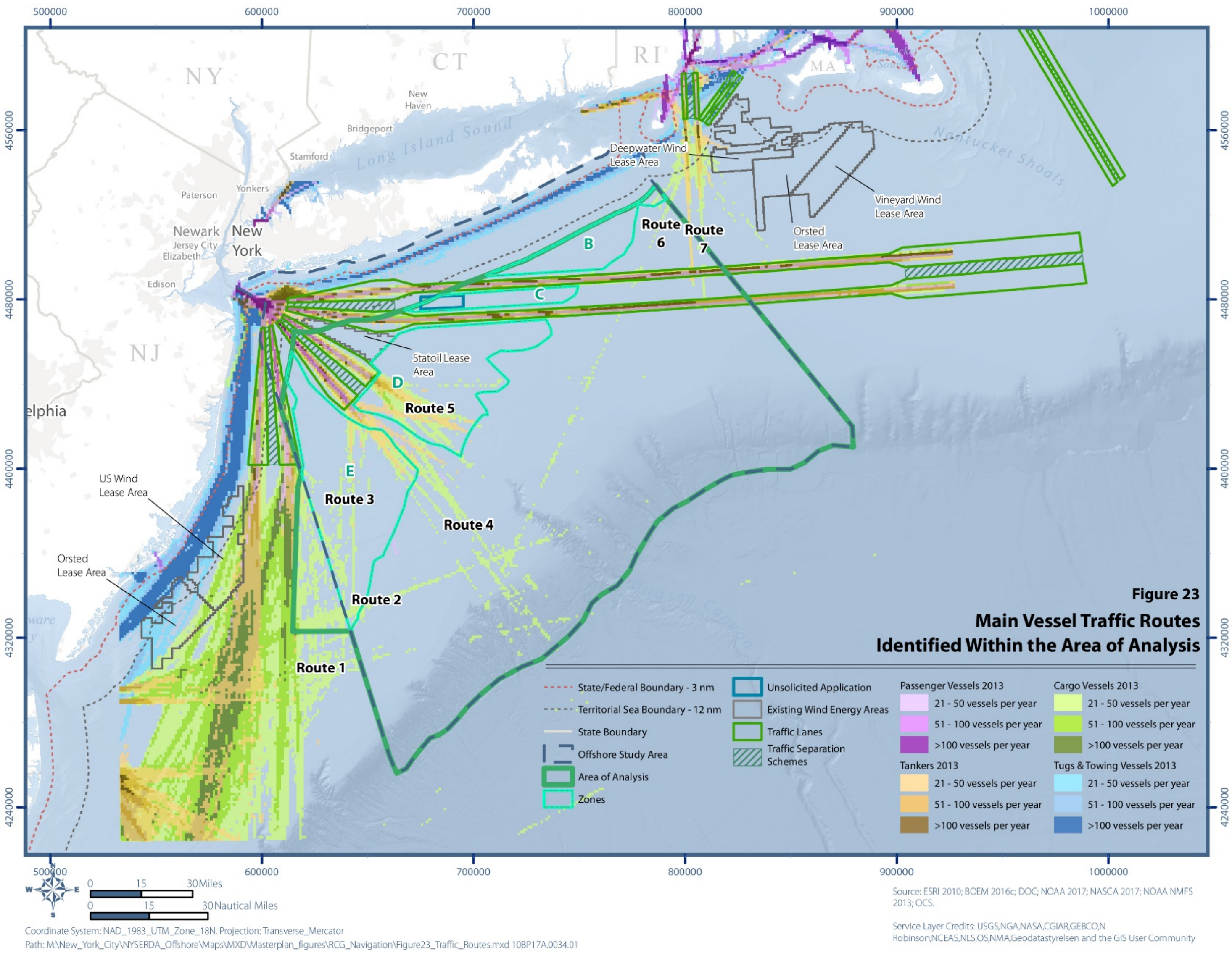
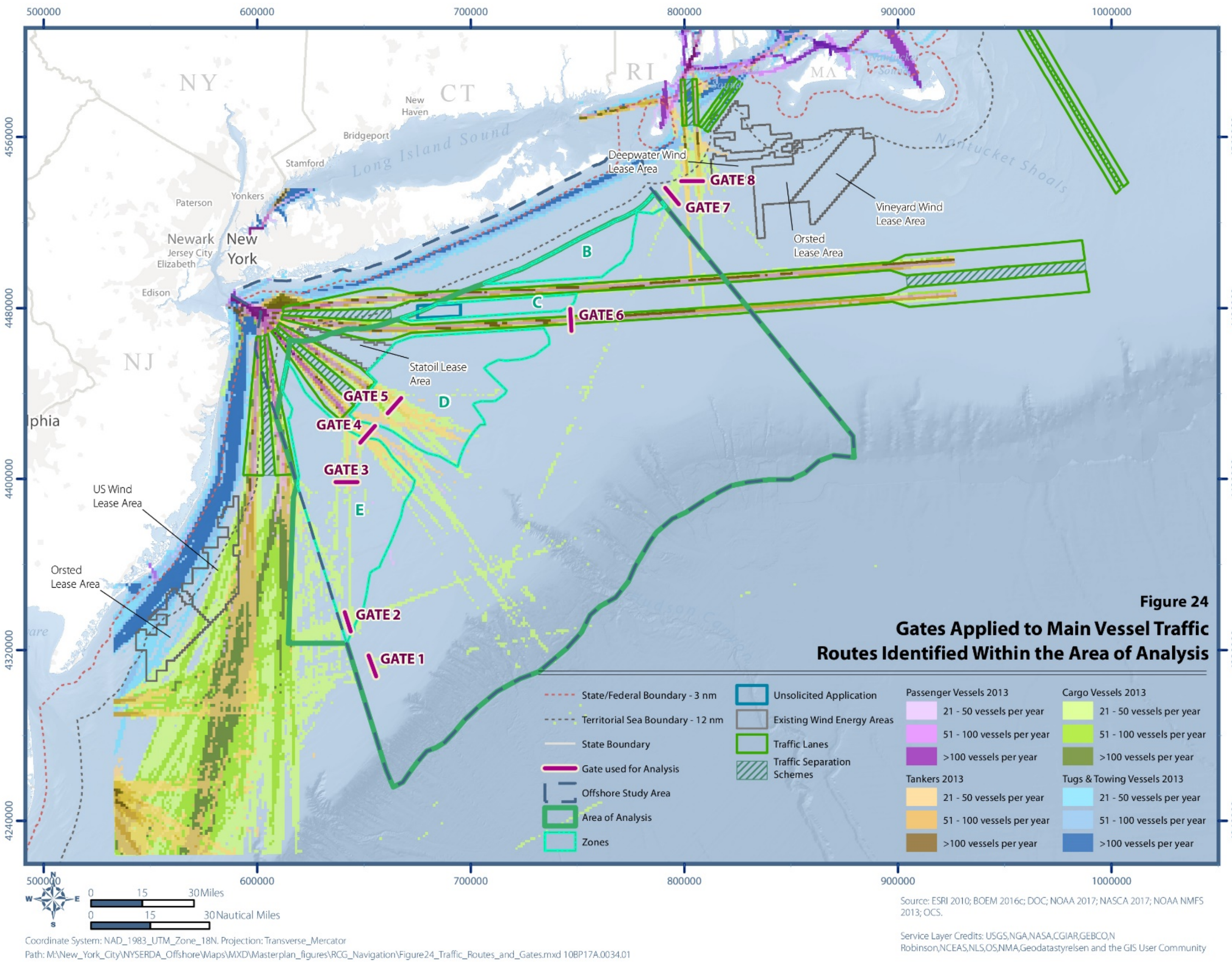


Figure 24. Gates Applied to Main Vessel Traffic Routes Identified within the Area of Analysis

Source: ESRI 2010; BOEM 2016c; DOC; NOAA 2017; NASCA 2017; NOAA NMFS 2013; OCS



In summary, routes 1, 7, and 8 are unlikely be impacted by potential offshore wind development within the Zones and bear no potential impact on Zone boundaries as they well outside of these areas. However, they should be considered in any future project-specific NSRA. This should include an analysis of potential displacement of traffic from routes 2 and 6 to routes 1 and 7, caused by deviation around any wind farm sited in the corners of these Zones.

Routes 2, 3, and 6 are also unlikely be impacted by potential offshore wind development within the Zones and bear little potential impact on Zone boundaries. Vessels using routes 2 and 6 could easily navigate around any future offshore wind farm, and vessels using route 3 could remain with the outbound traffic leaving the Ambrose-to-Hudson TSS or, more likely, take the Ambrose-to-Barnegat TSS in a more direct route to their destination.

Routes 4 and 5 were considered significant in terms of traffic concentrations and the requirement for unrestricted and safe access to and from the Hudson Canyon-to-Ambrose and Ambrose-to-Hudson Canyon TSSs.

Figure 25. Vessel Traffic Through Each Gate

(n = total number of vessels per year, and l = min-max length of vessels)

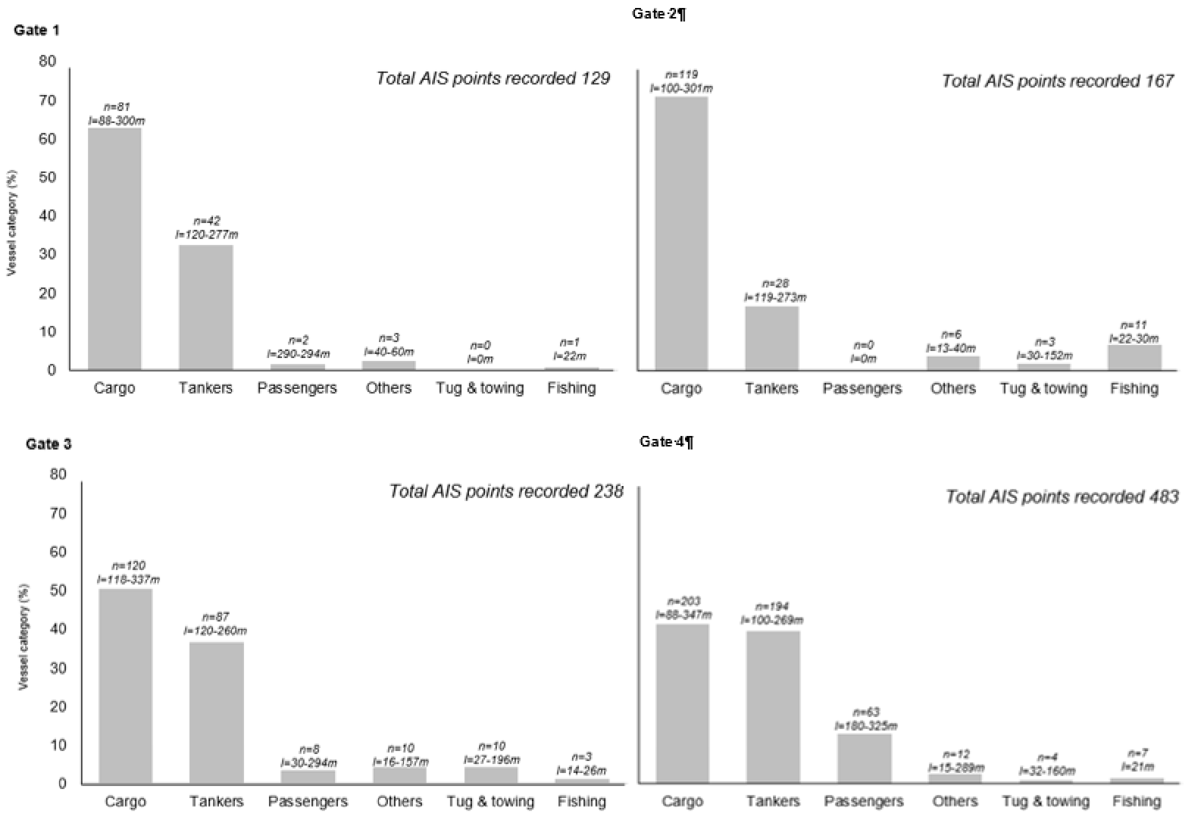
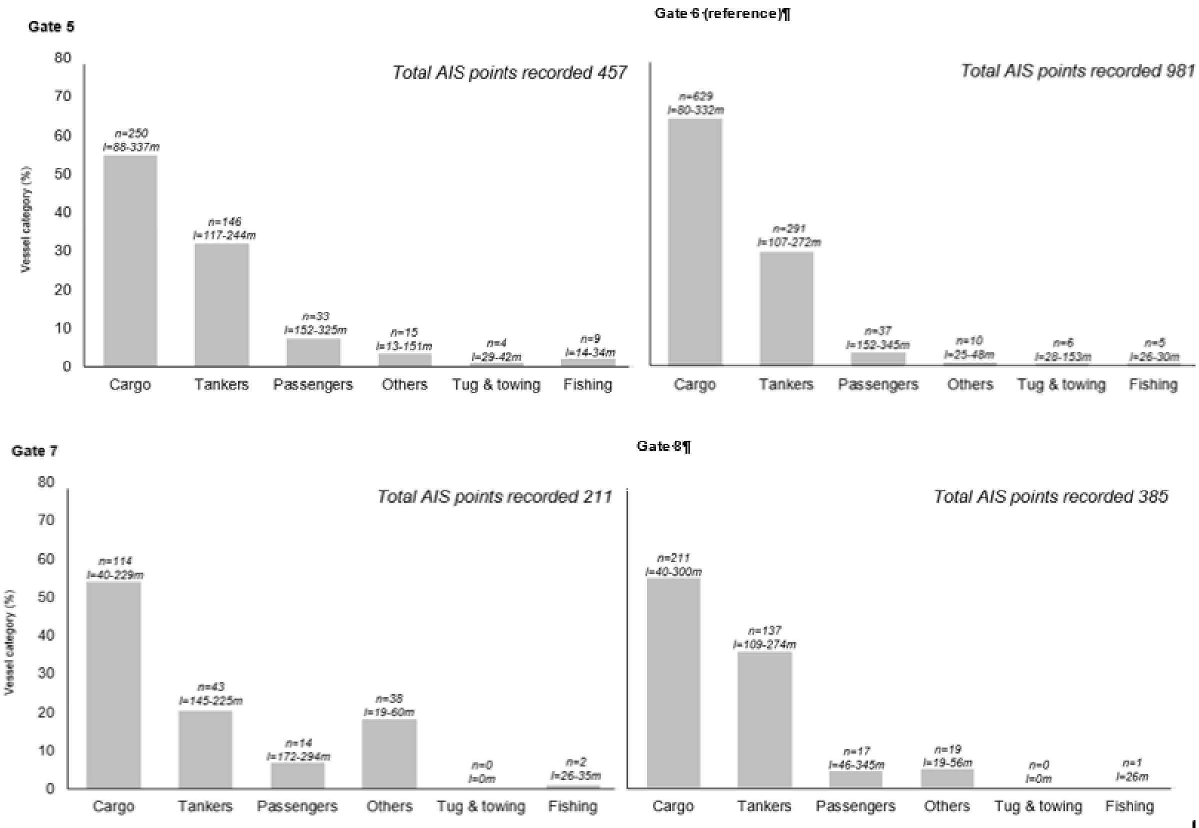


Figure 25 continued



5.1 Main Vessel Traffic Route Implications for Zone Boundary Modifications

The areas with the highest vessel density were the inbound (route 4) and outbound (route 5) portions of the Hudson Canyon-to-Ambrose and Ambrose-to-Hudson Canyon TSSs (Figure 24). These routes show a very high concentration of large commercial cargo vessels, tankers, and passenger ships. In addition, some traffic leaving the outbound Ambrose-to-Hudson Canyon TSS appears to take the shortest passage south by using route 3. Vessels using route 3 are likely to be too large to transit through a wind farm and, if one were located within this area, would likely reroute to converge with outbound traffic associated with route 4. This would decrease sea space for maneuverability and could increase the risk of collision and allision.

If a wind farm were located within the southwestern portion of the Zone initially proposed to encompass route 5, this would result in inbound traffic having to be rerouted, potentially displacing traffic southwards, which could merge with route 4 (and route 3 if wind farms were sited on either side of these routes). This could decrease sea room for maneuverability and potentially increase the risk of collision and allision. In addition, AIS data showed a significant amount of fishing vessel activity between routes 4 and 5.

The mix of all vessels being potentially concentrated with a decrease in sea room for maneuverability could put vessels at a greater risk of collision with another vessel and allision with a turbine if vessel concentrations increased.

Future traffic needing to avoid a hypothetical wind farm in the northern corner of the proposed Zone encompassing route 6 could be displaced into route 7 while traffic goes around this corner, although there is potentially sufficient sea room eastward. Routes 3, 4, and 5 have sufficient sea room eastwards to accommodate any change in concentration of vessel traffic.

Future traffic using route 2 may have to avoid any wind farm located at the southern corner of the associated proposed Zone, which could increase vessel concentrations in route 1, although there is sufficient sea room eastward to accommodate such a shift.

Zones located either side of the inward- and outward-bound fairway lanes could technically be accommodated, as large commercial vessels are expected to and do stay within the fairway.

In summary, routes 1, 2, 3, 6, and 7 are main traffic routes that are unlikely to warrant changes to the proposed Zones; however, they should be considered in any future NSRA when siting specific wind farms.

6 Study Findings: Navigational Risks

Offshore wind farms have a typical design life of over 25 years and can potentially be repowered thereafter to extend overall project life. Given the longevity of these projects, the interests of regional ocean users should be considered over a long-time period during the planning and siting process (DECC, 2011).

The main potential risks posed by an offshore wind farm on shipping and navigation have been extensively documented.[18] Since 80% of all disasters at sea are caused by human error, certain safety buffers between vessels and offshore structures are necessary and prudent to ensure safe vessel transit and maneuverability (Nautical Institute, 2013).

Most vessels tend to navigate clear of wind farms to avoid collisions with other vessels or allisions with turbines or other structures. Turbines spacing varies between projects and, to date, has been on the order of 0.5 to 0.75 nm (1.0 to 1.5 kilometers). Future projects may have broader spacing to accommodate larger turbines. However, it is generally not prudent for large commercial vessels (>70 meters in length) to transit between them, as this would constrain their maneuverability and limit their ability to avoid a collision caused by human error, environmental conditions, or mechanical failure.[19]

Figure 26 describes some of the main potential risks associated with navigating near offshore wind farms. In general, the type and nature of the risk varies by how the vessel interacts with the wind farm (i.e., go around, through, or within it).

To fully evaluate the potential navigational risks posed by a specific offshore wind farm over its lifecycle, a site-specific NSRA is typically undertaken. Based on the findings of the NSRA, risks to navigation can be understood and addressed, and potential mitigation measures (including marine emergency response) can be implemented (MCA, 2016).

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18 Examples: Anatec Limited (2012). Strategic assessment of impacts on navigation of shipping and related effects on other marine activities arising from the development of Offshore Wind Farms in the UK REZ. Report; and Rawson, A. and E. Rogers (2015). Assessing the impacts to vessel traffic from offshore wind farms in the Thames Estuary. Scientific Journals of the Maritime University of Szczecin.

19 Based on the AIS data used to inform this navigation study, large vessels were defined as anything >70m in length.

Figure 26. Navigation Topics and Potential Risks Relating to Offshore Wind Farms

Topic	Description of Potential Risks
Use of existing navigation aids and controls	Navigation aids and controls must still be effective and may need to be enhanced following offshore wind energy development. Offshore wind farms can potentially affect maritime radar, both ship- and shore-based (e.g., clutter). There also may be effects on military and air traffic control radars. The distribution of vessel traffic also compresses around navigation obstacles where vessels attempt to reduce the distance sailed while also maintaining a safe passing distance from the obstruction (Rawson, A. and E. Rogers 2015).
Navigation around offshore wind farms	The need to navigate around a wind farm is one of the most obvious potential impacts of offshore wind energy development to mariners. Issues associated with this include: changes to traffic densities; increased crossing maneuvers; obscuring of smaller craft such as recreational, fishing, and maintenance vessels; and effects on radar (e.g., reflections, false echoes, and other spurious effects) (MCA & QinetiQ 2004) (Marico Marine 2007). Other issues include changes to transit times and crew patterns for passing vessels, depending on the degree of deviation. Collision risk can increase because of increased concentration of vessel routes. If a wind farm is located adjacent to another navigational constraint, or adjacent to another wind farm, then vessels transiting in between them have reduced room in which to maneuver to avoid a collision; such areas are often referred to as “choke points”. The buffer distance a vessel chooses to navigate around a wind farm is weighed against commercial pressures associated with additional distance, fuel, and passage time requirements. Distance should be a comfortable buffer so that if an incident was to occur on board, or another vessel was encountered, there would be sufficient sea room to make an evasive maneuver. In this case, there may be different watch-keeping requirements when navigating near a wind farm.
Navigation between offshore wind farms	Where there is more than one wind farm area, there may be a need to navigate between them. Issues associated with this include potentially reduced widths of navigation channels between wind farms and the need for, or modification of, traffic separation or management schemes. Navigation between wind farms could increase the risk of allision if a vessel loses power, is adrift, or takes evasive action to avoid collision with another vessel.
Navigation through offshore wind farms	If a wind farm is exceptionally large, a navigational channel may be established through it. Issues associated with this are roughly the same as navigating between multiple wind farms, although the navigation channel width may be even less.
Navigation within offshore wind farms	Vessel masters are obligated to navigate in a safe manner around any structures present (turbines, offshore stations, and submarine cables if the vessel is anchoring). There will always be some vessels that must navigate within the wind farm, such as vessels installing and maintaining the wind farm and vessels repairing or maintaining other infrastructure that may be present.

6.1 Considerations for safe navigation near wind farms

Vessel navigators consider a wide range of factors when setting waypoints for a journey, such as environmental conditions, obstacles (including wind turbines), bathymetry, and navigational aids and controls.

Large commercial vessels tend not to navigate through wind farms; it is generally more prudent to navigate large vessels around wind farms to minimize risks of allision. However, to navigate near a wind farm, the following objectives should be met:

- Leave sufficient space or buffer around the wind farm to account for any unplanned incident on board or encountering another ship that would require enough sea room to make an evasive maneuver.
- To minimize radar interference from wind turbines, which are known to affect a ship's radar by causing, for example, reflections and false echoes, a vessel may choose to navigate further from a wind farm to reduce these effects and improve their situational domain awareness.
- Deviate from a previously unobstructed course. Typically, ships take straight routes between waypoints to reduce transit time and fuel costs, but additional fuel and passage time may result if ships need to navigate safely around a wind farm.

6.2 Incidents Recorded Within and Around the AoA

This Study examined marine incident reports from the U.S. National Transport Safety Board (NTSB) and data from the USCG's internal database of incidents (occurring from 2004 to 2017) to examine whether recorded incidents would enable the identification of potential high-risk areas that should be avoided in the offshore wind farm siting process (U.S. National Transportation Safety Board 2017). The USCG datasets relevant to New York and New Jersey contained 2,840 incidents, 32 of which occurred within the AoA, and the NTSB datasets contained one additional incident that occurred within the AoA, the sinking of the fishing vessel "Miss Penelope" that occurred in 1998, before the USCG database was enacted.

Figure 27 shows the 33 incidents recorded within the AoA by category.

Figure 27. Recorded Marine Incidents Within the Area of Analysis (by Category)

Source: USCG 2017b and NTSB

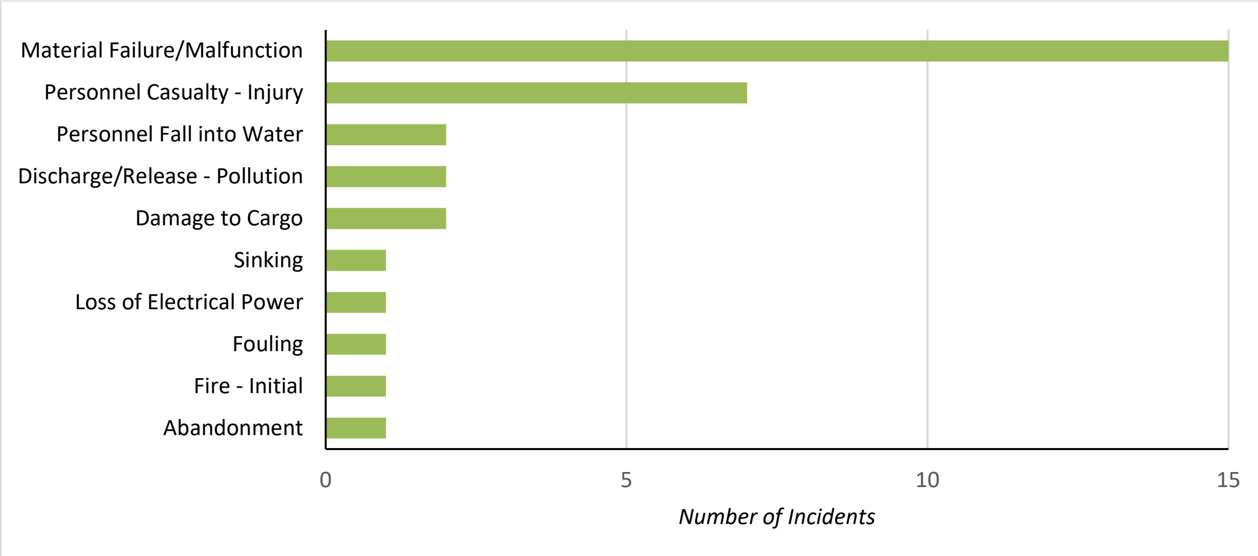
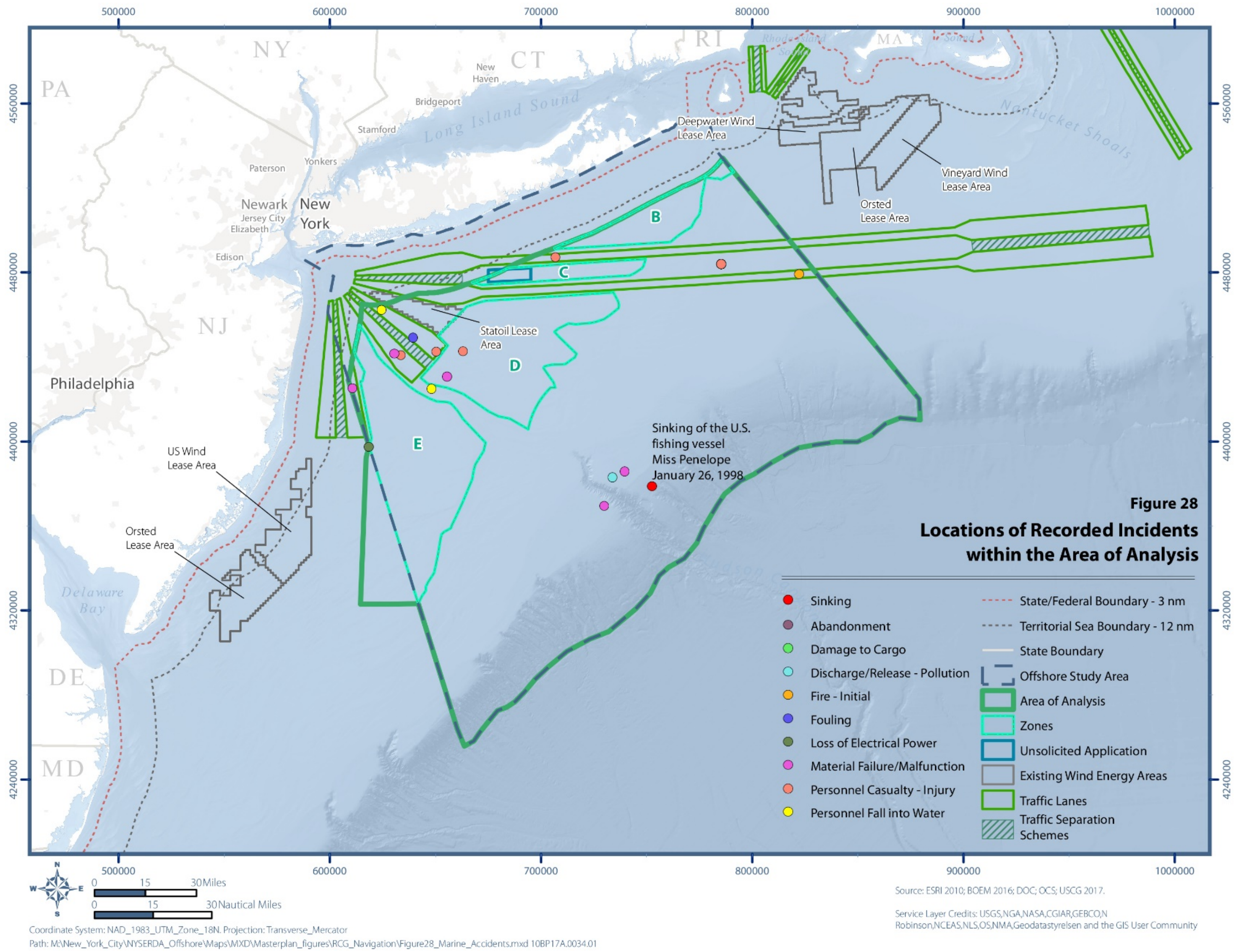


Figure 28 provides a map of where the 33 recorded incidents occurred within the AoA. It shows that there are no incident-prone locations for allisions, collisions, sinkings, or groundings within or near the Zones, however, according to the USCG dataset, 17 incidents were recorded at a single point between the Ambrose-to-Nantucket and Nantucket-to-Ambrose TSSs, which is outside of the Zones.

Figure 28. Locations of Recorded Incidents (within the Area of Analysis)

ESRI 2010; BOEM 2016c; DOC; OCS; USGS 2017



To provide some context for potentially relevant incidents that have occurred, case studies for the sinking of the Miss Penelope, and multiple allisions with the Ambrose Light were considered.

6.2.1 Case Study: Sinking of Fishing Vessel Miss Penelope

Around 3:30 p.m. on January 26, 1998, the commercial fishing vessel Miss Penelope departed Newport, Rhode Island, and headed for fishing grounds in the area south of Montauk, New York. The crew consisted of the vessel master, a mate, and two deckhands. The vessel arrived at the fishing grounds around 11:30 p.m., and the crew began fishing. At approximately 03:00 a.m. on January 27, the weather deteriorated, and the master decided to suspend fishing, shut off the engine, and let the vessel ride out the heavy seas by drifting with the wind, waves, and currents. The ship began to sink while adrift in heavy seas. According to the NTSB, the Miss Penelope likely started to sink due to flooding from an unknown origin. Once the crew abandoned the sinking ship, only the master, mate, and one of the deckhands managed to board the life raft. The USCG dispatched three rescue helicopters, which rescued all crew members, but the second deckhand did not make it into the life raft and was later pronounced dead (US National Transportation Safety Board 2017).

6.2.2 Case Study: Allisions with the Ambrose Light

The Ambrose Light Station was located at the convergence of the Ambrose Channel, Nantucket-Ambrose Shipping Lane, Hudson Canyon-Ambrose Shipping Lane, and Barnegat-Ambrose Shipping Lane leading in and out of the Port of New York and New Jersey. Ambrose Light signaled the rendezvous zone for pilots to meet with ships; there they reduced speed, so pilots could board. The light station was hit three times in its 41 years of operation; the incidents are described below. After the first allision, the tower was rebuilt approximately 1.5 miles seaward of the previous location to allow inbound and outbound traffic more room to maneuver near the pilot station (U.S. National Transportation Safety Board 2017).

- Allision of AEGEO tanker (October 1996).
  - Cause: captain’s error.
  - The master of the AEGEO misjudged the distances between his vessel, an outbound ship, and Ambrose Light and failed to navigate his ship appropriately.
- Allision of Kouros V bulk freighter (January 2001).
  - Cause: high winds (master’s explanation).
  - The master initially reported to the USCG that high winds had forced his vessel into the tower after he had reduced speed to board a pilot. This incident was not investigated by the NTSB, and the USCG report is not publicly available.

- Allision of Axel Spirit tanker (November 2007).
    - Cause: Master's failure to use all available resources to determine the vessel's position and course during transit past Ambrose Light. For example, he did not use the Automatic Radar Plotting Aid feature on the vessel's radar, which calculates the vessel's closest point of approach to the tower, and the timing of when the vessel would pass it. The master had first-rate navigation equipment and a lookout on the vessel bridge, and was an experienced navigator, yet failed to use available resources effectively.

7 Study Findings: Recommended Minimum Distance

It is difficult to apply a standardized minimum distance between wind farms and navigation routes, as risks will vary depending on the location, proximity of turbines to a route boundary, prevailing metocean conditions, and existing and future vessel traffic profiles.

7.1 U.S. Perspectives

The USCG ACPARS study presented draft Marine Planning Guidelines (MPGs), which made recommendations for buffer zone distances between actual wind farms and TSSs (USCG, 2016). While the MPGs are not finalized, offshore wind farm developers and marine planners should consider these guidelines as *de facto* best practice for undertaking an NSRA and associated consultation. The USCG has looked to European countries with operational, COLREG-compliant offshore wind farms (for maneuvering, stopping, and emergency situations) to inform the USCG's view on safe minimum distances. Currently, the MPGs propose that offshore wind farms should be at least 2 nautical miles (nm) from the outer edge of a TSS and 5 nm from the entry/exit of a TSS.[20] While this conflicts with the BOEM precedent of a 1 nm minimum distance (used for all currently identified WEAs, including the first New York WEA, now leased by Statoil), wind farm lessees will be required to undertake detailed NSRAs that could result in physical setbacks or restrictions that reflect the ACPARS's MPGs safe distance recommendations. However, the USCG also acknowledges that, based on site-specific findings, mitigation efforts (other than setbacks) could potentially reduce the MPG-required minimum distances for a particular wind farm.

7.2 European Perspectives

MCA guidance and COLREGs are the most widely used references for marine spatial planning. The MCA's MGN 543 replaced MGN 371 in January 2016 and is the latest guidance specific to offshore wind farms. MGN 543 is less prescriptive in establishing vessel traffic route distances to wind turbine boundaries, although the position on tolerability distances using ALARP remains the same i.e., a tolerable distance of between 0.5 nm and 3.5 nm (with mitigation in place) and intolerable <0.5 nm (Figure 29).

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20 A 5 nm boundary may be more appropriate for harbors with only one TSS, whereas New York and New Jersey have three.

Although the USCG applied MCA guidance MGN 371 in the ACPARs study, they recommended a 2 or 5 nm minimum distance to a TSS, which is greater than the minimum distance proposed in MGN 371.

Figure 29. MCA MGN 543 Tolerability Thresholds for Minimal Distances Between Turbine Locations and Shipping Routes

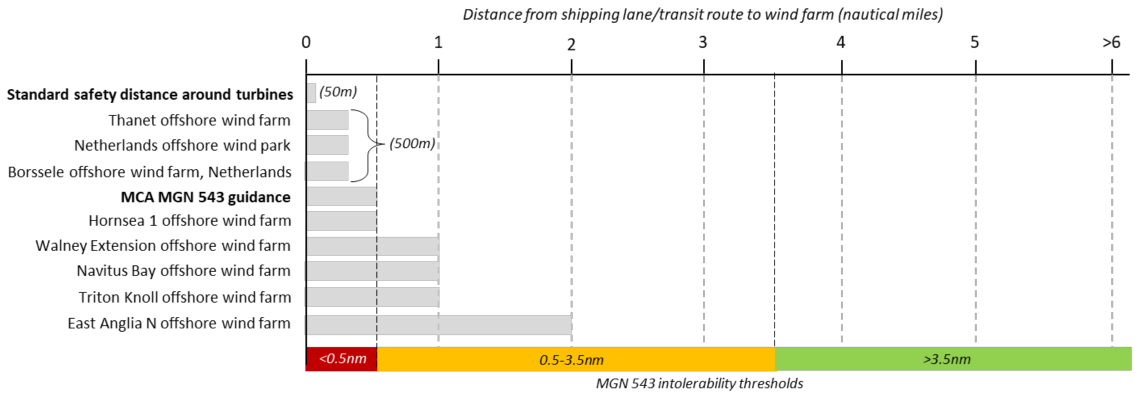
Source: MCA MGN 543 2016

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

From the example projects in Europe reviewed, the most common distance between a wind farm and shipping lane is approximately 1 nm (Figure 30). The 640 MW Thanet offshore wind farm in the United Kingdom has 0.3 nm (500 m) between turbines and the nearest vessel route. This distance was accepted by master mariners upon consultation once the wind farm layout, turbine spacing, and agreed mitigation measures were presented (e.g., introduction of new waypoints set between 0.5 nm and 1 nm from the wind farm site boundary). Other similarly small minimum distances have been or are expected to be adopted, such as the layouts for the planned Netherlands offshore wind park and Borssele offshore wind farm (0.3 nm).

Figure 30. Minimum Distances Between Example European Offshore Wind Farms and Shipping Routes Compared with Intolerability Thresholds

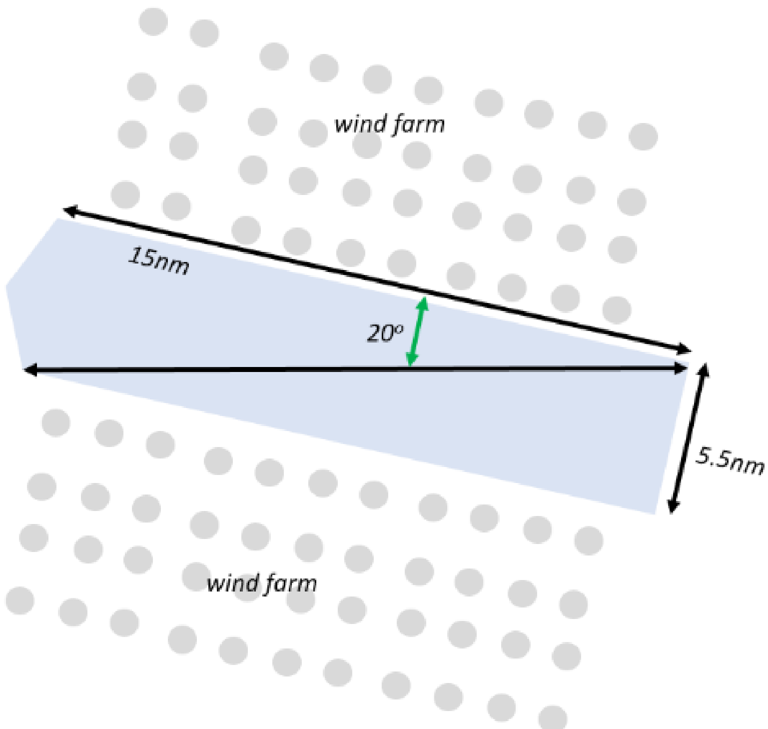
Source: MCA, 2016



The MCA guidance also cites the COLREG guidelines regarding emergency turning distances and buffer zones between wind farm boundaries and TSSs. The minimum distance applied to a TSS per the COLREGs appears to be more stringent than the minimum distances applied to operational wind farms in Europe, which have been applied on a case-by-case basis. The USCG acknowledges that wind farm projects are unique and require individual review and consultation to refine and assess the appropriate controls for navigational safety.

According to COLREG guidelines, a vessel captain must consider all navigation and collision risks when determining an appropriate closest point of approach to another vessel. To do this, the factors listed on Figure 29 must be considered. A closest point of approach of 0.5 nm to 1 nm is considered acceptable under normal conditions, although this can be extended in poor conditions to ensure safe passage. While approaching a wind farm boundary presents its own risks to the mariner, passage between wind farms requires additional considerations to avoid allision with a turbine. The MGN 543 guidance indicates that a ship track could deviate as much as 20 degrees or more during transit, and this deviation has an influence on the minimal distance calculation. MCA uses the “20-degree rule” whereby a 15-nm-long row of turbines could result in a corridor width of 5.5 nm between wind farms (Figure 31).

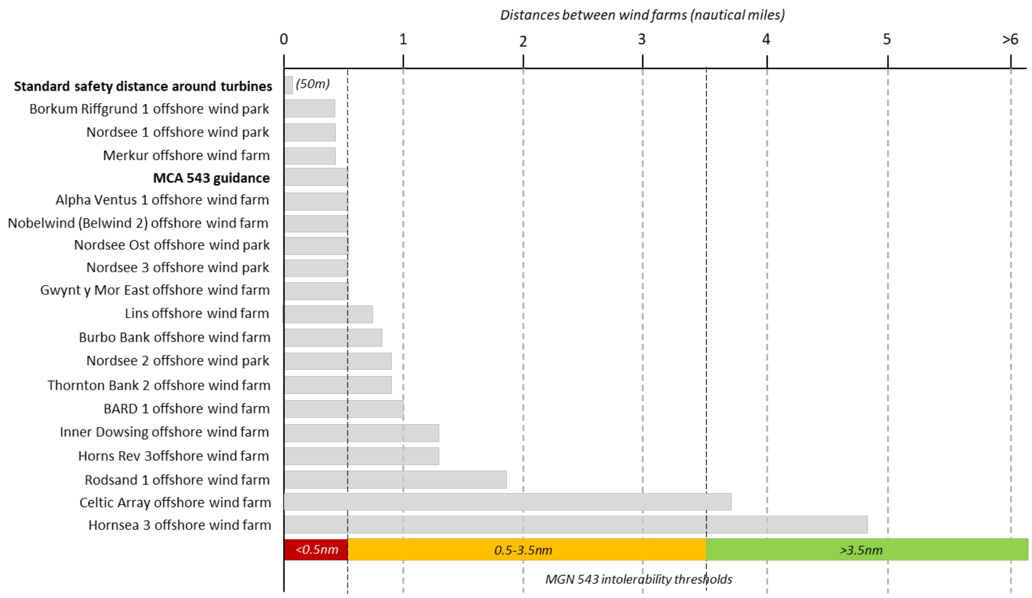
Figure 31. Illustration of the "20-degree Rule" from MGN 543 Guidance



However, the specific configurations and distances between examined operational wind farms show that this rule is not uniformly applied and that projects are sited on a case-by-case basis. Figure 32 shows that the most common distance between wind farms in Europe is approximately 1 nm.

Figure 32. Minimum Distances Between Example European Offshore Wind Farms Compared to MCA Intolerability Thresholds

Source: MCA, 2014



7.3 Study Perspective and Content

Given that the large Zones within the AoA are intended to provide flexibility in siting future WEAs after considering a variety of factors, setting a minimum distance based on the ACPARS study guideline is considered an overly conservative starting point, as a footprint of any specific wind farm has yet to be proposed. For master planning purposes, and based upon operational experience of wind farms in Europe and other currently available information, the MCA's recommended minimum "tolerable" distance of 1 nm (with appropriate mitigation in place) is considered appropriate for initial planning purposes and informing the preliminary identification of area for potential locating of WEAs.

The proposed layouts of individual wind farms will be assessed in a NSRA using a variety of risk analyses to determine an appropriate safe distance and factoring in specific information relevant to the proposed locations, including information that may not have been available when this Study was prepared.

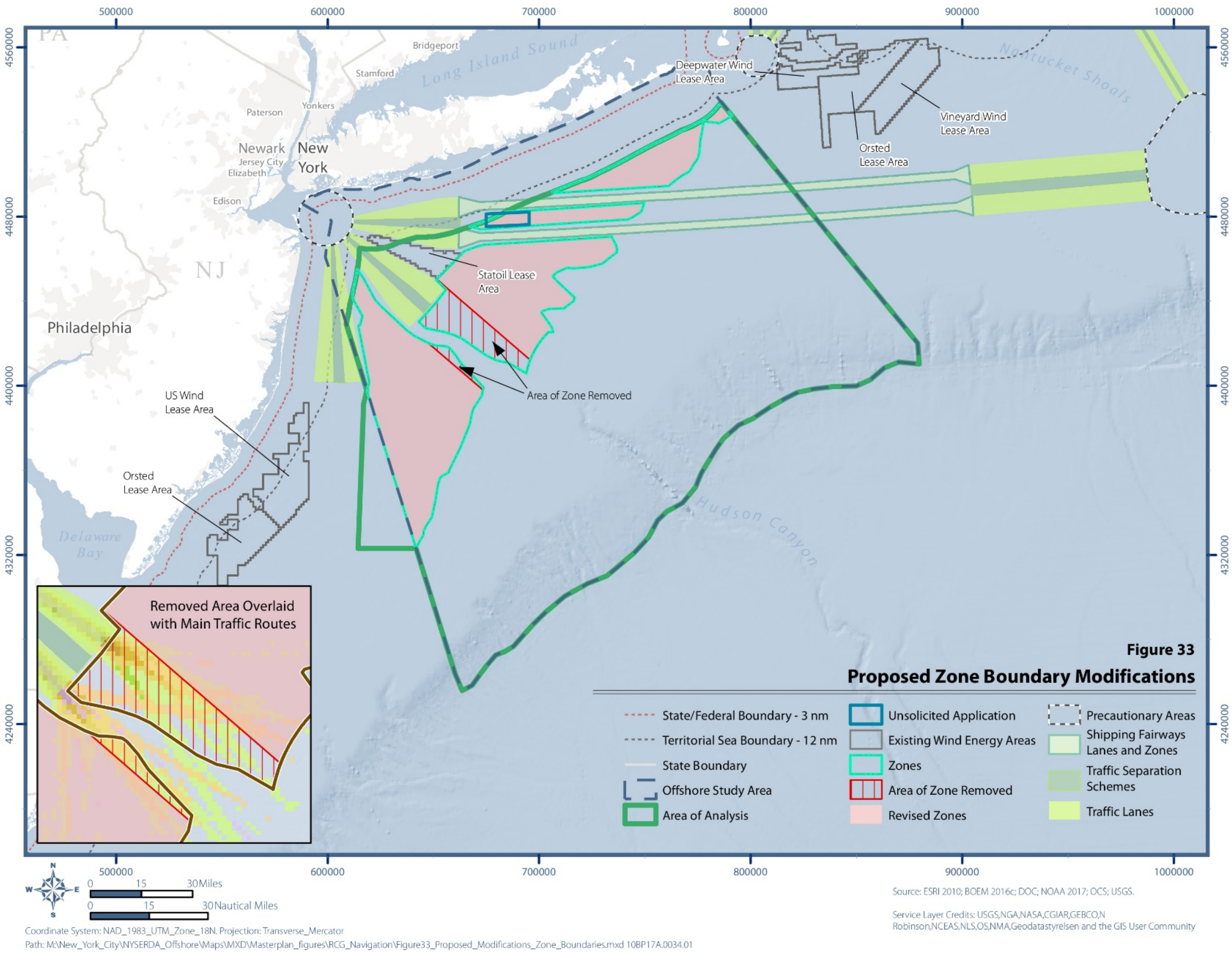
This study suggests that 1 nm is an appropriate setback for initial planning purposes and informing the preliminary identification of area for potential locating of WEAs, and actual setbacks between shipping and navigation lanes and WEAs (and sites) should be determined at a later stage in the siting process following completion of a full NSRA.

8 Study Findings: Zone Boundary Modifications

Based on the AIS and gate analysis, vessels using main traffic routes 3, 4, and 5 would be impacted by offshore wind development within certain Zones of the AoA. Therefore, the Zone boundary modifications shown on Figure 33, which also include a 1-nm setback from existing traffic routes, are recommended. In this scenario, inbound and outbound traffic will have unobstructed access to the Ambrose-to-Hudson and Hudson-to-Ambrose TSSs.

Figure 33. Proposed Zone Boundary Modifications

Source: ESRI 2010; BOEM 2016c; DOC; NOAA 2017; OCS, USGS



9 Conclusion and Recommendations

This Study evaluated the potential shipping and navigation risks associated with the potential development of one or more portions of the Zones. The Study used results from the AIS analysis to identify main vessel traffic routes, which were considered to represent frequent on-going or regular runner/operator routes. This enabled a clearer understanding of the potential risks that could be posed by the future siting of wind farms within the initial Zones on current and future shipping patterns, and enabled the development of a recommendation for a safe minimum distance between vessel routes and offshore wind structures that can be used for initial planning purposes.

Regardless of the initial distance between potential WEAs and official and unofficial navigation routes, NSRAs would typically be undertaken by the developer of a wind farm site to determine the safe distance of actual turbines from traffic routes. For initial planning purposes and informing the preliminary identification of area for potential locating of WEAs, and taking current best practices and spatial planning examples into account, this study recommends that the minimum distance between a Zone boundary and a main traffic route, including formal routes such as TSS and fairways, should be 1 nm.

This Study has also identified a high-traffic shipping and navigation area associated with inbound and outbound traffic from the Hudson Canyon-to-Ambrose and Ambrose-to-Hudson Canyon TSSs. Because of the potential for high concentrations of converging and dispersing vessels, including inbound and outbound large commercial vessels and passenger ships and fishing activity, it was recommended that the initially proposed Zone boundaries be modified to accommodate the traffic transiting in this area. Other main vessel traffic routes were identified that traversed the proposed Zones (routes 2, 3, and 6), but modifying Zones to accommodate these routes was not deemed necessary at this master planning stage.

This study concludes with the following recommendations.

9.1 Modification of Zone Boundaries

Because of the high concentration of vessel traffic entering and leaving the Ambrose-to-Hudson Canyon TSS and Hudson Canyon-to-Ambrose TSS, the Zones currently including this area should be modified as described in Section 8, prior to the identification of an Area for Consideration.

9.2 Continued Stakeholder Consultation

As with any navigational assessment, the use of models and AIS data can address only some of the issues relevant to navigational issues and concerns at sea. Therefore, continued consultation with maritime stakeholders is recommended, especially during the process by which BOEM may allocate new WEAs off New York's coast within the Area of Consideration. The Zone boundary modification recommendations discussed in Section 8 do not provide a prescriptive solution for ensuring adequate coastwise transit pathways across the modified Zones or between potential WEAs (although applying the "20-degree" rule shown on Figure 31, at least in concept, is recommended). It is expected that, given the size of the modified Zones, there is ample room for siting enough WEAs to accomplish New York's offshore wind energy goals while maintaining enough flexibility for BOEM to continue to work with the USCG, the maritime community, and other stakeholders to ensure that traffic lanes between or around WEAs are appropriate for continued use of the region by its maritime stakeholders.

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Appendix A. Best Practice Guidelines

Figure A-1. Best Practice Guidelines for Minimum Distances Between Wind Farms and Main Vessel Traffic Routes

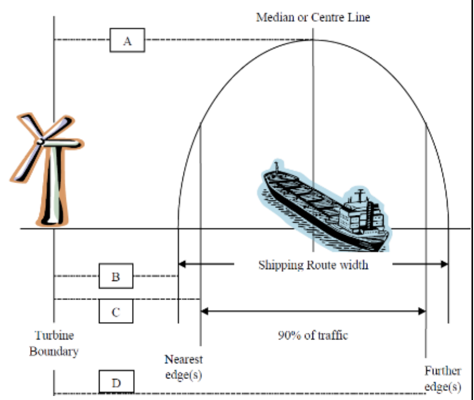
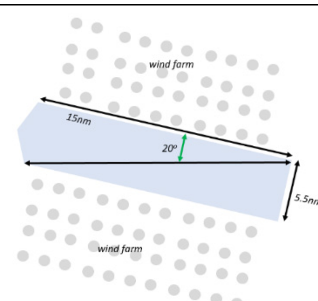
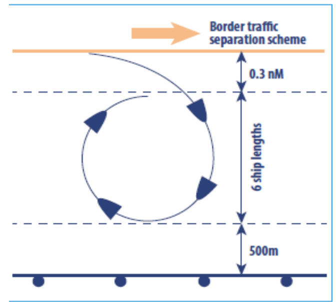
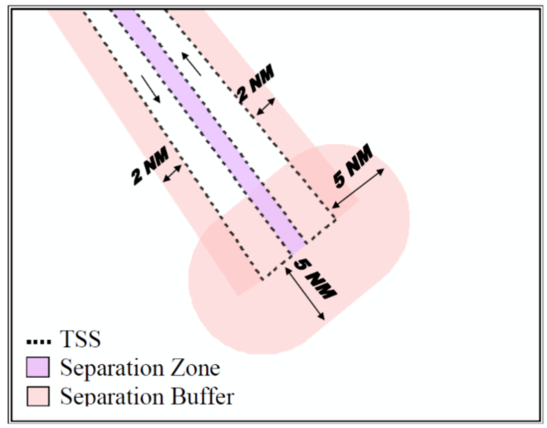
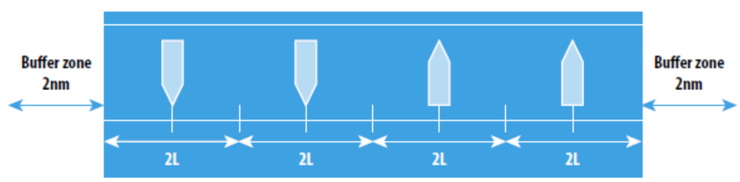
Reference	Summary
MGN 543. Safety of Navigation: Offshore Renewable Energy Installations (OREIs) - Guidance on UK Navigational Practice, Safety and Emergency Response (MCA, 2016)	MGN 543 refers to two methods of determining distances, one based on Permanent International Association of Navigation Congresses (PIANC) assessment for channel design and the other based on a risk assessment. The PIANC assessment recommends an “obstacle free, or buffer zone of 2 nm between hazards and shipping lanes (PIANC 2014).”  Risk assessed distances are based on domain theory, a safety buffer around a navigating vessel, and the impacts of turbines on radar. Shipping routes are demarcated by 90% of the lateral distribution of vessel transits (derived from AIS data). Distances from turbines are based on As Low as Reasonably Practicable (ALARP) justifications, where <0.5 nm is intolerable, 0.5 to 3.5 nm is tolerable so long as it can be justified that the risks are ALARP, and > 3.5 nm is broadly acceptable. Standard turning circles for vessels are six times a ship’s length. Requirements for stopping in an emergency must be considered, for example, following a steering gear failure, a crash stop (the quickest way to stop a vessel’s movement) for a large tanker may take up to 1.6 nm. Image source: Maritime and Coastguard Agency
	For a wind farm, the impact of a boundary line row of turbines for vessels transiting along its length will influence the minimal distance calculation. A ships track could deviate 20° or more. MCA uses the 20-degree rule (e.g., a 15 nm row of turbines results in a corridor width of 5.5 nm between wind farms). However, this doesn’t need to be applied to Zone boundaries as they do not necessarily represent a wind farm boundary or a physical row of turbines.  Image Source: RCG 2017
International regulations and guidelines for maritime spatial planning related to safe distances to multiple offshore structures (e.g. wind farms) (CESMA, 2016)	The Netherlands has used data supported by PIANC for channel design, but several options exist. In general, they strive for an obstacle-free buffer zone of 2 nm between wind farms and shipping lanes. However, they also suggest that developers must consider a turning circle of 6 vessel-lengths and a safety buffer of 500 m from the edge of a shipping lane. Yet at some wind farm sites, major shipping routes have buffers up to 1.5 nm.
Baltic SCOPE Project (Baltic SCOPE Project, 2015)	Swedish guidelines do not provide a formal minimum distance, and point out that the results of individual risk assessments for individual wind farms can have different distances. In all cases, safe distances have been dealt with locally based on traffic and other factors.

Figure A-1 continued

Reference	Summary
German guidelines (WSV.de., 2009)	The minimum distance between wind farms and shipping lanes (and other routes used by vessels) shall be determined on an individual basis that considers vessel traffic and other peripheral conditions. A guideline of 2 nautical miles plus 500 m safety zone shall apply.
IMO International Regulations for Preventing Collisions at Sea (COLREG) (IMO, 1972)	IMO regulations are endorsed by The Confederation of European Shipmasters' Associations (CESMA). An emergency turn radius is considered 6 times a vessel's length. A buffer zone is based on vessel length. Traffic surveys would also identify any route bias where mariners may naturally turn starboard to facilitate passing encounters. Image Source: CESMA 2016 

Appendix B. Research Studies

Figure B-2. Research Studies on Minimum Distances Between Wind Farms and Main Vessel Traffic Routes

Reference	Summary
ACPARS (USCG, 2016)	The ACPARS examined whether waterways required routing measures in relation to offshore wind farm areas. However, the study did not predict changes in traffic patterns or determine the resultant change in navigational safety risk for different siting scenarios of offshore renewable energy installations.  The limitations of the ACPARS were flagged by the Pacific Northwest National Laboratory (Copping, 2013). The USCG applied MCA guidance (MGN 371, which has been replaced by MGN 543). The ACPARS proposed 5 nm separation from the entry and exit of a TSS, and 2 nm from the parallel outer, or seaward, boundary of a traffic lane.
UK Nautical and Offshore Renewable Energy Liaison Committee (Nautical Institute, 2013)	This setback and lane width calculation is based on 2x vessel lengths for each lane of traffic plus an obstacle-free buffer zone of 2 nm between hazard and shipping lane. This is based on the UK's Nautical and Offshore Renewable Energy Liaison Committee recommendations. 
Pacific Northwest National Laboratory (PNNL) (Copping, 2013)	Used modeled data to predict traffic risk profiles associated with an offshore wind farm, but the report does not explicitly state the distance vessels choose to navigate off a wind farm. However, Rawson and Rogers (2015) seem to suggest the research implies 5 nm (Rawson, A. and E. Rogers 2015).
Swedish guidance (Steamship Mutual, 2009)	This states that it would be prudent for passing vessels to lay off courses at least 2 nm clear of a wind farm.
UK Strategic Environmental Assessment (BMT Cordah, 2003)	This assessment treated a Traffic Separation Scheme as a maximum constraint.

Appendix C. Case Studies

Figure C-3. Case Studies on Minimum Distances Between Wind Farms and Main Vessel Traffic Routes

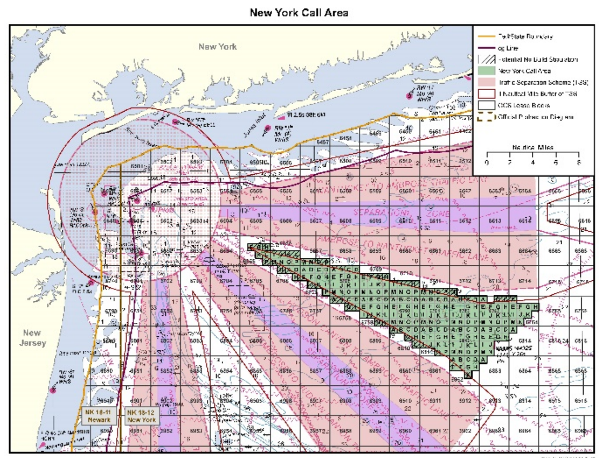
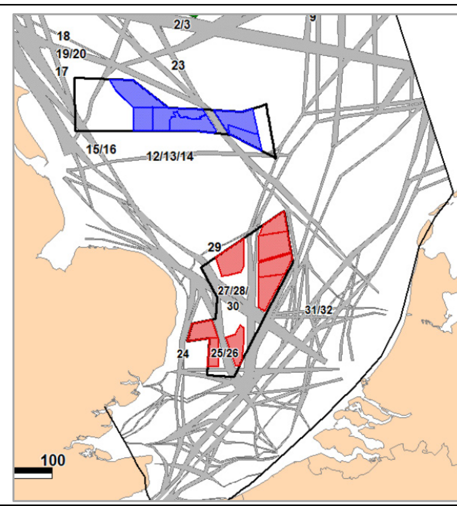
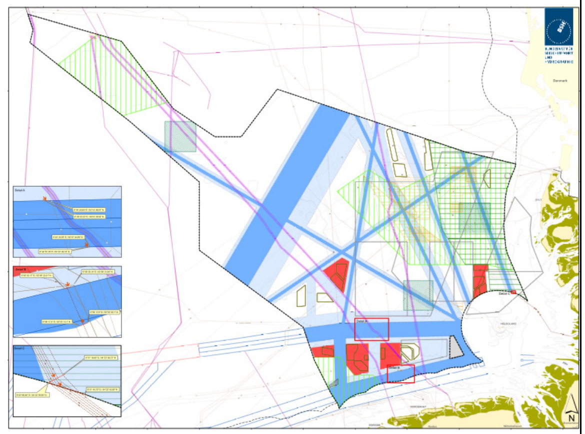
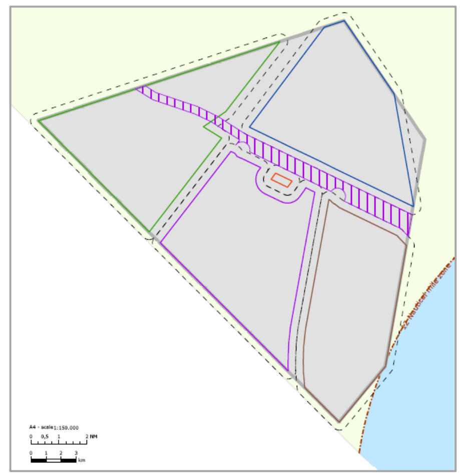
Reference	Summary
BOEM NY WEA (now leased by Statoil) lease area	BOEM excluded aliquots within 1 nm (1.9 km) of the two TSSs that border the Zones (the Hudson Canyon-to-Ambrose TSS and the Ambrose-to-Nantucket TSS). Image Source: BOEM n.d. 
Navitus Bay offshore wind farm (UK) (Anatec, 2014)	This project applied MCA MGN 371 guidance. Modelled commercial traffic as leaving 1 nm between the wind farm boundary and their route, although ferry operators expressed a preference for a 2 nm passing distance.
Triton Knoll offshore wind farm (UK) (RWE Npower renewables 2011)	This project applied MCA MGN 371 guidance. A passing distance of 1 nm was acceptable.
Thanet offshore wind farm (UK) (Marico Marine, 2005)	This project applied MCA MGN 543. It used a minimum distance of 0.3 nm (500 m), but each vessel route was modified using new waypoints (identified by master mariners through consultation) between 0.5 and 1 nm from the site boundary.
Hornsea offshore wind farm and East Anglia wind farms (UK) (Forewind, 2014)	These projects examined the cumulative impacts of navigation from 3 major wind farm zones in the North Sea. Each project applied MCA MGC 543. For East Anglia, the shortest distance between wind farm areas was 3.6 nm, and the distance from vessel transit route to the wind farm boundary was 1.9 nm. For Hornsea, the shortest distance between wind farm areas was 3.9 nm, and the distance from the outer edge of the vessel transit routes to the wind farm boundary ranged from 0.5 to 0.75 nm. 

Figure C-1 continued

<table>
<tr><th>Reference</th><th colspan="2">Summary</th></tr>
<tr><td>Germany master plan for offshore wind
(BSH n.d.)</td><td>In the German master plan, the distances between wind farms are variable, but the minimum distance is 3.2 nm, and it appears that the distance from the shipping transit route follows the Dutch model of 0.3 nm (500 m).
Image Source: BSH n.d.</td><td></td></tr>
<tr><td>Borssele offshore wind farm
(Netherlands Enterprise Agency, 2016)</td><td>The minimum distance between wind farms is 1 to 1.1 nm, but the distance from the proposed shipping transit route between wind farms is only 0.3 nm (500 m).
However, the longest length of the innermost boundary (assume to represent a row of wind turbines) is 2.8 nm, which is within the MCA's rule for a 20° deviation.
Image Source: Netherlands Enterprise Agency 2016</td><td></td></tr>
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